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SUSTAINABLE BUILDINGS CONSTRUCTION PRODUCTS & TECHNOLOGIES

EXTENDED ABSTRACTS

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SUSTAINABLE BUILDINGS – CONSTRUCTION PRODUCTS & TECHNOLOGIES

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Preface

Climate change, increasing energy demand and resource scarcity not only require a change in infrastructure and industry but also in buildings and cities with smart technologies and systems.

Research and innovation crucially contribute to sustainable and energy-efficient buildings and cities. In the course of the research programme “Building of tomorrow” in the last years my resort has supported many concepts and key technologies for buildings. International co-operations made it possible to successfully disseminate Austrian research results. Today Austria plays an international pioneer role in energy-efficient building.

The new research programme „City of tomorrow“ aims to face coming challenges by funding technological research and development projects of systems and services for the city of the future.

I am therefore very pleased to introduce here at the Sustainable Building Conference 2013 this new research programme to an international audience for the first time. Dedicated to essential questions reaching from renovating buildings and quarters to smart cities, the conference is an excellent platform to present Austrian technologies and know-how in the realms of buildings and cities.

With this in mind I wish those attending the international conference stimulant and exciting discussions!

Doris Bures
Bundesministerin
für Verkehr, Innovation und Technologie

Fotonachweis: bmvit / Peter Rigaud

Preface Minister

The klima:aktiv building standard is Austria´s most prominent quality label for buildings

Sustainable building and renovation are essential instruments of climate protection and represent an important step towards energy autonomy. About one third of our energy consumption results from private and public buildings and from service buildings. Due to space heating and their demand for electricity buildings cause a substantial part of the greenhouse gas emissions.The klima:aktiv building standard is Austria´s most prominent quality label for buildings

Sustainable building and renovation are essential instruments of climate protection and represent an important step towards energy autonomy. About one third of our energy consumption results from private and public buildings and from service buildings. Due to space heating and their demand for electricity buildings cause a substantial part of the greenhouse gas emissions. With comprehensive thermal retrofitting, greater energy efficiency in new buildings and an increase in the share of renewable energy we can protect our climate for the long term. Austria possesses extremely extensive know-how in the fields of environmentally benign and energy-efficient construction and heating technologies. Our country is a frontrunner in the passive house technology and all over the EU one out of three solar energy systems is already from Austria. We must exploit this immense potential.

My ambition is to achieve energy autonomy, meaning that, on balance, Austria produces enough energy from renewable sources to be self-sufficient. To attain this goal until 2050 I am strongly promoting a shift of our system towards renewable energy and higher energy efficiency. With my climate protection initiative klima:aktiv, the subsidisation priorities in the climate and energy fund, the promotion of environmental projects in Austria and vigorous action to foster thermal refurbishment, the Ministry of Life offers concrete advice and financial support. These investments have also significant economic impacts in Austria: They bring about economic recovery and growth and provide new green jobs.

The klima:aktiv programme "bauen und sanieren" for building and renovation aims at making energy-efficient building and comprehensive thermal-energetic refurbishment an issue of public interest. The klima:aktiv building standard of the Ministry of Life is the most prominent Austrian quality label for residential buildings and service buildings. It is awarded to buildings which satisfy very demanding energetic and ecological requirements. Energy-saving and energy-efficient building is an essential criterion which we have to fulfil to achieve energy autarky. A construction sector which is oriented towards sustainability has positive impacts not only on the environment: With new green jobs it provides promising perspectives on the job market and induces economic advancement.

The Sustainable Building Conference 2013 in Graz comprises highest standards concerning "blue buildings", "green products" and "smart cities". We are convinced that the klima:active building standard will contribute to the high quality of this international conference.

I wish the Sustainable Building Conference 2013 a sustainable success and lots of interesting discussions and insights.

Nikolaus Berlakovich
Minister of the Environment

Ladies and Gentlemen,
dear participants of the “Sustainable building Conference 2013”

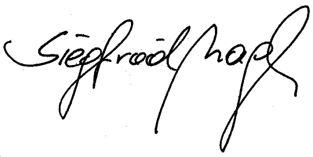
A cordial welcome to Graz, the World Cultural Heritage City, the City of Human Rights and the City of Design!
All three titles have one thing in common: They are all connected to UNESCO.
If we leave out the U-N and O, then it is about Education, Science, and Culture.
We like to think that our city is built on these three pillars, but one pillar is missing here and that is commerce and industry.
But, as you know, this fourth pillar results from promoting the first three.Knowledge is power. Research and the resulting competitive edge form the basis for surviving in today’s global competition.
The ever growing body of knowledge, which is making it more and more difficult to gain an insight into and an overview of specialized fields, means that working in networks is indispensable. These networks between universities provide the foundation for world-class research.

However, networks are a significant factor for progress and development on all levels—both for individuals as well as projects and businesses.

The worldwide growing urban centres need new and creative solutions for ecological and sustainable house building, as well as plant manufacturing. We need also sustainable energy supply, short distances between accommodations, offices, kindergartens, schools and shop centres etc. and we need smart solutions for the traffic.

Therefore, I would like to wish your conference a successful outcome and hope to be able to welcome you again soon in our city!

Yours sincerely,



Mayor Siegfried Nagl
City of Graz

Dear SB 13 participants,

As director of the executive department for urban planning, development and construction of the City of Graz it is a great pleasure to be able to welcome you to Graz, where sustainability in building has long been an important topic. We understand the importance of communicating with other cities and other regions in order to be able to compare the best examples, both in research and in practice. This enables us to discuss their relevance for each city and therefore find optimal solutions. Everyone benefits from being involved in this sort of international cooperation.
The City of Graz has already achieved international recognition for its efforts to find sustainable solutions. This has been made possible through cooperation with numerous experienced partners such as the University of Technology in Graz, Province of Styria and also with outstanding companies working within the research and energy sector. For this reason our concept for a Smart City, the sole flagship project in Austria, has been awarded with a financial sponsorship from the federal running into millions.
This means that we are now able to begin the detailed planning phase of building a sustainable, futureproof, energy self-sufficient district which will be built on an old industrial brownfield near to the main train station in Graz.

Concerning the project “Energy City Graz-Reininghaus”, an overall energy concept including energy networks will enable sustainability for this district. The first steps of the implementation can already be seen.

At SB 13 internationally renowned experts will highlight all aspects of sustainable construction in numerous talks and lectures. The topics range from sustainable, energy self-sufficient urban technologies and the building of new, futureproof buildings to environmentally friendly building materials and sustainable renovation as well as the development of whole districts in such a way that resources are conserved and the observation of the entire lifecycle of buildings.

The fact that young researchers have been invited to come and present new research methods shows that we do not want to simply be satisfied with that which we are building now, but that we want to focus on the future. I have high hopes that the International Sustainable Building Conference 2013 in Graz will represent an important milestone in the development of sustainable building!

I wish you every success and best wishes for a sustainable future!

DI Mag. Bertram Werle
Director of the executive department for urban planning, development and construction
City of Graz

As most visible elements of our built environment, buildings satisfy a deep rooted human need for protection, comfort and well-being. Be it on the workplace, at home, or the public sphere, constructions most strongly determine our quality of life.

But construction and operation of buildings also form part of highest primary resource consumption, energy intakes and environmental pollutants. With 30 to 40 % of pollution and energy consumption within the industrialized world being associated with our buildings, quality and efficiency improvements can provide profound contributions to a more balanced and ecologically sound society.

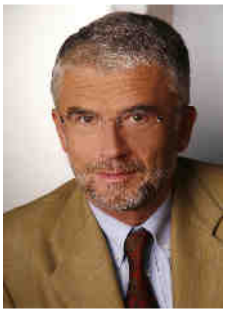
Therefore all constructive disciplines, civil engineers, architects, infrastructure planners- as well as socio-cultural scientists and political representatives need to be interlinked in order to make a difference by implementing new and innovative technologies. With life cycles that last over decades, generations and often centuries, application of newest technologies and standards is paramount when it comes to ecologically sound and economically efficient buildings.

Being a powerhouse of sustainability, Graz University of Technology is the perfect place to host this “International Sustainable Building Conference”. Through our Field of Expertise “Sustainable Systems”, as well as via the “European sustainable energy innovation alliance” (esaia), we form part of a highly dynamic global sustainability network. Your conference participation most clearly displays the successful path this institution has taken. The coming days will provide you with ambitious intellectual, scientific as well as social inputs. All this is needed to help implement long lasting solutions – and develop new ideas – on how to reduce our primary and secondary resource consumption in building and construction. I hope that after the coming days you will associate Graz with visions, ideas and solutions on how to make our planet a better place!

Yours

Harald Kainz
Graz University of Technology

Foreword

Meanwhile sustainable development has got to a place in the building and construction sector. Therefore it is time to transpose the paradigm change into practice on an overall basis. Whereas in Austria energy efficiency, use of renewable energy or reduction of greenhouse gas emissions were synonyms for sustainable construction we can notice today an increasing acceptance of the holistic approach, the necessity of considering ecology, economy and sociocultural aspects in the building sector simultaneously over the entire life cycle.

The European Commission enforced this development by releasing numerous strategies, directives and regulations such as e.g. the Energy Performance of Buildings Directive, the Lead Market Initiative Sustainable Construction or the new Construction Products regulation with the new Basic Requirement 7 (*Sustainable Use of Natural Resources*). Parallel to these mandatory regulations, a suite of standards (e.g. European standards for sustainable construction) and non-mandatory building certificates particularly in the area of office and retail buildings emerged. This intensive supply of information, however, leads to many more questions from clients and practitioners, especially on how buildings can be constructed and maintained in a sustainable way.

With these facts in mind, we highly appreciate the initiative of CIB, UNEP, iiSBE and FIDIC of having established the series of SB conferences and are very happy to host the last one of the central European SB conferences in 2013 here in Graz.

One of the most important starting points is the sustainable handling of the existing building stock therefore the SB conference in Graz addresses not only new buildings but also restoration and refurbishment. Hence, we combined the SB13 Graz conference with the öko**san** conference, which is normally hosted by AEE INTEC (Institute for Sustainable Technologies). Öko**san** is a symposium on ecologically sound refurbishment technologies and best practice examples and together with AEE INTEC we have a strong partner, which offers the possibility to merge theory and practice.

Graz University of Technology and particularly the Faculty of Civil Engineering Sciences acted always as an interface in technology transfer between all stakeholders. Therefore, we do hope to contribute with this conference to a knowledge transfer in the scientific community, but especially with commercial partners from industry, planners and public authorities, in order to realise a sustainably sound built environment without overflow of rules and regulations. Standards and assessment tools should be accepted as support and assistance, not as a restraint.

We are looking forward to your vital participation in the sessions and workshops and wish you a pleasant stay in the green heart of Austria.

Prof. Dr. Peter Maydl
Graz University of Technology

Ass.Prof. Dr. Alexander Passer
Graz University of Technology

Dr. Karl Höfler
AEE INTEC

Dear Participants of the “Sustainable Building Conference 2013”,

The global issues we are all currently facing are multiple. A central one is certainly the continuously rising global demand for sustainable solutions and the building sector is playing a key role in this area.
The supply of future oriented building material solutions and optimized production processes of building materials are consequently the core of the Wienerberger sustainability strategy.
Our target is the delivery of building concepts for tomorrow today. Our long-lasting, resource-conserving building materials as well as our energy-efficient house concepts help our customers make a substantial contribution to environmental protection. Our e4-Brickhouse 2020 for example has a positive energy and CO_2 balance and in this way makes an active contribution to climate protection.

Wienerberger sees also an important potential in the education of young people in the field of sustainable building solutions. Therefore, Wienerberger provides an international education program dedicated to Masters Students of Architecture, Civil and Environmental Engineering who are outstandingly motivated in the field of sustainable building and wish to extend their knowledge and experience in this area. Within the first round of the Wienerberger’ s Sustainable Building Academy (WISBA 2013/2014) we invite 12 students from three different countries for a fully financed one semester training together with experts from science and economics in the field of sustainable building. We start the program of WISBA 2013/2014 in cooperation with the Sustainable Building Conference 2013 in Graz because it guarantees our scholarship recipients the scientific exchange on a high level with the most important experts in Europe. The 3-day kick-off event of WISBA will then be followed by four international workshops during the next months and a final conference in spring 2014.

Sustainable management has been a key part of the Wienerberger corporate culture for many years and is fully integrated in all areas of the company. In order to make our sustainable management activities even more transparent, we have decided to announce our sustainability goals for various areas in the sustainability report 2012 and will report regarding our progress in the future. I invite you to form your own opinion of our efforts with respect to sustainability management and to join us on a sustainable course into the future. For the Sustainable Building Conference 2013 in Graz I wish you all interesting discussions and a promising outcome.

Yours,

Heimo Scheuch, CEO

A1

Legal and economic frame conditions for ecological high quality refurbishment

Chair: Robert Schwertner
FFG – Austrian Research Promotion Agency, Austria

Comparison between energy usage and thermal comfort of typical masonry houses in Ireland before and after receiving retrofit

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Short Summary

This paper presents findings from a case study set of typical masonry residential buildings in Ireland to determine the efficacy of typical insulation and building fabric upgrade works in reducing energy and greenhouse gas emissions, as well as their affect on the perceived thermal comfort of the occupants. This is achieved by monitoring 19 houses and assessing the internal environment, energy consumption, comfort and occupant behaviour, before and after typical residential insulation improvements. The retrofit provisions included pumping the cavity walls with insulation and increasing the level of ceiling (attic) insulation. The level of satisfaction expressed by the occupants in relation to the thermal comfort conditions before and after the upgrade works varied. As expected, the upgrade of insulation of the houses lead to increased internal temperature, but also in most instances an expected decrease in overall energy consumption. With deep retrofitting required on houses in Ireland if Ireland's target to reduce CO_2 emissions of buildings by 90% by 2050 is achieved, further research on actual energy savings from retrofitting measures is vital.

Keywords: Lifecycle assessment; Retrofit; Embodied energy; Embodied carbon; Residential.

1. Introduction

With a considerable portion of Ireland's existing building stock initially constructed to relatively poor energy performing standards, retrofitting packages will play a vital role in landscaping Ireland's future housing stock and will be important to achieving energy targets [1]. Hence, the importance of a lifecycle analysis study, in terms of energy and carbon, for retrofitting projects is authenticated. Previous studies have highlighted possible energy savings through SEAI retrofitting schemes [2]. Furthermore environmental life cycle assessment (LCA) studies highlighted the importance of actual operational energy and carbon usage in homes as a true carbon footprint indicator [3,4]. Therefore, before the largest national retrofitting scheme is undertaken in Ireland it is imperative the true potential of retrofitting project initiatives is carefully assessed. A residential housing estate was identified in Ballyshannon, Co. Donegal as a suitable case study. Operational monitoring started from November 2012 with upgrade retrofit works completed in December 2012. This paper contains provisional results as monitoring is ongoing. A full economic and environmental lifecycle analysis is presented, which considers both the energy consumption and carbon emissions embodied in the retrofit works together with those associated with the operation of the home.

2. Case study retrofit project

The Highfields residential housing estate in Ballyshannon, Co. Donegal consists of 19 masonry housing units constructed in 2004 consisting of semi-detached single-storey and two-storey dwellings. Thermal upgrade retrofit works were completed in 2012 consisting of basic thermal cavity wall and ceiling insulation upgrades [5]. Average pre-retrofitting works Building Energy Ratings (BER) ranged from D2 to C3 for estate houses with estimated annual primary energy consumption and carbon dioxide emissions varying from 185-294kWh/m^2/yr and 47-75kgCO_2/m^2/yr, respectively, using the Dwellings Energy Assessment Procedure (DEAP), which is the Irish official method for calculating and rating the energy performance of dwellings. BERs improvements are recorded in all homes post-works. Average post-retrofitting works BERs ranged from D1 to C2, which equates to post-works annual primary energy consumption and carbon dioxide emissions of 169-267kWh/m^2/yr and 43-67kgCO_2/m^2/yr, respectively. Sensors were installed to measure temperature, humidity, oil usage and electricity usage in homes. Occupant surveys were also conducted on tenants both pre- and post-insulation works. Appropriate Met Eireann external weather data was gathered.

Provisional results suggest a slight immediate increase in internal temperatures following insulation upgrade works completion. Consequently average internal temperatures appear to decrease after a period which may be caused by user behaviour or external influences. Average internal temperature and relative humidity vary substantially between homes and rooms. Therefore, occupant user behaviour cannot be ignored when estimating actual energy and carbon savings following retrofitting. Tenant perception on the internal thermal comfort of their homes pre- and post-retrofitting reflects favourably on the perceived benefit of retrofitting to the internal environment of houses. Nine of the case study houses experience decreases in average daily electricity usage after upgrade works. Estimated economic annual energy spending analysis suggests an average estimated annual space and water heating spending reduction of €9 per m^2 of floor area for the one-bedroom semi-detached single-storey dwellings after insulation works. Little or no monetary spending estimated savings are recorded for the larger semi-detached houses. On the other hand, 60% of assessed estate tenants had found noticeable energy savings following the upgrade insulation works according to survey results. Such results favourably represent the client perceived residential retrofitting approach. There was a noticeable difference between the estimated savings using DEAP and the perceived savings from occupants. This highlights the significance of perceived operational energy savings when used as a benchmark. Issues such as physical and occupant ‘take-back’ and energy usage offsetting may have an impact in retrofitted results. Further analysis over a longer period will highlight such issues.

3. Conclusions

A noticeable improvement in internal temperature and occupant perception of internal thermal comfort was recorded in many homes following completion of basic cavity wall and attic (ceiling) insulation upgrade works. Provisional results recorded half the assessed homes held a noticeable average daily electricity usage decrease following completion of works. A survey of occupants undertaken soon after retrofitting works were completed highlights the significance of perceived energy savings as a result of retrofitting compared to actual or relative occupant savings. Care is needed when utilised as a retrofitting energy benchmark. Future Irish retrofitting strategies may need to account for the actual operational savings impact compared to the perceived for various retrofitting packages on Irish residential buildings.

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Collaboration Models for Industrialised Renovation Methods and Prefabrication – Experiences and Outlook on Organizational and Legal Frame Conditions

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Short Summary

The application of innovative industrialised renovation methods and prefabrication can improve renovation quality significantly and reduce time on-site and costs during renovation. The feedback of seven building renovations in the E2ReBuild project provided a better understanding concerning the influence of the applied collaboration model on its successful implementation. Communication and know-how exchange were crucial for joint development and optimization of quality, costs and time. Neither the current *Design-Bid-Build* nor the *Design-Build* approaches were able to meet the requirements of industrialised renovation methods. Procurement framework restricted owners to compose teams according to project specific requirements and hindered the collaboration of planners and contractors in early planning stages. Finally, all interviewed stakeholders within E2ReBuild stated a high replication potential of the applied technologies, processes and models – provided that framework conditions would facilitate their implementation.

Keywords: Building Renovation; Energy-efficiency; Industrialization; Prefabrication; Collaboration;

1. Motivation and objectives

E2ReBuild aimed at further development, demonstration and promotion of cost-effective, energy-efficient retrofit strategies for broader application on the market. First feedback from practice showed that industrialised methods and implementation of prefabricated façade and roof elements were especially sensitive regarding collaboration among actors. Thus, the aim of the analysis and evaluation of collaboration models within E2ReBuild was to identify framework conditions that influence appropriate collaboration, to uncover barriers and risks that hinder successful team set up, to identify necessary actions within legislation and to present key aspects for successful collaboration models.

2. Methodological approach

Based on a dialogue between researchers, developers and owners the seven Demo projects served as a source for analysis and evaluation of the applied collaboration models. By means of interviews, site-visits and stakeholder discussion panels the experiences were collected and documented in collaboration charts and action line diagrams.

3. Definitions

The definition developed in the E2ReBuild project targeted to define collaboration models beyond sole business models and described the target-oriented concerted actions with defined interfaces, responsibilities, rights and obligations to achieve a common goal.

4. Findings: Design-Bid-Build vs. Design-Build approaches

The analysis of collaboration charts and action line diagrams showed two basic models for the planning and construction process applied in the E2ReBuild Demos: The *Design-Bid-Build* and the *Design-Build* model. While the *Design-Bid-Build* was characterized by the "*Bid*" as a clear step in the process to appoint the planners and contractors, the *Design-Build* approach united the planning and construction under the umbrella of one *Total contractor.* Hereby tendering of different trades was avoided, subcontractors were chosen by the *Total contractor* with reference to costs and time fixed in the global contract.
The question of risks and responsibilities dominated collaboration in the Demos. In the *Design-Build* models, the risks and responsibilities were transferred to the *Total contractors*. In contrary in the *Design-Bid-Build* models the owners were very active in controlling and steering processes, methods.
Communication was a crucial point. It needed a lot of personal effort to keep tenants informed and respect their needs. Everybody was aware of that. In contrary, communication and know-how transfer among planners and contractors was less sufficient and the awareness of the importance to facilitate know-how sharing for joint development was quite low.

5. Conclusions

This project showed that neither the current traditional *Design-Bid-Build* nor the *Design-Build model* could sufficiently meet the requirements for industrialised renovation methods. Nevertheless, similar requirements on organizational level and obstacles within legislation were identified:

- Communication and know-how exchange among professionals was crucial for industrialised renovation methods and the application of prefabricated façade and roof elements.
- The link between the planning team and the contractors. Early and good integration of relevant contractors ensured optimization of workflow, costs, time and implementation quality.
- Procurement framework restricted owners to compose teams according to project specific requirements and hindered collaboration of planners and contractors in earlier planning stages.

6. Further information

This paper reports the legal and economic aspects identified and evaluated within the WP "*Innovation in Planning and Design*" in E2ReBuild. Further aspects concerning opportunities, obstacles and risk are shown in the paper "*Collaboration Models for Industrialised Renovation Methods and Prefabrication – Opportunities, Barriers and Risk" [3]*. The detailed report "*Evaluation of Collaboration Models*" [2] is available as download on the E2ReBuild website.

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Cost optimal building standards – evidence based! The case of Austria

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Short Summary

The new EPBD requires that the cost optimum over the life cycle of buildings is taken into account when requirements for the energy performance of buildings are established. National minimum standards should be set by the Member States based on the cost optimum for construction costs and operational costs. Therefore, the European Commission has submitted the regulation No. 244/2012.

A crucial question regarding the cost-efficiency of nZE buildings is whether calculated energy demand and costs assumptions are corresponding with measured energy consumption and real cost data from buildings in use. Up to now there is little empirical evidence to answer this question on a broad basis, even in those countries where a considerable number of nZE is already realized.

This paper is based on recent research results based on a broad empirical survey by e7 together with the Austrian Federation of Limited-Profit Housing Associations (gbv). The survey was launched in order to collect energy consumption AND cost data from innovative multi-family-residential buildings which can be regarded as nZE buildings in order to analyze the cost-effectiveness of those buildings. The paper presents results derived from a broad sample of about 90 buildings.

Based on this survey, there is empirical evidence that the measured energy consumption for heating in nearly zero energy buildings is lower than for low-energy buildings. However, the difference in practice is significantly lower than expected from design values.

Whether passive house or low energy standard: there is a broad range of factor three, in the actual energy consumption, depending on accurate construction, proper operation of the building and user behavior. It would be misleading to draw conclusions from studying only small numbers of buildings. On the other hand, this provides a high potential for the optimization of the buildings operation and thus to reduce running costs for the users.

Maintenance costs vary widely and those buildings with ventilation systems tend to have higher maintenance costs. The lower energy costs of passive–house and lowest-energy building types therefore tend to be partly compensated for by higher maintenance costs.

In general, the lower costs for heating energy do not compensate for the higher investment costs for the passive-house standard of building. At least for the specific situation in Austria it seems, that lowest-energy standard (energy heating demand about 20-30 kWh/m².a) turns out to be the range for cost-optimal building standards. This is well in line with theoretical calculations on cost-optimal building standards for multi-family-residential buildings in Austria, carried out independently in 2012.

Keywords: Cost-optimality, residential buildings, energy use, cost-optimal building standards, nearly zero energy buildings

Comprehensive Assessment of Refurbishment of Existing Buildings in China

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Short Summary

In the wake of structural degradation and the enhancement of China’s building energy saving standards, large numbers of China’s existing buildings need to be rehabilitated. A comprehensive assessment system for the existing building’s refurbishment in China is developed. In addition, an assessment to forecast the remaining life of the existing buildings after retrofitting is also presented in the system. Finally, a public building in Liaoning province of China is analyzed as a case study to demonstrate the feasibility and validity of the system.

Keywords:Existing Building; Refurbishment; Comprehensive Evaluation; Energy Efficiency; China

1. Introduction

Currently, more than 11 billion square meters in the old buildings have problems with respect to safety and inner environment.China's construction industry has begun to enter the period of renovation and strengthening from the period of construction [1]. Hence, integrally, comprehensive and reasonable evaluation of the existing buildings refurbishing in China is important. In this study, a multi-objective and multi-level comprehensive evaluation system for the existing building strengthening and retrofitting in China is developed.

2. Methods and results

2.1 The comprehensive assessment index system

In the process, we refer to the British BREEAM, American LEED [2] etc. Considering the current situation of China, we also refer to the Technical Standard for Residential Performance Evaluation (GB/T50362-2005) and Green Building Evaluation Standard of China (GB/T50378-2006).

A Comprehensive Assessment System for the Strengthening and Retrofitting of Existing Residence (CASSRER) is designed with 3 level indicators. Level one includes 6 indicators, and level two includes 23 indicators, and level three contains 100 marking criteria.

2.2 Weights system

This paper adopted the analytic networks process (ANP), which use comparison matrix function in the super decision software (1.4.2), to determine the weight system based on a questionnaire survey of experts.
The comprehensive evaluation system for the strengthening and retrofitting of existing buildings obtains a score through the evaluation of each indicator. Finally, we obtain level one indicators' scores, as shown in Fig. 1.

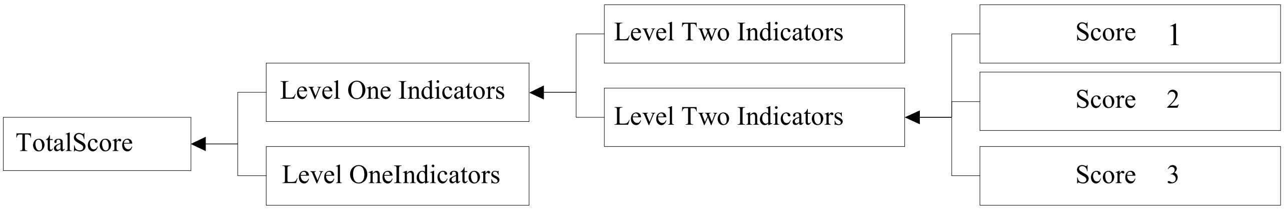

Fig. 1 Scoring Method

In this paper, four level-one indicators are divided into as objective indicators, meanwhile, two level-one are divided into as subjective indicators. Five grades scoring points for the subjective indicators are excellent, good, fine, qualified and bad, and respectively correspond to 1, 0.8, 0.6, 0.4 and 0.2 of the five scores. The preliminary rating standard is set for: 1. Being in urgent need of refurbishment (0 ≤score ≤ 30); 2. Being in need of refurbishment (30 < score< 60); 3. Being in no need of refurbishment (60 < score < 100).

2.3 Case study

A laboratory building constructed in 1992 and located in Liaoning Province of China was evaluated by the proposed system. In the process of refurbishment of the laboratory building, some new technologies were adopted. Table 1 is the result of the comparison of building before and after refurbishment.

Table 1 the comparison of the results

Results of the Building before Refurbishment			Results of the Building after Refurbishment		
The Indicator Scores			*The Indicator Scores*		
Total Score	43.00	Renovation	Total Score	65.00	Renovation
Building and Structure	46.00	Renovation	Building and Structure	50.00	Renovation
Indoor Environment	54.00	Renovation	Indoor Environment	62.00	Renovation
Energy efficiency	24.00	Urgent Renovation	Energy efficiency	85.00	Urgent Renovation
Outdoor Environment	66.00	No Renovation	Outdoor Environment	66.00	No Renovation
Regional	76.00	No Renovation	Regional	76.00	No Renovation
Economy	45.00	Renovation	Economy	51.00	Renovation

3. Conclusion

An existing building strengthening comprehensive evaluation system is developed in this paper. The evaluation system provides a useful tool for assessing the performance of existing buildings, the grade of strengthening and reconstruction necessity as well as the specific direction of strengthening and reconstruction can be determined.

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Life cycle perspectives in a high quality refurbishment - Part 1

Chair: Christian Hofstadler
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Critical Issues in Application of New European Standard EN15978 in building refurbishments

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Short Summary

This paper focuses on the specification of critical points in the assessment of a chosen building to be elaborated according to EN 15978 [2] and EN 15804 [3]. It is based on the scenario for a specific building refurbishment – underground part of the building was maintained, upper part was deconstructed and built as new re-using the most of the deconstructed building materials possible. The calculations of environmental performance are not part of this paper, but are planned as a next step of the future work of the authors.

Keywords: Life cycle assessment; refurbishment; building assessment; environmental performance of buildings

1. Introduction

Life cycle assessment of buildings is nowadays used first of all for new buildings. The situation is quite different in assessment of existing buildings and their refurbishments. There are only quite few LCA analysis for existing buildings in the world, and most of them are only simplified versions. It is clear that we should focus on LCA of existing buildings because it is generally known that new buildings represent just a minor portion of the total number of buildings (for example the annual growth rate of new buildings added to the housing stock is 1.5%) [1]. From this point of view, we are able to influence the overall environmental performance of buildings more efficiently if we also focus on improvements of the existing ones.

It emerged from the background research that there is not a sufficient number of relevant examples of life cycle analysis of refurbishments of existing buildings. Furthermore, the assessment method according to the European Standard EN15978 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method [2] is quite new and no LCA studies have been done so far. It has been decided to create a detailed LCA of a typical Czech existing building intended for refurbishment. Detailed scenarios are modelled for individual modules of life cycle of the building and particular and problematic issues are defined within the process.

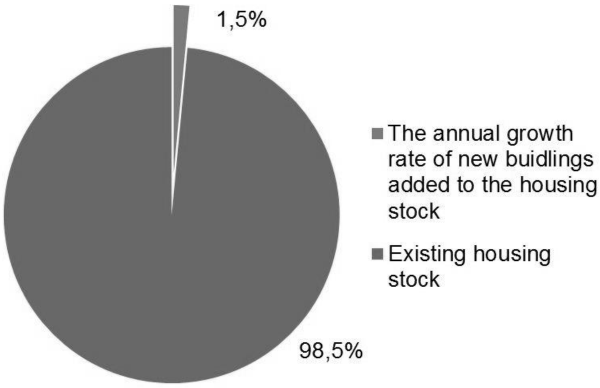

Fig. 1: The annual growth rate of new buildings added to the housing stock [1].

2. Purpose of the assessment

The purpose of the assessment is defined by the goal, the scope and the intended use of the assessment. In our case, the intended use of the assessment is according to the norm [2] following:

- Assistance in decision making process (for example comparison of the environmental performance of different design options);
- Documenting the environmental performance of the building;

3. Conclusions

This study of problematic issues during creation of LCA model of a building is a beginning of a complex project of LCA assessment of existing building.

The results of this preliminary study show us several critical issues that influence the overall LCA result. The common feature of the critical issues is their **unpredictability in the future**. This unpredictability should be always taken into account when creating LCA scenarios and interpreting their results.

The major uncertainties that influence most of the modules and are hard to be predicted are following:

- Service life (moral and technical) of building and particular parts;
- Change of building use;
- Social and urban changes;
- Technological progress in transport methods, construction processes, ways of disposal, recycling etc.;
- Legal changes;
- Insufficient data on environmental performance of materials and building components.

The resulting LCA will always be accurate only within a certain **probability measure** which is hard to be determined as well because the number of possible development scenarios may be infinite.

4. Acknowledgement

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Environmental and economical assessment of refurbishment concepts

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Short Summary

This paper summarises the results of the recent research Methods and Concepts for Sustainable Renovation (MECOREN) carried out at VTT (Häkkinen et al. 2012). The objective of the research was to develop methods and concepts for sustainable renovation of buildings.

Alternative refurbishment concepts were studied on the level of the Finnish residential building stock. Different refurbishment concepts were compared by assessing the impact in terms of energy and greenhouse gases (GHGs). When assessing GHGs of buildings and the effect of refurbishment on GHGs, it is important to choose a right method with the help of which the emissions are calculated. This is especially important when district heat and electricity are used as sources of energy.

The paper also assesses the significance of embodied environmental impacts in sustainable refurbishment projects. The environmental impact of renovation materials was compared to the saved environmental impact due to the energy saving achieved with the help of refurbishment. The demolition and building a new building was also considered as an alternative.

The assessment of the economical potentials of refurbishment concepts was carried for cases where an extensive refurbishment is needed for an out-dated building.

Keywords: Sustainable renovation

1. Introduction

The paper presents analyses the impacts of alternative renovation scenarios on Finnish building stock in terms of greenhouse gases (GHGs). The focus of the study was on residential buildings. The calculations were carried out for years 2010, 2020 and 2030. In addition to the assessment of the renovation concepts of building stock, the objective of the paper is also to

- discuss and give recommendations about the use of environmental data for energy sources
- discuss and make conclusions about the significance of building materials in renovation projects from the view point of greenhouse gases and total energy use
- assess and make conclusions about the economic impacts of building renovation.

2. Environmental profiles for electricity and district heat

In order to assess the environmental potential of different renovation concepts the environmental profiles for heat and electricity was calculated as an average value for 2004–2008. The newest prediction made by the Finnish Ministry of Employment and Economy was done in the connection of the new climate and energy strategy. The paper also assessed the impacts of renovation when the results were calculated with the help of the predicted values.

3. Environmental impact of materials in building refurbishment

The objective of this part of the study was to assess the significance of building materials in building renovation in terms of GHGs. The environmental impact of renovation materials was compared to the saved environmental impact due to the energy saving achieved with the help of renovation. The case study indicates that the increased material consumption because of refurbishment to the level of low-energy and passive-level structures causes an increase in GHGs but this is significantly lower compared to the saved GHGs because of saved operational energy.

4. Energy consumption of the current housing stock and energy saving potential

The heating energy use and electricity use were calculated for all residential buildings by using model buildings. An exemplary building was created to present each of the different age-type groups in the building stock and these model buildings were then used for calculating the energy consumption of the housing stock.

5. Effect of calculation rules

As there is a rapid change in the assessed CO2 values of electricity and district heat between the years 2010, 2020 and 2030, the possible consideration of this change in LCAs of buildings has a significant effect on final results. It is here recommended that especially when making building level or stock level life cycle assessments over 50 years' period, the assessed change in emission values should be considered. An example of the significance of the issue is given in the paper.

6. Economical assessment of renovation concepts

The assessment of the economical potentials of refurbishment concepts was carried for cases where an extensive refurbishment is needed for an out-dated building. However, also separately done refurbishment measures such as changes of windows, refurbishment of facades etc. should lead to a reasonable improvement of energy performance. The economical life cycle impacts of refurbishment depend on the investment cost and the reduction of energy consumption. However, a successful refurbishment also affects the resale value of the building. A significant increase in the value (market value) by means of extensive refurbishment can be achieved when the building is located in a relatively valuable neighbourhood and when the whole neighbourhood is renovated at the same time. Compensation can also be achieved by increasing the density of the area (with the help of extensions such as an additional storey or building).

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LCA and LCC based Energy Optimization of Building Renovation Strategies

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Short Summary

The aim of the paper is to evaluate the efficiency of retrofitting of the built asset in order to choose the most sustainable strategies. This work aims to give a contribution in defining a practical LCA and LCC-based method applied on a specific case study.
A multi-storey residential building located in Northern Italy was analysed in order to evaluate different renovation alternatives. The methodology is based on the evaluation of a wide range of possible refurbishment alternatives. The most sustainable one (Option B) was compared to a full demolition plus reconstruction (Option A). From the achieved results it is clear that, over a 50-year service life, renovation is the most convenient choice in terms of energy, GHG savings and costs.

Keywords: Renovation; Housing; Sustainability; LCA; LCC; Retrofitting; Carbon Footprint.

1. Introduction

In building sector, resources exploitation, energy consumption and harmful gas emissions have to be taken into account and cannot be neglected in order to obtain an improvement of energy and environmental efficiency. An economical and environmental analysis has been carried out (LCC and LCA) on a case study to compare a building energy refurbishment and a complete demolition plus new building reconstruction. The case study is a social housing building in Brescia, Italy.

2. Methodology

A 50-year service life has been taken into account to make a comparison between demolition plus new construction (Option A) and refurbishment (Option B).
Option A consists in the case study building demolition and the subsequent construction of a more efficient building, analyzing its operational phase in the service life.
The study of Option B is focused only on energy refurbishment, neglecting the benefits that could be generated from acoustic insulation, anti-seismic features or architectural upgrading. The functional unit considered for LCA and LCC is 1 m^2 of living area.

The environmental impact indicators considered for the analysis are the non-renewable Cumulative Energy Demand (CED) and the CO_{2eq} emissions into the air.
Amounts of materials are primary data relative to the case study, while materials production and other processes are secondary data taken from Ecoinvent 2.0 database and calculations performed with Simapro 7.3.3 Software.
Besides, in the economical analysis only the technical costs of the building operations have been taken into account and the overheads, the charges related to safety, business profits, VAT and the increasing of price of money during the life cycle have been neglected

3. Case study

The building case study is located in the Casazza - Brescia (Italy) and was built in 60-70s.

IDENTIFICATIONE OF TIME	Contemporary (1964-1975)
CONSTRUCTION MATERIALS	Brick-Cement
TYPE OF CONSTRUCTION	Beams and columns
BASEMENT DIMENTIONS	11m x 42m
TOTAL ELEVATION	22,5 m
GROSS VOLUME	12781 m^3
TOTAL NET AREA (usable)	2046 m^2
PERIMETER WALLS	2296 m^2
ROOF	400 m^2
FRAMES EXTERNAL	351 m^2

Figure 1: Characteristics of the building case study.

4. Inventory analysis

Demolition (Option A) plays the highest contribution in term of economic costs, whereas waste disposal is crucial for environmental impact because of the length of treatment processes. The demolition technique used for the operation is the use of excavators (De Angelis et al [2]).
The new building has the same living area of the existing building and better energy performances, with a primary energy need of 13,92 kWh/m^2year. Operational electric energy consumptions play an important role in GWP and CED impacts. Demolition phase is responsible of 6% of the total economic costs and of 1% of the environmental impacts.
Option B consists in an envelope energy refurbishment aiming at obtaining a reduction of building life cycle consumptions. Some basic activities on envelope have been studied from the economic and the environmental point of view, varying the insulation thickness and the kind of insulation material. These basic activities were combined to find the best set of operations able to guarantee environmental, economic and energy savings. The best mix consist in: ETICS in EPS with a thickness of 15 cm, slab insulation in EPS with a thickness of 15 cm, roof insulation with loose fill cellulose with a thickness of 20 cm and window substitution with a frame in PVC and low-e glasses 4-16-4 filled with argon.

5. Results

If only energy performance of the building is considered as benchmark (operational energy and use), in an extended service life perspective of 50 years, refurbishment (Option B) is the most convenient strategy.
The envelope insulation is one of the easier refurbishment activities on existing building that could assure the decrease of energy consumptions. In this case, the performances that could be attained will never be the same as the ones achievable in a new construction, but significant savings can be obtained upon decreasing heating needs in operational phase.

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Nearly Zero Energy Renovation of houses: Life cycle costs and environmental impact

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Short Summary

This paper describes the results and conclusions from an LCC and LCA analysis performed on a case study. An actual deep energetic renovation example in Torhout, Belgium was studied on its cost efficiency and environmental impact, comparing it to different other renovation scenarios: standard renovation – in which measures were applied to obtain an energy consumption level similar to the minimal energy requirement (EPB) for new houses and NZE or Nearly Zero Energy renovation, where the as built (or as renovated) situation was used as starting point and additional renewable energy systems were installed to strive to zero energy consumption. This allows on the one hand to verify which scenario is the most interesting in terms of costs and environmental impact, and on the other hand to gain insight in the feasibility of obtaining a NZE level in renovation of houses.

Keywords: Deep Renovation; NZE; Life cycle assessment (LCA); Life cycle costing (LCC)

1. Introduction

The principles of low energy buildings, passive houses and nearly zero energy houses have proven their feasibility within the context of construction of new buildings. However, in a renovation context it is not clear to what extent deep energetic renovation measures will be worth the effort.

The ERACOBUILD One Stop Shop project [1] focused on deep, energetic retrofits of houses and considered case studies of renovated houses to verify the feasibility of obtaining a ‘Nearly Zero Energy’ (NZE) level in renovation. More specifically, the cost effectiveness and the environmental impact of different renovation scenarios were determined using life cycle costing (LCC) and life cycle assessment (LCA).

2. Case study in Torhout, Belgium

Architect Luc Dedeyne renovated and transformed two neighbouring houses, dating from the early 1970s, into a single family house with private practice. The most important measures in the actual renovation are:

- Replacement of the floor slab on the ground floor and installation 15 cm EPS insulation;
- Replacement of the roof and installation of 32 cm additional mineral wool;
- Renovation of the street façade by demolishing the outer leaf of the cavity wall and installing 24cm of cellular glass with a ceramic materials as finishing layer;
- Replacement of old windows by triple glazed aluminium windows;
- Addition of Vacuum Insulation Panels (VIP) to the aluminium doors and garage door.
- Installation of a large (25m²) solar boiler, floor heating, heat pump and PV-installation (3.4 kWp).

The as built ‘Low Energy’ renovation with a Heat Pump (**LE-HP**) as energy source for heating & hot water is compared to:

- A building where the same measures for the envelope were taken, but a condensing boiler on natural gas is used for heating & hot water (**LE-CB**)
- Based on the LE-HP scenario, additional PV panels and a larger solar boiler are considered, in order to obtain the **NZE-HP** alternative.
- A Standard Renovation scenario is defined, based on minimalistic insulation measures and a condensing boiler (on natural gas) system: **SR-CB**. Attention was paid that the same degree & type of façade finishing are kept, in order to be comparable in costs.

3. Results

3.1 Cost efficiency

Investment costs are relatively high, especially for the wall renovation. This is because of the special (architectural) solution chosen (cellular glass & glued ceramic tiles), and the bad condition of the bearing wall when the outer façade wall was demolished, which needed considerable reparation and preparation works. The investment cost dominates the life cycle cost. It is not compensated by the lower energy consumption cost over 30 years. Taking into account subsidies (anno 2012) makes the NZE scenario as profitable as the LE scenarios, but the SR scenario remains the best option.

3.2 Environmental impact

Adding the environmental impacts of materials, replacements and energy use over 60 years together, provides further insights in the total environmental impact of the different renovation measures. The impact related to the energy use clearly determines the largest impact. As a result, the environmental impact of the renovation measures decreases for renovations with increasing levels of energy performance (from SR to NZE: -68%).

4. Discussion & conclusions

The results of the Torhout case study are compared to the results of other case studies [2][3][4][5]. The general trend is confirmed: in terms of costs, it is usually not cost efficient to strive for a very low energy consumption level, due to the higher investment costs – and in some cases the higher maintenance and replacement cost of the more complex building systems. Taking into account subsidies allows to flatten the difference. In terms of environmental impact, the more energy that can be saved by materials and installations, the better.

5. Acknowledgements

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Retrofitting solid wall buildings: carbon costs and savings

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Short Summary

Regulations and technological advances over the last decade have led to improved energy efficiency for new buildings. However much of the existing European building stock has poorly insulated fabric leading to low energy efficiency and high carbon emissions. In the UK we have a particular problem with homes built prior to 1930 with un-insulated solid walls. This paper briefly reviews the multiple barriers to retrofitting solid wall insulation in the UK. It then quantifies the whole life (operational and embodied) carbon of a solid-walled dwelling, first in its original state and then retrofitted with one of four solid wall insulation products. The results show that all of the products modelled repay their cradle to grave embodied energy and carbon costs within 13 months of installation through the operational savings achieved. The authors conclude that retrofitting with solid wall insulation can result in considerable whole life carbon reductions. While the barriers remain considerable, greater understanding of the issues will help contractors, home owners and developers to make informed design choices.

Keywords: retrofit, whole life energy and carbon, life cycle assessment, solid wall insulation

1. Introduction and background

Buildings account for close to 40% of the energy used in most countries, with space heating still the main factor. Reducing heating demand through energy efficiency measures could reduce energy use in the domestic sector by 50% or more [1].

Regulation and technological advances over the last decade have led to increasing improvements in the energy efficiency of new buildings, with net zero energy due to become the norm in the UK by 2019. However much of the existing European building stock has poorly insulated fabric leading to low energy efficiency and high carbon emissions. In the UK we have a particular problem with homes built prior to 1930 with un-insulated solid walls; 31% of existing dwellings fall into this category [2] and these are responsible for over 30Mt CO_2 emissions per year. In 2013 a financial instrument, the Green Deal, was launched to encourage the retrofit of existing homes. This is expected to increase the up-take of solid wall insulation in particular.

Although insulation systems have been around for many years, a number of barriers still exist in the UK. The extra cost of installing external systems due to the additional work required, and the loss of space from installing internal systems in already small houses, are both considerable concerns. The lack of expertise and knowledge is an important factor for both installers and home-owners, as are the valid fears of incorrect installation potentially leading to damp problems. The Green Deal should go some way towards alleviating the economic barriers, leading to an increase in uptake and subsequently a greater experience of and confidence in the technology. As demand increases, the focus on manufacturers and specifiers will be to produce thinner systems, without a huge increase in embodied carbon.

The process and materials involved in retrofit also have a carbon impact which needs to be included in any calculation of savings. This paper models the embodied carbon costs, and operational carbon savings, from the installation of four different solid wall insulation products.

2. Results, discussion and conclusions

A standard small semi-detached home was modelled in full using the Standard Assessment Procedure SAP to calculate the operational carbon, and a tool developed in house to model the whole life embodied carbon from cradle to grave. The results of the modelling are given in the table below, which shows the whole house operational carbon per year and total embodied carbon for six different external wall designs. As can be seen, all four solid-wall insulation products have very low payback periods. In particular it is clear that the embodied carbon of external wall insulation is low compared to the operational carbon saved over its lifetime.

Table 1: Comparison of external wall options

ID code	U-value (W/m^2K)	Description	Operational carbon (regulated) (tCO_2e/yr)	Total embodied carbon (tCO_2e)	Relative embodied carbon (tCO_2e)	Payback (mths)
2355	2.09	Solid wall, no insulation	3.93	33.23	-	-
2356	0.29	Option 1	2.36	34.41	1.18	9.0
2357	0.28	Option 2	2.35	34.65	1.42	10.8
2358	0.26	Option 3	2.33	34.56	1.33	10.0
300	0.20	Option 4	2.27	35.07	1.84	13.3
200	0.25	Cavity brick and block with 100mm cavity fill mineral wool insulation	2.32	32.31	-0.92	-

This paper concludes that the embodied carbon impact of retrofitting solid wall insulation to existing UK homes is very low compared with the carbon saved during the building's lifetime. The carbon payback time is calculated at around one year for each option, with only small variations between the four products studied. Even with the acknowledged variation between actual energy saved compared with that as modelled here by the SAP, the payback is likely to be very much shorter than the lifetime of the product.

There are undeniable technical arguments for applying solid wall insulation, and it is clear that the take up of this insulation should be encouraged for the large proportion of solid-walled UK homes, in order to reduce whole life carbon emissions from the building stock. While the barriers remain considerable, the increase in uptake which is likely to result from the Green Deal will lead to greater understanding of the issues, which in turn will help contractors, home owners and developers to make informed design choices.

A3

Life cycle perspectives in a high quality refurbishment - Part 2

Chair: Manuela Almeida
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Life Cycle in Timber Facade Systems – Robust Design Patterns

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Short Summary

Scope of the paper is the system declaration and improvement of environmental properties of the prefabricated TES EnergyFaçade retrofit system on product level [1]. It is the fundamental step towards the description of ecologic quality of a smart envelope refurbishment method. The task is a comparison of various dependencies between the technical requirements and the material effect, which is relevant for the environmental characteristics. The outcome shows a high influence on environmental impacts result from different technical and functional requirements to facade elements.

1. Introduction

The main objectives for a practical application of reduced environmental impact of prefabricated façade elements are defined by König et al. in [2]. The impact for the most influential life cycle phases – production and end-of-life – has to be quantified for sustainability benchmarks. This information is required in certification systems and supports decision making. All relevant considerations are evaluated and optimized for the finding of relevant design patterns. Hence the aim is at demonstration of the constructive measures of the parts of the timber facade system.

2. Methodology

Life-cycle optimized construction systems have four important basic requirements: the objectives are to maximize the lifespan of important components such as the primary structure, minimizing the flow of material, increase the possibility to reuse and recycling, as well as maximize the decommissioning. In a poly-hierarchical model, input parameters are connected with the requirements and critical dependencies from the impact of the choice of material are derived.

3. Results

The results focus on the material input and related burdens and benefits. A major goal is to compare the full systems with the benchmark of the conventional retrofit systems for facades. It is taken also on the bandwidth of the inflows of primary energy and the outflow indicators for the global warming potential. Moreover, very good and very bad solutions can be identified and better appreciated. The averages for the primary content and the global warming potential give important indications of the performance of the entire system. They are also orientation values for the edging areas of the spectrum and the degree of deviation.

4. Conclusions

The TES system is analysed to, which features most of the modernization projects are sustained and what features constitute individual solutions. This inquiry is necessary to be able to use the catalogue of requirements for all projects as universally as possible. The dominant parts of the system have not the highest environmental impacts. Rather, they make a positive contribution to the environmental impact by saving a high percentage of carbon. This remains very similar in various construction structures, as the dominant shares are of renewable resources. But right selection of structure and insulation material can influence the positive properties of TES EnergyFacade to a large extent.

Keywords: Refurbishment; energy and resource efficiency; system declaration; environmental product declaration; environmental impact; life cycle assessment; reference service life;

5. Acknowledgements

TES EnergyFacade, run from 2008 to 2009, and still running SmartTES, from 10/2011 to 09/2013 are funded in the European ERA-Net Woodwisdom-Net by the German federal ministry for research BMBF, represented by PTJ.

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Naturwall: active timber wall for renovation of existent buildings

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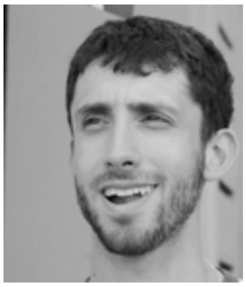

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Short Summary

The renovation of old buildings is actually the challenge to cope with increased effort in order to reduce climate global change, channeling more investment and awareness in this sense, defining more experimentations and find innovative solutions. The difficulty of carrying out an intervention on the existing buildings necessarily arise from the lack of information on the existing structure and the lack of coordinated processes between the multidisciplinary skills involved, as well as a difficulty to optimize the process that would make it even more competitive on the renovation work instead on the new construction.
Naturwall is an innovative energy saving system for existent buildings by using wood in multifunctional components able to mitigate the environmental effort in building management. The project meant to introduce an industrialized design method in the renovation of existing build environment that highlights opportunities gave by "off site" production and parametric design approach, without neglecting the aesthetical values and the possibility to change the architectural image of residential and non residential constructions. The project aims to create a representative model of solution that will be promoted in Italy and widespread in other similar context.

Keywords: wood, prefabrication, retrofit, building, urban renewal, renovation,

1. Introduction

Renovation is the key issue of recent European policies about energy saving. The renovation of existent built environment is driven by new European rules and projects on building efficiency. The recent Smart City program, EU climate action "20-20-20" or the last EPBD directive 2002/91/EC are promoting initiatives in the field of renovation, introducing new issues and perspectives in the use of materials and components performed for this goal.
The aim to achieve energy saving in buildings is a complex process, especially if buildings are very ancient. From the last report of Buildings Performance Institute Europe (BPIE), about the situation of building sector in EU 27 [1], is shown about performances of building stock the amount of old construction characterize by poor energy saving potential.

2. Naturwall – a sustainable way for the envelope retroffitting

The target of the Naturwall method is primarily focused on the building's energy efficiency improvement and as direct consequences in the reduction of GHG emissions. “Energy efficient buildings poses special demands on the quality and performance capabilities of the facade” [5] In the field of renovation and refurbishment high energy retrofitting results and greenhouse gases reduction could be achieved by using multifunctional facade systems. Smart facade solutions using the surface of the building envelope as “active skin” confirm the increasing number of experience in this sense (TES EnergyFacade, enVELOP system, PHI-Wood façade, GAP façade system, etc..).

2.1 Multidisciplinary integrated workflow

The aim of this project it’s to propose a reflection about the opportunity gave by using industrialized system in the retrofitting approaches in urban spaces. The situation of the context, especially in real urban dense areas, is very important to define a strategy that conceive the operative condition and time costing of the retrofit operation. One of the purpose of this research is the connection among design phase and construction, through the re-organization of the whole process - digital measurement – planning off-site fabrication – on-site assembly - describing the instruments and phase necessary to bring the renovation to the end, evaluating all the issue and pay-back return.

3. A refurbishment case study in Piedmont

Naturwall becomes a real program of intervention within Territorially Agency of Home (ATC) endorsement that has sustained our initiative permitting to develop a case study model to verify the feasibility of this retrofit process. Chose the building more responsive to the average characteristics of the buldings made in the post Second World War period, we define a smart requalification process that combine Naturwall with other renewable systems to reduce the impact of those buildings towards near zero goal.

4. Conclusion

Naturwall is a retrofit technological system that means to achieve energy savings objectives in the next years. Our building needs a restoration process to upgrade their performances and reduce the management costs and impact on the environment. With a preliminary study on the existing it’s possible to make a frame for the requalification process, inside of which can be constructed work scenarios, finding the best solution for restoring, quantify the added value of regeneration.

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Finding the Balance between Measures Reducing Energy Demand and Measures Based on Renewable Energy Sources in Building Renovation

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1. Short Summary

Calculations carried out for renovations of generic single family buildings in Austria, Denmark, Norway, Portugal, and Switzerland show that the most significant and cost effective reductions on greenhouse gas emissions and primary energy use are obtained by switching to a heating system based on renewable energies, yet that significant synergies exist when combining this with energy efficiency measures on the building envelope.

Keywords: Building renovation; cost-effectiveness; greenhouse gas emissions; energy efficiency; energy need; renewable energies; reference buildings; life-cycle-costs; insulation measures; renovation packages

2. Abstract

Energy use in existing buildings is a major source of energy consumption and greenhouse gas emissions in Europe. Until now, related standards and regulations have mainly focused on energy efficiency measures reducing energy need; however, measures based on renewable energies might to some extent reach environmental objectives more cost-effectively. Consequently, there is a need to investigate the balance between these two types of measures, and related implications for target setting in standards and regulations.

Calculations were carried out with a tool taking into account generic building characteristics of residential buildings in Austria, Denmark, Norway, Portugal, and Switzerland, related climate conditions, prices and emission factors of different energy carriers, as well as costs and effects of different renovation measures comprising both measures reducing energy demand and measures to use renewable energy. Results of these calculations show that a combination of measures reducing energy demand with measures to use renewable energies does not lead to large differences in terms of cost-optimal efficiency levels of the building envelope, compared to a situation when the energy carrier remains unchanged. At the same time, calculations show that the number of building elements included in building renovation determines energy performance of the building and cost-effectiveness of the building renovation more than the efficiency level of a single building element. Furthermore, a switch to renewable energy sources has been found to reduce emissions more strongly than energy efficiency measures.

As heating systems based on renewable energies usually have lower operational energy costs than conventional heating systems, it could be expected that the cost-optimal energy efficiency level of the building envelope is already reached at a lower ambition level, if a switch to renewable

energies is carried out. However, the results show that if measures reducing energy demand are combined with a replacement of the heating system, there are to a large extent synergies and not trade-offs between measures reducing energy demand and renewable energy measures, as demand side measures reduce peak capacity of the heating system which reduces costs more strongly for renewable energy systems than for conventional heating systems. It can also be shown that in order to reduce the impact of buildings on primary energy use and greenhouse gas emissions, it is advisable to promote the renovation of several elements of the building at the same time and in particular to switch also to renewable energies, rather than setting higher energy efficiency levels for individual building elements.

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Management and financial tools for housing regeneration

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Short Summary

From housing built to tackle a social emergency, identifiable in the dwellings of the Economic and Popular Construction (Edilizia Economica e Popolare - ERP) built in Italy during the period 1950-1970, social housing is acquiring ever more importance as the potential user group enlarges and becomes instable as a result of the ongoing crisis which in Italy has damaged the economic possibilities of the lower-middle and middle classes. The existing stock requires urgent redevelopment that demands economic resources, but because of the ongoing economic crisis and the consequent changes around the concept of the social state it is no longer possible to consider financing for social housing as an exclusive burden of the public administration. It is necessary therefore to understand what might be the best way to attract potential parties willing to invest resources in a sector traditionally considered as non-remunerative.

Keywords: Social housing, energy management, economic and financial processes, public-private partnership

1. Introduction

The strategies useful for the redevelopment of social housing in Italy have to consider the relationship that exists between the conditions of the housing stock, the growth of the user group and the economic and financial possibilities of those who intend to operate in the sector.

2. Social housing in Italy

2.1 The conditions of the housing stock and the resident users

The majority of the dwellings that can be identified in Italy as social housing and mostly constructed in the period 1950-1970 are in a condition of disrepair and require extensive redevelopment. The environmental emergency also makes it necessary not just to redevelop in relation to the starting performance, but also to adapt to the new energy standards required.
In Italy, the ongoing economic crisis has been particularly damaging for the social group of the lower-middle and middle classes. The collapse of the economic capacities of the middle class has led to the birth of a new category, identifiable as “grey users”, who possess discontinuous economic capacities depending on what is happening in the labour market, and is not always able to access the housing market. This category of users falls within the group that is potentially the target of social housing, increasing its numbers and creating a new social emergency.

2.2 The crisis in the building market and the scarcity of resources in the public administration

The need to build and manage dwellings destined for social housing in Italy has always been resolved through the use of non-repayable funds provided by the public administration. Today these resources are dwindling, and the public administration on its own is unable to employ the resources necessary to solve the problem. Turning to forms of public-private partnership is therefore necessary. The few resources available at public level, being part of the so-called “structured funds” or of the “Cassa Depositi e Prestiti” (Deposits and Loans Fund) are not able on their own to sustain decisive interventions. Their presence therefore has to be linked to other possibilities operating at the economic level, which might include the intervention of private investors interested in operating in the sector. It is therefore important to try to understand what elements might attract private investment and in what way these investments might be managed.

3. Possible strategies. From the consumption of energy as a problem to production as a resource

3.1 The new operators in the energy market

The themes of energy saving and management are arguments that are increasingly accepted and understood by the collective. The concept of the building as a consumer of resources is something that is strongly rooted and extended to all the measures connected with the term energy saving.
One possible means to attract investors interested in the social building sector is that of considering the building as a producer of energy resources, and no longer as a consumer of the same. The final objective is that of planning the redevelopment of social housing freeing itself from the conditions of being a user, investing in other sectors such as that relating to energy management. The figures potentially able to operate in this sense are those that operate in the energy market, such as the ESCOs (Energy service companies). These are private companies which invest by paying the costs relating to the intervention, and waiting for an economic return deriving from the management of the same. A case study in this sense was carried out in the setting of the FRESH project with a pilot study in the municipality of Reggio Emilia in which the energy redevelopment of a residential building was supported by the intervention of the ESCO.

4. . Self-reliance and economic sustainability

4.1 Incentivising economic sustainability; the Funds

The forms of public-private partnership with the help of ESCOs need suitable instruments to be able to overcome the risks and difficulties connected to their activities, above all, the lack of guarantees on investments made in a sector of public interest.
The Funds of the Cassa Depositi e Prestiti (revolving Kyoto fund, EEEF) represent an instrument capable of supporting possible initiatives and reducing the risks. The concept of economic sustainability passes through a phase in which the possible initiatives have to be incentivised to allow their successive large-scale diffusion, as has happened in general with the production of energy from renewable sources, which has gown in Italy in the last few years very quickly and extensively.

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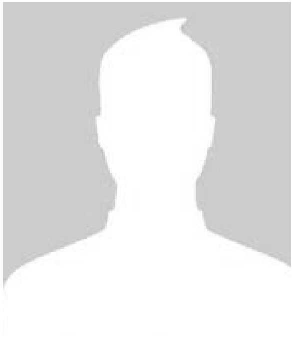
Catalogue of passive house details for refurbishments



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Short Summary

The IBO catalogue of passive house details for refurbishments [1] is a comprehensive resource for solutions for refurbishments tasks. Construction and connection details, checked for their physical, ecological and technical properties, are offered to designers, the building trades and producers of building materials. Typical refurbishment tasks like roof space conversion, basement drainage, façade renovation are treated systematically. Ecological and hygienic aspects are pivotal for the evaluation of innovative solutions. This paper uses examples of façade and basement renovation to demonstrate the comprehensive approach used in [1].

Keywords: deep renovation – passive house details – ecological amortisation - hygienic aspects

Introduction

Refurbishment of existing buildings to comply with the passive house standard or refurbishments using passive house components may lead to savings in terms of heating demand from 75 % to 90 %. Conventional refurbishment will realise less than half of this potential. Refurbishment with passive house components guarantees a marked improvement of physical safety in terms of condensation and mould development.

Results

Building tasks

Treated are buildings from the 19th century to the 1980s, mainly in central Europe with a focus on Germany and, especially, Austria. Fig 1. shows an example of a refurbishment detail in 2 variations for a building built before 1918 with solid brick outside wall and vaulted ceiling.

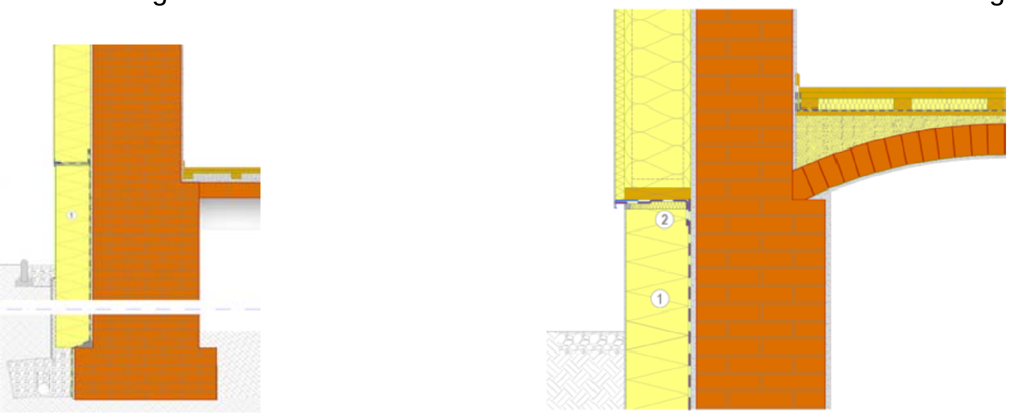


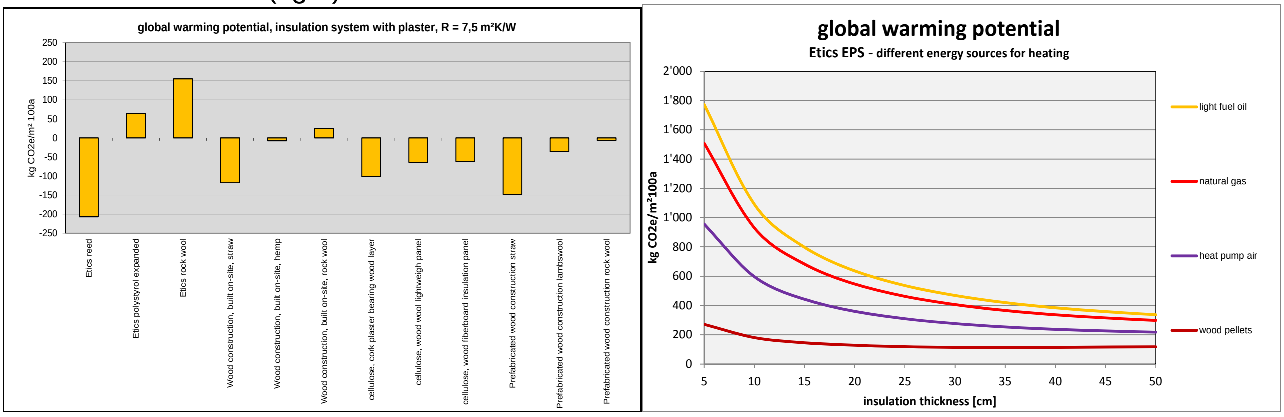
Fig 1. Example of a refurbishment detail: detail with 2 variants for a building built before 1918 with solid brick outside wall and vaulted ceiling (Notice: Variant basement floor insulation is insulated on the perimeter only at those parts of the basement wall which are in contact with outside air.)

Example: Ecological amortisation in façade renovations

For an outside wall thermal insulation one may consider rear ventilated or composite (ETICS) systems, plastered or non-plastered systems, glued or mechanically fastened systems. Systems may differ in

- level of prefabrication
- fastening technique (glued or screwed)
- flatness tolerance and tolerance for adhesiveness of existing surface

A detailed evaluation in building physics and ecological issues is given for different kinds of constructions and insulation materials. Expenditures for production of refurbishment components are to be balanced against achievable heating energy savings resulting from minimized heat transmission losses (fig 2).



Optimum values of insulation material thickness in EPS ETICS are beyond 50 cm in most cases. Only with wood pellets heating and CO_2 neutral combustion there is a minimum of expenditure at 35 to 45 cm insulation material thickness. Thermal insulation with EPS, an ecologically less favourable insulation material, should be applied with thicknesses required for the passive house standard. Optimum thickness is even higher with insulation materials that carry more favourable ecological expenditures of production.

Example: cellar climate and optimisation of insulation measures

low moisture penetration **higher moisture penetration**

Fig 3 : Water content with lower or higher moisture penetration and an air exchange of 0.1/hr (1 January)

Capabilities of a cellar to store goods and also regarding risk of mould development the variant with umbrella-type insulation is preferable. The variant with basement insulation is most unfavorable, the unrefurbished initial state is in a middle position.

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A4

Technologies and aspects of high quality refurbishment in non-residential constructions

Chair: Vanessa Gomes
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Requirements and solutions for high performance school renovations

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Keywords: School renovation; energy-efficiency; ventilation; passive cooling; indoor environment quality

1. Introduction

Schools were mostly built from the 1950ies to 1980ies. Beside educational aspects these existing school buildings are in high need of renovation. While in rural areas an increasing number of schools are closed down, the urban areas lack of space for the increasing numbers of pupils in consequence of growing populations in the cities. So school renovations are often municipality driven projects, they claim governance and expert advice. The renovation process should raise both energy efficiency by high performance retrofit strategies and thermal comfort by proved solutions for ventilation and protection from heat. School owners and users demand short renovation time, high indoor environmental quality and summer comfort of school renovations.
A transnational research approach to strategies and solutions for school renovations was made by the European ERACOBUILD-project School*Vent*Cool.

2. School renovation strategies

Comprehensive and holistic renovation strategies follow an "Integrated Design" approach that covers all relevant aspects. In many cases the influence of the location and infrastructure, the indoor air quality, overheating challenges or even educational aspects are not included or discussed within the renovation process. This is suited for a change and was one of the outcomes of School*Vent*Cool as shown in *Figure 1* [1] – renovation of the school building stock starts with the Scope and ends up with Best Practice school renovations.

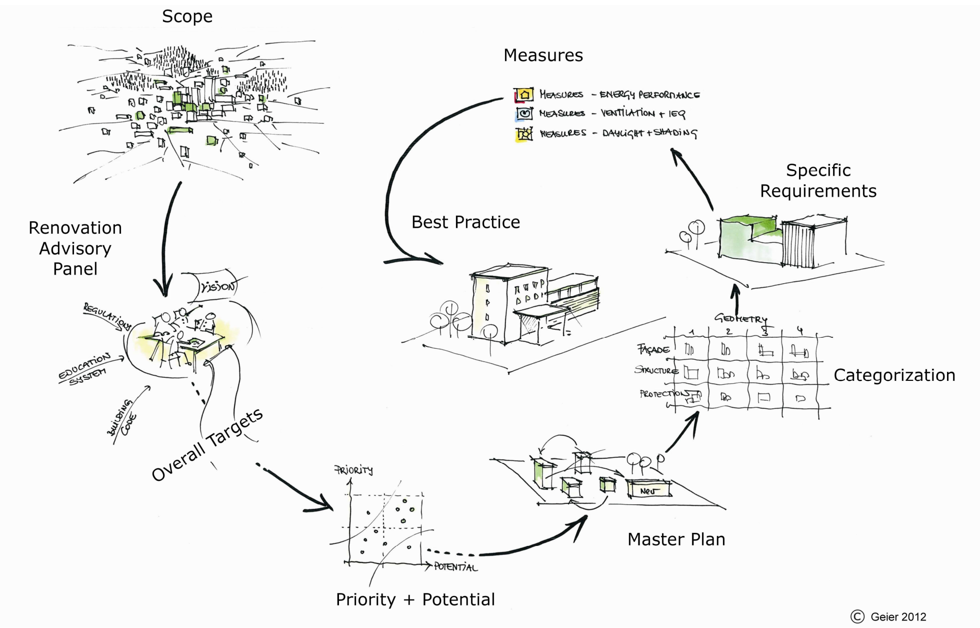

Figure 1 The SchoolVentCool methodology approach

At the classroom level, visual, thermal, humidity comfort and air quality (olfactory comfort) regarding best classroom indoor environment and learning ability are crucial requirements.

2.1 School building typology (setting "specific requirements")

Analysing the typology of school buildings, a lot of similar constructions appear.[2] Conformities exist in facade structure, floor number, classroom dimension, window area, entrances, staircases, other facilities. The typology work distinguishes general from focus types, whereas the general types are mainly characterised by the number of stories and the type of façade, the focus types by e.g. window area, parapet, lintel and room heights regarding a specific interest like space for ventilation ductwork etc.

2.2 Prefabrication (intelligent "measure")

Renovation often means disturbance of the building's users, individual and error-prone construction works and dependence on weather conditions. Prefabrication is a very interesting aspect to overcome this challenge. The module manufacture is weather-independent, the construction works on site are short and can be made during summer when pupils are out. The critical path for school buildings is the air ducting system because of the high air volume needed in the classrooms.[3]

2.3 Passive Cooling (important "measure")

Existing school building stock is mostly equipped with big window areas without acceptable thermal and shading standard. Thermal analyses have shown that thermal standards for summer comfort will be very important in future especially thinking of "summer- / all day schools" [4]. Calculations have shown that the worst case in renovated schools could be one quarter of a year with temperatures above 26℃ in the classrooms, includin g summer holidays. Passive cooling concepts have to include "intelligent" shading control and (night free) ventilation systems to avoid overheating. Manifold studies during the last decades have shown that ventilation is a vital aspect in getting classrooms to high indoor air quality (IAQ) standards, ensuring pupil's health and their ability to concentrate during lessons. The way to appropriate ventilation solutions is again determined by the existing school building typology and IAQ criteria. A design criteria list weather centralized or decentralized mechanical or hybrid / natural (including night-) ventilation is best, helps for the decision making process.[5]

3. Conclusion

If the scope is clear and the master-plan for the existing school sites done, a range of solutions for school renovations based on typology can be found. Prefabricated wooden elements or the use of modular design components are very promising ones to raise renovation standards.

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All these papers and the brochure have been elaborated in the frame of the ERACOBUILD-project School*Vent*Cool – www.schoolventcool.eu.

Indoor Environment Quality in Riga City Kindergarten Buildings: Actual Data, Problems and Solutions

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Short Summary

Latvian Energy Development Guidelines for the years 2007-2016 define that heat energy consumption should decrease by 28%, but by 40 % in the time period up the year 2020. Big heat energy demand in buildings is part of Latvia’s heritage from the Soviet era. Our analysis shows, that partial renovation: heat insulation of buildings with windows change, does not give heat energy consumption economy as established.
Another target of this study was to evaluate indoor air pollution in kindergartens.

Keywords: Kindergartens; IAQ; VOC.

1. Introduction

Local Latvian laws are based on significant decisions of the European Parliament and European Council [8],[9],[10],[11]. Building and reconstruction must also be provided by the IAQ framework requirements [1],[2],[3],[4],[5],[6],[7],[12]. But does this apply to all cases? We will provide the answer in the present article. We have reflected and compared the results of our investigations on the IAQ in relationship to heat energy consumption in unrenovated, renovated and newly erected kindergarten buildings.

Reconstructed, old natural ventilation and mechanical systems do not provide the necessary air exchange and quality.

2. Materials/Methods

In this study we used MINILOG GSOFT 40K V7.80 (air temperature logger), EASYLOG 40RF GSOFT 40K V7.80 (air relative humidity logger) and Wöhler CDL 210 version 1.1.6 (air temperature, relative humidity and carbon dioxide quantity) loggers. Loggers have been used in kindergarten rooms approximately 1.5 m above the floor. The gas chromatographic (volatile organic compounds – VOC expressed as carbon) and high-pressure liquid chromatography (aldehydes) method was used for the air pollution investigation. The air polluting substances were absorbed in charcoal tubes in the case of VOC and silica gel cartridges treated with 2,4-dinitrophenylhydrazine (DNPH) in the case of aldehydes.

3. Results

We detected indoor air polluting substances – aldehydes (formaldehyde 0.023±0.005mg/m3; acetaldehyde 0.015±0.003mg/m3; benzaldehyde 0.004±0.001mg/m3; propylaldehyde 0.003±0.001mg/m3) and volatile organic compounds expressed as carbon 0.56±0.11mg/m3 in kindergartens in the case of floors covered with linoleum and with plastic windows without a ventilation system.

Poor and unconformable IAQ indicate the necessity to make ventilation systems according to current building legislation.

Partial renovation of buildings has not decelerated heat energy consumption and has not enhanced the IAQ to the required level.

4. Discussion

Intensity of heat energy consumption per annum in unrenovated kindergarten building is less than in the other conditions of buildings. The partially renovated kindergarten building has an indoor air temperature that is lower than defined in many cases. In all cases, indoor air temperature has the property of mimicking changes in outdoor air temperature. This has been indicated on an unbalanced heating control unit. Indoor relative air humidity is for the most part lower than the set standards. Ventilation systems without air humidifiers are responsible for the cause and effect.

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SB13 Graz - Re-Commissioning Services: Immediate Savings and Triggering Building Refurbishment Measures in Non-Residential Buildings

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Extended Abstract

In many cases the question arises, how and where to start with the energetic optimisation and high quality rehabilitation of complex, large-volume non-residential buildings like hospitals, universities etc. Usually, an energy audit is carried out, measures are defined by an expert and a decision making paper for the management is worked out.

A completely different approach offers Re-Commissioning: a systematic approach to examine existing building equipment systems, their operation and maintenance procedures and – highly important – communication and interactions with facility building management staff and occupants. Through Re-Commissioning the first 10% of the energy bill can be saved without immediate investments. Staff is trained in energy efficiency and the users are motivated to change their behaviour and contribute with own ideas to smart energy savings. The process and the first successes lead to a higher energy consciousness and the desire for greater savings. Investments into comprehensive refurbishment measures as a result of an internal evaluation process are more likely to follow.

The process follows a standard Plan-Do-Check-Act management cycle; it is compatible with energy management systems as described in ISO 50001 and builds on 5 key components:

1. Establishing an energy information system
2. Data analysis and selected measurements
3. Optimisation of existing building technologies
4. Information and motivation of building occupants
5. Monitoring and quality assurance instruments of the project results

In the “Re-Co.eu” project[1], energy efficiency engineers, economists and marketing experts from 10 partners are joining forces to develop Re-Commissioning services and markets in 8 European countries and test the feasibility of the concept.

[1] Supported by the Intelligent Energy Europe program of the EU

In our speech we will summarise Re-Commissioning services, components and tools (e.g. process flow, pilot project log, data base for measures implemented and the measurement and verification approach). We will report on preliminary results of selected pilot projects implemented in hospitals and universities, show examples of successful measures and strategies and how these results are communicated to stakeholders.

We will conclude with the lesson learned that for the achievement of sustainability in large-volume, non-residential buildings a comprehensive approach is necessary. Besides high-performing building technologies the continuous adaption and optimisation of the technology, the communication with the staff and the integration of energy efficiency in management routines are important elements.

Keywords: Re-Commissioning; www.Re-Co.eu; large-volume buildings; energy management system; energy efficiency

Risk Assessment for Energy Efficient Refurbishment of 19th Century Townhouses Using Interior Insulation

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Extended abstract

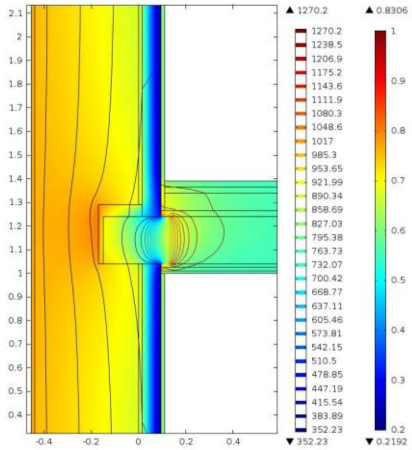
Increasing energy consumption in buildings was leading to greater awareness of energy conservation and to rising energy efficiency. The highest potential for thermal optimization lies in renovating existing buildings. Due to the fact that many buildings are listed worthy of preservation renovating the historical façade with a thermal insulation system is obsolete. Therefore interior insulation is gaining tremendous importance and many research institutes, planers, executives and consulters are busily engaged with the process.
Hereafter the planning process of interior insulation systems and related questions are discussed. At the beginning the correlation of significant planning parameters are analysed. Subsequently the theoretical planning process is demonstrated by a case study. The approach is based on the specifications of the "Framework for Probabilistic Assessment" according to the IEA Annex 55.

Fig. 1: Influencing parameters

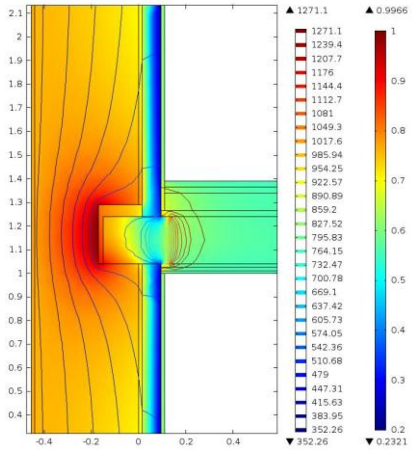
The planning and evidence of internal insulations can be divided into different **levels of complexity**. This ranges from the entire building to individual components and specific connection details. At the beginning of a project the **targets and the performance criteria** as well as the consequences of these criteria must be considered as shown in the figure on the left. These parameters are based on the **existing conditions and the general information** about the building to be retrofitted. From the results of a building survey **retrofitting strategies** can be assumed.

Once the systematic building survey has been completed and the different influencing parameters have been weighted by importance the risk assessment can be carried out. Thus the risk of damage of a construction is recognized. On the basis of life-cycle costs different alternatives of renovations and interior insulation systems can be compared. For constructions with a high risk potential higher restoration costs have to be assumed. These higher costs will negatively affect the life-cycle costs.
In order to determine the risk of damage of an internally insulated construction the combination of different boundary conditions and influencing parameters has to be taken into account. In addition to the uncertainty of climatic boundary conditions especially material parameters vary significantly.

The second part of the paper deals with the choice of the right simulation geometry and the right boundary conditions. Various calculation models are described.
The case study of a wooden beam head on the right shows the impact of different 3D-simulation methods. The beam is situated in a brick wall. At the bearing the wood is surrounded by air. The interior insulation system consists of mineral wool with an air-tight layer on the inside. The simulations were carried out with COMSOL Multiphysics. Temperature, relative humidity, partial pressure and the air flow were evaluated. In three different calculations the same model was simulated using different boundary conditions.
The first figure on the right shows the easiest way to calculate the 3D model. Only vapor diffusion and heat transfer are taken into account.

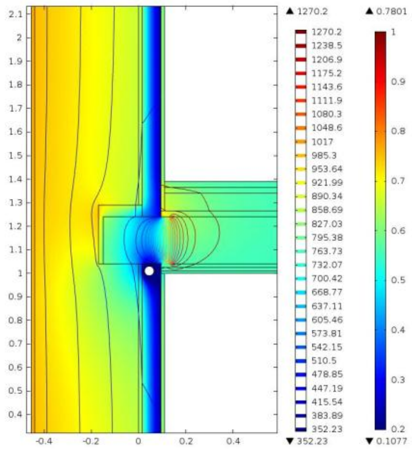


The second figure on the right shows the same model but with consideration of air flows through a gap in the construction. The static thermal pressure difference is also taken into account.



Comparing the two models one can see the impact of air-flows through constructions and the wide range of simulations' results. It shows that considering or neglecting a single parameter in a simulation can cause completely different results. Therefore it is very important to evaluate all parameters. In the paper the influences of some other boundary conditions are described.

The risk for rotting and mould growth can be minimized by selective temperature control in the joist's bearing. A patent for temperature control of the wooden beam's end which was invented by the Research Center of Buildiing Physics and Sound Protection of Vienna University of Technology will be offered in the presentation. The third figure on the right shows the effect of the temperature control. The temperature level is raised at the joist's bearing. So the relative humidity can be kept low in order to avoid rotting.



In the future, the evidence of the durability and the functionality of interior insulation systems should be based on a probabilistic safety concept. The basics such as the formation of probability distributions of material parameters and climatic boundary conditions are currently being processed. By using probabilities the retrofitting costs and life-cycle costs can be estimated in a better way.

Keywords: Interior insulation; building component tests; wooden beam head; risk assessment; life cycle costs

Analysis of the thermal behavior of historical box type windows for renovation concepts with CFD

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1. Need for advanced renovation techniques

Europe´s built environment consists to a notable extent of buildings established in the early 19th century to the mid of 20th century. The box type window (BTW) was the dominant window construction system in central Europe for that time. Today in Germany and Austria still more than 100 million of BTWs can be found as essential components of buildings´ facades.
Because of their constructional design BTWs can easily be renovated in accordance to the requirements of heritage protection.
Renovation of BTWs, especially improvement of their thermal performance reduces the energy consumption as well as the embodied energy otherwise spent on new windows. In addition the change of BTWs in modern windows would cause a crucial impact on the appearance of historic European cities. The development of advanced renovation techniques requires a detailed understanding of thermal behavior and flow characteristic inside BTWs. This paper is concentrating on simulation of the some promising renovation concepts for traditional BTWs.

2. In situ measurement of two box type windows

In situ measurement was used for monitoring the thermal behavior of a refurbished BTW and an improved BTW (Fig. 1, (1)). The windows were located in one of the reference objects of the Austrian research project denkmalaktiv I [1].
Several sensors were installed to measure temperature, humidity, air flow and global radiation. For the validation of the simulation results four temperature sensors were used. The sensors were attached to the window glasses as well as placed inside the BTW´s cavity (Fig 1, (2) and Fig 1, (3)).

3. Numerical simulation of flow characteristics

While measurements provide only values for installed test points, Computational Fluid Dynamics (CFD) can give a deeper view inside the thermal behavior of BTWs. Main goal was to reproduce

the physical behavior for the inner cavity of the BTW. All simulations of this study were accomplished by the use of the CFD software called ANSYS Fluent [2]. The computational simulation included the numerical reproduction of air flows, buoyancy effects, energy balancing, thermal conductivity as well as the consideration of long wave radiation. A two dimensional CFD-model including the BTW itself and the surrounding was developed (Fig. 1, (4)).
In a first step the convective air flows inside the BTW cavity were determined. In the second step the determined temperature profiles were compared with the measurement results. Based on that evaluation of the refurbished BTW (A), four models representing promising concepts for the thermal improvement were developed: (B) a gasket frame for the inner casement, (C) insulated glass for the inner casement and thermal insulation for the shutter box, (D) an additional interior casement and (E) a vertical airproof divider within the cavity.

4. Summary of results

The simulation model was able to reproduce the thermal behavior and showed a comprehensible flow characteristic. The expected temperature stratification in the inter cavity for a cold night in winter can be seen in Fig 1, (4). The circulation between the cold external window pane and the warm internal window pane was highly influenced by the design of the window joints between the frame and the casement.
The enormous influence of solar radiation on the convective flow and the temperatures was indicated by high temperature peaks inside the cavity. This was confirmed by the in situ measurements in accordance to the simulation results.
The computed temperatures for the refurbished window (A) showed a good correlation to the results of the corresponding measurements.
All investigated renovation concepts influenced the flow characteristic and the temperatures and obtained an improvement in the thermal behavior. Exchange of interior pane by an insulated glass as well as the integration of a thermal insulation for the shutter box (C) had the best performance of all. The concepts with the additional interior casement (D) and the vertical airproof divider (E) also showed a significant improvement in their thermal behavior. The BTW´s thermal behavior was slightly improved by the installation of an gasket frame for the inner casement.

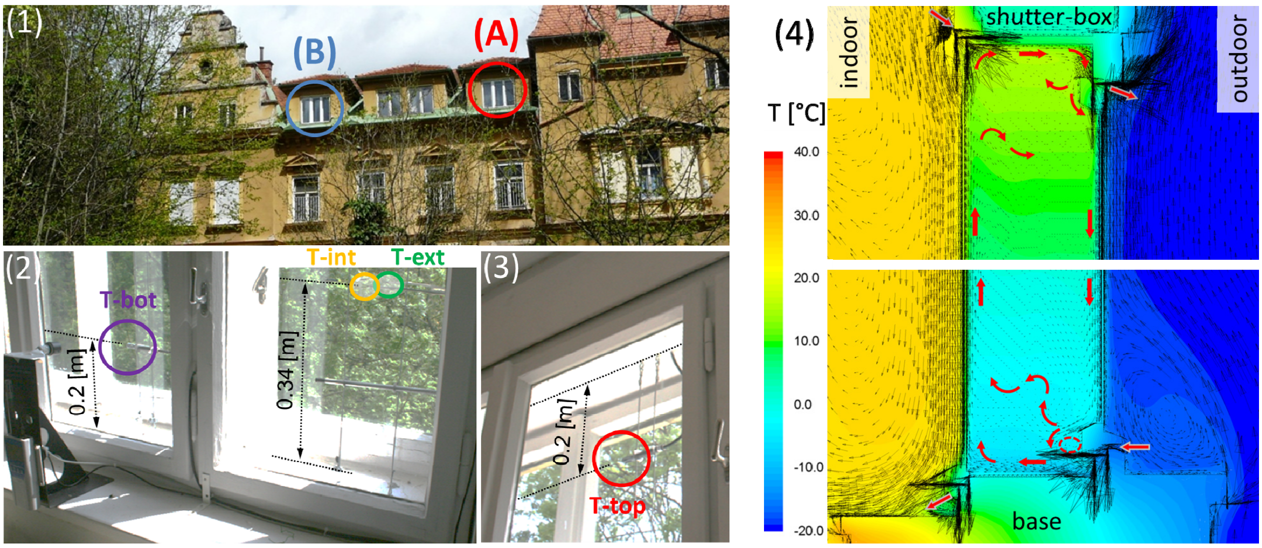

Fig. 1: (1) south façade of the historical building Schönbrunngasse 30, Graz, including a refurbished (A) and an improved (B) BTW, (2) and (3) pictures of the BTW and details about temperature measurement build up, (4) illustration of temperatures and air vectors for the upper and lower region of the inner cavity of the refurbished BTW (A).

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A5

Opportunities and potentials for an energy efficient modernisation of syndicates of municipalities

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Selection of refurbishment construction solutions to improve the Indoor Environmental Quality and Sustainability of buildings


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Short Summary

Building refurbishment is essential to achieve the targets defined by the Energy Efficiency in Buildings Directive recast regarding energy efficiency, reduction of carbon emissions and use of on-site renewable energy sources. Besides the energy efficiency the Indoor Environmental Quality of Buildings and environmental impact must also be considered when planning a refurbishment project. Thus to propose an effective building rehabilitation is necessary select the adequate construction solutions taking into account their impact on the energy performance, thermal and acoustic comfort, indoor air quality and environmental impact of the building. In this work a multi-criteria decision analysis method is applied to balance all these aspect, during the design phase of a refurbishment project, in order to assist the design team on the selection of construction solutions.

Keywords: Refurbishment; Thermal behaviour; Acoustic performance; Energy efficiency; Multi-criteria decision analysis

1. Introduction

The rehabilitation of the building stock is an opportunity to achieve the Energy Efficiency in Buildings Directive (EPBD) and the "EPBD recast" goals (reduce the energy needs and the European Union energy dependency as well as the greenhouse gas emissions) [1, 2]. In Portugal, 80% of the building stock was built before 1990, year of the publication of the first Portuguese thermal regulation, leading to high levels of thermal discomfort and excessive energy consumption, as the majority of the existing buildings was built without any thermal concerns and shows very high energy consumptions even when minimal comfort conditions are required [3].

To correctly select the rehabilitation construction solutions it is necessary to consider their contribution to the energy efficiency, and indoor environmental quality (thermal, acoustic and visual comfort, the indoor air quality), its environmental impact, etc.. However, these goals are often in conflict and there is not a unique criterion that describes the consequences of each alternative solution adequately and there is not a single solution that optimizes all criteria. Thus to propose an effective building refurbishment is necessary to select the adequate construction solutions and materials taking into account their impact on the energy performance, indoor environmental quality (IEQ) and environmental impact of the building.

Multi-criteria decision analysis is an important tool in such problems, since it can be used in any location and employs mathematical models that evaluate alternative scenarios, taking into account both their objective characteristics and the preferences of the decision makers regarding the objectives and constraints of each project.

The aim of this study was to select the materials and construction solutions to refurbish the façade walls of a building.

2. Methodology

The case-study building to be refurbished is a detached single family house, from the 1980s. The building is a single residential unit with two bedrooms, north oriented, with 54.42 m^2 and 2.44 m of floor to ceiling height. The construction system is a low cost construction system based on a steel reinforced concrete pillars and beams structure, single pane hollow concrete block walls (CMU) and clear single glass with aluminium frame windows with PVC (Polyvinyl chloride) roller shutters. The window to wall ratio is roughly 20%.

ELECTRE III (ELimination Et Choix Traduisant la REalité - ELimination and Choice Expressing the REality) was the multi-criteria decision analysis method selected to the evaluation of the alternative solutions for the façade walls as it takes into account the uncertainty and imprecision, which are usually inherent in data produced by predictions and estimations [4]. The use of ELECTRE III can also systematically analyse expert judgments on the decision factors and alternatives that can rationalize the selection process.

The criteria selected in this study (thermal and acoustic insulation, embodied energy, superficial mass and thickness) are related to the most important characteristics of the IEQ and are mandatory (the thermal and acoustic comfort). These criteria were also selected because it is possible to predict them in an early stage of the design phase, are under the designer scope and are the issues that are also the most valued by the users of the buildings. The embodied energy, the weight and the thickness of the solutions are also relevant as they affect the environmental impact, the structural design (and the thermal inertia) of the building and their useful area.

3. Conclusion

Throughout the multi-criteria analysis performed, it was possible to verify that the refurbishment solutions with ETICS (External Thermal Insulation Composite Systems) system, with low U-value and embodied energy and higher superficial mass were ranked the best rehabilitation options.

The solution with cork and a second hollow brick pane, that presents the second lower U-value, the higher acoustic insulation and a high thermal mass, was ranked third.

The existing solution with the worst thermal and acoustic performance and the ventilated walls, with the lowest U-value, high thermal mass, with the second and third best acoustic insulation, but with the higher embodied energy were ranked last.

The best ranked options were not the ones that had the best performance in the criteria with highest weights. This example shows that applying this methodology, due to the use of weights and thresholds, the best action is not the one associated to the highest weight, even if it is the one that has the best performance in that criterion.

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The uncertainty of the energy demand in existing Mediterranean urban blocks.

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Short Summary

The objective of the paper is to describe a stochastic model that has been developed to obtain load profiles for household electricity. For the study, several profiles have been generated in order to simulate the electrical demand of a residential building block or neighbourhood and evaluate the uncertainty of its energy use. The paper is divided in three different parts: development of the model, validation and determination of the uncertainty demand. In the first parts the basis of the model and how it works is explained. The second one represents the validation of the model, the input data and its results. The last step is focused on a statistical analysis of the electricity demand of a block of dwellings to evaluate minimum number of dwellings needed to estimate the average demand representative of the Mediterranean dwelling with different levels of accuracy.

Keywords: stochastic model; electric load; residential building; Mediterranean regions; cluster of buildings

1. Introduction

The study has been carried out using mainly the data from the SECH-SPAHOUSEC project [1], where there are a detailed characterization of the energy use of the residential sector in Spain. In this paper, the results are related to Mediterranean region and for block of apartments.

2. Results and discussion

The model is able to generate random profiles of electric consumption for a dwelling or several dwellings, with preservation of important qualitative features (Fig. 1). The load profiles are realistic and their annual consumption is consistent in comparison to Spanish data and from other European countries. However, analysing the results in detail there are slight differences between the simulation and the reference data. The reasons could be due to the limitation of the model: 1) the technical parameters of the equipment are constants over time. 2) Although the input data (hourly consumption of each equipment) takes into account the length of the cycle, in the model there is no relation with the previous hour and the duration of the cycle is not simulated.

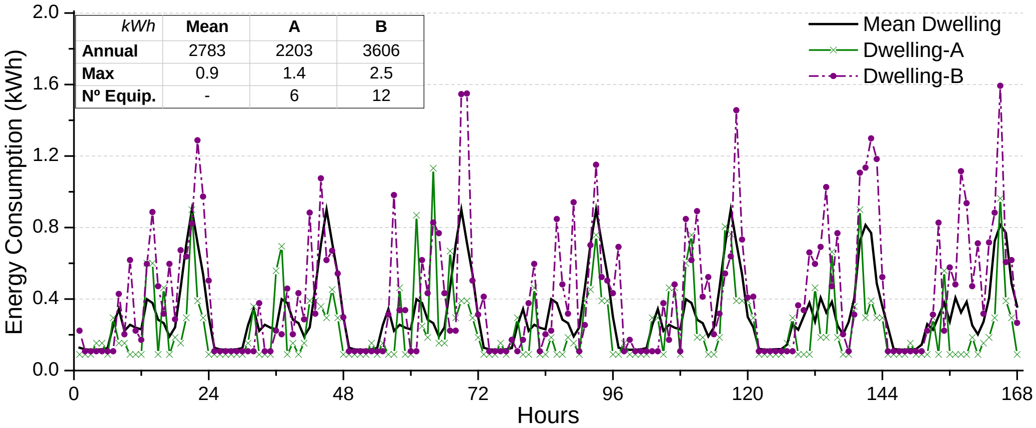
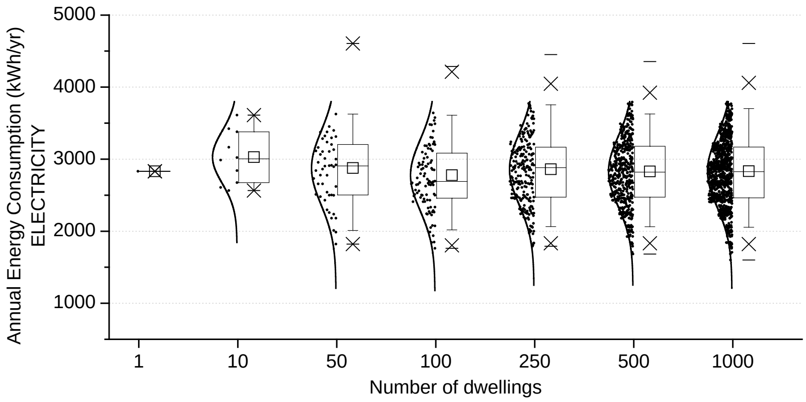


Fig. 1 Hourly electric consumption for a winter week. Example output of the model, two random dwellings and the mean dwelling (reference data).

A statistical analysis of the uncertainty of the electrical energy consumption of Mediterranean dwelling is done. The objective is to evaluate how to reduce the uncertainty in the energy consumption choosing the adequate size sample of dwellings during the design process. The Fig. 2 shows the distribution of the annual energy consumption simulated for different sample sizes.



nº DW	STATISTICS (kWh/yr)			
	Mean	SD	MIN	MAX
10	3028	364	2565	3611
50	2877	513	1822	4606
100	2777	492	1763	4287
250	2861	495	1791	4452
500	2829	484	1683	4354
1000	2834	499	1600	4606

Fig. 2 Distribution of the annual energy consumption for dwelling, increasing the number of dwellings. In the right table, the statistical values of each sample.

The use of this type of models is a good tool that could help to reduce the uncertainty of the energy consumption of the residential sector, improving making decision process in the early stage of refurbishment projects.

3. Acknowledges

The research was supported by the MED Programme of the European Union under the MARIE strategic project (Agreement Nº 1S-MED10-002). The authors also want to thank to IDAE for providing the data base of the SECH-SPAHOUSEC project.

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PV integration in the open urban space redevelopment of historical villages in Italy

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Short Summary

In a contemporary perspective, the building refurbishment is no longer indifferent to technological innovation and energy efficiency goals. The photovoltaic (PV) integration becomes a possible way for design in "sensitive contexts". The research proposes, within a wider strategy of sustainable reconstruction, some experimental projects for urban voids rehabilitation in minor historic villages hit by earthquake. The developed case-studies demonstrate possible and affordable ways for integrating PV within urban/architectural innovative zero-energy concepts in sensitive areas.

Keywords: BIPV, historical centers, refurbishment, reconstruction, photovoltaic.

1. Introduction

The refurbishment of many historical villages abandoned or hit by earthquake, is today an issue of vital relevance in Italy and it is a complex and multidisciplinary field of research, in which the focus on sustainability can be recognized as a potential scenario of common development. Despite the current background often directed to demagogic "in style" interventions, an innovative way of research is aimed to rethink these settlements in relation to a "sustainable" return to life in next years that can't neglect the topic of energetic efficiency, both at building and urban scale. Unfortunately the less physiological "measurability" of some factors involved and the greater disciplinary complexity are an actual barrier and too often the premises are discouraged, determining an inactive and dangerous tearing between sectors. The first objective of the ongoing research path, begun some years ago, has been the definition of the main forms of compatibility among PV systems and the wide range of environmental, landscape, historical and material values of these places. In a contemporary perspective, no longer uncaring of environmental topics, so, PV integration can be recognized as one of the key-aspects for a more responsible design in "sensitive contexts". The goal of the presented research, following other studies already made about methodology of BIPV (Building Integrated Photovoltaic), is to experiment the real PV compatibility (in historic villages hit by earthquake of 06.04.2009 in Italy) through the development of case-studies regarding the urban voids rehabilitation. The study takes into account 3 different areas within a village, considering different historic and landscaping scenarios. The use of PV is conceived not only as an energy goal but also as a part of a wider and more complex refurbishment project that is characterized by architectural distinguishability with ancient, technological reversibility/temporality/lightness and energetic autonomy. Outcomes of these case-studies show as PV may become, within a careful and aware project, a compatible and characterizing factor within an innovative logic of reconstruction, demonstrating a possible and effective co-existence with historical and landscaping values of these places. Furthermore the complex reality typical of these areas requires a "controlled transformation" variable case by case. Following these experiences, the believed scenery of the research is a real applicability in the reconstruction process, through knowledge transfer, development of guide-lines, tools, criteria and advices to be implemented in urban planning and building rules in next years. PV will require to be considered as an architectural and urban opportunity as well as an innovative challenge to be deepened, introducing the perspective of Nearly-Zero Energy Villages in the contexts concerned. Future prospected works along this path will be other case-studies in margin areas (valley, green areas…) and in urban grids (streets) aimed to extend the PV integrability concept from building to a wider scale. This general topic will also match some new international Task related to "Solar Energy and Urban Planning"

2. Refurbishment of urban voids as a new challenge: case-studies

Refurbishment design and accordingly PV integration in reconstruction areas, will have to face with the voids of the urban system. Just visiting any of the historical villages around L'Aquila there is the perception of a "negative of the original" with the overthrow of full and empty due to the "voids" created by collapse and the rubbles within the original open spaces (streets, squares ...) [9]. From this state of art, the presented research experiments possible ways for recovering these urban spaces through an approach aimed to environmental and material lightness, energy self-sufficiency and a controlled distinguishability from existing historical matter. Although the main topic was PV integration in sensitive areas, the presented case-studies cannot give up a wider design sensibility as well as the need to realize more general goals for the life return of these villages, for providing services during the reconstruction process or for introducing memory signs of the tragic event. Projects has been developed with Building-Engineering/Architecture students within a specific lecturing module at University of L'Aquila, and concerns one of the most hit centres due to the 2009 earthquake that is Sant'Eusanio Forconese nearby L'Aquila in Italy. The small village, born between XII and XIII centuries, has about 400 inhabitants and is located in a very meaningful natural environment: after the earthquake it was completely abandoned. Considering the hard reconstruction process waited for the next years, the presented study has been directed to experiment a new coexistence between memory and solar technology, through the proposal of urban elements. The chosen areas are located either within the historical centre than at the edge with landscape, representing different design possibilities in dissimilar kinds of urban voids.

Fig. 1: Pictures of the 3 different urban voids in the post-earthquake status

The developed case-studies concerns a sensible media box in the central square, a temporary laboratory for the reconstruction and an urban library at the edge of the historical perimeter. PV integration becomes the characterizing factor of these interventions that, in turn, is declined in the strategy for the architectural language, for the customization of urban spaces, for introducing sensible media spaces within historical areas as well as for providing the required energy demand in the perspective of nearly-zero energy centres. Some findings show that a premeditated re-planning of the urban voids could allow a significant solar implementation, satisfying a main part of the village energy demand and improving the urban quality. The believed scenery is a real applicability in the reconstruction process, through a transfer of skills and tools to be implemented, considering PV as an architectural and urban opportunity, an important design resource and an innovation challenge for the energy efficiency.

Energy efficient roofs retrofit for communist prefab concrete blocks

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Extended abstract

During the communist regime, Romania had a similar evolution in construction field with the other soviet influenced European countries. All projects were designed by the National Institute of Standardized Buildings, then erected all over the country. There were few types with many subtypes, with no great openings used by other states in prefabricated housing construction due to seismic movements. As general features, 30 cm modulation and maximum weight of panels limited to 5.5 tons were used everywhere, with some local details. Most of these buildings are used at their full capacity even today, with an infrastructure and facilities inadequate to such big number of population and cars.
One of the most extensively used projects, called 770 [1], with its twelve subtypes, can be found all around the country [3]. The last improved variant was designed in 1983 (the year of its application) developing rectangular "matchboxes" with 6 types of apartments, small structural cells and a standard coupling width. The different ending block panels offer 88 sections of buildings and 72 types of concrete panels, with 1 to 4 staircases. The structure is made out of concrete, with exterior panels made out of three layers and 30 cm thickness, the interior walls and slabs also from reinforced concrete. The flat roof has a thick thermal insulation (expanded clay or autoclaved aerated concrete), usually deteriorated by the poorly executed waterproofing works and many uncontrolled leaking. The plumbing features were also prefabricated as well as the carpentry elements (apartment windows and doors), the common spaces having metal doors.

Once the capitalism started (after 1989's Revolution), the apartments' new owners started to improve their own comfort through small scale interventions: replacement of wood fenestration, closing balconies, HVAC units, individual heating system, enlarged ground floor apartments, single apartment exterior insulation – showing the financial power and knowledge of each occupant. By retrofitting the flat roof with smallest price works and no concern for the whole building image, together, the architectural appearance was completely changed with result (mostly) worst than the primary conformation.

Started in 2002, the National Program for Thermal Rehabilitation [4] of collective dwellings reached its peak in 2009. Some of the selection criteria were: older buildings, greater number of apartments, construction envelope type (preference for concrete prefabricated panels), technical conditions, mildew or dampness, climatic area, the rehabilitation measures (only for housing) including thermal insulation, pitched roof (but no attics), the replacement of exterior doors and windows and the replacement of common mechanical features. The final "product" doesn't show a contemporary aesthetic attitude, just vivid colours on facades, white PVC windows and improved comfort inside - less money for energy costs with individual heating system.
A combination between thermal exterior insulation and pitched roof was developed by real estate agencies or contractors in exchange of new attic apartments with maximum saleable area. A whole new level offered the opportunity of having extra housing units in the same urban area, too crowded by cars, with problems like: legal aspects, fire and structural resistance maintained, long time disturbance, insufficient mechanical features and more parking spaces needed.

A sustainable solution applied on this prefabricated “commieblocks” should consider, first of all, the great opportunity of applicability all over Romania. By treating problems like comfort, social all ages areas + parking; together with the use of energy efficient composite materials and exterior design to provide contemporary comfortable new plus old apartments could be a possible retrofit. Leaving from 770 type, the study case considers a building with three staircases, no settlement joint and three different subtypes. The hypothetical building allows another (similar) block to be urban related with the studied one.

As a reaction to other contemporary similar designs, this study was developed considering that an example should be done, as a reaction to the actual interventions through less interference with the residents by a quick execution, respect for legal constraints (elevator, fire resistance, light weight), a new aesthetical image for old blocks.
The old apartments were treated with the respect of private property, proposing some variants with very small structural but controlled damages have been proposed: exterior thermal insulation with mineral wool, replacement of wood windows plus controlled ventilation, a new outside image. The new level uses the same staircase space, together with an exterior detached elevator. The interior design is open space and has no structural barriers, with recessed closing vertical elements, completely separated from the structural frames offering a continuous terrace to the new apartments. The facades were very important in rehabilitation process along with the changed image of urban vicinity.
The solution of roofing retrofit was developed using only energy efficient composite materials, light [2], good fire behaviour and quickly erected: the reinforced concrete was used for light prefabricated frames that reabsorbs during its lifetime the CO_2 produced during its fabrication process [5]; triple layer walls – Glupan 125 [5] for the vertical elements ; flat roof with Kingspan KS1000x-dek steel panel [6]; new PVC doors and windows from Internorm type Kunstoff Passion 4-16-4; applied in situ PUR insulation for existing terrace; 10 cm of Rockwool insulation used for existing exterior prefab concrete panels and basement ceiling. For the existing analyzed block and the extended one, a thermal and energetic expertise was done.

The innovation of this attic solution is given by a mixture of: new attic / penthouse design adverse to general adopted solution with pitch roof; new prefabricated materials used for structural and enclosing part, opposite to wood / masonry/metal/small tiles; different joint type between the original concrete walls and the new reinforced concrete frames instead of monolith solutions; little structural elements inside the new apartments; large covered terraces for the penthouse apartments; the new elevator used as a dynamic element for the back/inner court facade (with less balconies). All enumerated above contribute to a daring roof retrofit and may represent a challenge for Romanian people, running away from flat roof, prefab concrete structures and small spaces. Other countries experienced similar attempts [8].

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Methodology for improving and testing the quality of renovation actions: a case study application

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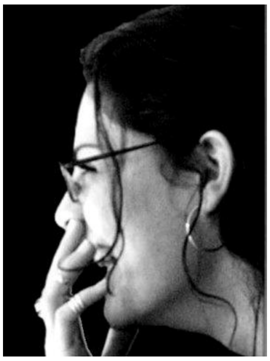

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Short Summary

This paper presents a synthesis of some results obtained from an on-going national research program carried out at the University of Bologna, Department of Architecture, focusing on sustainable renovation processes and effective solutions for increasing the energy efficiency of the existing housing stock. The proposed methodological approach is based on a step by step retrofit strategy, tested by a simulation model, aiming to reduce the energy demand from the current significant present value to at least 15 kWh/m^{2}y. This performance level was assumed as the target of the retrofit action that has been developed by assessing the effectiveness of the different technological solutions adopted. This methodology and simulation set are going to be used for a further development of the retrofitting solution that foresees the use of pre-fab wood panels.

Keywords: retrofitting; volumetric additions; energy savings; quality; housing renovation

1. Starting position and objectives of the research

With the Directives 2010/31/EU and 2012/27/EU, the European Parliament and the EU Council promoted a wide range of improvements in the energy performance of buildings within the EU, proposing a methodology that takes into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. Specific targets are provided for new constructions and existing buildings. In order to meet these targets and exploit the construction sector growth and employment opportunities (including the production of construction components, services rendered by professional studios of architecture and engineering), the Member States are required to establish a long-term beyond 2020 strategy for pushing investment in the renovation of residential and commercial buildings. This intervention strategy should address significant cost-effective renovations leading to refurbishments that can reduce both the supplied and final energy consumption of a building by a significant percentage when compared with the pre-renovation levels, therefore resulting in a very high level of energy performance. Since the existing residential building stock represents the single biggest potential sector for energy savings, not only for its dimension and widespread presence on the territory, but also for its related behavioural implications, the expectation of the EU is that the rate of renovation interventions are going to increase in the very near future.

2. Research methodology

Based on the significant demand, on a national scale, for high quality residential units – which, following the financial crisis of 2008, is very hard to meet – the research program, run at the University of Bologna, Department of Architecture, investigated the impact of volumetric additions to existing buildings in terms of quality improvement. Starting from a theoretical matrix of strategies for volumetric additions, this research studied specific topics concerning the re-dimensioning of the units, and increase in energy efficiency and the installation of equipment applying them on some case studies involving Italian residential buildings.
In order to make effective and sustainable the process of retrofitting (not only in financial terms), some topics of strategic importance are pointed out:

- A reduction in operating energy demand;
- Meeting the need for new space arrangement and level of quality;
- An introduction of passive or active solutions to exploit renewable sources;
- The optimization of the energy balance.

All of the above are considered strategic factors in the definition of the design approach for interventions and in addressing the methodology. The research mainly considered multi-family housing and selected several case studies, located in the main Italian and European cities, built from 60's to 90's, in order to obtain an index of the construction techniques originally adopted and a diagnostic analysis of the main pathologies and damages.
The methodological approach, proposed by the Research Unit of UNIBO, focuses on a step by step retrofitting strategy, to be tested by a simulation model, with the aim to reduce the current very high energy demand to a value of at least 15 kWh/m^{2}y. This performance level is assumed as the target of the retrofitting action that was developed by assessing the effectiveness of the different technological solutions adopted.

3. Renovation scenario

A renovation intervention should have an impact on two main aspects: first of all a reduction in the current energy demand in order to obtain a more sustainable behaviour of the building and a drastic decrease in operating costs, and then an upgrading of the units layout and dimensions to meet the new needs. Both of these could be achieved without having to move the residents out by reducing the impact of the intervention inside the unit and the building as a whole. A simulation has been performed on a case study to evaluate the effectiveness of a renovation scenario based on a wood sandwich solution. Even if a volumetric addition seems to be much more expensive when compared to an implementation of the building envelope, the scenario proposed above shows a difference of just 9% in terms of construction costs.
The cost/benefit ratio evaluation is an essential tool in order to steer the design phase towards the most effective solution. Therefore sharing the decisional process with the end-users for what concerns the management activities, the functional features and the ordinary use can be a strategic factor to define effective solutions. The evaluation process can also influence the choice of the construction methods and the technological solutions.
From a methodological point of view, the experience tested in the simulation model allowed to point out some fundamental steps for the retrofit actions. The functional program, the typologies and the possible construction systems should be flexible in order to be able to adapt them to the results of the financial evaluation and to ensure a successful results of the project in terms of economic investment, quality improvement, energy savings requirements, environmental standards, etc.
The aim of the proposed methodology and simulation model is a comparison of the costs-benefits ratio for the different solutions. The simulations run during the research demonstrated the efficiency of the assessment approach even if the results are still affected by a certain degree of uncertainty due to the difficulties in predicting costs, trends of energy costs, tax relief policies and financial aspects. In conclusion, this research focuses mainly on a series of comparison of different solutions, in terms of an assessment of the cost-benefits ratio.

A6

Demonstration projects considering new technologies and innovative concepts in rehabilitation of large-volume buildings

Chair: Katharina Kowalski
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Comparative analysis for the refurbishment of the high-rise concrete building stock based on life cycle assessment scenarios

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Introduction

The **prefabricated reinforced concrete large-panel construction** method was spreading throughout Europe during the reconstruction work following the World War II in order to decrease the general housing shortage. During the 1970s and 1980s, altogether 510.000 flats of this type were built throughout Hungary; therefore their refurbishment is inevitable and urgent. This paper deals with the question 'What makes the existing reinforced concrete high-rise building stock sustainable in the long term?'.

The **typology of the precast large-panel building stock** was set up by grouping buildings according to their age, architectural and technical parameters: the most frequent types based on expert judgements, in this study 3 typical types of **the Kelenföld housing estate** in Budapest were chosen for analysis: one of the largest housing estates in Budapest consists of altogether 53 construction blocks roughly with some 8500 flats, that means the homes of about 20.000-25.000 citizens.

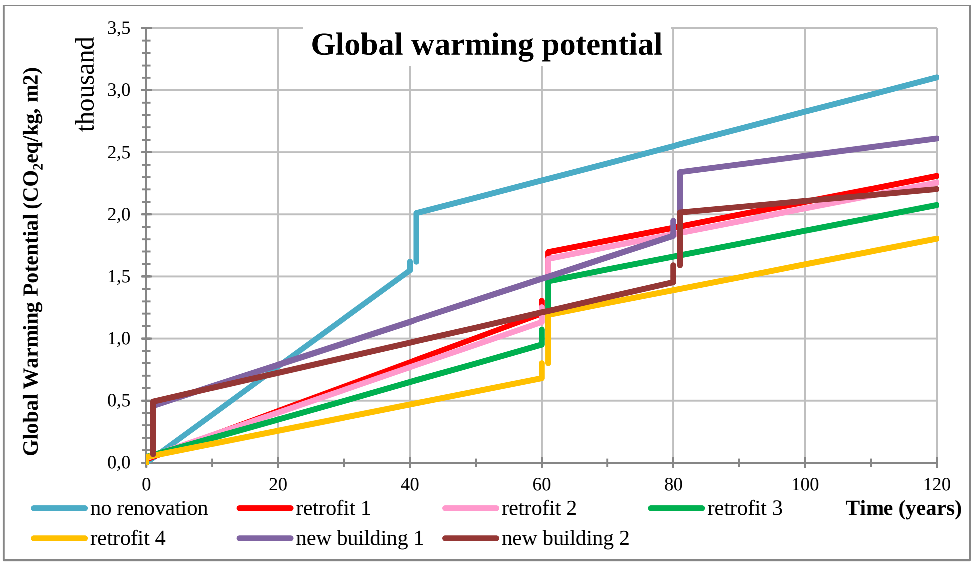
Three typical prefabricated reinforced concrete large-panel buildings in Hungary: building codes in order: terraced panel building, A10 and Kf10.

Methodology

During the research **a methodology was developed** for the analysis of the refurbishment options of prefabricated concrete buildings in order to reduce their impact on the environment. The method is based on **Life Cycle Assessment (LCA)** that studies the environmental aspects and potential impacts throughout a building's life from raw material acquisition through production and operation

to disposal. A comparative analysis was developed: different refurbishment options were studied in order to compare their relative environmental impacts.
During the research the **non-renewable cumulative energy demand** method the **CML method** was used to assess the environmental impacts, both are internationally accepted and widely used.
The whole remaining life cycle of buildings was considered. The **life cycle was divided into five phases:** production, operation, maintenance, retrofit and disposal. During the research it is assumed that the retrofit is expected **to increase the remaining life span of the building**.

The normalization showed that buildings have the most significant contribution in the category of global warming (GWP) and also the acidification potential (AP) is relevant, but the contribution is less than half of the GWP. The normalised ozone depletion and eutrophication caused by the retrofit are insignificant. According to the results of normalization in this paper the **global warming potential**, as the most significant environmental indicator is demonstrated in more detail.



The global warming potential of all the alternatives in case of ‘Kf10’ building

The ‘no overall renovation’ scenario has the lowest life cycle CO_2 eq emission in the first 2-3 years, but after this time the retrofit options have a lower global warming potential: the energy and the environmental impact invested into the retrofit is quickly recouped. The **comprehensive retrofit is the most environmental friendly option until about 60 years**, when the renovated building reaches the end of its expected life time. In an even longer term (60-80 years), as it is difficult to predict the future regulations about the energy performance of buildings and the possible changes of the building materials in the long term, there is an increasing uncertainty involved in the assessment.

From the results of the individual buildings the total energy saving and the mitigation potential of the housing estate can be calculated taking into account the number of building types per district.
The **global warming mitigation potential** of the analysed area is 44.4 % that would be achievable if the buildings were upgraded to fit the requirements of the current building code. In case the existing large panel buildings were be high-level retrofitted the decrease of global warming potential would be 64.6%. Since the energy mix of the district heating is based on fossil fuels the **non-renewable cumulative energy demand and the ozone depletion potential** are quite similar to the global warming indicator.
Concerning the **eutrophication and the acidification potential** the decrease is lower approximately 26.6-26.7% in case of general retrofit measures but there is not significant change if the high-level refurbishment were taken into account (24.6-27.3%).

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"Johann Böhmstrasse": Renovation concept towards energy plus standard with prefabricated active roof and facade elements, integrated home automation and grid interaction"

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Short Summary

The existing building stock in Austria consists of a variety of buildings from the post-war period. Due to their poor quality of construction those buildings consume an enourmous amount of heating energy.
In Kapfenberg one of these bad energy performing social housing buildings from the sixties is being renovated to become net zero building. The sixties bloc will be converted into a futuristic showcase. The house in Kapfenberg has 32 apartments on four floors. 200m2 building integrated solarthermal collectors and up to 1.200m2 photovoltaic modules have been mounted on a large scale solar wing that extends far beyond the existing roofscape. In the annual average energy balance, the building will produce more energy than it consumes on the primary energy level. Johann Böhmstrasse is a „Building of Tomorrow" flagship project funded by the BMVIT.

1. Introduction

The existing building stock in Austria consists of a variety of buildings from the post-war period. Due to their poor quality of construction those buildings consume an enourmous amount of heating energy.
In Kapfenberg one of these bad energy performing social housing buildings from the sixties is being renovated to become net zero building. The sixties bloc will be converted into a futuristic showcase. The house in Kapfenberg has 32 apartments on four floors. 200m2 building integrated solarthermal collectors and up to 1.200m2 photovoltaic modules have been mounted on a large scale solar wing that extends far beyond the existing roofscape. In the annual average energy balance, the building will produce more energy than it consumes on the primary energy level. Johann Böhmstrasse is a „Building of Tomorrow" flagship project funded by the BMVIT.

Fig. 4: On the left the newly refurbished building can be seen as a comparison to the old building on the right.

Block of Flats from 1958, Rejuvenated with Wood

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Summary
A rundown 1958 post-war housing estate in the west of Munich was first an object of study, then a planning model and finally a showcase project for holistic wood renovation. For an ideal lifecycle balance and overall economy, the following is vital: maintain the carrier substance, rebuild, recompress, passive-building envelope pre-fabricated in wood, timeless design and regenerative energy supply.

Keywords
Solar construction, renew stock, recompress, set of objectives, lifecycle balance, grey energy, wooden construction, pre-fabrication, passive house, solar energy

Location	Munich-Sendling, Badgasteiner-/ Fernpaßstraße
Building owner	GWG Städt. Wohnungsgesellschaft München mbH
Planning+construction management	KLA Kaufmann.Lichtblau.Architekten, München/ Schwarzach
Structural planning	MKP Merz.Kley.Partner/ EST Energie.System.Technik
Funding/ Research	KFW, dena, LH München, E2ReBuild
Construction dates	Original 1958/ Constr. Phase 1 2010-11 (Phase 2 2012-13)
Net dwelling area	3.323 m2 (originally 2.012 m2, + 65 %)
Units	46 flats/ district housing office (originally 36 flats)
Envelope quality Ht'	0.26 W/m2K (originally 1.56 W/m2K)
End energy	22 kWh/m2a (originally 280 kWh/m2a)
Primary energy	22 kWh/m2a (originally 340 kWh/m2a)
Building cost	950 €/ m2 GFA (German DIN cost groups 300/400, gross

Abstract

The housing estate owned by GWG was still in its original condition from the late 1950's when planning began. Typical features included: widely spaced blocks of flats with nondescript outdoor lawn areas; mixed masonry construction with wooden-framed windows and concrete ceilings below non-insulated roofs; spartan, standard floor plans for flats around internal stairwells; massive deficits concerning fire safety, sound insulation, variability and comfort; basic building technology, high energy costs, inacceptable indoor climate.

The planning process for the necessary complete renovation began in 2007 with a student project entitled "Weiterbauen" (Building further) at the Technical University of Munich, Faculty of Architecture, Wooden Construction). Starting from this basis, the architects and building owner prepared a catalogue of target specifications concerning:
A High-quality usage: Quantity, quality, accessibility (disabled-friendly) and outdoor areas
B Energy for the future: Efficiency, regenerative supply and overall economics
C Sustainable construction: Substance-conserving, ecological wooden construction, process and design.

The planning team led by Kaufmann.Lichtblau.Architekten developed a higher-density renovation model. By incorporating a new building for the district office of GWG, the load-bearing structure of the original buildings could be retained but the access was changed, and the flats were transformed into individual modern residential units with attractive outdoor areas. The new building envelope, including that for an added storey, consists of pre-fabricated wooden elements meeting passive-building standards, with maintenance-free wall cladding and green roofs. Exemplary solutions were developed for life-cycle and energy balances, building science and structural aspects, fire safety, sound insulation and an efficient construction process.

The first building phase was completed in 2012, phase 2 has begun. Holistic value enhancement, energy efficiency which is fit for the future and a wooden construction offering active climate protection, combined with optimal usage quality, promise the highest total economic viability for generations.

Renovation to plus- energy- standard schools – Rainbach im Mühlkreis/Austria

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Short Summary

The aim is to renovate the whole school complex to a plus-energy-house-standard.
A functional as well as a technical overall view are necessary due to the closeness of the two main structures, the shared facilities such as gym-hall, multi-functional hall, as well as the gas heating facility and water supply, the boarding for pupils and the shared cleaning staff.
With the construction of a new hall which unites elementary, secondary modern schools and gym-hall all different functions of the complex are interlinked. Moreover, the outer surfaces of the secondary modern school are reduced remarkably, and for the elementary school and the gym-hall this fact means that no separate thermal insulation is necessary at all.
To provide sufficient fresh air, the complex will be equipped with a mechanical ventilation system with heat recovery.
All windows will be provided with centrally controlled moveable sunblinds.
The existing water well will be used for the toilets.
Electric lighting is controlled in the same way as the sunblinds.
For the generation of electric current a 50 kWP photovoltaic plant will be established.
After thermal renovation heating will be effected by means of wooden chips.

Keywords: prefabrication, sustainability, comfort, economic efficiency, fire safety, cost effectiveness, recyclability, precision, integral planning, renewable materials

The market town of Rainbach is situated 720 meters above sea level in the north of the Province of Upper Austria. From the climatic point of view this region is characterized by its relatively high altitude above sea level and the frequency of defogged days.

The two schools of the market town Rainbach are situated near the market town center on a separate, adequately dimensioned school ground with sufficient open area. The nearby publicly owned sports ground is also used by the schools. The catchment area for pupils exceeds the community boundaries, a fact which shades cross-community importance on the construction of the schools.

The renovation of the building in an energetic technical way leads to a sustainable reduction of total energy use without consumption of further building land and without construction of new building surfaces.

On the one hand renovation has a high potential of energy-technical savings and offers on the other the creation of modern room structures with sustainable materials and elaborate planning.

An objective of the municipality is to maintain a renovated, optically attractive building. Furthermore the erection of a building should - on the long term – put only little strain on the municipality budget and also involve regional enterprises in the renovation. The building must be and remain affordable over its life time cycle in relation to the costs of reconstruction, energy, cleaning, disposal, etc.

All the surfaces of the buildings were analyzed and the following measures will be implemented: the exterior walls of the Secondary modern school and of the gym-hall will be renovated with prefabricated wooden-framed-elements. In building projects with short execution times this is a perfect method to previously transfer work flow to the production hall. The prefabricated wooden elements guarantee high end quality and can be produced independent from weather conditions.

The outer walls of the Elementary school will be insulated with an upgraded insulation with wood fibre insulating boards.

The windows correspond to passive house standard and are carried out with triple glazing and wooden-aluminium frames – their thermal transmittance (k value) is 0.8 W/m²K.

The requested new classrooms will be established in a heightening above the present entrance area on the north side. This is the cheapest way to produce extra room as the necessary fundaments and the base plate can be used.

The new hall between Elementary school, secondary modern school and the gym-hall unites all the functions of the building complex. In this central hall overall tasks such as library, boarding of the pupils, gym-hall and a nearby function-room are interconnected.

To prevent overwarming in summer time with the high insulation standard and the high number of persons in the rooms (especially in May, June and September), cooling with the cool night air will be applied.

All windows – except on the north side – will be equipped with centrally controlled moveable sunblinds. These sunblinds can be controlled individually, but foremost they are centrally controlled by light sensors.

Ventilation appliance: It corresponds to the passive house standard regarding energy consumption, heat recovery and tightness. With one single appliance ventilation of the whole complex with its different occupation times can be effectively done.

Light control is combined with the control of the sunblinds. Dimming, occupation sensors and daylight control can reduce the consumption of electric energy of up to 70 %.

As the roof construction of the gym hall had to be renewed anyway, it was redone with an inclination to the south and furnished with photovoltaic elements with a capacity of 42 kWh peak. Further elements with 8 kWh peak will be situated on the roof of the Elementary school.

Secondary Modern School:	Existing Building – 103.9 kWh/m²a After Renovation – **11.6 kWh/m²a**
Gym hall and new hall	Existing Building (gym hall) – 119.5 kWh/m²a After Renovation (gym hall + new hall) – **16.3 kWh/m²a**
Elementary school	Existing Building – 110.6 kWh/m²a After Renovation – **17.6 kWh/m²a**

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E-Office: a prime example for energy efficiency

Extended Abstract

The corporate development of the company, then known as Steweag, at the end of the 1950s gave rise to the establishment of a central administration office. It was specified that the site of the new administration building should be conveniently located for transport, whilst in an inner-city location. Between 1958 and 1961, the Steweag administration building was constructed as a single 10-storey edifice, which was accessible from Leonhardgürtel.

Competition on the electricity market due to liberalisation demands the use of synergies. After the merging of the companies, the fundamental need for a joint administration office for Energie Steiermark was clear. Once the planning parameters had been determined, an architectural competition was held based on a feasibility study. The winning project was designed by architect DI. Ernst Giselbrecht. The decisive factor for the general renovation was the absolutely terrible energy performance of the building and the technical ageing of its technical facilities.

The winning project makes excellent use of the plot as an extension of the existing property and creates an unmistakeable landmark on the Graz cityscape. The entire western part of the plot accommodates the underground garage, however the area above ground could be developed into parkland.

Fig. 1: View of new E-Office (west side)

The façade design includes a sun protection system with folding shutters, so the façade can take on a different appearance every day, regulated by the user. The folding shutter shades the window, whilst not obstructing the view outside. The skylights were fitted with LED strips, which enable a colour display of the façade. The interior of the building is based on a colour concept: each floor has a distinctive floor colour, which helps to identify which employees

“belong” to which floor. The office space configuration includes individual offices and group office solutions.

For anyone interested, a one of a kind, interactive experience exhibition on the ground floor – the "E-Wunderwelt" – offers a fascinating insight into the field of renewable energy. Guided tours can be booked. In total, the investments came to around 36 million euro.

The E-Office is a showpiece in the area of energy efficiency, as a total of 550 square metres of solar panels were incorporated into the facade and roof of the building, providing energy for more than 30 households. Furthermore, 12 geothermal energy systems and a solar plant ensure the international low-energy standard is observed. More than 1.8 million litres of precious drinking water can be saved each year through the intelligent use of rain water. Interior motion sensors and the use of LED technology ensure a saving of up to 90 percent in comparison to traditional light systems.

Keywords
energy-efficient office, renewable energy, energy saving

B1

Best Practice in Sustainable Buildings

Chair: Claudia Dankl
ÖGUT, Austria

Best case - plus-energy renovation of a residential building in Kapfenberg assessed with ÖGNB (TQB) and klima:aktiv building standards

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Summary

Building assessment systems can serve as powerful agents of change in efforts to reduce the environmental impact caused by the building sector.
Building assessment systems provide building performance information such as energy consumption, materials used and operational costs. Assessment systems define various levels of performance within the marketplace, above and beyond the minimum defined by codes and standards. As a consequence, building assessment results can be utilised as a marketing instrument, thus increasing the demand for cost-efficient, user-friendly, and environmentally sound buildings. At the same time, they produce a substantial reduction in environmental impact.
In Austria, the TQB building assessment scheme has been in place since 2001.
This conference contribution describes the development of the TQB assessment scheme, and the successful refurbishment of the lead project "e80^3-Buildings" of the research program "house of tomorrow – plus" will be shown in detail, presenting the development of high-performance retrofitting concepts, focusing on plus-energy buildings with the prefabricated façade elements, built-in building services and net integration.
High-performance refurbishments can only be achieved through an integrated design that includes advanced energy concepts. Specifically, this will require a high-quality thermal refurbishment of the building envelope with simultaneous integration of energy-producing active elements (solar thermal collectors and photovoltaic elements), as well as network integration for electricity and heat.

Keywords: sustainable buildings, building certification, energy efficiency, renewable energy, sustainable development, green building assessment scheme

1. Introduction

In Austria, many of the buildings built between 1950 and 1980 are now being retrofitted or refurbished. If these refurbishments achieve a high level of energy performance, or even reach a plus-energy standard, they would represent a major step towards achievement of the European 2020 targets. A change from buildings that consume energy to plus-energy buildings requires building functions and systems to be completely redesigned. High-performance refurbishments can only be achieved through an integrated design that includes advanced energy concepts. Specifically, this will require a high-quality thermal refurbishment of the building envelope with simultaneous integration of energy-producing active elements (solar thermal collectors and photovoltaic elements), as well as network integration for electricity and heat.
In the paper the successful refurbishment of the lead project "e80^3-Buildings" [1] - *reconstruction concepts towards energy plus house standard with prefabricated active roof and facade elements, integrated home automation and network integration* - of the research program "house of tomorrow – plus" will be described in detail. This project is realized as a case study – demonstration project – in Kapfenberg (Styria/Austria) by the property developer „Gem. Wohn- u. Siedlungsgenossenschaft ennstal" in the years 2010 to 2013.

2. Results of the sustainability performance

In the past few years, an increasing number of building certification systems have been placed on the market. In the current project a complete assessment by the use of TQB-assessment system [13,14,15,16,18,19] and monitoring [17] are part of the objectives for the research project.
The results for the first assessment in the planning phase are pictured in *Fig. 1*.

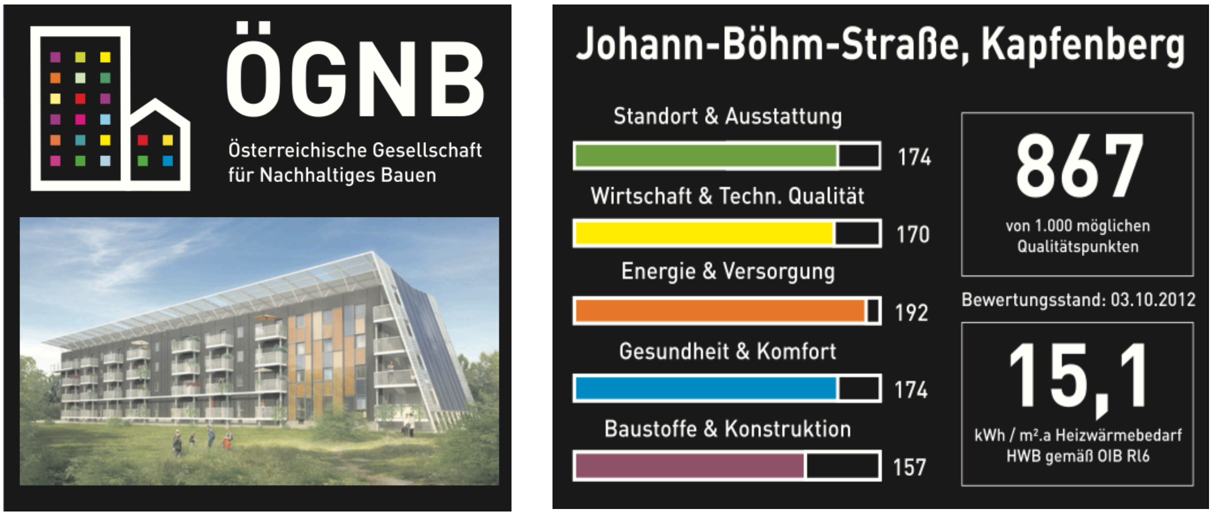

Fig. 1: Result of the TQB-certification

3. Conclusions and outlook

The demand on buildings, which allow the enhancement of the principles of a sustainable development, will gain more and more importance in the private as well as the public sector. This trend is based not only on marketing demands but also due to the need of better life cycle performance. One of the instruments in proving the performance is building certification, which includes aspects as e.g. LCA and LCCA as well as user comfort (as part of the functional performance) or technical aspects. For the building sector this results in increased requirements primary focusing on new buildings. Whereas the building stock offers the biggest potential to contribute to these targets.
In the current case study it is shown, that a high-quality refurbishment towards plus energy buildings is possible only through an integrated refurbishment approach including an energy concept. Thus it means a high-quality thermal refurbishment of the building envelope with simultaneous integration of energy-producing active elements (solar thermal collectors and photovoltaic elements), as well as network integration for electricity and heat. By the use of prefabricated elements the goal of a more energy efficient and lower environmental building sector can be reached.

4. Acknowledgements

The research project *e80^3-Buildings* [13] - *"reconstruction concepts towards energy plus house standard with prefabricated active roof and facade elements, integrated home automation and network integration"* is funded by the Federal State of Styria and the program "Building of Tomorrow" of the Austrian Federal Ministry of Transport Innovation and Technology (BMVIT) via the Austrian Research Promotion Agency (FFG).

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Certification System for Research and Laboratory Buildings – The Case Study MED CAMPUS Graz

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Summary

In the year 2004 the Medical University of Graz (MUG) was founded as an autonomous university and is currently split into several locations spread all over the city of Graz. A project called MED CAMPUS will provide an opportunity to merge the university with the existing university hospital in one unified location. Physical contiguity will do more than solving the difficulties of the current situation; it will enable teaching, research & development and patient care to reach an international level of excellence.
The project area consists of two construction sites where twelve institutes are combined in four centers. Facilities will include teaching facilities, administration offices, a library, a canteen an assembly hall, and space for start-up companies operating in related fields. The building as a modern university, research and communication center will have space for around 1700 employees and 4300 students.
From the project's inception, the rectorate managed its development as a sustainable and healthy property in the broadest sense, and this has resulted in sustainability quality targets having been included in the public competition requirements.
This case study presents the architectural concept of the project MED CAMPUS Graz. Further more the applied assessment method and the achieved level of building sustainability based on the assessment criteria of DGNB/ÖGNI certification of lab buildings [2] will be shown.

Keywords

Sustainability; DGNB/ÖGNI certification of lab buildings; building assessment case study

Acknowledgments

This described work in the paper was carried out in the project MED CAMPUS Graz by Medical University of Graz and Bundesimmobiliengesellschaft m.b.H. with the generalplaner Riegler-Riewe Architects ZT GmbH (architects, commissioned by BIG) and Team TU Graz (Prof. Maydl, commissioned by Med Uni Graz). We would like to thank all partners for their support and their inputs.

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B2

Evaluation of Embodied Energy and Carbon Dioxide Emissions for Building Construction (Annex 57)

Chair: Isabella Zwerger
Federal Ministry for Transport, Innovation and Technology, Austria

IEA ECBCS, ANNEX 57

-EVALUATION OF EMBODIED ENERGY AND CARBON DIOXIDE EMISSIONS FOR BUILDING CONSTRUCTION-

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Abstract

The evaluation of energy consumption and related carbon dioxide (CO_2) emissions due to the use of buildings is becoming increasingly accurate and is being applied in the design of more energy efficient building envelopes and systems. As such, the importance of energy consumption and CO_2 emissions due to stages other than the use of buildings is increasing. Therefore, the scientific basis of the embodied energy and CO_2 emissions for building construction should have been investigated by organizing the new Annex and an international team for the IEA ECBCS program.

The project (IEA ECBCS, Annex 57, 2012-2015) is investigating methods for evaluating embodied energy and CO_2 emissions of buildings, to develop guidelines that contribute to practitioners' further understanding, and to find better design and construction solutions for buildings with less embodied energy and CO_2 emissions.

This paper describes the research area of Annex 57 and research items regarding embodied energy/CO2 emissions due to building construction. The profile of CO_2 emission in Japan is shown in which embodied CO_2 due to building construction and civil engineering is 19.2% and operation of buildings, 23.2%. *A*n estimation of the total CO_2 emissions in various countries and the corresponding fractions of embodied CO_2 due to building construction and civil engineering is shown. Embodied CO_2 in the world is between 5 and 20% of the total CO_2 emission in the world. In particular, the fractions of embodied energy are higher in developing countries and often exceed the building operation energy. The energy consumption and CO_2 emissions in gate factories in supply chain are estimated to show the characteristics of the databases based on ISO and IO analysis.

Design and construction methods for buildings with low embodied energy and CO_2 are being improved by the use of recycled materials, prolongation of building life, retrofitting, and also reduction of non-CO_2 greenhouse gas emissions. An approximate estimation was made to find out the significant factors to reduce embodied energy/CO_2.

This paper shows the whole quantity of embodied CO_2 due to construction which fraction is between 5 and 20% of the total CO_2 emission. The measures and the effects to reduce embodied energy/CO2 were also shown, in which the prolongation of building life is effective and the influence due to Freon gases is significant.

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Keywords

IEA ECBCS; Embodied energy; Embodied CO_2 emission; Data base; Case study

Key contributors to embodied carbon and energy of four Brazilian case studies

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Short Summary

Identification of key materials, which effectively define a building's impact profile have important implications not only on research time and investment, but also on understanding by designers and successful implementation of such concepts in their daily specification practice. Ranking building materials based on embodied energy (EE) and embodied carbon (ECO_{2e}) and its disclosure to designers empower the material selection process, enabling more efficient, impact-driven specifications and materials balance. Disclosure of impact profiles to the general public can also provide the grounds for societal pressure for mitigation and technological improvement of the related industries, as well as advise public and sectorial policy-making. However, definition and calculation methodology of these metrics reflect current conceptual vagueness or even divergence, challenging replication, results aggregation and benchmarking. In this paper, cradle to gate LCAs were performed using SimaPro 7.3 software and followed ISO 14040:2006 methodological guidelines. Production cycle modeling used secondary data collected from national literature or adapted from international literature and databases. Inventory outputs were related to total material quantities (mass or volume) to calculate cradle-to-handover embodied energy and embodied CO_{2e}, normalized per unit of gross floor area (m^2_{GFA}) of four Brazilian case study buildings. For the analyzed typology, computed EE and ECO_{2e} were around, respectively, 1.030 MJ/m^2_{GFA} and 128 kg CO_{2e}/m^2_{GFA}. Top six contributors (Portland cement CP III-32, ceramic brick, steel rebar, sawn timber planks, plywood and PVC tube) respond for over 80% of the total EE computed. Analogously, over 80% of the accounted ECO_{2e} was related to cement, steel rebar, ceramic brick and PVC tube and conduit. Also, a core database encompassing twelve building materials and components provides a very accurate (over 97%-coverage) description of the accounted EE and ECO_{2e} profiles altogether, which can possibly streamline indicators monitoring scope.

Keywords: embodied energy; embodied CO_{2e}; LCA; building material; indicators; eco-efficiency

1. Introduction

The building sector is responsible for important impacts on the environment. On a global scale, building material manufacture and transportation as well as installation and construction of buildings consume great quantities of energy and emits large amounts of greenhouse gases.

Carbon footprint and embodied energy are indicators that, referring to buildings, measure, respectively, the CO_2 emission and the energy used during the manufacture of building materials and components, in transporting these to the site, and during the construction process itself. Given their life cycle perspective, they further include the measurements of energy and CO_2 emission incurred during renovations and replacement of components, as well as those resulting from demolition, waste and reprocessing at the end of the building service life. Calculation of both metrics can be assisted by LCA platforms or, when appropriate, databases such as [1] and [2]. In Brazil, studies performed by [3] and [4] emphasize the necessity of developing life cycle inventories for the local industry and/or carefully validating international data before their application in national studies.

Identification of key contributors that define a building's EE and ECO_{2e} profiles has important implications not only on research time and investment, but also on understanding by designers and successful implementation of such concepts in their daily specification practice. Focused disclosure to designers empowers the material selection process, enabling more efficient, impact-driven specifications and materials balance.

This paper presents calculations of life cycle embodied energy and embodied CO_{2e} normalized per unit of gross floor area (m^2 $_{GFA}$) and provides preliminary Brazilian benchmarks based upon four case study buildings.

2. Methodological approach

In this paper, life cycle embodied energy and embodied CO_{2e}, normalized per unit of gross floor area (m^2), are applied at the building material level to assess material eco-efficiency of Brazilian case study buildings. Cradle-to-gate LCAs were performed using SimaPro 7.3 software and followed ISO 14040:2006 methodological guideline. Input data for materials/components modeling were collected from national literature or adapted from international literature or from or from ELCD v.2.0, Ecoinvent v.2.2 and Industry Data v.2.0 databases. Obtaining of embodied CO_{2e} figures was assisted by CML 2001 v.2.05 environmental impact analysis, which presents equivalency factors for all greenhouse gases in the global warming impact category, and expresses results in mass of CO_{2e} per functional unit. The studied typology is basically comprised by low-rise (up to 3 floors), low window-to-wall ratio, reinforced concrete-framed, masonry façade and partitions, and ceramic or metallic roofing buildings. Total usage of material/components was quantified for four case studies - according to the functional unit previously defined – then divided by the total gross floor area, and corrected by national estimates for construction waste. Portland cement and ready-mixed concrete are here expressed considering three amounts of ground granulated blast furnace slag (ggbs) as clinker replacement, consistently with Brazilian standards (5% in CPI-32, 30% in CPII-E-32, and 66% in CPIII-32).

3. Final remarks

For the studied typology, the top six contributions (Portland cement CP III-32, ceramic brick, steel rebar, sawn timber planks, plywood and PVC tube) respond for over 80% of the total embodied energy computed. Analogously, over 80% of the accounted embodied CO_{2e} was related to cement, steel rebar, ceramic brick and PVC tube and conduit. A core database encompassing twelve building materials and components provided a very reasonable (over 97%-coverage) description of the accounted embodied energy and CO_{2e} profiles altogether, which can possibly streamline indicators monitoring scope.

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Embodied energy and CO2 emission associated with building construction by using I/O based data and process based data in Japan

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Summary

This study quantifies the embodied energy and embodied CO2 associated with building construction by using energy intensities and CO2 intensities obtained by process analysis and I/O analysis, and compare with each others in Japan.

The energy intensity and CO2 intensity table is calculated, which is based on 2005 I/O tables in Japan. In the intensity table, intensities of energy consumption and CO2 emission are shown as values of MJ and kg-CO2/million Yen, and each values are shown as based on producer's and purchaser's prices. It can be possible to calculate embodied energy and CO2 emissions due to constructions of various buildings.

The process-based data were referred to existing databases in Japan.

In this study, following comparisons are implemented;

・Comparison on energy intensity and CO2 intensity of building materials of the different databases: cement, concrete, steel, glass, glass wool and lumber.

・Comparison on embodied energy and embodied CO2 of building by using different databases: a reinforced concrete office building and a steel frame structure office building.

The energy and CO2 emissions associated construction buildings were calculated by using energy intensity and CO2 intensity obtained by the I/O based analysis and the process based analysis. The results showed that many of intensities by obtained I/O analysis are larger than the intensities by obtained process analysis. The embodied energy and CO2 of office buildings by using I/O analysis are approximately 13% larger as the results of process based analysis.

Keywords: Embodied energy; Process based database; I/O based database

B3

Facade

Chair: Daniel Kellenberger
Intep – Integrale Planung GmbH, Switzerland

Leichtbau 3.0: Material, Structure, Energy

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Lightweight constructions basically mean the striving to design structures with a minimal weight compared with a full use of the material properties. In future this has to be complemented by a maximum reduction of the cumulative energy demand (amount of energy consumed over the whole lifetime) for structures.
The example of the development of a hybrid building envelope will demonstrate that evolution.

Fig 1. a) Spatial envelope: Zlote Tarasy, Warszaw [Waagner Biro], b) Façade: 1 Angel Square, Manchester [Daniel Hopkinson].

Each component of the structure has to act as a load-bearing member and has to fulfil the functional requirements of a building envelope at the same time. In this respect, the use of the glass elements as surface structures, the load transmission and the boundary conditions become particularly important.
The concepts of lightweight construction are the basic principles of a holistic development and design in building construction. The example shows that facades and building envelopes as part of our infrastructure are offering new development opportunities and innovations in structural engineering and design.

Keywords: Lightweight Structures, Facade, Surface Structures, Hybrid, Glass, Energy

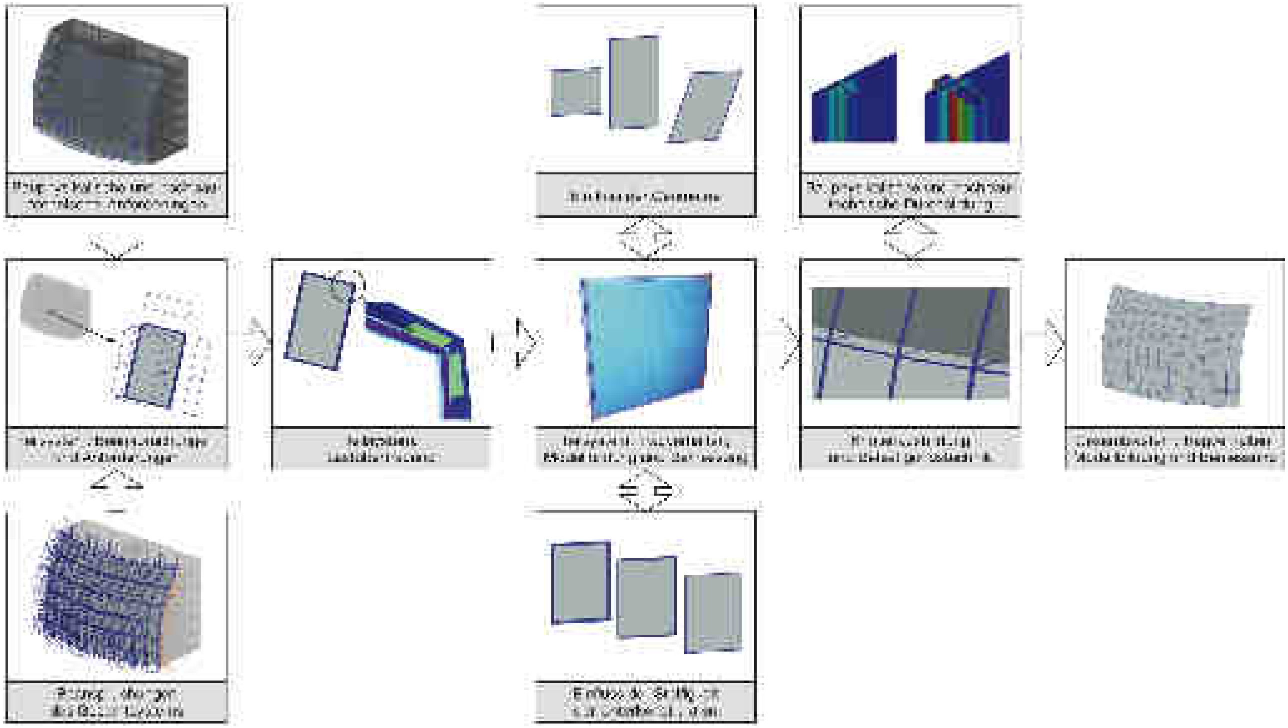

Fig 2. Hybrid Glass-Steel-Elements: impacts and relations for the use in building envelopes.

Energy performance of windows in various building types

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Short Summary

The paper presents an analysis of the influence of various building energy characteristic on the window energy balance in Polish conditions. The analysis is based on the building energy balance with hourly time step calculation in accordance with the methodology described in the ISO 13790 : Energy performance of buildings - Calculation of energy use for space heating and cooling. While the method of windows energy balance calculation is based on ISO 18292 : Energy performance of fenestration systems for residential buildings - Calculation procedure.
In the analysis two different public building types and several energy characteristics have been considered. The results indicate that the building energy characteristic significantly affect the energy balance of windows and thus should be taken into account in the process of setting of the reference data used for widows energy performance calculation.

Keywords: Windows; Fenestration; Certification; Labelling; Energy performance;

1. Introduction

New regulations such as the European Directive 31/2010 Recast impose new demands on the construction industry and investors. New low-energy buildings should be built using advanced technology and design techniques.
The windows play an important role in ensuring the comfort of indoor climate conditions. Commonly used factor for windows thermal efficiency is the heat transfer coefficient U. This factor, however, does not describe the full balance of the window. In fact, windows are also a source of solar heat gains and allow air infiltration. That means that the lowest U-factor does not guarantee the best thermal performance.
Existing windows certification systems are based on more or less complex energy balance of windows based on some reference data such as heating/cooling degree hours and utilized solar irradiation. These parameters depend, however, on both climatic conditions and the general building energy characteristics. Therefore two windows with identical properties can have different thermal balance depending on the operating conditions.

2. Methodology

In order to analyse the influence of building energy performance on the energy balance of windows two different building types under various operating conditions have been examined. The analysis includes:

- two reference building types (office building and hospital) of two different energy standards (current and from 1970s) with two different thermal masses (light and heavy),
- three climatic zones,
- separate energy balance calculation for both heating and cooling seasons,
- combined heating/cooling energy balance.

The assessment procedure in ISO 18292 requires data on both solar heat gains and heat loss through windows. Since both of these parameters depend largely on the climate and the energy characteristic of a building, detailed calculations for each reference building located in the three climate zones in accordance with the procedure proposed in ISO 13790 have been conducted. As not all of the available solar energy can be utilized for heat demand reduction, utilized fraction of the available solar energy is calculated on an hourly basis for the reference house.

3. Results

The heating and cooling degreehours and utilizable irradiation have been calculated for both reference building types and the three construction standards for the three climate zones. On the basis of the calculated values a set of 12 different windows has been analyzed. The results indicated that the number of degreehours and irradiation varies significantly for different building types which leads to different windows ratings. However the rating for various locations and building standard and orientation was similar.
The results indicated that windows with a lower U-value are not necessarily the best performing windows as they significantly reduce the amount of obtained solar energy in the heating season.

4. Conclusions

U-value of windows cannot be used to compare energy performance of windows. Therefore in order to provide decision makers information on the actual performance of windows it is necessary to develop a windows rating scheme based on an overall energy performance during both heating and cooling seasons. The development of a such system is possible as the performance of windows does not differ significantly for various locations, building envelope standard and orientation. However different building types are used in a different way, therefore there is a need of a proper set of data depending on the building function, that would allow calculation of the energy balance of windows in buildings with various energy characteristics.
Thermal performance of windows is not the only aspect that should be taken into account, windows are an important source of natural daylight that allows for reduction of electricity consumption for lighting, therefore a method of daylight potential implementation into the windows rating system should be developed. Windows are also providers of natural ventilation, thus improving the indoor thermal climate and reducing cost/energy consumptions for mechanical ventilation. These effects should be considered in future studies.

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The pitfalls of building integrated photovoltaic.

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Abstract
BIPV the short version for building integrated photovoltaic is one of the possibilities to turn a low or zero energy house into an active energy generating house.
There was a big development in products as well as in projects the last years. Market reports predicted tremendous growth rates which turned out to be wrong [1].
So there was no great breakthrough in the real market. Only few installations were realized in so called lighthouse projects.

Purpose
The purpose of this paper is to clarify the pitfalls of this lack of breakthrough. It goes into detailed consideration about the product development and product range. It will consider the question if there is a sufficient range of possibilities to meet the demands of designers and architects. Who is involved in the planning process, are the interfaces clarified between façade-, glass-, electric- and photovoltaic design? Is there an opportunity to standardize the process and the products? Are the highly costs the main impact of the slight market growth?

Result
The paper will figure out the market demand (enquiries for individual projects) versus real built installations. It will also show paths of possibilities to realize well design BIPV projects. On one hand regarding the design process itself, on the other hand regarding the standardization of products and projects.

Conclusion
Within this paper the author tries to find a way to optimize the boundary conditions of the BIPV industry, with the motive to accelerate the number of realized projects for renewable buildings.

Keywords
building integration; photovoltaic; architectural design

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Novel type of façade-window solar thermal collector

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Summary

The use of renewable energies in everyday life become more attractive from day to day. Even their use in buildings offer great benefits in terms of fossil fuel reduction as well as make eco- labelling of the architectural goods. Particularly, the use of solar thermal systems in building integration has a big potential.
Façade solar thermal collectors show double benefits in new architectural goods: integrated functional elements that do not disturb the architectural appearance and there is a high fraction of solar energy as a part of total energy needs of the building. These are the main characteristics of facade solar thermal collectors.

The new model of the window façade collector is described in this work. Namely, it is an ideal way to build-it in the south façade of the building that can be residential / office building or manufacturing plant. With these type of façade collectors/modules, the architectural appearance of the buildings is not destroyed and at the same time those build-in elements are functional: participate to a great portion of total energy needs of the building. This is a sustainable way of use of solar energy and consequently decrease the CO_2 impact to the environment.

Keywords: facade solar thermal collectors, energy-efficiency, solar architecture, building integration, long term stability.

1. Novel type of window facade collectors (modules)

The main characteristics of novel type of window facade collector (module) are summarised as follows: a good appearance of these modules on the buildings (Fig. 1). The CS facade – window collector could be produced in different colours as shown in Fig.1a). The window module could be assembled in window facade collectors (Fig.1b). The surface area of contact between Cu tubes of the absorber and flat plate (that is Al or Cu) is bigger than that one of the standard collector; it means that is a better heat transfer between absorber towards absorber's fluid; the contact between Cu tubes and absorber's plate is stable and do not changed during aging period of collectors; there is no any damage on selective coating; no melting on the selective coating in spots as it is in other type of welding such as laser or ultrasound welding; there are no waves on Al or Cu absorber plate due to the novelty in absorber's welding (novel CS type of welding). Since the fact that selective coating is totally undisturbed - there is no diffusion processes of oxygen, hydrogen and absorbers' plate, no corrosion could happen during the long period of collectors' lifetime. The efficiency is greater than other types of flat plate collectors (Fig. 2) - there is no use a portion of collector's energy to evaporate the humidity from the inner side of the collector since that it doesn't exist.

The window module is made of two glasses - between them is the absorber. Behind the absorber is material that absorbs the humidity in the inner space found during the assembling of the collector; the inner area is totally without any humidity and consequently no oxidation or reaction between O_2/water and the absorber or Cu tubes could happen.

a) b) c)

Fig. 1.Window facade collectors: a) different coloured collectors, b) window module, c) window facade modules integrated in the first demo building (middle column of the building's windows are replaced by windows collectors).

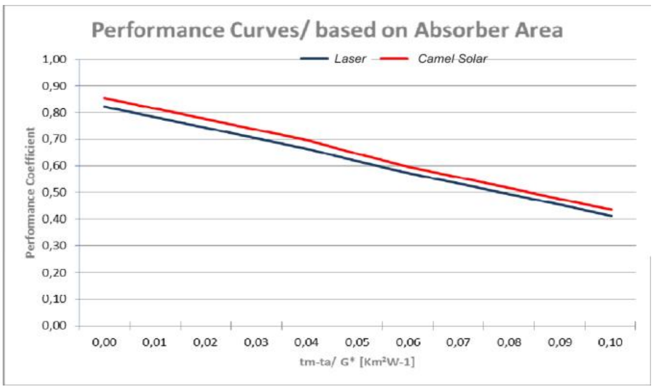

Fig. 2. Comparison of efficiency curves of two types of absorbers: laser welded (blue line) and CS new type of absorber (red line).

2. Conclusion

Novel type of window facade collector are functional elements in the new building concepts. Beside their good architectural appearance they provide a big portion of the total energy needs of the building and that portion comes from renewable source.

Another benefit for solar facade collectors is the fact that their appearance could be very similar to the windows glass surfaces (Fig. 1c). It means that facade windows-collectors are free of welding lines, waves and folds and present good replace to classical windows. They could be mounted on the same windows frames as the windows. The long term stability of these functional architectural components is solved, no humidity issues exist, no water vapour condensation during the life time of the facade collectors. Consequently, collector’s efficiency is prolonged and stable during their lifetime. Performance tests for these collectors are in progress.

Development of innovative building skins in the context of sustainability assessment

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1. Short Summary

The construction sector plays a key role towards sustainable development. Therefore, it is necessary to begin thinking about efficient ways to reduce harmful environmental effects. In this regard the focus should not only be on saving energy during the buildings operation, but also on the environmental performance of construction materials.

In this paper the consequences of sustainable development and sustainability will be discussed with respect to recent standardization activities and building certification systems. The development of innovative building skins in the context of sustainability assessment is presented for the case of a multifunctional plug & play facade (MPPF). Special solutions for energy-efficient operation, active and passive facade components for the use of solar energy will also be presented and evaluated, comparing the MPPF and a commercially available Façade.

Keywords: Facade; use of natural resources; end of life scenario; energy efficiency

2. Introduction

This paper gives an overview of the standardization activities of CEN and current building certification systems with a special focus on building skins. In the first part of the article the latest developments of the standardization work on “Sustainability of Construction Works“[1] will be explained. The paper also shows a preview of future construction regulations, which include the new basic requirement No.7 “Sustainable Use of Natural Resources“ [2].
In the 2nd part of the paper the consequences of sustainable development in the construction sector and the role of building certification systems will be explained. Using the example of the multifunctional plug & play facade (MPPF) [3], the main measures of criteria for sustainability assessment will be explained. Solutions for energy-efficient operation such as active and passive facade components for the use of solar energy will be discussed. The increasing comfort of the interior and the structural issues in production phase, as also for the maintenance works or any changes in use of the facade will be considered as well.
The importance of environmental assessment is one of the optimization tasks for future construction. The higher environmental requirements for buildings and materials that will result from these trends will reduce environmental impacts.

3. Standardization and Certification systems

During the last few years a large number of regulations for the environmental performance of construction materials and buildings were put into force. In particular, the CEN/TC 350 worked out a set of new standards in the field of sustainability. In this context the two most important standards for the Austrian market, are the ÖNRM EN 15804 and the ÖNORM EN 15978. These two Standards form the basis for environmental performance of construction materials and buildings.
In addition to standards and regulations, building certification systems play an important role as voluntary instruments. In these certification systems a set of criteria is defined assessing the individual performance categories of buildings, allowing a comparison of different buildings.
At the international level, there already exist a large number of certification systems, such as BREEAM (BRE Environmental Assessment Method), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) or LEED (Leadership in Energy and Environmental Design). In Austria there are currently three systems, to be mentioned. First the ÖGNI system (Österreichische Gesellschaft für Nachhaltige Immobilienwirtschaft), which is derived from the German DGNB system . Second the TQB (Total Quality Building) system of the ÖGNB (Österreichische Gesellschaft für Nachhaltiges Bauen) with its related Klima:aktiv system.

4. Research Project Multifunctional Plug & Play Façade (MPPF)

The goal of the k-Project “MPPF – multifunctional plug&play façade” was the development of a multifunctional façade system to be used in modular construction methods with the highest possible level of prefabrication for newly built large-scale residential and office buildings and the renovation of existing houses. MPPF worked on the integration of electricity and lightning protection systems and the development of test facilities. Another focus lied on the integration of PV and solar thermal systems in the façade - several prototypes of glass and shading with integrated PV were developed. One room of the test building in Stallhofen has been especially devoted to research in the field of adaptive control systems

In the course of the project two test façades (prototypes) were installed and intensively measured at the consortium leader’s place. The development of the second prototype was accompanied by environmental assessment activities, which ended by comparing the environmental impact of the MPPF with that of a conventional commercially available façade system.

5. Acknowledgements

The research described in the paper is part of the project "Multifunctional Plug & Play Facade" (Project-No.: 815075), supported by funds of the Austrian Research Promotion Agency (FFG), by the federal states of Styria, Carinthia and Lower Austria, as well as by a consortium of scientific institutions and companies, guided by the "Hans Höllwart - Forschungszentrum für integrales Bauwesen AG" (CEO, Mario J. Müller).

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B4

Best Practice

Chair: Peter Maydl
Graz University of Technology, Austria

Environmental performance of energy efficient residential building – a case study of Lithuania

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Short Summary

The paper presents life cycle analysis (LCA) results of the passive house in Lithuania. For the first approach three the most common and relevant impact categories of the life cycle were chosen – energy consumption, global warming potential and ozone layer depletion. Results of the LCA together with simulations of operational energy demand assert that embodied energy (construction & maintenance) constitutes 1/3 of the whole LCA energy, 1/5 embodied ozone layer depletion, and 2/3 of global warming potential. The environmental impact of various life cycle phases is presented. It is concluded that for different climates, during the life cycle of the energy efficient house, embodied energy is higher than in conventional buildings. Therefore sustainability of the construction materials and different occupation profiles has to be considered very carefully. In addition, influence of the occupants on LCA of the building is illustrated. Results show that it is not always purposeful, when performing dynamic LCA to take into account changes in occupation of the house.

Keywords: LCA; energy efficient house; embodied, occupants, environmental impact, simulation.

1. Introduction

With the increasing energy efficiency of the buildings, demand of the construction materials is also increasing. Main European Union's legislative measures, related to energy efficiency of buildings, do not take that fact into account, because many studies show that the highest environmental impact is made during the operational phase of the building. Just some newest researches show that embodied energy becomes also an important issue for energy efficient buildings.

The presented study aims: 1) to assess environmental impact of the energy efficient single-family house, using LCA methodology, involving building's constructions and all engineering systems of the building (energy production, heating, ventilation, water supply, sewage and electrical installation); 2) to identify phases of the life cycle and elements of the building with the highest environmental impact; 3) to apply and evaluate measures to reduce environmental impact of the building during its life cycle; 4) to assess influence of occupants' characteristics (household size and age) and on life cycle of the building.

2. Methodology

The LCA was undertaken using the computer tool SimaPro 7.2, with the functional unit 1 m^2 of the useful floor area. The single-family house in Lithuania and its subsequent use were calculated over a 100-year period. The key data for inventory analysis were identified by the data derived from IMPACT 2002+ V2.10 method SimaPro libraries. For the energy assessment of environmental performance during the operational stage of the building, also dynamic building energy simulation with DesignBuilder was performed. The life cycle phases included in the study are: 1) production/construction, 2) operation & maintenance, 3) dismantling and recycling, 4) transportation in all phases.

3. Results

Environmental impact of the whole life cycle of the building. Simulations of the operational energy consumption together with the analysis of the embodied energy (construction and maintenance) have shown that for the building built according to the national passive house requirements (simulated annual heating energy demand - 17.7 kWh/m^2), embodied energy constitutes 31 % of the whole LCA energy and embodied ozone layer depletion – 21 %. Situation is different with the global warming – the highest impact (63 %) is made in construction and maintenance phases.
The environmental impact of various life cycle phases is presented in Fig. 1. As we can see, the phase of operation & maintenance dominates in all impact categories. This phase covers the operational group as well as it includes a part of the embodied group – a renewal of the building elements.

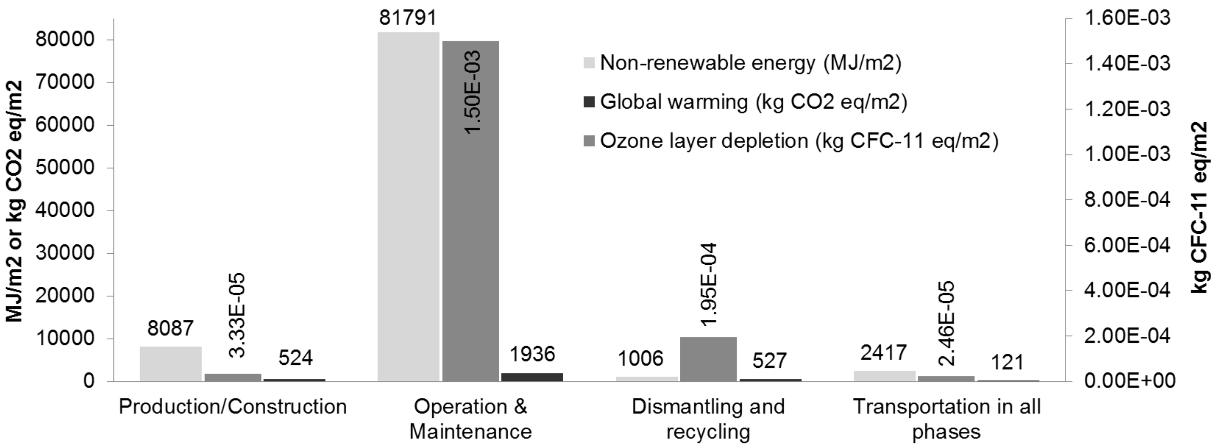

Fig. 1: The environmental impact of various life cycle phases

Embodied energy and emissions. Analysis of the embodied energy and emissions of the building has shown that major impact is made by materials used to create building envelope, especially walls, roof and floor. Alternative improvements of these constructions were evaluated.

Operational energy and emissions - influence of the occupants characteristics. There are many studies proving that operational energy consumption of the building might be significantly influenced by characteristics of occupants, e.g. [1]. To illustrate, how occupants may influence life cycle performance of the building, different occupation alternatives were simulated. Results show that occupants characteristic, such as family size and age have influence on all environmental impact categories. Differences in operational energy consumption for analysed households occur because of DHW consumption, which depends mainly on size of household. In addition, energy consumed for heating and lighting is influenced by occupation profiles (hours).

4. Aknowledgement

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REALITY CHECK OF A BRICK MADE PLUS ENERGY DWELLING

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Summary

Within the Austrian research project 'Solares Plus Haus' a plus energy building concept for a brick constructed dwelling is developed, planned and put into operation. The energy performance of the operated building is previously assessed by theoretical analysis of AIT and research partners. Since autumn 2012 a scientific monitoring is operated. This paper documents on the energy performance of the building based on measurement data acquired from January 1st till April 30th 2013. Monthly energy balances were calculated and selected detailed monitoring data of the energy performance of the heat delivering and distribution system are documented and assessed. Key findings are drawn and an outlook about the future research activities is given.

Keywords: Plus annual energy balanced building, energy efficient bricks, solar combisystem, photovoltaics, thermally activated brick wall, monitoring

1. Introduction and objectives

Within the Austrian research project 'Solares Plus Haus' a plus energy building concept for a brick constructed dwelling is developed. The energy performance of the operated building is already and will be assessed by the Austrian Institute of Technology (AIT) by means of a scientific monitoring from autumn 2012 to the end of 2014. In particular high solar fractions above 50% for covering the demand for heating and domestic hot water (DHW) preparation contribute significantly to a negative annual primary energy balance (non-renewable part). The research activity focuses intensively on the feasibility of improved use of solar heat by applying the 'Sonnenhaus-Konzept' [1] in combination with thermally activated brick walls. The research project approves the energy performance of the building and thermal indoor comfort with the analysis of measured monitoring data of the operated building and creates advices how to design and control the solar heat activated brick walls.
Preliminary calculation performed by AIT, i.e. energy modelling and building simulation, result into a negative annual primary energy balance (non-renewable part), which could be so far interpreted as a 'plus energy balanced building' [2]. Since December 2012 the brick constructed dwelling is operated and is occupied by the building owner; a four person family. AIT has developed an energy monitoring concept and the required technical equipment of the scientific monitoring over two years is installed and put into operation. This paper essentially documents on first monitoring results related to the energy performance of the building and its subsystems from January 1st till April 30th 2013. Main objectives of the monitoring campaign are:

- Demonstration of the functionality and feasibility of the 'building concept under real system operation and with the impact of user behaviour
- Quantification of the annual primary energy balance based on measured data
- Quantification of achieved solar fractions beyond 60% in practice
- Identifying measures to optimize the annual energy performance

2. Findings and outlook

Based on measurement data acquired from January 1st till April 30th 2013 a first documentation and assessment of the energy building and system performance of the 'e4Ziegelhaus2020' [3] is submitted. Monthly energy balances were calculated and the daily energy performance of the heat delivering and heat distribution system were analysed based on monitoring data of March 2nd. With the analysis of the selected monitoring data some conclusions are drawn. Key findings are:

- In comparison to preliminary theoretically generated annual energy balances it is most probable that the building operation will exceed the expected heating demand. During the first four month of 2013 the heat delivered to the under floor system and the thermally activated brick walls already cover 72% of the preliminary predicted 11,770 kWh heating demand including heating system losses. It is obvious that higher indoor temperatures of around and above 24 degree Celsius lead to higher amounts of delivered heat
- Especially due to marginal sun hours in January and February the amount of heat delivered by the flat-plate collector system wasn't significant. In January the solar fraction was only SF_{Jan} = 9% and in February SF_{Feb} = 14.1%
- The hot water tank operated with reasonable and stable stratification.
- The thermally activated brick wall operated with low supply temperatures, but the major heat was delivered via the under floor heating system
- The solar electricity delivered on site by the photovoltaic modules in March already equalises the total electrical consumption – see Figure 2. The percentage of directly used solar electricity in the building was between 29.2% and 49.4%
- The scientific monitoring system operated with an average permanent electrical power of 68 Watt and that implies means a share of 8.5% up to 14.3% of the total electricity consumption

Future research work will focus on:
- Continuation of the scientific monitoring till the end of 2014
- Acquisition of one complete monitoring data set from January 1st till December 31st in order to provide the annual energy balance based on measured data
- Comparison of theoretical models with measurement data (especially heat delivering system)
- Analysis of both the thermal building performance and the heat delivering system in summer (e.g. risk of overheating, risk of stagnation of the collector field)

3. Acknowledgements

This research project 'Solares Plus Haus' is funded by the Austrian 'Klima- und Energiefonds' within the programme ‚Neue Energien 2020' 4th Call.

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LCA of a Net Zero Energy Office Building - The New Technology Park of Bolzano

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Short Summary

We have performed a life cycle assessment of an office building of the planned Technology Park in Bolzano, Italy. The analysis takes into account embodied, operational and transport energy, carbon emissions and other environmental impact factors. Further, we have created two virtual scenarios that show how green choices during building design and operation can potentially reduce total life cycle energy and carbon emissions by 60%. Assessments of this kind are still missing in most design and tendering procedures, and even if they are done, they usually focus only on one single aspect at a time. Such an approach may result in a considerable waste of resources and increase in environmental impact. We have estimated that for Net Zero Energy Buildings embodied energy and transport energy may account for more than 90% of the total life cycle energy. Therefore, we strongly recommend integrating these factors in building design.

Keywords: office building; embodied energy; operational energy; transport energy; green insulation; emissions reduction; sustainable mobility; Net Zero Energy Building

1. Introduction

A comprehensive Life Cycle Assessment (LCA) that includes Embodied Energy (EE), Operational Energy (OE) and Transport Energy (TE) is still rare in procurement, design and tendering procedures for new buildings. A study on residential buildings in line with such an approach has shown that EE and TE together can amount to almost 50% of the total life cycle energy demand in passive houses [1]. Office buildings are a much more complicated system from a construction and technological point of view. In this work we would like to analyse how the impact of different building life stages is transforming in a vision of very low energy demand office buildings.

2. Methodology

We have taken into account OE, EE and TE in order to develop three main scenarios (Table 1) of the expected total life cycle energy (LCE) and emissions of the building. The method is replicable in other designs of office buildings. For all scenarios, we have evaluated the EE of the construction materials with the online tool “SBS Building Sustainability” (SBS) developed at the Fraunhofer Institute for Building Physics. We have computed the OE with a dynamic simulation model developed in TRNSYS. In the OE calculation, the PV field energy production has been subtracted from the thermal and electrical loads for HVAC&R and lighting. Regarding TE, we have compared three transport configurations: the as is case, a case based on expected changes in Bolzano in the

20 years and a case going beyond based on electric vehicles only. We have calculated TE taking into account the total yearly travel distance of all users, their transport modes and the associated direct energy intensities (energies per unit of distance necessary to power the vehicles) [1].

Table 1 Comprehensive scenarios for LCE analysis

Scenario	EE	OE	TE
1	XPS- and EPS-insulated aluminium envelope	PV field on the roof of the Black Monolith only	As it is
2	XPS- and EPS-insulated wooden envelope	PV field on the roofs of the Black Monolith and the adjacent historical industrial building	Urban Mobility Plan for Bolzano (PUM 2020)
3	Hemp fibre-insulated wooden envelope	PV field on the roofs of the Black Monolith and the adjacent historical industrial building	Only electric vehicles

3. Results

In order to be able to compare the impact of OE, EE and TE, we have normalized the energy figures to kWh per year and the CO_2-eq. emissions to kg or tons per year. Figure 1 reports the overall LCE for the three scenarios.

Scenario 1 is the as is situation. The OE amounts to 38.5 kWh/(m^2 year). The PV field on the roof of the Black Monolith is estimated to produce 49.7 kWh/(m^2 year). OE, EE and TE share 43%, 27% and 30% of the total LCE, respectively. 50% of the CO_2-eq. emissions are due to transport ("transport carbon"), 36% are due to building operation and 14% are due to "embodied carbon".
Scenario 2 represents an intermediate solution. OE, EE and TE share 6%, 43% and 51% of the total LCE, respectively. The high shares of TE and EE are due to the use of cars and EPS and XPS as envelope insulation materials. If TE is not considered, EE amounts to 87% and OE to 13% of the total LCE. Although the PE consumption due to transport is different from that in Scenario 1 by less than 1%, the CO_2-eq. emissions are reduced by 38%. Nevertheless, transport is mainly responsible for carbon emissions (72% of the total carbon emissions).
In Scenario 3, EE amounts to 50%, OE to 8% and TE to 42% of the total LCE. The CO_2-eq. emissions are 73% caused by transport ("transport carbon"). "Embodied carbon" amounts to 27% and is lower than 1% during the operational phase.
Scenarios 2 and 3 demonstrate the potential and the importance of mobility plans tailored to the commuters' needs. Transport energy may account for 50% of the total LCE and substituting the current transport network with a network based on electric vehicles (shared cars, buses, trams and trains) supplied by RES, PE savings due to transport of up to 60% could be achieved. We conclude that a comprehensive LCA that takes into account OE, EE, TE, carbon emissions and environmental impact factors such as GWP, AP, ADP, etc. should be part of every integrated design and tendering procedure for highly energy efficient and sustainable new office buildings.

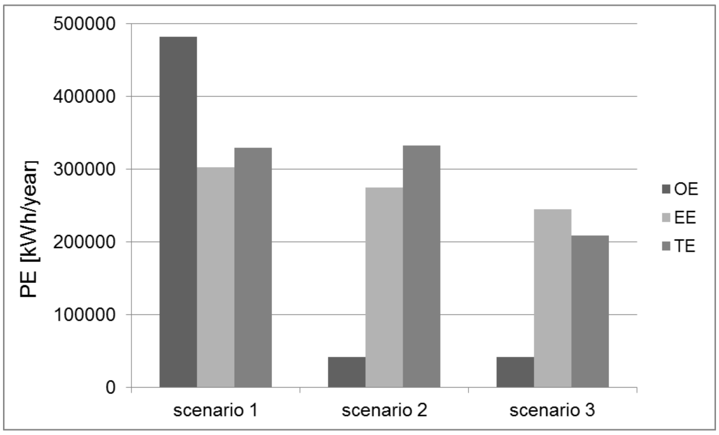

Fig. 1: Shares of OE, EE and TE in LCE for the scenarios listed in Table 1

4. References

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Integration of sustainability targets into the planning process and their effects on project results – case study of the MED CAMPUS Graz

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Extended Abstract

In the year 2004 the Medical University of Graz (Med Uni Graz) was founded as an autonomous university and currently operates from several locations scattered across the city of Graz. The MED CAMPUS will combine the university with the existing university hospital in one unified location[1]. Physical contiguity will do more than solve the difficulties of the current situation; it will enable teaching, research & development and patient care to reach an international level of excellence.

The project area consists of two construction sites where twelve institutes are combined in four centres. These will include teaching facilities, administration offices, a library, a canteen, an assembly hall, and space for start-up companies operating in related fields. The building complex as a modern university, research and communication centre will have space for around 1700 employees and 4300 students.

From the project's inception, the office of the university's rector managed its development as a sustainable and healthy property in the broadest sense, and this resulted in sustainability quality targets being included in the public competition requirements. The project is currently being certified with a DGNB/ÖGNI Certification of Lab Buildings [2].

The present contribution describes the approach chosen by the university as customer and user, and key milestones for implementing sustainability targets in the planning of the campus. The effects of this strategy on the results of the project are presented.

In summary, it can be said that as far as can be judged at present, the very ambitious goals of the Med Uni Graz for the sustainability of the buildings will be reached. The extra effort of the design process is therefore worthwhile from the point of view of the Med Uni Graz.
The future will reveal how far this extra design and organizational effort can be reduced by developing standardized instruments and procedures. However, it does appear that the best solutions will always be highly specific to the location and the planned uses of the buildings. If we consider that diversity often seems to be one of the best survival plans, then this finding can be seen in a positive light.

Acknowledgments

This described work in the paper was carried out in the project MED CAMPUS Graz by Medical University of Graz and Bundesimmobiliengesellschaft m.b.H. with the generalplaner Riegler-Riewe Architects ZT GmbH (architects, commissioned by BIG) and Team TU Graz (Prof. Maydl, commissioned by Med Uni Graz). We would like to thank all partners for their support and their inputs.

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Keywords
Sustainability; DGNB/ÖGNI Certification of lab building; planning process; design consequences;

Plus Energy Building in Estonia

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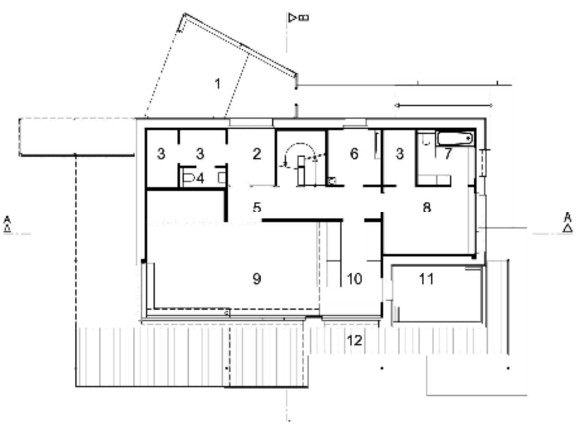
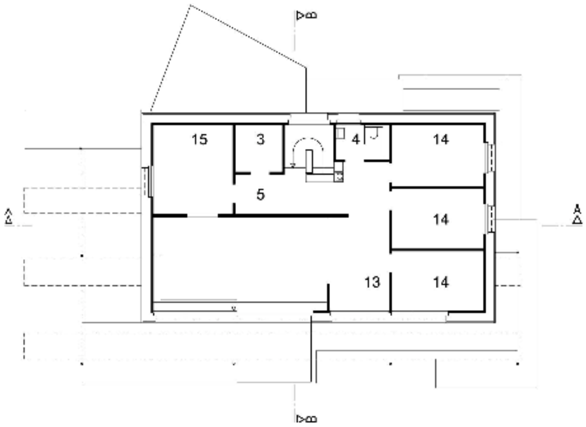
Abstract

The project serves the goal of providing an example of an architectural interesting house which realizes the capacity the passive house concept as well as of extensive passive and active solar techniques. The building should demonstrate that it can produce the same amount of energy than is needed over the year - even in northern countries. A progressive architectural concept was used to create a model single-familiy building: it is based on the passive house idea, using the energy of the ground and of the sun (thermal active, passive and PV). Since the winter sun has to contribute a big part of the heating of the house the south side of it is opened with big windows. This goes back to the fact that just in the south façade windows can give a positive balance over the heating season (and not windows at other orientations). Like a second façade and a second skin a simple construction overlaps the southern façade and the roof. This construction helps to keep the south side of the house at summer in shadow. This second façade carries above the roof 90 m^2 of photovoltaic panels. On the northern side of the roof integrated slanted thermal collectors (12 m^2) give space for a natural summer ventilation system for the house (beside of the summer the ventilation is done with the usual mechanical passive house ventilation system). Those roof collectors are optimized for the summer sun (warm water production). Integrated in the façade thermal collectors are optimized for the winter operation (13 m^2 for heating and warm water). Those vertical collectors gain special profit from the deep inclination of the winter sun and from the permanent snow reflection at this time. Prototype architecture for Estonian conditions demonstrates that even in a cold northern climate it is possible to build energy productive houses. Main attention should be on aspects to reduce heat losses.

The building described in this paper uses the passive house concept for a Nordic country and should serve as a model for passive and plus energy buildings in northern latitudes. The building is housing for a typical Estonian family with 5 members and should demonstrate that a passive house concept combined with active solar technologies can produce same amount energy than is needed over the year - even in northern countries.



1st floor



2nd floor

B5

Database & Tools

Chair: Florian Gschösser
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Towards a new generation of building LCA tools adapted to the building design process and to the user needs?

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Summary

This paper presents general recommendations to move towards a new generation of building LCA tools. They are based on the findings from the recent European project EeBGuide. This project developed a comprehensive guidance document as an online InfoHub for building LCA practitioners and LCA tool developers. The major outcomes are a proposal for adapting the data, calculation rules and methodology according to three different study types: screening, simplified and complete LCA. These study types let the possibility to conduct a LCA study in an early stage of a building by focusing e.g. on default values and adapted calculations rules while more detailed data can be chosen for specific assessment.

Keywords: LCA tools, buildings, products and equipment, water, energy consumption, screening, simplified, complete assessment.

1. Introduction

As new buildings now consume about the same amount of energy during an average 50 year lifespan as it is necessary to build them, new assessment methodologies encompassing the whole life cycle of building are required. Life Cycle Assessment (LCA) studies based on ISO 14040-44, the ILCD Handbook) are being used more and more by leading practitioners as a means of demonstrating the ”whole life” energy efficiency of buildings.
Though previous papers on building LCA research perspectives recommend integrating the existing body of knowledge (i.e. ISO 14040-44, ILCD, recent CEN standards EN 15804 and EN 15978 for building LCA), it is unclear how a tool developer or a practitioner can currently do it due to current inconsistencies and diverging guidance. As a consequence, the European landscape of

LCA calculation rules is not dominated by harmonized methods, these inconsistencies being also found in available building LCA tools.

2. Proposal for an improved framework for building LCA

The proposal consists in a list of important aspects to be taken into account for building LCA under different goal definitions e.g. assessment of a building stock, comparison of design alternatives within a design team, assessment of the environmental performance of a building, comparative assertions etc. The framework and the description of the aspects have been defined by a European LCA expert group including a panel of review experts as well as a public consultation process to get feedbacks from stakeholders on these recommendations. One of the major outcomes of EeBGuide is to propose harmonization of the life cycle stages based on EN 15978, distinction between consequential and attributional LCA, breakdown of the results per contributors. The full list of important general aspects to take into account in building LCA are reported in the online InfoHub for each step of the LCA framework.

3. Proposal for three building LCA study types

In this section, a proposal for three study types is described for three contributors of the environmental impacts of a building: the impact related to building products and equipment, the impact related to the energy consumption and the impact related to the water consumption. Conducting LCA may be very time consuming and is not very often matching the design team needs [22]. As a result, screening and simplified LCA are proposed here to help during the early design or for quick assessment where no detailed modelling is possible due to a lack of information. In opposite complete LCA provides a broader scope with more requirements in terms of cut-off rules or specific data. More precisions on screening and simplified methods are proposed in [25]. A full description of the study types for each contributor is also available in the InfoHub of the EeBGuide project [18].

4. Example of the use of the study types

A LCA analysis was undertaken in the context of the French pilot project HQE performance [26] concerning the assessment of the environmental performance of an individual house. To be in line with the requirements of HQE Performance project, a detailed assessment was chosen for these contributors. In addition, the three study types (i.e. screening, simplified and complete LCA – see Figure 3) were performed for one contributor, i.e. the water consumption. The results show that the study type does not mislead the assessment interpretation, since the same order of magnitude is found for the different indicators. The deviation between the results is not linked to the complexity of the study type. It can be concluded that each study type should be used according to the stakeholders' needs and data availability.

5. Conclusions and perspectives

If the LCA approach is to be applied in ecodesign, research projects, but also in building labelling schemes and EPD schemes, LCA practitioners need on the one hand provision and guidance, and on the other hand should be supported by reliable and easy-to-use building LCA tools. The proposal presented in this paper aimed at integrating the important aspects identified for building LCA in the European EeBGuide project and the proposed study types (screening simplified and complete). Other outcomes include the structuring of the results according to the life cycle stages of EN 15804 and EN 15978 standards for increasing the comparability of European LCA studies, the breakdown the results and the calculation rules per contributor. Finally it is important to move towards a core and consistent set of data, rules and indicators for the new generation of LCA tools to have more comparable building LCA results. In that perspective, it seems relevant to have core rules at the European level and then more detailed guidance e.g. within each European country.

The use of Generic LCIA Databases in the Process of Building Sustainability Assessment – the case of SBTool$^{PT®}$

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Short Summary

The main constrain for the widespread use of LCA in the building sector is the lack of environmental data for most building materials, products and technologies. Based in the work of CEN TC 350 and in the work of iiSBE Portugal in the development of the Portuguese rating system SBTool$^{PT®}$, this paper aims at presenting and discussing the development of a method to simplify LCA for effective use during the design phase and in the processes of building sustainability assessment.

Keywords: Database, LCIA, LCA, Environmental performance, Sustainability

1. Introduction

The two most important barriers for the quantification of the environmental indicators and therefore to the incorporation of LCA in rating systems are [1]: a lack of LCI data for all building products and the inherent subjectivity of LCA. Environmental Product Declarations (EPDs) are a good source of quantified information of LCI environmental impact data. In order to potentiate their use, rating systems should be based in the same LCA categories, as stated in the CEN standard. Nevertheless, at the moment, there are important limitations on this approach, since there is only a small number of companies either having or making publicly the EPD of their products.

This paper proposes a solution to overcome the abovementioned problems that is based in the development and use of databases with the LCIA data of the most used building materials and components. Therefore, based in the work of CEN TC 350 and in the work of iiSBE Portugal (in the development of the Portuguese rating system SBTool$^{PT®}$), this paper will present and discuss the development of an LCIA database with the environmental data for conventional and non-conventional Portuguese building solutions (macro-components). A macro-component is, according to our definition, a component of a building for which a technical specification can be given in relation to a set of essential structural characteristics and that is actually a combination of various materials. This database is continuously updated and covers common building technologies for each building macro-component (floors, external walls, partition walls, roofs, windows and doors), the most used building materials and the impacts of the transportation processes, according to the used type of transportation.

2. LCIA database of SBTool$^{PT®}$

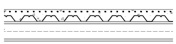
2.1 Environmental impact categories

The developed LCIA database covers the six parameters that describe environmental impacts, according to EN 15804:2012.

2.2 Communication format

Figure 1 presents how the information is organized in the LCIA database for a building macro-component and the list of environmental indicators and LCIA methods used. In the database of the building components the quantification is presented per each component's unit of area (m^2) and in the materials database, figures present the environmental impacts per each unit of mass (kg). Quantification is presented for two life-cycle stages: “cradle to gate” and “demolition/disposal”. Using this database it is possible to estimate the overall impact of a building using a bottom-up up approach. The quantification begins at the level of the embodied environmental impacts in building materials and ends at the whole building scale. To evaluate the transportation impacts, the designer must know (for each building material or product) the distance from the factory to the construction site and the distance from the construction site to the recycling/management centre. By multiplying the distance (km) by the weight (ton) and by the unitary impacts associated to the used type of transportation it is possible to estimate the transportation impacts of the building technology. Adding the transportation impacts to the figures presented in Figure 1 it is possible to estimate the overall life-cycle impacts of a building technology.

At this stage, the developed database covers more than 100 macro-components of buildings (16 floors, 28 external walls, 22 partition walls, 23 roofs and 18 types of windows), 47 construction materials and the potential environmental impacts associated to the use of 12 acclimatization and hot water production equipments [2].

Building technology	**Collaborating slab (with steel structure and lost steel formwork) for floors**								**Ref: Floor 10**
	Life-cycle stages	**Environmental impact categories**						**Embodied energy**	
		ADP[1]	GWP[2]	ODP[3]	AP[4]	POCP[5]	EP[6]	ENR[7]	ER[8]
	**Cradle-to-gate**	3,84E-01	5,79E+01	2,10E-06	1,69E-01	2,32E-02	3,31E-02	7,08E+02	1,55E+01
	End-of-life	1,02E-01	1,48E+01	2,39E-06	7,00E-02	2,70E-03	1,46E-02	2,35E+02	1,37E+00
	Total	4,86E-01	7,27E+01	4,49E-06	2,39E-01	2,59E-02	4,77E-02	9,42E+02	1,69E+01
	Comments:	**Considered materials:** Concrete and steel (including steel panels, profiles and reinforcing steel bars) **LCIA methods:** CML 2 baseline 2000 version 2.04 (to assess the environmental impact categories) and Cumulative Energy Demand version 1.04 (to assess the embodied energy) **LCI libraries:** Ecoinvent system process and ETH-ESU 96 system process							

Notes: [1]Abiotic depletion potential in kg Sb equivalents; [2]Global warming potential in kg CO_2 equivalents; [3]Ozone depletion potential in kg CFC-11 equivalents; [4]Acidification potential in kg SO_2 equivalents; [5]Photochemical ozone creation potential kg C_2H_4 equivalents; [6]Eutrophication potential in kg PO_4 equivalents; [7]Non-renewable embodied energy in MJ equivalents; [8]Renewable embodied energy in MJ equivalents.

Fig. 1: Part of the SBTool$^{PT®}$ LCIA database

3. References

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ADAPTING EXISTING LIFE CYCLE INVENTORY OF BUILDING PRODUCTS FOR THE BRAZILIAN CONTEXT

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Summary

The construction sector is responsible of several environmental impacts among which energy and water consumption, climate change and waste generation. For instance, the primary energy consumption for regulatory uses (heating, air-conditioning, ventilation and hot water) on a 50-year period for a French building is about the same as the embodied energy for its manufacturing and construction processes. In this context, new assessment tools are required to assess the global environmental performances. Thus, there is a growing need to assess the environmental performance of buildings by means of Life Cycle Assessment (LCA). Databases are also needed to make available Life Cycle Inventory data of building materials and processes for each national context. However, in Brazil, few data have been provided so far by the building industry e.g. by means of Environmental Product Declaration (EPD). Two solutions can be distinguished: development a new national LCI database or adaptation of existing LCI databases. If the first option is the most relevant, it requires time and resources, while the second solution is scientifically acceptable and practicable.

The aim of this paper is to present an approach to adapt existing LCI data of building products for the Brazilian context in order to propose a set of consistent and representative LCI datasets. The approach is based on literature researches, analyses of Brazilian and generic LCI data and on the adaptation of European LCI data for the Brazilian context for some key parameters e.g. the energy mixes, the types and distances of transportation. The feasibility of the methodology is then supported by case studies comparing the environmental indicators of concrete, considering the use of Brazilian, original and adapted LCI data.

The approach can be easily applied to other building products. The comparisons show the weaknesses of some Brazilian data e.g. in terms of completeness of the system boundaries. The results for primary energy and global warming potential indicators show that the adapted

LCI data is found to have less impact than the indicators calculated with the original LCI (differences between 5 and 10%). This is mainly explained by the efficiency of the Brazilian energy mix despite the large consumption of the non-renewable energy due to the type and distance of transportation. The adapted LCI must now be improved e.g. by working closely with Brazilian producers to get more accurate data on the foreground processes.

Key-words: performance, environmental requirements, Life Cycle Inventory – LCI, Life Cycle Impacts Assessment – LCIA.

LCC and LCA of dynamic construction in the context of social housing

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Short Summary

Continuously changing household needs and evolving building standards require a frequent upgrade and renovation of our existing residential building stock. A lack of adaptability of buildings, however, often leads to destructive interventions, resulting in financial and environmental impacts. The goal of this paper is to contribute to the search for new design concepts enabling easier and more cost-effective upgrade and renovation of buildings. It should moreover contribute in achieving a lower life cycle environmental impact. A more dynamic design is evaluated in the specific context of a social housing project in Mechelen (Belgium). In this context, building elements with reversible detailing techniques facilitating disassembly and component reuse are compared to more traditional static elements. The benefits and drawbacks are assessed at the building level using a life cycle approach of economic and environmental aspects, i.e. a Life Cycle Costing (LCC) and Life Cycle Assessment (LCA). Different renovation scenarios are simulated focussing on the internal restructuring of the housing units. Two alternatives were investigated: dynamic assemblies of all internal walls versus dynamic assemblies of only those internal walls which are expected to change more frequently. The analysis revealed that the building concept and layout are important for making more dynamic design beneficial or not. Building layouts which provide opportunities for change generally require limited constructive adaptations during the building life span. Application of dynamic assemblies to only those walls which are assumed to be changed in future is then preferred over an application to all internal walls. This could be called a ‘selective’ approach. Such a ‘selective’ approach can result in life cycle environmental benefits while the additional financial costs remain limited.

Keywords: adaptability; building level, life cycle assessment; life cycle costing; renovation.

1. Extended abstract

Continuously changing household needs and evolving building standards require a frequent upgrade and renovation of our existing residential building stock. A lack of adaptability of buildings, however, often leads to destructive interventions, resulting in financial and environmental impacts. To avoid these, a more dynamic design approach can be proposed, using concepts like disassembly, adaptability, transformability and multi-functionality. The basic principle is the integration of time as design parameter in order to enable buildings to deal with changing needs over their building life cycle [1].

The goal of this paper is to apply and evaluate a dynamic design approach in the specific context of the upgrade of the social housing neighbourhood “Mahatma Gandhi” in Mechelen (Belgium). The focus is set on the evaluation of a number of representative renovation scenarios at the building level, considering dynamic alternatives for internal wall systems (i.e. assemblies using reversible detailing techniques, in order to facilitate disassembly and component reuse) [1]. The benefits and drawbacks of these dynamic alternatives are assessed using an integrated life cycle approach combining economic and environmental aspects, i.e. a Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) [3],[4].

The case study focuses on one specific building block and consists of a qualitative and quantitative assessment. In the qualitative assessment the adaptability of the design proposal is evaluated in terms of construction method, characteristics of the building layer and plan layout of the housing units. This analysis revealed that different aspects related to adaptability are integrated in the case study (e.g. flexible plan-layout, space and technical clustering, adaptability for wheel chair users, external circulation). In the quantitative assessment different renovation scenarios are simulated focussing on the internal restructuring of the housing units (i.e. transformation of a two-bedroom apartment to a one-bedroom apartment). For each renovation scenario two alternatives for the traditional (static) wall systems are compared with (a) dynamic assemblies of all internal walls and (b) dynamic assemblies of only those internal walls which are expected to change more frequently. The analytical results revealed that the benefits of the dynamic design of the internal walls compared to static wall systems depend on the renovation scenario (required layout adaptations) and on the considered indicator (for example lower life cycle environmental impact but higher life cycle financial cost).

It can be concluded that the building concept and layout are important to make dynamic design beneficial or not. Due to the flexible plan-layout of the case study, renovation scenarios required only limited interventions and hence a generalized use of dynamic assemblies were found not beneficial, neither from an environmental nor financial perspective. Instead, a more selective application of dynamic assemblies, i.e. to only those walls which are assumed to be changed in future should be preferred. This selective approach can result in life cycle environmental benefits while the additional financial costs remain limited.

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B6

Certification sheems

Chair: Oliver Englhardt
Graz University of Technology, Austria

Guidelines and Indicators for Sustainable Mega-Event-Buildings

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Short Summary

Over the past years organisation committees of mega-events, like Olympic Games or European or World Football Championships, have more and more been demanding for the evaluation of the sustainability performance of their venues. These assessments have been made with different instruments and a comparison of the sustainability is not yet possible at all. Therefore the abstract will show a new common set of sustainability indicators for the whole life-cycle of mega-event venues that integrate ecological, social, and criteria, as well as aspects for sport events.

Keywords: Sustainable mega-event venues, sport facilities, planning instruments, assessment methods

1. Introduction

Mega-event venues are not only sport facilities, they stand for national and regional representation and shall show the competence of technology, engineering and architecture of the Olympic cities or European or World Football Championships countries. In the last years the organisation committees of sport events are demanding for environmental assessments for their temporary and long-lasting buildings (venues, multi-functional halls, exhibition centres etc.) and also tools for legacy and sustainability aspects have been implemented in the planning process of mega-event venues to guarantee ecological, economic and social infrastructures for sport events. Further on slogans, like „*Green Games*“ or „*The Greenest Games in modern times*“ have been shown during the recent Olympic Games, like Beijing 2008, Vancouver 2010 or London 2012. But are these slogans just a “Greenwashing” or will these *„Green Games“* or *„Green Venues“* concepts be reality?

2. Green and Sustainability Assessment Methods for Mega-Event Venues

To implement sustainable concepts in Olympic Games or in Football World and European Championships, the IOC (International Olympic Committee) and also the FIFA/ UEFA (International Football Association Board/ Federal International Football Association/ Union of European Football Associations) have started to demand for sustainability impact assessments for venues since a couple of years. Regarding to this demand different sustainable planning concepts and the use of sustainability assessment methods have been adopted by the host cities and organisation teams. Examples are the venues of the Vancouver 2010 Olympic Winter Games (LEED Canada certification), the London 2012 Olympic Games (BREEAM certification) or for the Stadia for the Football World Cup of Brasilia (LEED U.S. certification). But this process is just at the beginning and the implementation of sustainability aspects into mega-event venues is still on an early stage.

3. Criteria and indicators for the Sustainability Performance of Mega-Event Venues

At the moment a comparison of the sustainability performance of mega-event buildings is not yet possible at all. In most cases just ecological aspects and the use of the buildings during the mega-event were analysed. Social, economic, technical, functional, process and site orientated criteria, as well as the re-use of the buildings after the event have not been addressed so far.

Therefore the abstract shows a new common set of criteria, indicators and benchmarks for the sustainability performance of mega-event architecture. The evaluation method for sustainable mega-event venues has to consider ecological, economic, and socio-cultural points similarly, as well as technical, process and site aspects. Besides the six pillars model, special aspects of mega-events has to be considered as well. An overview is given in the following [1 und 2]:

- Ecological quality: resources, energy, life cycle assessment (LCA), water, waste, materials, land use, recycling, biodiversity etc.
- Socio-cultural and functional quality: comfort, healthiness, user, barrier free accessibility, area efficiency, reuse, security, public accessibility, service comfort, architecture and design, regional and cultural aspects, innovation etc.
- Economical quality: value stability, life cycle costs etc.
- Technical quality: fire protection, durability, cleaning and maintenance, resistance against hail, storm, high water and earthquake, technical building equipment, building shell, ease of deconstruction etc.
- Process quality: planning process, integral planning, tendering, construction site, operation etc.
- Site quality: risks at the site, options for transportation, circumstances at the site, bicycle comfort, image and conditions at the neighbourhood, vicinity of amenities etc.
- Quality of mega-event buildings: reuse and legacy, temporary and existing buildings, sport functional aspects etc.

This set of indicators is based on the results of the dissertation “Sustainability of Olympic Venues” that was published in 2010 [1], and on the outcomes of the research project “Guidelines for Sustainable Venues of Mega-Events” that was supported by the BMWi (Federal Ministry for Economics and Technics) from 2012 to 2013 [2]. The main goal of these projects was to develop a guideline for the assessment of buildings of mega-events in order to be able to compare the sustainability of mega-event buildings over the whole life-cycle (design, event, post-event and end-of-life). During these studies, analyses of the concepts and impact assessments for recent Olympic Games and Football Championships have been done. Also sustainability reports of NGOs, like UNEP, Greenpeace or WWF have been integrated into the analyses, as well as the sustainability guidelines and regulations of the IOC and the FIFA/ UEFA.

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A free building assessment tool facilitates change in the construction sector towards environmental, economic and social sustainability

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Short Summary

The ÖGNB offers a comprehensive sustainability criteria framework for residential and non-residential buildings which should be used from the very beginning of a building project. In 2012, ÖGNB organised a series of workshops for the ÖGNB members to deal with concerns regarding the related costs, on the one hand for the building assessment procedure itself, and on the other hand regarding a potential increase in construction costs as a consequence of building performance requirements. These review workshops resulted in many small adjustments, and in addition, the workshop participants agreed on some major revisions, among others for the criteria *energy, building operation, accessibility without barriers,* and *fire safety*, which represent selected examples described in the full version of this paper. The revision of the building assessment framework contributed to the discussions among the ÖGNB members and initiated discussions in the respective associations and companies. It did not only improve the assessment framework but also contributed to awareness creation regarding the costs of the building assessment itself, the feasibility of the required building performance and the associated construction and life cycle costs, thus revealing the need and the potential for technological innovations.

Keywords:Green building; building assessment; integrated planning; building optimization

1. Introduction

The ÖGNB - Österreichische Gesellschaft für Nachhaltiges Bauen (English: Austrian Sustainable Building Council) builds on the experience gained from the participation of its founding members in the international *Green Building Challenge* starting from 1996. Austria joined 1998 and experts from different fields developed the first Austrian building assessment scheme with the support of three Austrian Federal Ministries. [1] Today, ÖGNB still runs this building assessment scheme in the form of a further developed version and offers also building certification based on this system. Above all, the building assessment scheme is used as a communication and information tool as well as an instrument to facilitate change in the construction sector. In this regard, in 2012 a sequence of criteria-review workshops has been conducted with the members of the ÖGNB, to discuss the assessment criteria, the targets, allocation of scores and required supporting documents in the light of new technical developments, changing framework conditions, lessons learnt from previous building assessments, European research projects and experiences of other building assessment schemes offered in Europe.

This conference contribution presents selected results of the criteria-review workshops and their implication on the assessment scheme, resulting in an adjusted version. Like the previous one, the adjusted version is publicly accessible via the Internet, free of charge and available in English.
It is easy to understand and to operate and van be used in education, for quality control, risk assessment and product innovations, in order to facilitate the change in the construction sector towards environmental, economic, and social sustainability.

2. Background information: ÖGNB building assessment procedure

ÖGNB offers a comprehensive criteria framework for the sustainability assessment of residential and non-residential buildings. It is available in the internet and corresponds with the web-based tool which is applied to collect building related information during the building assessment process to prove whether requirements are met or not. These are the so-called supporting documents which are specified for each criterion to ensure the comparability of assessment results. In short, the ÖGNB building assessment procedure is carried out in five steps:

- Building documentation using online declaration tools; carried out by consultants who are appointed by the ÖGNB
- Handover of submitted project to the ÖGNB and application for building surveying
- Verification of proof by ÖGNB auditors, who are listed by the ÖGNB; if necessary revision of proof by ÖGNB consultants
- Approval of assessment results by ÖGNB after consulting with submitters
- Publication of assessment results in ÖGNB press, above all on ÖGNB website

3. ÖGNB building assessment – review workshops

ÖGNB members recognise ambitious building performance requirements to approach the goal of sustainability in the building sector. However, there are also concerns regarding the related costs, on the one hand for the assessment procedure itself, and on the other hand regarding a potential increase in construction costs as a consequence of building performance requirements. In 2012, ÖGNB organised review workshops to deal with these concerns and to elaborate the basis for revising the assessment criteria, scales and guidelines accordingly.

The main objectives of the review were the following ones:

- To compare assessment criteria and targets with the technical development and the development regarding the regulatory framework, and to agree on necessary adaptations
- To check whether the procedure to produce supporting documents can be simplified
- To analyse the relation between the efforts needed to meet a requirement and the scores allocated to this requirement, and to agree on necessary adaptations

The review workshops resulted in many small adjustments, based on the experience gained during the application of the criteria, scales and guidelines, and the utilisation of the assessment tool.

In addition, the workshop participants agreed on some major revisions such as for the following criteria representing selected examples which are described in the full version of the paper:

- Energy (adapt to change of regulation to save effort for preparing supporting documents)
- Building operation (in view of nearly zero energy buildings and plus-energy buildings: what to consider to ensure low energy consumption during building operation)
- Accessibility without barriers (take into account construction costs of building assessment requirement)
- Fire safety (relation between the efforts needed to meet a requirement and the scores allocated)

4. Conclusion

The revision of the building assessment framework contributed to discussion among the ÖGNB members and initiated discussions in the respective associations and companies. It did not only improve the assessment framework but also contributed to awareness creation regarding the costs of the building assessment itself, the feasibility of the required building performance and the associated construction and life cycle costs, thus revealing the need and the potential for technological innovations.

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SCHOOLS GO GREEN - EXTENSION OF THE BNB-CERTIFICATION METHODOLOGY FOR EDUCATIONAL BUILDINGS

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Short Summary

The development and implementation of a sustainability certification methodology for buildings is considered to be a milestone of establishing principles for sustainable construction. In order to anchor this approach as widely as possible within the construction practice a continual extension of the certification methodology for different types of buildings is necessary. This paper outlines such a process on the basis of the system development and implementation for sustainable educational buildings.

Keywords: Sustainability; certification methodology; educational facilities; new system implementation

Extended Abstract

The construction and real estate industry is regarded as one of the key sectors for a sustainable development. The German Federal Government takes this into account and addresses the sector in its national sustainable development strategy accordingly. For many years the establishment of principles for sustainable construction has been a fundamental part of this strategy, especially concerning public construction projects. Therefore it is necessary to document the ecological, economic and social sustainability performance of buildings transparently and checkable. To realize these requirements the certification methodology *"Nachhaltiges Bauen des Bundes (BNB)"* was developed involving important stakeholders and launched as a basic system appropriate for the typology of office buildings.

But a broad anchoring of the strategic approach requires a certification methodology's extension for different building typologies. And educational buildings are such a highly relevant typology because the corresponding real estate represents a significant part of the entire public buildings portfolio [1]. This further development of the BNB-basic system is challenging because the different forms of use to be mapped vary considerably and the consequential heterogeneity of the user structure leads to an enormous range of requirements and quality respectively sustainability criteria. Although several assessment criteria of the BNB-basic system could be adopted, a large number of criteria had to be adjusted to specific needs of educational buildings. Furthermore additional criteria had to be developed for the aimed system version "*Nachhaltige Unterrichtsgebäude*"[2]. Thereby the assessment methods and levels had to be configured without advantaging or discriminating one special form of use.

For the last few months the first version of a system draft for sustainable educational buildings has been tested intensively by implementing a phase of initial application. As part of a research project in total seven new built educational buildings of different forms of use were selected as pilot projects assessed by using the system draft for sustainable educational buildings. One of the key findings of the initial application is that the system draft is basically suitable for a sustainability assessment of multiple forms of educational buildings. But secondly particular assessment criteria were not adequately specific to map different forms of use or showed selective blurs in assessment levels. Lastly several assessment methods left inacceptable margins for interpretation by their application [3].

This diagnosis including the identified need for action was subsequently transformed into a strategic approach of finalising the system draft towards an operational market version for sustainable educational buildings. The according measures were to increase the specificity of assessment criteria by considering different forms of building usage within the cluster of educational buildings explicitly as well as to enhance their selectivity through a more precise partition of the assessment benchmarks and a new configuration of quantitative assessment methods i.e. by narrative substantiation. Since sustainability certification methodology always has to be adjusted to technical or scientific progress the system version “Nachhaltige Unterrichtsgebäude” will be subject to a continuous process of developing and updating in the future.

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Challenges of LCA in a European context – Findings from the research projects OPEN HOUSE and EeBGuide

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In recent years Life Cycle Assessments (LCA) in the building sector has increasingly gained in importance. They are applied in the certification of sustainable construction (e.g. BREAM, HQE, VERDE, DGNB), provide a base for environmental declaration of building products (EPD) and progressively serve as well for decision support. Nevertheless on an European level LCA still faces some challenges. For future progress in LCA it is important that these are transparently pointed out and discussed within LCA experts. Therefore the major challenges figured in the European research projects OPEN HOUSE [1] and EeBGuide [2] are addressed and set in the overall European context:

- Inconsistency of legislative guidelines and standards

  The different available legislative guidelines (e.g. ILCD handbook) and standards (e.g. ISO14040, ISO14044, EN15804, EN15978) differ from each other regarding Lifecycle Impact Assessment (LCIA) and other LCA related methodological aspects.

- Availability and inconsistency of LCA datasets and EPD [3]

  So far the majority of available datasets are not consistent regarding modelling principles and also the documentation of these datasets are usually not sufficient.

- Inconsistency in LCA approach for labelling schemes
  Another problem is the differing LCA approach in the different labelling schemes. Building labelling schemes use their own individual sets of calculation rules for building LCA, and maybe just refer to EN 15978 but are not compliant with.

- Reference service life
  Besides basic principles mentioned in ISO 15686, data about average service lives and laboratory findings regarding repair, refurbishment and maintenance of construction products are so far very rare.

- Surface calculation methodologies and national EPBD versions
  Another challenge for building LCA on an European level are the different surface calculation methodologies and national EPBD versions. Both are crucial input data for building LCA, but differ by large numbers depending on the country.

All in all LCA in construction already passed a long way and established the life cycle thinking idea in construction industry. But there is a huge need for standardization and harmonization on a European level in order to maximize the output of every LCA study and to be able to rely on these results.

The presentation will focus on these mentioned major challenges. Emphasis will be given to explaining the challenges and approaches of future research projects and standardization work.

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Keywords
LCA, EeBGuide, OPEN HOUSE, challenges of LCA

Practical Aids, Instruments and Tools of the Assessment System for Sustainable Building (BNB)

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Short Summary

In March 2011, the reworked Guideline for Sustainable Building was introduced by the German Federal Ministry of Transport, Building and Urban Development (BMVBS). Thus the Federal Building Authorities were obliged by edict to evaluate Office and Administration Buildings, using the Assessment System for Sustainable Building (BNB).

Every assessment system requires the most diverse basic data and practical instruments to work efficiently. Parallel to the BNB-System several tools and instrument were developed, involving the working groups of the Round Table of Sustainable Building. Furthermore several schemata and tableau are supporting the user in the planning and building process as well as in evaluating the building with the BNB-System.

1. Introduction

According to the national Sustainability Strategy the German Federal Ministry of Transport, Building and Urban Development (BMVBS) the Guideline for Sustainable Building was revised and completed in 1012/13 [1]. The first time this guideline was published in 2001. It was made obligatory for the Federal Building Authorities and operate as a practical aid in the planning phase, the construction, the utilisation including the structural maintenance and the modernisation. In March 2011, a reworked version of the Guideline for Sustainable Building was introduced by the German Federal Ministry of Transport, Building and Urban Development (BMVBS). Thus the Federal Building Authorities were obliged by edict to evaluate Office and Administration Buildings, using the Assessment System for Sustainable Building (BNB). Using the Assessment System is voluntary for other building authorities, such as Federal States, municipalities or the private sector.

The Guideline for Sustainable Building is structured as follows:

- General Part
- Part A Basic Principles of Sustainable Building
- Part B New Buildings
- Part C Recommendations for Sustainable Operation and Maintenance
- Part D Building Stock / Modernisation

The Guideline directly refers to the Assessment System for Sustainable Building (BNB) [2], based on several research project, financed by the BMVBS research initiative “Future Building”. The quality of sustainability, as requested in the Guideline with silver level, is to verify by using the BNB-

System. This system based on a holistic assessment procedure which considers the life cycle of a building and a comprehensive quantification.

2. Practical Aids and Tools

Every assessment system requires the most diverse basic data and practical instruments to work efficiently. Parallel to the BNB-System several tools and instrument were developed, involving the working groups of the Round Table of Sustainable Building. At present three important instruments are available:

- WECOBIS (Web-based Ecological Building Material Information System)
- Ökobau.dat (German building material database)
- Use life of Construction Parts
- Checklists and worksheets.

WECOBIS as a “Web-based ecological building material information system” supports the planning team with qualitative information to sanitary and ecological aspects of building material.

The Ökobau.dat contained generic quantitative information on the ecological quality of building material. The Ökobau.dat is used in the Life cycle assessment (LCA) and other criteria. It based on the Environmental Product Declarations (EPD) with proved manufacturer based information (environmental indicators). They are available for various building products and are undergoing an independent review.

The Table of Use Life gives information about the average useful life of building material and constructions.

Furthermore several schemata and tableau are supporting the user in the planning and building process as well as in evaluating the building with the BNB-System.

In the moment a research project is in progress, in which an EDP-aided assessment and documentary report (eBNB) is to work out. This report has to take into account the requirements of the criteria of the BNB-System, but also important framework conditions of the public building sector, as the “Guideline for the Realisation of Federal Building Measures (RBBau)”.

3. Conclusions

The Guideline for Sustainable Building will be implemented into the practical work of the Federal Building Authorities. The Assessment System BNB enables a transparent, objective and comprehendible evaluation or qualification of the sustainability of buildings. The publication is carried out with the Information Portal Sustainable Building “www.nachhaltigesbauen.de”.

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Keywords: Building; Guideline; Assessment; Tool; Instruments; WECOBIS; Ökobau.dat;

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Building Information Modelling

Chair: Aoife Wiberg
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An integrated BIM-LCA framework for building assessment: Case study in Tianjin, China

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Short Summary

In order to develop a methodology for building ecological and economic assessment and optimization from the early design stage, a framework that facilitates the integration of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) with Building Information Modelling (BIM) is proposed. Buildings are described in the Revit model as assemblies with information of construction, material and cost, whereas in the LCA and LCC model, they are described as elements of different life spans, which are linked to the life cycle inventory (LCI) data of building materials. Energy load is calculated with Energyplus and related to inventory data of Chinese energy products. BIM provides a parametric database including cost, material, and elements related to a visual interface during the whole process. This framework is applied to a retrofit project in Tianjin.

Keywords: BIM, LCA, LCC; building; assessment; China

1. Introduction

The development of building stock accounts for considerable part of energy consumption and environmental impact in the Chinese cities. The design of more performing new buildings, the renovation of existing buildings and the material recycling in the end-of-life phases need new assessment tools. The resulting environmental impacts, energy consumption and life cycle costs must be estimated in a consistent way to avoid partial decisions. A common framework with calculation tools concerning new buildings and refurbishment will be the basis for design and management decisions as well as for advanced sustainability certificates.

This contribution aims to develop an integrated BIM-LCA framework with supporting tools that can be easily applied to the designing and evaluating process of the Chinese buildings. The methodology could enhance the efficiency and accuracy of the assessment. It also helps evaluate and optimize the project from the early design stage.

2. Methodology

The assembly database is the bridge that links BIM to LCA. The assembly category and material schedules derived from BIM can be imported in the integrated LCA model and be linked to LCI data and costs, so that the inventory analysis of building LCA can be largely simplified. Moreover, the information of life cycle impacts and costs of the assemblies can be reimported to the BIM database, which helps the designers to choose building elements with low environmental impacts in the early design stage.

The BIM model can also carry information for operational energy calculation, such as the U values of building elements, window to wall ratio and space information. The results from energy simulation tools are linked to the integrated LCA and LCC model, too.

An integrated LCA and LCC model is built using Chinese data with Excel program, because it conveniently matches to the BIM take-off schedule. In the model, buildings are described as assemblies with the information of construction details and material composition.

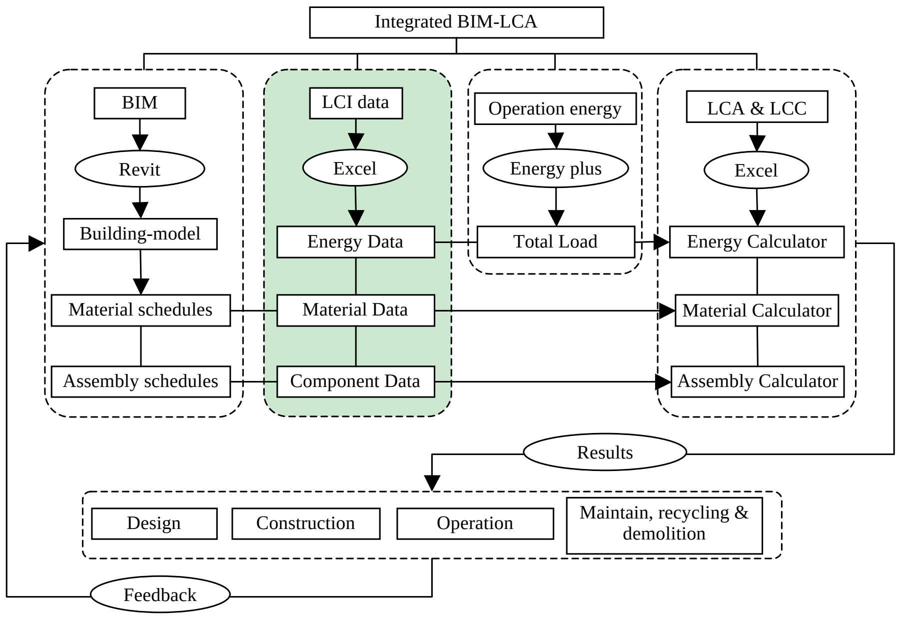

Fig. 1: Framework for integrated BIM-LCA methodology

As the first step of the BIM-LCA model, major assemblies are chosen from the standard drawings and are described as families of different categories (e.g. walls, windows, doors, floors, roofs) in Revit. On this basis, buildings can be described and information for energy calculation and the input data for LCA can be deduced. Design-builder based on Energyplus is used to estimate operational energy demand in order to get more reliable results.

3. Case study in Tianjin, China

Case study of a renovation project, a teaching and office building in Tianjin University is analyzed. The old building was constructed in 1980. It is 4 stories with a gross floor area of 5380 m^2. The renovation aims to improve the energy efficiency and the comfort level of the building.
With the BIM-LCA methods and tools, the primary energy consumption, environmental impacts and costs of the renovated building is analyzed. Different renovation strategies are compared. The results demonstrate that the energy efficient renovation, especially the hybrid solar heating system has a large contribution to improve the environmental performance of the building.

4. Conclusion

The parametric information databases of building assemblies, LCI data for building materials and their costs are the foundation of Integrated BIM-LCA application. The first results from a renovation project shows that the BIM-LCA methodology based on Autodesk Revit, energy simulation tools and excel program for LCA and LCC can support the optimization and evaluation of the project.

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Life Cycle Sustainable Assessment and BIM

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Short Summary

The transition in the sustainability assessment from a qualitative to a quantitative evaluation increases the need to exchange and adapt data related not only to the technical and functional requirements of the building but also to the sustainability oriented requirements throughout the life cycle. Therefore, the integration of sustainable building assessment and benchmarking systems with the different stages of BIM (Building Information Model) is suggested. This paper presents the sustainable indicators developed in the frame of the SuperBuildings project and analyses how they are supported by the latest version of BIM.

Keywords: Sustainable Assessment, Sustainable indicators, BIM, IFC, IFC4, Property Sets

1. Introduction to Sustainable Building Assessment

The assessment of the contribution of individual buildings to sustainable development is a complex task. This has to do both with the specifics of the object of assessment and the complexity of the assessment task. The object of assessment is the building including its plot. In the assessment the entire life cycle of a building is included from the manufacture of building products to the construction of the building on its plot as well as from the stage of operation, management and maintenance to deconstruction and disposal.

Currently, in the sustainability assessment a shift is taking place. There is a transition from a previously predominantly qualitative (e.g., presence of green roofs) to a predominantly quantitative evaluation (e.g., calculation and evaluation of the GWP). For example, the Life Cycle Analysis is applied, which combines the Life Cycle Assessment (LCA) with the Life Cycle Costing (LCC), while this is often supplemented by a user satisfaction analysis, or a complaint management.

The management of data both on the life cycle of buildings (perspective of object of assessment) and in the life cycle of buildings (perspective of a process of the life cycle of the building) becomes essential.

2. The need for harmonised indicators

In the frame of the SuperBuildings project, more than 20 key indicators have been either selected, or improved or developed, and documented through a structured format. They cover the 3 pillars of sustainable development, but not all the related issues. Some are of particular interest and include added-value because they have been newly developed, as land use, cultural heritage, aesthetic quality, long term stability of economic value.

The next step is now to identify if and how the integration of these sustainable indicators with the BIM is feasible.

3. Relevance of a BIM based approach

The Acronym BIM is sometimes turned into “Building Information Model” or “Building Information Modelling”, one representing more the concept and the other the approach. The notion of BIM presents several facets of, among others, the most important ones are:

- It covers the whole life cycle of a building project;
- It is a structured collection of building and construction objects including physical components, spaces, processes, and relationships between these objects. All of these objects may be enriched by shared or specific properties. Quantities or values stored in these properties can be reused as the source of information to perform calculations, analysis or simulations.

The concept of BIM is easy to understand but hard to turn into a tangible reality in a current working environment as there is a strong need for an interoperable exchange format, rich enough to allow ALL users / stakeholders working simultaneously around the same digital model to enrich and retrieve data from the same single model. BuildingSMART International (neutral, international and non for profit organisation coordinating technical and standardisation work around the BIM) is supporting the notion of OPEN BIM and thus promoting the use of a unique exchange language to dialogue with the BIM. This language is the IFC. Among others, one of the main assets of the BIM is to provide a unique repository of data along the whole life cycle of a construction project. In order to facilitate the understanding among the various actors, the exchange model and corresponding language (IFC) is structured and documented to ensure a semantic continuity about the information exchanged and stored at the various phases. It appears that:

- For the Environmental indicators 10 (among the12 studied) have a direct equivalent in IFC, one has an indirect support and one is not supported;
- For the Societal indicators 7 (among the 9 studied) have a direct equivalent in IFC and 2 are not supported;
- For the Economic indicators none (among 2) have a direct equivalent in IFC, one has an indirect support and one is not supported.

4. Conclusion

Among the noticeable outcomes, the indicators developed represent the corner stone of a sustainable assessment process that becomes now more quantitative than qualitative. As environmental issues and sustainability increasingly have become hot topics in the building industry, there is a real need to perform sophisticated simulations and analysis based on detailed initial data and the analyses should be introduced as early as possible to allow for early collaboration between the design and assessment teams. To perform such assessments it necessary to have an easy and quick access to input information such as the construction characteristics (dimensions of the building elements, composition and material used, physical and environmental characteristics, etc...). This is typically where the open BIM approach makes sense. The IFC model has proven its ability to convey necessary information to perform these assessments. This paper has demonstrated also the ability of this language, especially in its latest version to support sustainable assessment results. Even if there are still some gaps most of the indicators developed or selected in the frame of the SuperBuildings project are already supported by the IFC4.

5. Acknowledgement

The results presented in this paper are based upon the work done during the SuperBuildings project (http://cic.vtt.fi/superbuildings/) led by Tarja Hakinen from VTT and supported by the European Commission under the Seventh Framework Programme (FP7).

The sustainability effects of Product/Service-System design validated through Life Cycle Assessment

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Short Summary

Temporary buildings are generally considered to be unsustainable compared to permanent buildings due to the short life span of the materials applied in the building. The construction materials typically have a longer use life than the required use life of the building, which results in functioning building materials going to waste after deconstruction. In an attempt to improve the sustainability of temporary buildings, a Product/Service-System (PSS) strategy is here applied to a case project. The case project concerns a temporary building design by Lendager Arkitekter. This design uses leased materials and building components such as shipping containers, scaffolding materials and lifts. The major research question for the case is how the supplier's continued ownership of the building materials influences the sustainability of such buildings. The validation of the improved sustainability of the PSS-based building solution is achieved by comparing the PSS and an equivalent conventional approach for the building materials through a comparative Life Cycle Assessment (LCA). The results show that the total environmental score of the entire life cycle is 27% lower for the PSS solution than for the conventional solution.

Keywords: Product/Service-Systems; temporary buildings; Life Cycle Assessment; closed loop systems; circular economy; functional economy; life cycle design; waste prevention.

1. Introduction

The case study building is a temporary building based on a Product/Service-System concept of leased construction materials, which keeps the materials in a closed loop. The continued ownership of the materials will ensure that the building materials are re-used at the end-of-life stage. This is expected to reduce impacts related to production, prevent waste and improve the overall environmental sustainability of the temporary building. A life cycle assessment will be carried out to quantitatively assess the sustainability of the Product/Service-System solution.

2. Product/Service-Systems for construction materials

In a Product/Service-System, the supplier sells the right to use the material, rather than the material itself, typically through a lease agreement. After use, the manufacturer will take back the product and re-use or recycle it. As PSS's focus on the value of use rather than the value of ownership, it encourages longer product lives. Product/Service-System may be an important step in the transition from a 'buy-and-throw-away' consumption culture, to a system where the utility of products is optimised, and environmental resources carefully managed.

3. Life Cycle Assessment

3.1 Compared scenarios, functional unit and system boundaries

The Product/Service-System scenario of re-used and re-usable materials is compared to the conventional scenario of applying first-use materials which receive conventional Danish end-of-life treatment. In other words, the LCA compares a model with multiple use cycles of materials with a model with only one use cycle of the materials.

The two scenarios are compared on the basis of the functional unit, which is defined as: "*Providing 790 m^2 office space in Denmark for 8 years (2013-2021) including heating, ventilation and cooling according to Danish energy requirements for 2015.*" The LCA includes the entire life cycle, from raw material supply to end-of-life, including re-use, recovery and recycling potentials.

3.2 Results

The weighted and aggregated results of the life cycle assessment can be seen in Figure 1 below.

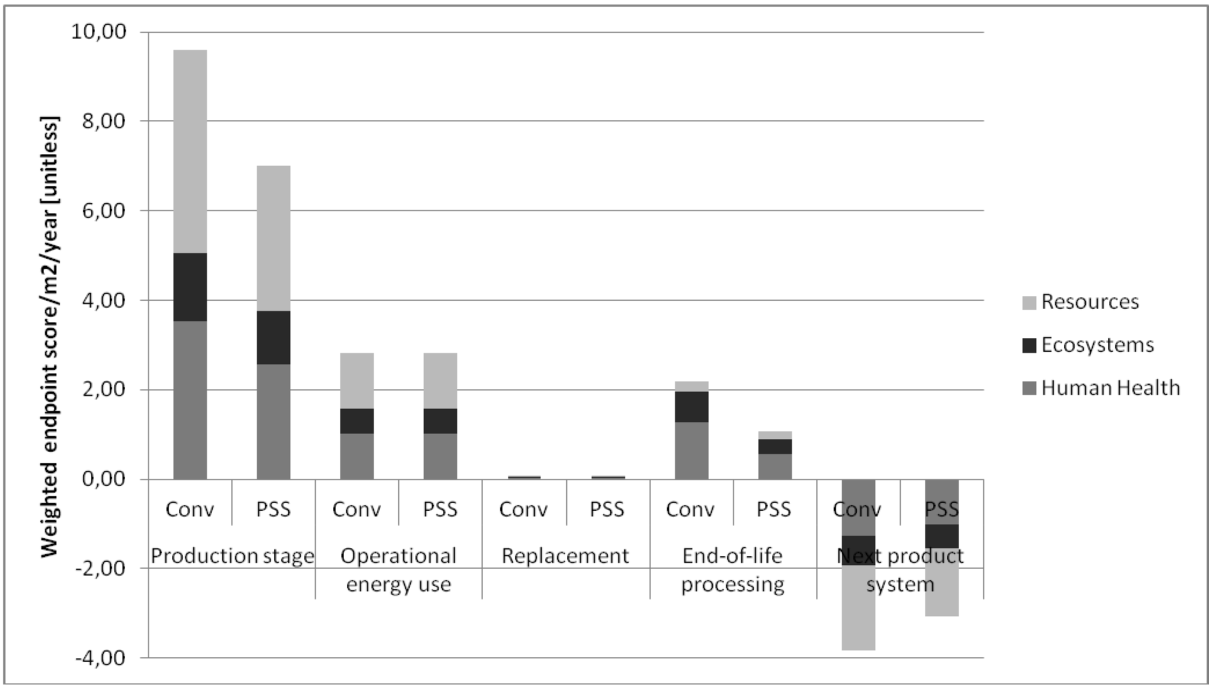

Fig. 1: Weighted endpoint scores for the full life cycle of the conventional solution and PSS

4. Conclusion

The results show that Product/Service-Systems can improve the sustainability of single building components radically, in this case up to 85%. However, since not all necessary building materials can be leased, the leased materials in this case must be supplemented to form a functioning building. Thereby the overall reduction of impacts in the materials stage is 27% in this case study. The environmental impact related to the end-of-life processing is reduced by 52% in the PSS solution, due to avoided energy-heavy recycling of metals. The total life cycle environmental impact of the PSS solution is 27% lower than the conventional solution when including operational energy and 37% lower when the operational energy is excluded. The fact that the operational energy only amounts to 26% of the total impacts of the temporary building due to the short life span underlines the importance of improving the sustainability of materials used in temporary buildings, by e.g. leasing materials through a PSS.

An LCA Study on a Concrete Structure by Variations of Compressive Strength of Concrete to define the characteristics of GHGs emission

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Short Summary

This study aims to define the characteristics of Carbon Dioxide emissions from concrete structures when different compressive strength of concrete applied to structural systems having the same functional unit with different durability. A total of 24Mpa, 40Mpa and 60Mpa cases is analyzed to define the characteristic by Life Cycle Assessment including the stages of production, construction, maintenance and disposal. As results, the amount of cement appears to be a major factor for the emission from the production stage, the amount of concrete from construction and disposal, durability of concrete from use and maintenance. It is recommended to develop optimal mixture designs for sustainable concrete in the consideration of life cycle characteristics of concrete structures to be used.

Keywords: LCA, CO_2 emission, Concrete structure, Compressive strength, Reinforced concrete structural wall system

1. Introduction

This study is intended to evaluate quantitatively potential impacts of a concrete structure throughout its construction, use and disposal from the perspective of global warming. It analyses the characteristics of greenhouse gas emissions for concrete structures as there can be the differences in the amount of inputs and durability by the compressive strength of concrete even in the same structure.

2. Results of the LCA

So far, the life cycle environmental burdens with varying compressive strength of concrete were analyzed from the perspective of carbon emissions. From the assessment results, it was found that in the walls built with a concrete compressive strength of 24MPa, total 6,064.4 m^3 concrete was consumed over 120 years of assessment period and the total amount of carbon emissions was estimated to be 4,749,901 $kgCO_2eq$. In the case of 40MPa, total 2,490 m^3 concrete was consumed and the total emissions was estimated to be 2,194,482 $kgCO_2eq$. In the case of 60MPa, total 2,110.7 m^3 concrete was consumed for 120 years and the emissions estimated 1,767,422 $kgCO_2eq$. Due to the difference of durability by compressive strength, about 54% of carbon reduction over the life cycle of 120 years was shown in the walls with high compressive strength of 40MPa, compared to the walls with general compressive strength of 24MPa, and about 63% carbon reduction appeared in the 60MPa walls.

3. Conclusions and Further Studies

The following procedures and assumptions were applied for analyzing the characteristics of carbon dioxide emissions of concrete structures with varying compressive strength of concrete.

(1) Performance requirements including size, wind load and seismic load were set to maintain the same structural performance in a 25-story apartment housing.
(2) After setting the compressive strength of concrete with three types of 24Mpa, 40Mpa and 60Mpa, and calculating the amount of wall for specific compressive strength required for the same structure performance, the emission factors for each material were applied. At this time, the use period of structures was set to 120 years.

As a result of analyzing the global warming effects of concrete structures for specific compressive strength calculated by the procedures above, the following conclusions were obtained.

(1) At the production stage, the carbon emissions appeared to be higher in the concrete structure with 40MPa, compared to the structures with 24Mpa and 60Mpa, implying that large cement inputs influenced the emissions.
(2) At the construction stage, the carbon emissions appeared to be 1,664 kgCO2eq for the case of concrete walls with a compressive strength of 24MPa, 1,366 kgCO2eq with 40MPa, and 1,158 kgCO2eq with 60MPa. The results indicate the increase in the amount of concrete also increases the carbon emissions.
(3) The concrete structure with 24MPa was assumed to undergo one time reconstruction during the service life of 120 years at the use stage, resulting in increased emissions as in the production stage.
(4) At the disposal stage, the carbon emissions increased with increasing concrete inputs, implying the concrete structure with 24MPa made high environmental impact.
(5) For the carbon dioxide emissions during the life cycle, due to the difference of durability by compressive strength, about 54% of carbon reduction over the life cycle of 120 years was shown in the walls with high compressive strength of 40MPa, compared to the walls with general compressive strength of 24MPa, and about 63% carbon reduction appeared in the 60MPa walls.

4. Acknowledgement

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C2

Smart Cities

Chair: Holger Wallbaum
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Environmental sustainability assessment of urban systems applying coupled urban metabolism and life cycle assessment

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Short summary

The necessity of assessing and addressing the environmental sustainability of urban systems is becoming increasingly relevant due to growing urbanization across the globe, higher consumption in urban systems and related competition for finite resource stocks. In this study we present how fused urban metabolism (UM) and life cycle assessment (LCA) can be applied to assess the absolute environmental sustainability of large urban systems including up- and downstream production activities related to the metabolism of urban systems

Keywords: Urban metabolism, life cycle assessment, UM-LCA, planetary boundaries

1. Introduction

UM has over the last 4 decades served as a credible mean to assess the environmental performance of urban systems. In its purest form, 1st generation UM, this urban analysis model provides the magnitudes of non-standardized material or rather mass flows through the study systems making it difficult to assess the true scope of a city's environmental impacts or provide meaningful comparative analysis of the environmental performance of different cities. Independently over the last 3 decades emergy has been implemented as a 2nd generation UM analysis model by systems ecologists. However, due to its complex thermo dynamical origin, the emergy based UM analysis models are opaque to non-practitioners and are at a disadvantage to communicate results to the public and policy makers alike. In the present study we introduce 3rd generation UM, relying on the coupling of UM and full-scale (i.e. complete indicator set) LCA, the UM-LCA approach.

2. Methods and results

The UM-LCA coupling was tested out on existing UM studies covering 5 major urban areas [1]. The results of this UM-LCA application study clearly underline that the UM-LCA coupling facilitates comparison across cities, mainly due to the ISO standardized LCA framework. Further the study by [1] reveals that the major sustainability burdens of cities are not related to the impacts within the cities but occur up- and downstream of the cities demonstrating that the major impacts are caused by the provision of energy and goods for consumption in the cities and the waste and goods excreted by the cities. Furthermore, as presented in table 1, the representation of urban environmental loading with common indicators (e.g. global warming potential) appeared to improve communication of UM-LCA results over earlier UM methods.
Application of LCA for relation of product system impacts and planetary boundaries as suggested by [2] is still in its infancy [3] but the available data suggests that LCA can serve as a means address the absolute sustainability of product systems and the systems that consume products (e.g. cities). In this presentation we propose an UM-LCA framework to assess the absolute sustainability of urban systems, relating the climate burdens (i.e. greenhouse gas (GHG)

emissions) of the 5 urban systems assessed in [1] to the planetary climate boundaries suggested by [2] as a cursory example.

Table 1: Midpoint impacts for the 5 case cities. PMF = Particular Matter Formation, POF = Photochemical Oxidant Formation and pr. = per resident. Highest value within each midpoint impact is marked in bold

Midpoint Impact	Beijing	Cape Town	Hong Kong	London	Toronto
Agricultural land occupation [m2a/pr.]	1700	1500	2200	**3300**	2700
Contribution to GWP [t CO2-eq/pr.]	17.1	11.2	10.2	12.2	**18.0**
Fossil depletion [t oil eq/pr.]	4.8	2.3	3.1	3.6	**4.9**
Freshwater ecotoxicity [kg 1,4-DB eq/pr.]	**170**	62	31	36	43
Freshwater eutrophication [kg P eq/pr.]	**0.88**	0.33	0.35	0.29	0.51
Human toxicity [t 1,4-DB eq/pr.]	**1.9**	1.0	0.8	0.4	0.6
Marine ecotoxicity [kg 1,4-DB eq/pr.]	134	42	**672**	19	22
Marine eutrophication [kg N-Equiv./pr.]	**26**	13	20	12	18
Metal depletion [t Fe eq/pr.]	**8.2**	0.4	0.7	0.7	0.8
Natural land transformation [m2/pr.]	2.33	1.42	2.83	2.02	**2.86**
Ozone depletion [g CFC-11 eq/pr.]	0.83	0.36	0.42	**2.78**	1.39
PMF [kg PM10 eq/pr.]	**42**	18	18	11	16
POF [kg NMVOC/pr.]	**60**	29	42	25	34
Terrestrial acidification [kg SO2 eq/pr.]	**106**	56	54	34	54
Terrestrial ecotoxicity [kg 1,4-DB eq/pr.]	**5.2**	5.0	5.3	2.3	4.5
Urban land occupation [m2a/pr.]	355	206	349	217	**408**
Water depletion [m3/pr.]	22900	9400	8400	10600	**114900**

Table 2: GHG emissions reductions quantified by the planetary boundary for climate change quantified by [2] applying the fused UM-LCA approach and two sets of political perspective determined CO_2 emission quotas allocation.

	Beijing	Cape Town	Hong Kong	London	Toronto
Contribution to GWP [Mt CO2-eq/year]	291.9	34.0	67.5	90.3	91.3
Emission reduction needed by 2050 - egalitarian allocation of CO2 boudary quotas (%)	86.2	79.0	76.9	80.7	86.9
Emission reduction needed by 2050 - individualist allocation of CO2 boudary quotas (%)	87.0	75.3	-11.5	-4.1	21.9

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Modelling the transformation of heat supply and demand – a case study for the residential building stock of the city of St. Gall

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Short Summary

In Northern European countries, the transformation of prevailing systems to supply and use energy for heating residential buildings is considered a major challenge in urban development. Ongoing renewal and growth in the residential building stock allows increasing energy efficiency by introducing new buildings standards. By additionally encouraging alternative sources for heat supply such as geothermal and solar energy, a significant reduction of greenhouse gas emissions seems feasible. To evaluate options and conditions favourable for such a development, we developed a spatial explicit, dynamic model for the transformation of the residential building stock. This model was used to assess energy demand and greenhouse gas emissions for heating the residential buildings in the City of St. Gall and analyse alternative scenarios for future development. The model incorporates the communal energy plan as well as empirical data of 50 refurbishment projects. Model-based scenario calculations show that the City of St. Gall can reach its goals within the next 50 years. However, the municipality and private property owners have to provide substantial funding and make a great effort in refurbishing their old building stock.

Keywords: Space heating; spatially explicit building stock model; energetic refurbishments

1. Introduction

Many municipalities in Switzerland have set themselves ambitious goals in energy policy aiming at a reduction of individual energy demand to approximately one third of today's demand. The challenge in urban renewal oriented towards such ambitious goals lies in a pragmatic and goal-oriented combination of efficiency and renewable energies. The development and application of empirically based, numerical models can help to encourage this development. To this aim, various models have been developed. Yet, they are not sufficiently adapted to data available in Switzerland and to common planning tools.
In this paper, we introduce a model combing heat demand for residential buildings and the use of stationary heat in a settlement area that is adapted to data available on communal level in Switzerland and common planning tools. The model is applied for the city of St. Gall and used for scenario analysis.

2. Method

We introduce a stock-flow model for cumulative energy demand for non-renewable energies ($CED_{non\text{-}renewable}$) and greenhouse gas emissions (GWP) related to the heat demand of residential buildings.
Our model assesses the development of the building stock – based on assumptions about

refurbishment cycles using a deterministic model approach. Diffusion process for new energy systems are described with an s-curve representing the substitution of prevailing systems to provide heat for residential buildings with systems based on renewable resources. In addition, we calculate the expected costs for refurbishment activities in each period.

3. Case study: city of St. Gall

We choose the city of St. Gall located in eastern Switzerland as case study because it provides an excellent data base. The most important data base is the National Register of Buildings and Dwellings providing an appropriate set of geo-referenced data. Data for heat demand coefficients and refurbishment costs are taken from a survey of the effecs of refurbishment acitvities in the city of St. Gall in 2012. As data for refurbishment cycles, can not be based on emiprical evidence, we decided to use best estimates. In addition, we use the communal energy plan for information about planned transformation of energy supply.

To analyze the future development of demand and supply of heat for operating residential buildings in St. Gall, we define four scenarios. In scenario 1 and 3 we assume that 40% of all heat will be provided in future by a geothermal power plant; in scenario 2 and 4 the existing energy systems are maintained. In scenario 1 and 3 we assume that the entire stock of residential buildings is completely refurbished whereas refurbishment activities are moderate in scenario 2 and 4.

4. Results

The following figure shows the results of scenario calculation for the developments of cumulative energy demand from non-renewable resources and greenhouse gas emissions.

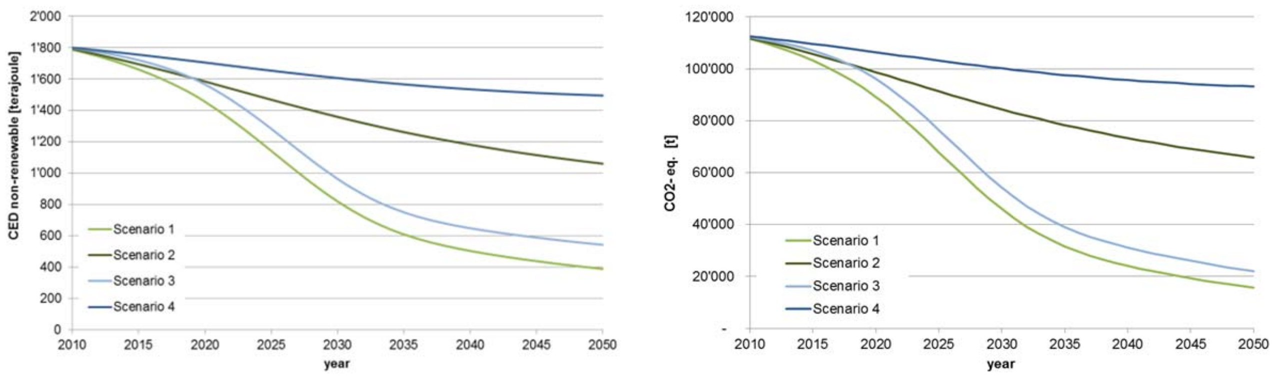

Fig. 1: Left: $CED_{non\text{-}renewable}$ development for all four scenarios; Right: GWP development for all four scenarios (Source: own analyses)

Both variables decline in all four scenarios. A comparison between the results of all scenarios reveals that assumptions on provision of heat for operating residential buildings have significantly higher impact compared to assumptions on refurbishment activities. The introduction of long-distance heating supplied by a geothermal power plant leads to a reduction of 70% $CED_{non\text{-}renewable}$ and 80% GWP even if we assume only moderate gains in energy efficiency due to refurbishment activities. Without changes in heat supply systems only a significantly smaller reduction can be obtained. In addition, introducing of long-distance heating supplied by a geothermal power plant is much less expensive than complete refurbishment of the entire residential building stock. Expected costs for real estate owners could be reduced significantly with a more differentiated approach for increasing energy efficiency in the building stock.

5. Conclusions

The application of the model introduced in this paper, can help planning authorities to monitor the ongoing development and evaluate alternative strategies if necessary. It supports prioritization of measures and adaption of existing concepts in energy policies. By using data from official statistics as well as commonly used planning instruments, it can be easily updated. It provides a consistent data pool of expert knowledge which can be improved continuously within the learning process on sustainable urban renewal.

Norwegian Smart Cities - Towards cross-scale indicators

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1. Abstract

“Cities of the Future” is a collaboration between the Norwegian Government and the 13 largest cities in Norway to reduce greenhouse gas emissions and make the cities better places to live. The new suburb of Trondheim, Brøset, will be carbon neutral. Built from healthy materials and using little energy, Brøset will make an integrated and future-oriented suburb. The work in Brøset will be given full priority in Cities of the Future and should become a model for future urban development.

The results of the Brøset parallel commissioning process showed that through planning and design of traditional technological issues such as building standards, energy supply and motorised transport, it is possible to directly reduce carbon footprint with 3 to 5 ton of CO_{2eq} per capita from 12 to 7-9 tons CO_{2eq} (Norwegian conditions) [1]. This indicates that careful design of buildings and infrastructure alone will not lead to carbon-neutral, resilient neighbourhoods, although such neighbourhoods are an absolute necessity in order to facilitate transition to a more sustainable future. Staying below 550 ppm CO_2 in the atmosphere (IPCCs 2-degree limit) requires far-reaching changes in built environment, energy systems, and people’s lifestyles, and particularly in the interfaces between them.

Design solutions in urban strategic planning, infrastructure and buildings, and the interfaces between them, will have a direct impact on the stationary energy performance of the Brøset neighbourhood, and it is therefore important to create a set of energy indicators able to incorporate these distinct physical scales and their interfaces.

This paper aims to contribute to the successful implementation of the Brøset vision by investigating if and how integrated energy design is dealt with in the parallel commissioning process documents. The analysis indicates a range of important topics – and, eventually, indicators – for setting up a long-term strategy for integrated energy design with clearly defined and measurable goals, ensuring robust and responsible system design that also can be adapted to changes in use, users, and technologies.

In assessment schemes, stationary energy is measured as kwh/m^2 or kg CO_{2eg}/m2, giving points to how much better the proposed building is when compared to current building code. The embodied energy is also rated a similar way, but there is no limit to the “allowed” total energy used or emissions from a project over its lifespan.

At Brøset, a different approach is chosen. First of all, all buildings should comply with the passive house standard or better (15 to 25 kwh/m^2) in terms of in-use energy consumption (or emissions). Second, the total emissions from the development should not exceed by

3tons CO_{2eq}/capita*year. This in return leads to an optimization of material consumption (embodied energy/emissions) and area per capita. Area efficiency is crucial in order to achieve the goals set for Brøset.

Also, on-site energy productions, energy storage, smart integrated grids and the areas albedo is taken into account in the design and development of the area. The idea here is to create excess energy that can be exported back to the grid, or be used for other purposes such as transport etc. Also the change in the albedo from the area will create a net “reduction” of CO_{2eq} from the area.
So where other assessment schemes look at stationary energy consumption, embodied energy and transport systems in relation to each other, but independent of each other, the Brøset projects limits the whole development with a final emission cap. This will in turn force an integrated design and search for synergies and energy design across different scales and disciplines.

The measures proposed by the parallel commissioning teams provide a plethora of robust, diverse and adaptable solutions and methods for integrated energy design at Brøset that can avoid lock-ins, provide adaptability to uncertain challenges, and create an attractive built environment.

The next phase will be the creation of an environmental programme, including development of standardized and clear criteria by which project proposals can be judged in a uniform manner. This environmental programme will provide a basis for monitoring all stages of development of the Brøset project, including design and selection of proposals, construction phase, and long-term management of the area. The parallel commissioning process clearly showed the importance of being able to describe correct and measurable goals, and exposed the lack of science-based, planning-friendly decision-making tools for the early design phases of a neighbourhood project.

Keywords: Smart cities, Sustainable neighbourhoods, urban planning, CO2

Efficiency Optimization of a Real Settlement

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Summary

The topic of "Smart City" gradually becomes more important, especially because of the growing world's population. For buildings, the establishment of an energy certificate is mandatory, with considerations of the building environment, locality, infrastructure provision and other issues that have not been taken into account. In this study, using a real community in Vorarlberg, Austria, various factors were investigated and their impacts were analyzed. The "Energy Certification of Communities" software, co-developed and provided by the Lower Austrian Land Government, Department of Spatial Planning and Regional Policy, was used for the calculations and analyses. The focus of this program is not only on the quality of the location but is more on the utilizations of various areas. Essentially, concerns of this development were mainly costs in Euro per living unit and year; it means the more built in an area the less the cost. The last part concerns the effects of developments on the CO_2 emission, which is affected by traffic emission. First, the present situation was calculated, including the following factors: Indicators, Partial areas, Development, Quality of open spaces, Connectivity and transportation and Locations and buildings. Considering these factors, different variants could be worked out. Initially, the existing green spaces would be partially removed to reduce the developmental costs. Another factor is to build a central school or shopping center. In this case, the individual transportation routes would be shorter and the CO_2 emissions would decrease. Other variants were also investigated and evaluated. Results show that we can achieve a lot, but more than two efficiency levels cannot be reached. An energy-efficient use of resources can be achieved in all cases.

Keywords: Smart city; Development costs; Building environment; Locality; Infrastructure provision

1. Energy pass of the actual state

The study area is located in Austria, Vorarlberg province, as one of the largest cities in the state. For this study, all of Dornbirn is too large of an area so the survey was narrowed down to only one part of the city. This part is located in the west of Dornbirn and is bounded by Josef Ganahl Straße, Lustenauer Straße, by the Dornbirner Ach and the railroad tracks. The region has a total area of 828,630.18 m² and an auxiliary of housing construction of 100,000 m². After defining the area, we divide it into subareas. Here, it is important that the topography and the alignment characters of the majority of the buildings are the same. Hence there were 25 arrangements.
In this housing estate, the rating of the energy efficiency class regarding to development is "G", which is the lowest level in the rating system. The next section includes an exact description of each of the subareas and how far they are apart from various reference points. Then, it calculates a sum of CO2 emission of traffic/LU/year of 0.26 t/LU/year, which is a satisfying rating of "D" level. The last section which weighs 0.35 in the overall calculation, is the quality of location and development. As the definition already tells us, the topographic location of every single subarea provides an influence. The type of building is also important, dividing into 4 different varieties: single family house attached or detached, row house and apartment complex. The last part for the overall evaluation is the alignment of the subareas. In our housing estate this section is rated "B" and therefore

the best rating in the weighting of classification. With those 3 calculated points of evaluation we have a total classification of the actual state in class “E”.

2. Research of alternatives

After the evaluation of the energy pass in the actual state, we attempted to increase the energy usage efficiency. In this process, it was important to avoid a big alteration of the area; a total resituating of houses or a modification already existed in the street courses.

2.1 Alternative 1

It was found that the development costs per year are the largest in weight. Considering the energy pass of this housing estate, the factor has a relatively bad rating. To change this, the interior and exterior developments should be reviewed and edited or more building land has to be added.
The first point includes length of pipelines, traffic development, water and electricity supply, street lighting and length of gas pipelines. The problem is that the alteration of the area is not desirable. This means that in order to change those developments, the lengths have to be shortened. But, that is possible only if the whole streets are altered or houses are relocated.
The investigated area has a total of 100,000 m² of auxiliary housing constructions, so this section will be extended. Two new subareas, one with 17,886.89 m² and 16 living units and the other with 27,969.23 m² and 28 living units are added. Consequently, there is still a green area and an ideal expansion of the housing estate that causes almost no modification in the cityscape and the small increase of living units has no influence on the improvement of the energy level of the development. Our chosen area has approximately 539 living units, with the expansion the number increases to 583. But, as there is a constant growth of population, the area is calculated with a triple expansion. This decreases the development costs per living unit from 88,376 to 25,000 euro per year and the energy efficiency increases by three levels. The remaining calculations did not reveal any increase so the end classification for a) is class “D”, factor b) is also at level “D” and the last factor c) reaches the level “B”. As a result of the increase the number of living units, a better classification arises and is now at level “C”, which is an acceptable result.

2.2 Alternative 2

Another alternative to improve the energy usage efficiency is to change the CO_2 emission and the quality of location and development. The latter is quite difficult to readapt, because it would be difficult to relocate the estate from a flat topography into a mountain range. For building the future estates, those factors should be taken into consideration in advance because it might be impossible or really difficult and costly to change it afterwards. That means, for the second alternative, the CO_2 emission is going to be influenced to get to a higher level of classification. Currently, the rating is at the level of “D”.
In this housing estate almost every subarea is at least 1500 m away from the town center, thus a reduction of 500 m is assumed. This could be realized through assuming that the existing peripheral area with the same development is close to the city area. Using this method, an improvement of every subarea of 1 to 2 levels can be induced. The other factor of improvement is the distance to the closest local amenity. The investigated area is part of a larger city and the local amenities are usually 1500 m away. Another increase of the outcome could be achieved through making sure they are only 1000 m apart. With those two improvements in the performance can be improved from level “D” to “B”. So, with a certain consideration of the structure of a housing estate, a significantly good usage can be gained. The remaining calculations did not bring any increase, so the end classification can be calculated with the respective weighting.
Development costs per LU/year: level “G”; CO_2 emission of traffic per LU/year: level “B”; Quality of location and development: level “B”. With the improvement of CO_2 emission of traffic the area increases to level “D” which means that there is a satisfying energy efficient usage of resources.

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SMART ENERGY DEMOnstration: First research results of an Austrian SMART CITY

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Short Summary

The small city of Hartberg wants to demonstrate a smart city within the Austrian promotion program "smart energy Demo". By establishing a zero emission district at downtown of Hartberg with outstanding showcases of "green" technologies Hartberg turns the conditions of a small city into advantages to support an expansion to the surrounding. Based on a comprehensive bottom-up approach and a scientific / technical monitoring a balanced bundle of demonstrations are being implemented, that are linked to each other interdisciplinary (smart… buildings, municipal disposal, energy, communication, mobility, business-models). „SMART CITY Hartberg" has already overcome several challenges to establish a small city of the future. Thus small cities show a significant potential for realizing a climate-protecting and sustainable environment.

Keywords: Smart city; demonstration; zero emission district; sustainability; energy.

1. Introduction

The small city of Hartberg (inhabitants: 11,000; area: 10 km²) faces the challenges as one of 6 Austrian SMART CITIES within the promotion program "smart energy Demo – fit for set". [1] In opposition to Hartberg major cities have significantly different framework conditions to demonstrate a smart city (modal split; energy politics & supply; more demonstration measures can be carried out in parallel with fewer complexity; more topics can be addressed at once; available resources are limited). Thus other actions are necessary to encourage demonstrations and investments. A demonstration of a zero emission district at downtown of Hartberg should be realised within the project by outstanding showcases of "green" technologies. Thus Hartberg turns the conditions of a small city into advantages to support an expansion to the surrounding.

2. Approach to establish a SMART CITY on small-town scale

(1) Technical feasibility study (incl. roadmaps and action plans) according to Hartberg's vision have been established on a comprehensive bottom-up- & interdisciplinary approach with focus on all smart city topics (interdivisional: energy, building, mobility, communication, society); (2) Implementation of more than 10 smart city relevant and connected demonstrations (incl. business models), that are very suitable / reproducible for small / comparable cities by addressing an integrated, balanced and adjusted bundle of realizable measurements (no single solutions); (3) Steady monitoring, evaluation and improving measures (incl. repeating loop, steady optimization measures and heterogeneous & integrated stakeholder-process); (4) Accompanying research activities (technical, social and economic orientated); (5) Comprehensive communication / dissemination of the reproducible results / findings and preparation of post-project activities; This project is financed by the AUSTRIAN CLIMATE AND ENERGY FUND and carried out within the programme „SMART ENERGY DEMO – fit4set".

3. First Results of the SMART ENERGY DEMOnstration

The earlier project development stage (establishment of the feasibility study) was much more timeconsuming as proposed, because the comprehensive bottom-up approach involved more than 200 meetings. This has been resulting in a very high motivation of the stakeholders. [2] The close contact to the citizens and stakeholders in all project stages supports an ideal living lab approach (“user in the loop” & e-participation), whereas a balanced bundle of demonstrations could have been worked out for the demonstration stage. Hartberg does not follow the implementation of single, but linked solutions. Hence compared to major cities several more topics and integrated demonstrations could have been addressed:

- Smart Buildings / Smart Municipal Disposal: (A) Establishment of an ideal new smart building complex for commercial & residential issues in a historical downtown area: highest efficiency, PV-integration (landmarked area), electricity storage, energy management, (re)utilisation of gray & rain water, e-mobility-infrastructure, city information system & carpooling. (B) Renovation of the landmarked town-hall of Hartberg: Building automation, e-mobility-infrastructure to an ideal historical smart city building.
- Smart Energy(grids) - Establishment of a smart biomass-based district heating network in the project core zone: (A) Load management / optimization / shifting to avoid grid enforcements. (B) Providing of a smart monitoring for consumers. (C) Optimization of consumption at the consumers (based on the monitoring data).
- Smart Communication and Information: Several information outdoor & indoor-terminals in the project core zone: Touch-screen-function, real-time-information (e. g. traffic & city news), integrated feedback-possibility, free WLAN, additional public utilization via internet & mobile phones, routing and communication, traffic guide to provide real-time information (e. g. congestions or news).
- Smart Mobility: (A) Establishment of car sharing: At the new basement garage of project “Alleegasse”. (B) Providing of an e-mobility infrastructure for bikes, scooters and cars: At the new basement garage and at the main square. (C) Establishment of 3 Shared Spaces: Main-square, Alleegasse & pedestrian zone-end. (D) Real-time-traffic information & optimization of carless transport chain from/to Hartberg. (F) Demonstration of an ideal emobility- package for single-buildings (typical characteristic of small towns): e-mobilitygarage with PV-roof, charging unit, electricity storage, energy management tool.
- Smart business-models for consumption & supply as well as a package for carpooling together with flat-sale.

4. Conclusions

For several investments the city of Hartberg acts as pre-commercial procurer. By these public preinvestments several private investors could have been encouraged to spend their money in smart city relevant projects. Thus a strong (financial) commitment of the city government enables leverage effects for private investments even in smaller cities (despite fewer economic growth potential than in bigger cities). Small cities show a significant potential for realizing a climate-protecting / sustainable environment. The activation needs to overcome several challenges that are different to major cities. „SMART CITY Hartberg“ has already overcome these challenges to establish a small city of the future.

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This project is financed by the AUSTRIAN CLIMATE AND ENERGY FUND and carried out within the programme „SMART ENERGY DEMO – fit4set“.

C3

Smart Cities

Chair: Annette Aumann
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KomMod as a tool to support municipalities on their way to becoming Smart Energy Cities

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Short Summary

For the upcoming transition of the energy system towards higher shares of renewable energies, the municipalities should be provided with a sound basis of information, scientifically supporting their decisions and aiming at overall optimal solutions. KomMod as a holistic high-resolution municipal energy system model offers such an analysis and the resulting strategic recommendations for a detailed and cost-effective future energy system of a municipality.

Keywords: Smart Energy Cities; KomMod; energy system model; municipality; mathematical optimisation

1. Introduction

As urbanisation is predicted to continue, the term “Smart City” has to have a special focus on energy, if humanity wants to tackle climate change [1]. The transformation process of municipal energy systems typically follows a pathway of three steps, the first two being analysis and feasibility studies [2, 3]. KomMod addresses the last and most detailed one, a refined specification of the municipal climate goals, together with a roadmap of concrete measures to be taken to reach this target energy system. For this third step, an in-depth analysis of the municipal energy system is needed. The energy system model KomMod delivers such an analysis and the resulting strategic recommendation for a detailed and cost-effective future energy system of a municipality, thus helping to pave the way for future “Smart Cities”.

2. The municipal energy system model KomMod

The development of KomMod is structured into three main tasks: analysis of the requirements, comparison of the requirements with existing models, and creation of an energy system model.

2.1 Identified requirements

The future development of a municipal energy system is influenced by many parties forming a municipal community. KomMod in the first place aims to address the needs of and find optimal solutions for this community as a whole.
As future energy systems will contain a high share of fluctuating renewable energies, an in depth-analysis has to be done in a high temporal and spatial resolution to make sure the energy supply is

guaranteed at all times and at all places.
A major aspect to be considered are interdependencies, reaching from cross-sectoral interdependencies between all four demand sectors (electricity, heat/cold, natural gas, and (local) transport) over intra-sectoral dependencies between different technologies to dependencies occurring between structure (design) and operation of the components of an energy system as well as dependencies between technical and economical aspects.

2.2 Holistic approach

KomMod is meant to serve as a tool for structural analysis and optimisation enabling strategic decisions from a holistic municipal community perspective. It is built with a homogeneous modelling approach, implementing all components with the same modelling environment and including the optimisation of system design and operation into one simultaneously solved equation system. As a modelling environment, AMPL is used in combination with the mathematical solvers Gurobi and Conopt [4, 5].
Due to the strategic objective, the model is provided with perfect foresight, enabling the model to dynamically optimise over the whole time horizon simultaneously. Dynamic here means that the requirements of future time steps are already taken into account for decisions regarding the current time step. Every time step is seen as a point of steady-state operation.
The component models include part-load efficiencies, load acceptance rates, minimal charging levels (reducing the net capacity of a storage) and self-discharge of storages for example. Technologies are grouped into components of similar physical behaviour which can be described with identical equations. The differences between the elements of a technology are expressed by a change in the parameter sets.
The temporal resolution is set to an averaging period of one hour, intended to be reduced to 15 minutes, which enables KomMod to provide answers to questions with respect to the amount and operation of short term storage. Spatially the model is divided into zones, sub-zones, and building types, each level being adjustable to the specific needs of the respective municipality.
KomMod delivers recommendations for the capacity and number of facilities to be installed, as well as the relevant time series for these operations and cost data, thus providing strategic recommendations for municipal stakeholders.

2.3 First results, discussion and conclusions

As a main outcome, the assumption could be validated that for a sound target energy system, and even more for the roadmap to get there, municipalities are in need of a detailed and high-resolution energy system model, tailored to their specific needs.
Furthermore it could be shown that the identified requirements have a notable impact on the optimisation results and that the course chosen to develop KomMod is plausible and in line with these requirements. The next steps will be to implement a spatial resolution, building types and district heating networks, followed by the integration of the transport sector and, of course, to validate KomMod and the first findings also with consistent real data.

3. Acknowledgements

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Project –"Morgenstadt: City Insights" - Analysis of Interactions Between Key Factors

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Extended Abstract

Keywords: Morgenstadt; CityInsights; sustainability; interactions; systemic interconnection; energy; buildings; government.

1. Introduction

The project „Morgenstadt: City Insights" is dealing with the complex interfaces of city developments. Its research activities on the most important sectors for the cities of the future – mobility, energy, communications, security, buildings, resources and governance – will lay the foundation for creating smart and sustainable system interconnection for urban structures. Different competences of the Fraunhofer Gesellschaft will join forces and combine technology management for essential technology- and organization-based urban systems with practical knowhow of industrial, political and cities partners. Now their expertise will be combined and focused in the collaborative, transdisciplinary research team. The goal of the project is to synchronize emerging urban demands and global best-practice approaches in a strategic research project and to thereby develop the basis for innovation of new strategies, products and urban solutions.

2. Research subject – Morgenstadt: City Insights

The research focus of the "Morgenstadt: City Insights" is to create a knowledge foundation about the urban environment and the interconnection of its key factors. Cities nowadays face various challenges that cannot be solved from only one key factor or separately in each key factor. Therefore, interactions between the key elements have to be analysed.

The key factors that are represented in the Morgenstadt: City Insight research - mobility, energy, communications, security, buildings, resources and governance - have been chosen because of their large impact on city developments and their participation in current challenges. So that growing Cities need to provide standards for new buildings, concepts for retrofitting, strategies for the arrangement and especially approaches for energy efficiency of future cities. In addition to the impact of buildings on energy challenges, recent years also introduced many challenges for the security of buildings, such as being resistant to floods. Through the example of Hurricane Sandy in New York City, which is one of the represented Cities in Morgenstadt: City Insights, it is demonstrated, that those fields interact with the security fields of urban environments. Security is a cross-sectorial component influencing every other field, especially in those cities at risk (i.e. natural disasters in New York City). There is security in traffic and transportation, security of buildings, security of energy resources, such as nuclear power plants and very recently the security of personal data is and ever-growing issue. How can we create easy access and interaction with information all around the city without risking data leakage or attacks in the network? Communication is gaining more and more importance in our everyday life and now we have the chance to use it to create better systems for our city of the future. At reviewing this event and its consequences for the whole city of New York you can see how many key factors interact and how their connections have to be integrated into solutions in order to overcome the challenges of the future.

Insight into all those key factors and their interaction will be created by analysis of six global cities with good reputations about their development and their ideas for the city of the future. New York, Berlin, Freiburg, Singapore, Tokyo and Copenhagen are the chosen cities. All of them are already working at developing their cities and preparing them for future challenges. For each city a defined number of known best practices will be investigated. Used legislative standards and technical concepts, financial programs and roadmaps, political incentives and laws will be examined to get an objective overview of state of the art and ambitious solutions.

3. Conclusion and Outlook

The Climate change, resource depletion, population growth, increasing consumption, individual mobility and climate resilience are dangers and questions that are all directing our attention to the development of our cities. They will be the anchor of our future living quality, economical markets and network structures. Considering such a large impact, the conception redefinition of urban environments has to be a key research field.

The enormous challenges that our future cities have to face can only be solved by creating an intuitive but deep insight into the systemic interaction of key factors inside a city. As shown in the example of New York City no solution can focus on only one key element if it is to be successful. New York City´s “superstorm” Sandy and its consequences show how climate change face cities with new challenges. The natural catastrophe also shows how many different key factors need to be combined to create innovative solutions against this problem. To use only governmental opportunity, would cause the endangered regions to be evacuated and resettled. On the other hand, you cannot handle without government, often as a key driver. Especially in the example of Sandy security shows its cross-sectorial character. The uppermost objective of the governance is the security of their people from any damage on their lives, their finances of their comfort. Therefor buildings, infrastructure, energy and water supply, communication privacy and limited resources are all used in respect to the wellbeing and safety of the people using them. Now NYC is developing a long-term plan to cope with extreme weather events that will get the lights back on quickly, keep the gas stations open, guarantee a working transportation system etc. It will become apparent in the future, if those measures had a holistic approach and could solve the future challenges.

Many urban environments have already developed various solutions to increase energy efficiency, reduce carbon emissions, create strong governmental participation and at the same time provide rich and healthy living for their population. Those concepts are important, but require the next step into necessary changes of urban systems. New relations between information, people, products and resources form the centre of an innovative loop over the next few decades and into sustainable urban cities. This will only happen if representatives from different business sectors, research institutes and governance officials join together for recreating urban systems.

The “Morgenstadt: City Insights” takes this first step into exploration and refinement of our future.

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Towards Sustainable Knowledge Ecosystem with Open Data, Co-creation and User Empowerment, Extended Abstract

Urban ecological space, encompasses the total natural capital and flows on which a city depends to meet the long-term needs of its inhabitant. In order to involve inhabitants to co-creation of sustainable ecosystem on can facilitate the development of the knowledge ecosystem, which by definition is organic configuration of dynamic virtual and physical places where one shares a context with others to create meanings. The explicit information is transformed to internatilized knowledge in knowledge creation processes. The purpose of this paper is to understand how the creation of meanings and knowledge can be supported and what kind of services city can develop for the users to support their environmental friendly decision making processes and behaviour.

Keywords
Urban ecosystems; open information, knowledge; user involvement; co-creation.

1. Method and sample

Two practical case studies are described by using document analysis, observations and focus group case demonstrations and interviews. The studies demonstrate how public sector through open collaboration can provide the knowledge and power needed for sustainable user decisions.

One case study is representing the virtual interface for sustainable open and dynamic energy system design, where traditionally separated information is gathered to one database as part of the strategic climate and environment actions of the City of Espoo. Purpose of opening energy related data is to promote innovation in the area of sustainable energy system development.

The other one is a physical place, Urban Mill, for knowledge creation, which aims to provide a common platform for different stakeholders of local ecosystem. The co-working place offers a platform for city officials and researchers to co-create sustainable innovations.

By filtering the gathered data through six dimensions one were able to identify the common themes in content but also visualise the weight of the comments by visualizing the analysis in Figure 1. The gathered data were analysed as single data and as combined data clusters of the user experiences. The six dimensions and the qualities for and scales of the six dimensions were:

Dimension	Scale and Qualities
a) atmosphere	1 weak – 6 strong
b) density and frequency of time	1 stable – 6 changing
c) functionality	1 single use – 6 multi-use
d) familiarity	1 difficult – 6 easy

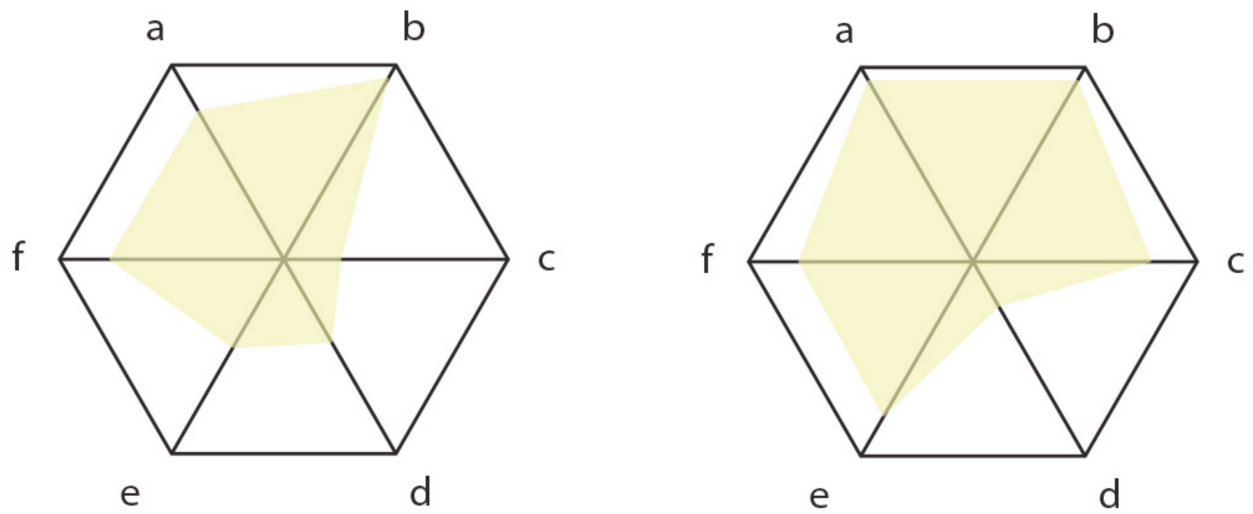

Figure 1. Visual analyses of user case qualities

2. Results

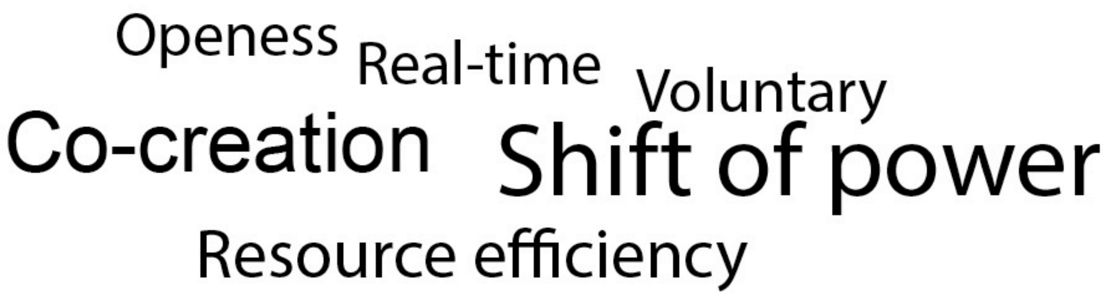

Figure 2. Critical Ba characteristics

The results indicate that in order to support sustainable behaviour the user centric approach is not only about designing sustainable solution. The more significant factor is to provide processes, which empower the users to make their own decisions and to change their mind over time based on user knowledge, this enables the implementation of user knowledge lost today and creates an open innovation sprawl. The comprehensive and shared knowledge is one of the most important elements of these processes. The empowering processes are the small initiatives towards sustainability strategies. As a result this paper suggests that we need to define the user and human centred dimensions and the means to create them in order to at an European level be able to create a digital innovation infrastructure and a human friendly, sustainable and empowering single innovation market.

Intensity and Spatial Influence of Urban Parks:
A case study in Sao Paulo, Brazil

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Summary

The main purpose of this ongoing research is to assess the cooling effects of vegetation in urban microclimate. Considering the influence of Leaf Area Index – LAI, this study will quantify the intensity and spatial distribution of the microclimate effects in border regions for urban parks, such as Trianon Park, located at Paulista Avenue in downtown São Paulo/ Brazil. Considering Trianon park as a large mass of vegetation with few sparse areas, an average leaf area index for the entire park was estimated based on two indirect gap-fraction method, the LAI-2000 plant canopy analyser (LI-COR) and a camera system with eyefish lens (Nikon Coolpix 4500). The hemispheric photographs were analysed using can-eye software. Microclimatic meteorological data was obtained in two areas of the park during four consecutive days of measurements, beginning on 28th October 2012. This database was important to adjust the ENVI-met model to local conditions before starting the parametric studies. Parametric simulations on ENVI-met were developed to investigate the effect of the park on its surroundings, indicating the influence of LAI measured previously. Results indicated that, concerning the intensity of the effect, the average difference between air temperatures inside the green areas (LAI=2.5) and the surrounding streets is about 2ºC at 2 p.m. and the extension of the effect can reach 10 m from the park.

Keywords: urban vegetation, urban microclimate, leaf area index, ENVI-met.

1. Introduction and Methodology

LAI is a dimensionless variable and is defined as one-half the total green leaf area per unit of ground surface area [1] drives the within and the below canopy microclimate, determines canopy water interception, radiation extinction, and water and carbon gas exchange. LAI is a key parameter in models describing the exchange of fluxes of energy, mass (e.g. water and CO_2), and momentum between the surface and the planetary boundary layer [2].

This study is part of an ongoing research about the impact of vegetation on urban microclimates, using predective models such as ENVI-met. This computational model considers the density of leaves to simulate the micro scale interations of surface-vegetation- atmosphere.

There are two main forms to obtain the LAI values: the direct and the indirect methods. The first one can be accessed directly by using harvesting methods such as destructive sampling or by non-harvesting litter traps during autumn leaf fall period in deciduous forests [3].

The indirect methods consist in measurements of light transmission through the tree canopy. It can be calculated by Beer-Lambert law, which defines the empiric relation between radiation intercepted by the canopy and the total incident solar radiation. For this study, two methods were applied based on gap fraction distribution: using the instrument LAI-2000 Plant Canopy Analyzer (LI-COR) and the technique via hemispherical canopy photography [19], between August and September of 2012.

Comparing the final results from both LAI measuring systems, it can be seen that the average LAI values had few differences, varying between 2.14 (hemispheric photographs) and 2.52 (LAI-2000), calculate from 22 defined points at Trianon Park in Sao Paulo.

2. ENVI-met Simulations

The micro scale model ENVI-met [4] was chosen for this study due to its advanced approach on plant-atmosphere interactions in cities. The numerical model simulates aerodynamics, thermodynamics and the radiation balance in complex urban structures with resolutions between 0.5m and 10m according to the position of the sun, urban geometry, vegetation, soil and various construction materials by solving thermodynamic and plant physiological equations.

Based on LAI measurements results, the ENVI-met simulations consider a medium canopy with LAI value of 2,5. The tree is 20m high and its leaf density started 4m above the ground to avoid obstruction for wind flux at the pedestrians' level. The parametric tree model had ellipsoid leaf area distributions with maximum LAD located in the middle height of the crown.

3. Analysis of Results

From the results of simulations, the receptor located in green areas of the park showed a reduction up to 2.0ºC compared to air temperature in the sidewalk. Over paved areas the simulations showed an average air temperature of 26.5ºC at 14h, while 24ºC under the canopies.

The results for superficial temperature indicated that trees have a significant impact by lowering the surface temperature by up to 29ºC. The tree canopy blocks part of the direct solar radiation and avoid the rapidly surface warming up. In the street, the superficial temperature varies from 41ºC to 45ºC, while in the green areas, it goes between 26ºC and 27.5ºC.

Concerning the intensity of the effect, the average difference among air temperatures inside the green areas and the surrounding streets is about 2.0ºC. For surface temperatures, the dense tree shading (LAI=2.5) has shown average differences of 17ºC under the canopy. In that sense, green areas can be an important strategy to mitigate the warming up effect in cities due to the shading and evapotranspiration process.

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ECR Energy City Graz-Reininghaus

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Short Summary

The City of Graz is currently the fastest growing city in Austria. The demand for living space has grown rapidly in recent years and will continue to grow according to forecasts in the coming decades. In this context, the upcoming major construction volumes desire for a sophisticated growth which has to be guided by the requirements of sustainability. Based on this motivation the research project “ECR Energy City Reininghaus” was developed. “Reininghaus” is a former brewery site and the biggest underdeveloped urban area in the City of Graz. The research project ECR aims to develop urban strategies for the new conception, the construction, the operation and the restructuring of the city district Graz Reininghaus. In order to cope with this complex task a large transdiscipliary team joins the research project, which is financed by the City of Graz, the federal state of Styria and the Austrian federal ministry for transport, innovation and technology (bmvit).

Keywords: CO_2 neutral city district / plus energy buildings and networks / framework plan energy

1. The City District Graz Reininghaus

The overall aim of the research project *Energy City Graz-Reininghaus* (ECR) [1] is to support the developing activities of the municipal government of Graz to establish a new city quarter in the area called “Reininghaus”. The area Reininghaus is an undeveloped piece of land (former brewery areal) close to the city center of Graz (about 1800 m distance to the main square) with about 110 hectare space and a possible full capacity for 12000 future inhabitants on a maximum net floor area of about 560,000 m².

2. The Research Approach

Working on the energy efficiency and/or sustainability of one building has a long tradition in the scientific community. Typical research teams in this field consist of an architect, an energy planer and an expert in the field of building physics. Contrary to working on the realization of one building which is usually can be done in a few years the development of a whole district means to plan in decades.
Based on the above-mentioned increase of the complexity of the project itself the complexity of the project management increases, which leads to a dramatically increase of time consummation in that field. Another consequence of the long time for development lies in changing the level of ab-

straction, which increases and leads straight to the thinking on the level of typologies.

3. The Research Team

One fundamental component in the research setup is the forming of the research team and the communication structure to all relevant stakeholders.

4. Framework Plan Energy

The research project [3,4] is based on the idea of designing an energy self-sufficiency and CO_2-neutral city district. For this reason an “energy framework plan” covering the whole district has been developed [5]. The framework plan energy concerns various fields of investigation. Electric energy, thermal energy and embodied energy has to be taken into account as well as the methods of urban design or the rules and mechanisms of the local authorities. The workplan is structured into a survey study of supply and demand, locally available energy potential versus demand, the development and Simulation of different scenarios for the overall energy concept and the development of default values for further development.

4.1 Development of different scenarios for the overall energy concept

The initial working hypothesis describes the conception of an energy- self-sufficient city district. This has to be seen as a visionary approach to force the project team to examine local energy potentials as far as possible and to anticipate already future developments.
The main focus of the examination lies in the attempt for the inter-linkage of buildings and industrial energy resources as more or less sustainable energy producers. Central supply solutions will be confronted with semi-centralized and decentralized possibilities of inter-linkage. In addition urbanistic attempts (activation of possible energy potentials, natural heat of the earth, building density, best possible building climate-oriented positioning, solar activation of roofs and facades, use of process heat, block-type thermal power station, feeding of the energy surplus to communal networks) will be investigated.

4.2 Development of default values for further development

The research project ECR is focusing on two different levels. On the one hand side it deals with the development on the city district Reininghaus itself, which has to be supported. On the other hand side the project has to work out generally valid results that can be helpful in similar development projects.

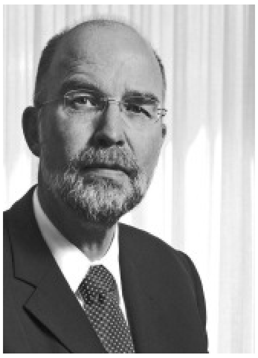
5. Plus-Energy Network Reininghaus South

The project aims at optimizing the energy concept of the single buildings as well as of the building cluster in order to achieve a plus-energy standard within the residential neighborhood.
Key objective is the development of a comprehensive energy concept regarding urban, thermal and building engineering for an entire city district. An overall energy master plan will be integral part of the “Charta Reininghaus” (agreement for the development of buildings) and will set preliminary standards for future investors.

6. Conclusion and Outlook

The expected result for the *Plus Energy Network Reininghaus South* is that the successful implementation of the project will create an exemplary role model and demonstrate the economic feasibility of plus energy networks for housing. A major innovation within the subproject *Plus Energy Network Reininghaus South* will be that, in contrast to already existing case studies, the successful integration of the project in the energy network will demonstrate the use of energy monitoring over a certain period (proof of concept of the network idea).

Social performance assessment of buildings according to the European standard prEN 16309



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Short Summary

Social sustainability aspects of construction and construction works are discussed in various contexts and thus address a vast amount of topics, aims and objectives. This paper describes the concept that has been developed for the assessment of buildings by the European Committee for Standardization (CEN). In 2003, all stakeholders that were defining the working programme of CEN TC350 committed to all three dimensions of sustainability, i.e. agreed to develop assessment standards for the environmental, economic and social performance of buildings.

Recently the new draft standard prEN 16309 has been finalized with the methodologies for the social performance assessment. It represents a comprehensive view on all 22 aspects that determines the social performance of the building-use as part of the building's life cycle. The assessment of the 22 aspects is carried out and presented in 7 information modules, each representing major activities in the building use: e.g. using the building, maintaining it, repairing, refurbishing, etc. All the processes of these activities may define how the building is performing for the user in terms of comfort, safety, etc. The methodology successfully follows the same structure and philosophy as applied in the CEN TC350 standards for environmental and economic performance assessment.

Keywords: social sustainability, social performance of buildings, CEN TC350 standards, EN16309, methodology, social indicators

1. Introduction

A sustainability assessment is much more than collecting data in a spreadsheet. It requires competence of the assessor on the use of the building, the construction process, the end-of-life processes, but also on adapting scenarios and corresponding product data given in the EPD (environmental product declaration). And the manufacturer, who is the sole owner of the EPD and liable for his declaration, cannot limit his assessment to his production process only: all upstream information must be included in the assessment. This is followed by scenario based downstream assessments on aspects and impacts of the product. The standards of CEN TC350 deliver a whole 'basket' of sustainability indicators for this downstream assessment. The indicators will also be important for the harmonised European product standards (hEN) for construction products that specify the requirements of the CPR (Construction products regulation adopted in 2011).

However, the standards only quantify building performances and do not qualify buildings or construction products Any program that qualifies buildings, e.g. BREEAM, DGNB, etc. is expected to apply the standards for the quantification. The standards are helping to process all the parameters into qualifications; Many of the programs use (or have announced to use) the CEN TC350 standards for collecting the data on product performance (EN15804 based EPD's) and apply them in the environmental, social or economic assessment of the building (amongst others the environmental assessment according EN15978). After quantification of the building's impact over its lifecycle these programs have their own methodology for qualifying on the basis of grouped parameters, giving different weight to different parameters.

2. Methodology of prEN 16309

This paper describes the new standard prEN 16309 ("Sustainability of construction works – Assessment of social performance of buildings – Methods") and shows that a building's social performance can be assessed now parallel to its environmental assessment. The methodology of assessment defined in prEN 16309 uses the same general topics and is structured in the same way as the environmental part of sustainability assessment: e.g. system boundaries, life cycle information modules, scenarios, etc.

Like the environmental and the economic performance assessments standards from CEN TC350 the new standard prEN16309 is applied for assessing the performance of buildings and in particular the effect of the building on the user of the building. This standard has, apart from the effect on the direct neighbourhood, boundaries that exclude societal effects caused by the building and its use: spatial planning, zoning, infra structure (traffic systems, utilities and utility supply), employment, etc., are subject of other assessment systems that apply a consequential analysis of sustainability performance. The sustainability assessment of buildings (and construction products) in the suit of standards of CEN TC350 quantify or describe the sustainability aspects of it attributionally.

The scope of the social performance assessment according prEN16309 is limited to the lifecycle "use stage". The use stage is split up in 7 information modules as in the methodology for the environmental assessment: the use of the building itself, maintenance, repair, refurbishment, etc. This modular approach requires to specify scenarios for each of the information modules but then allows to assessment how activities, circumstances and conditions impact the user in using the building.

The more detailed the scenarios for all the information modules are specified, the more detailed information on the social performance can be evaluated and can distinguish performances of different building designs. Rather vague and less detailed scenarios will result in outcomes open for many disputes. Describing scenarios certainly will show to be a crucial task of the assessor before starting with the checklist of indicators per aspect category.

The social assessment is based on 22 aspects each using a number of appropriate indicators. The aspects deal with accessibility of the building, adaptability, health and comfort, impacts on neighbourhood, safety and security. A differentiation is made whether the aspects are building fabric (materials and building model) or user control related. For the aspects, some indicators are quantitative indicators, in specific the indicators for the indoor performance and comfort aspects. But there are also indicators where a performance of the building cannot be measured and quantified within the possibilities of a standard. For these indicators a descriptive performance is attributed and assessed systematically in a checklist.

For the functional and technical related performance indicators of the building that have a social impact on the building user, the checklist methodology refers to the existence of applicable national or international requirements. Depending on the building type and on the building use the client and / or the assessor decide whether the social indicator is relevant. Most of the specified social performance indicators and measures are mandatory in the checklist however some are only given as examples as there are many ways to achieve or secure a performance in the respective aspect.

The CEN TC350 standards provide methodologies for measuring and describing but do not qualify what is sustainable or not: this is left to national or private tools that use evaluation, benchmarking, weighting and rating systems, based on the results of the assessments by the before mentioned methodologies. All CEN TC350 standards are, or will be available soon, as first generation standards. Stakeholders in Europe now have to gain experiences in working with the standards and in using the assessment results. Their feedback will be used to find further European agreement on how to revise and update these standards.

C4

Green Products

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Using life cycle based environmental assessment in developing innovative multi-functional glass-polymer windows

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Short Summary
The HarWin (Harvesting solar energy with multifunctional glass-polymer windows) FP7 project focuses on the development of innovative windows and their integration in buildings. These innovative windows aim at improving significantly the energy efficiency of windows and buildings and performing environmentally well on a life cycle base. The improvements are based on reduced material usage and weight, reduced thermal conductivity and energy consumption and hence, reduced environmental life cycle impacts. The innovation lays in the integration in the window of intelligent phase changing materials and novel glass-polymer composites with wavelength management capability. As windows are multi-component and multi-functional systems, an appropriate Life Cycle Environmental Assessment (LCEA) method is needed. Based on an evaluation of best available methods and tools for LCEA an adapted method for windows is proposed. This paper furthermore discusses how the method proposed can be used efficiently during the development process of the innovative window.

Keywords: Ecodesign, Energy related Product, Life Cycle Environmental Assessment, Multifunctional windows, Product Environmental Footprint, recyclability

Carbon footprint of green roofs in Singapore

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Short Summary

Due partly to the government incentives, green roofs are common in the tropical Singapore compared with the other eco-roof types. With limited land and natural resources Singapore is unique, as most system components for green roofs have to be imported from elsewhere while waste has to be incinerated. The main focus of green roof studies in this unique Singapore setting so far has been the in-use performance benefits in terms of cost, energy and water savings without considering the life time performance. However, resource costs as well as benefits need to be considered in the decision to promote any strategy.

This paper discusses preliminary results from a study that aims to develop a life cycle carbon footprint based decision framework for selecting eco-roof strategies. The results indicate that the carbon footprint of green roofs depends on the construction details and system components used. The end-of-life waste disposal contributes significantly to the carbon footprint, even with system expansion to include avoided electricity generation as a result of waste incineration, main method used for waste management in Singapore.

Keywords: green roof, life cycle assessment, carbon footprint, tropical climate, Singapore

1. Introduction

Singapore is a thriving world class city with over 5million population living in high-density housing in a land area of around 700km^2. Despite land constraints, Singapore is covered in a high level of greenery due mainly to conscientious planning over decades. Making optimum use of land, while ensuring green space is maintained at 8m^2/person and increasing greenery in high-rise buildings to 50ha by 2030 are goals of the Singapore Sustainable Development Blueprint [1]. Green roofs are an established strategy used commonly in Singapore to soften the harsh urban environment and to improve the quality of life.

2. Methodology

This paper considers the life-cycle performance of alternative green roof systems used in Singapore. Three green roof types, continuous intensive, continuous extensive and modular extensive, are considered. The study is based on industry data on material sourcing, typical construction details, maintenance practices and waste disposal scenarios. Although the benefits from green roofs cover a wide range, the paper is limited to implications on building energy use. The carbon footprint of establishment, maintenance, end-of-life disposal was established for the three systems over the useful life of green roof systems, which was assumed to be 20–30 years. The cooling energy benefit as a result of green roof over the useful life was also established in terms of avoided carbon footprint.

3. Results and Discussion

The results indicate that the life stage responsible for the majority of carbon emissions depends on the green roof construction system; continuous or modular. For continuous construction, over 70% of the total emissions are a result of initial construction, irrespective of whether it is an extensive or intensive green roof. For modular construction system the maintenance contributes the most emissions with around 90% of the total. This could be expected due to the short useful life of the tray, even though the trays are produced of recycled polypropylene in Singapore. Total emissions associated with the modular extensive green roof system are three times that of continuous extensive green roof while emissions of intensive green roof system are six times that of continuous extensive green roof.

Only continuous extensive green roof system saves sufficient electricity to pay off the emissions released as a result of green roof system over a 20-year period. Even with the system boundary considered for green roof systems expanded to include the waste-to-electricity generation, the performance of both extensive modular tray and intensive green roof systems improve marginally, with only 17% and 75% of the lifetime emissions recovered during the 20-year period as avoided emissions due to energy savings. This could be expected as although waste-to-electricity generation avoids generation using imported fossil fuels the process is emissions intensive.

3.1 Performance with longer useful life

If the useful life of green roof systems in Singapore is extended to 30-years, then the embodied emissions of the intensive green roof system can be recovered as avoided electricity emissions due to cooling energy savings over this period. However, due to relatively short useful life of trays which leads to higher embodied emissions, the modular tray green roof system does not pay back even over the longer 30-year period.

3.2 Performance with longer replacement cycle for modular tray system

Even with a longer replacement cycle of 7years instead of 5years considered in the base case, the embodied emissions of modular tray extensive green roof system cannot be recovered over the extended 30-year useful life. Although the contribution to the total by the maintenance stage is now reduced to 63% of the total from initial 90%, the cooling benefit provided by the roof is not sufficient to pay back the emissions associated with establishing the system.

4. Conclusions

This paper considered the carbon footprint of different green roof construction systems used in Singapore. The study suggests that the total carbon footprint and the life stage at which most emissions are released depend on the green roof construction system used. The results also indicate that the modular tray system is not a sustainable practice in terms of carbon footprint as the emissions investment cannot be recovered. The advantages of using green roofs, however, extend beyond cooling energy reduction, which were not considered here. For a true evaluation of environmental performance of green roof systems, the impacts on stormwater management also need to be included.

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Life Cycle Energy Performance of Semi-Transparent Building-Integrated Photovoltaic (BIPV) Windows in Tropical Singapore

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Short Summary

Sustainable buildings seek not only to increase energy efficiency, but also to adopt renewable technologies in its design. As such, semi-transparent building-integrated photovoltaic (BIPV) is gaining popularity among architects and building designers, mainly due to its ability to contribute towards a zero-(or even plus) energy building. Semi-transparent BIPV windows not only generate electricity but also allow daylight into the building and reduce the need for artificial lighting. As with other window façade elements, their incorporation will however, increase the cooling load due to solar heat gains. This is even more pertinent in tropical climates where temperatures are high all year round. This paper examines the life cycle environmental performance of a commercially available double-glazed semi-transparent BIPV module for window application under the tropical conditions of Singapore. Energy simulations were performed in *EnergyPlus* with measured data of the semi-transparent BIPV glazing in tropical conditions. Subsequently, a life cycle assessment was conducted to determine the long term performance in terms of energy and carbon emissions.

Keywords: building-integrated photovoltaic (BIPV); solar windows; energy performance; life cycle assessment; tropical climate

1. Introduction

Improving the energy performance of façade elements is a key challenge in improving building energy efficiency, because they are the interface between indoor and outdoor environments. In addition, adopting renewable technologies such as solar photovoltaic is becoming more popular due to the shift away from consuming fossil fuels. As such, building-integrated photovoltaic (BIPV) is considered to be an emerging glazing technology for building façades. When fully integrated with the building, BIPV is able to replace conventional building materials and to generate electricity. As part of the building façade, semi-transparent BIPV not only affects building energy efficiency through power generation, but also via its thermal properties and daylight transmission. Several researchers have studied their application and combined energy savings potential in different climatic regions [1-4]. Considering its multifunctional capabilities, its design and application will require optimization to ensure that the installed systems achieve maximum outcome. Such optimization will also strive to encourage real-life adoption of semi-transparent BIPV, as the current costs of BIPV systems are high. Due to the long lifespan (typically 25 years), long-term implications should also be taken into account when designing for BIPV systems. In this study, the integration of a commercially-available double-glazed semi-transparent BIPV module in an office building window was studied through a computer simulation under Singapore's tropical climates. The potential electricity savings, due to electricity generation and daylight transmission, was estimated. In adopting a long term view in designing of renewable systems, a life-cycle perspective was used to study its energy and carbon emissions, in terms of emissions intensity, energy payback time (EPBT) and energy return on energy investment (EROEI).

2. Results

Table 1 shows the annual electricity benefit that reflects the photovoltaic electricity generation, savings in artificial lighting and reduction/increase in cooling required. All four orientations indicate potential for semi-transparent BIPV adoption. A WWR of 90% was deemed practical for a highly glazed façade and its results were used for the life cycle assessment. Figure 1 shows the results of the life cycle assessment in terms of EPBT and EROEI. It indicates an EPBT range of 5.7-6.4 years and EROEI ratios of between 3.6 and 4.0.

Table 1: Annual electricity performance benefit for main orientations

Annual Electricity Benefit (kWh/m2/yr)				
	East	West	North	South
10	1.96	1.94	1.76	1.81
20	3.99	3.93	3.52	3.62
30	5.92	5.92	5.23	5.37
40	7.78	7.79	6.88	7.05
50	9.51	9.55	8.42	8.63
60	11.18	11.19	9.90	10.15
70	12.97	12.96	11.50	11.78
80	14.68	14.65	13.02	13.33
90	16.40	16.37	14.58	14.92
100	18.00	17.98	16.04	16.41

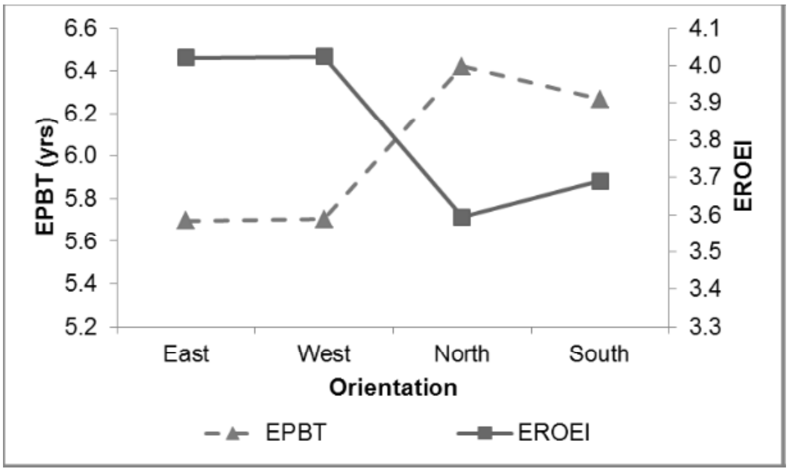

Figure 1: EPBT values and EROEI ratios for various orientations

3. Submission of contributions

The results suggest that semi-transparent BIPV windows are feasible on all facades in Singapore, due to the highly diffused nature of the skylight. There is significant potential for semi-transparent BIPV windows to be applied in Singapore's buildings. The potential areas for practical application go beyond orientations that fall within the direct sun path but also to those that do not.

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Medium-rise structural timber apartments: Luxury or long-term carbon storage solution?

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Keywords: Cross-laminated timber; apartments; embodied-energy; sustainable construction.

Abstract

It has been estimated that up to 85% of the buildings life cycle energy requirements are taken up in the operational phase of residential buildings. This has been gradually decreasing in low carbon, zero carbon, and living buildings. As the energy requirements to operate homes and apartments decrease there is a growing importance to reduce the amount of embodied energy through the use of sustainable construction materials. A growing body of literature reveals that the use of timber sourced from sustainably managed forests and plantations can significantly reduce the embodied energy in homes and apartment blocks in comparison to heavier materials such as concrete, steel and masonry. The last twenty years has seen the development of engineered wood products suitable for use in medium-rise apartments in particular cross-laminated timber (CLT). Europe has been the centre for the construction of a number of structural timber apartment blocks with the 9 storey 'Stadthaus' building in Murray Grove and the 8 storey 'Bridport House' in Hackney, London being the largest modern timber apartment blocks until 2012.

Structural timber apartment construction is limited in Australia due the market dominance of materials such as steel, reinforced concrete and masonry used in these projects. Increasing population densities requiring taller buildings, stricter building codes and standards as well as an established workforce and technologies all support the use of heavy materials in medium and high-rise apartment construction. The majority of apartment projects in NSW are built with reinforced concrete floor plates and columns. The national code of construction does not permit apartments greater than three storeys to be built out of structural timber elements so alternate design solutions are required to achieve compliance. This arduous process in addition to the strict fire and acoustic performance requirements of apartment buildings has resulted in heavy material utilisation in these types of projects until recently. Australia's first CLT building and the world's largest apartment block constructed of CLT has just been completed in the Docklands area of the city of Melbourne. The construction industry, investors and the general public are observing this project for success in the areas of erection speed, lightweight structure and environmental benefits. Contrary to other CLT apartment projects this development targets the higher end of the sales market, therefore placing a reliance on public perception for the uptake of this timber construction methodology.

This paper investigates the perception of Australians towards the use of timber as a sustainable building material, the desire of residents to invest and live in medium rise timber apartment blocks, and the willingness of consumers to pay a premium to live in low embodied energy buildings. Online questionnaire surveys were used to collect responses from residents of Australia's state of New South Wales. The sample group was composed of residents occupying and/or owning units or detached dwellings and having a background of either construction or non-construction related employment. This paper highlights Australian homeowners reluctance to invest and live in innovative timber buildings despite demonstrating an understanding of the benefits of using sustainable building materials in new construction. This paper presents the results of a questionnaire survey to homeowners and occupants in New South Wales, Australia and provides some strategies on how to increase the acceptance of the use of timber in innovative housing projects in Australia.

Optimization of wood based structural elements - Concepts for increased resource efficiency

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Short Summary

In several research projects of the Department of Structural Design and Timber Engineering (ITI) at the Vienna University of Technology (VUT) the combination of timber products with other conventional building materials and components, e.g. glass, steel and lightweight wood particle concrete was explored with the purpose to optimize structural performance, usability energy-efficient and ecological profile of composite systems [1, 2]. A number of show cases mixing different material elements are presented e.g. timber-glass, timber-steel and timber-lightweight concrete, use for beam, columns, shear walls and floor constructions.

Keywords: Sustainable building, sustainable redevelopment, wood based structural elements, resource efficiency

1. Introduction

Buildings play an important role when it comes to controlling climatic change through the reduction of CO_2 emissions in the production of building materials; during the construction phase itself; during the use of the buildings; during the recycling and destruction process; and in deposits. Nowadays, construction techniques in Europe are mainly based on the use of industrially produced materials such as steel, reinforced concrete, bricks, plasterboards, etc. Especially during the past two centuries, they have largely replaced natural materials which had been used for thousands of years, including wood, stone, and clay. The building market has always been the most important mass market for timber products. The European countries have to face profound changes in the demand for buildings. The building codes are in constant revision, actually nearly all European countries allow at least 4 stories buildings in timber as regular solutions and pilot projects had been built up to 10 stories. The renewable raw material “wood” is available in a sustainable way; the basic technologies are well known and good examples of wood-based building already exist. However, the potential of using wood in the building sector is still highly underestimated. Wood as a sustainable and an ecological material has an excellent chance to be an alternative construction material in urban areas. The technical possibilities have multiplied, new materials and new construction methods appeared and finally a set of completely new requirements concerning environmental aspects and criteria of sustainability has to be translated into the built reality.

In several research projects of the ITI at the VUT the combination of timber products with other conventional building materials and components, e.g. glass, steel and lightweight wood particle concrete was explored with the purpose to optimize structural performance, usability energy-efficient and ecological profile of composite systems [1, 2]. The developments focus on wood as renewable resources, waste and manufactured products of the forest industry. The ecological impact of the most performing structural elements was analyzed with regard to life-cycle analysis, following the whole fabrication chain of all components, and comparing the results to conventional ways of construction in order to demonstrate the competiveness of the developed wood-based systems.

2. Wood based structural elements

As a representative example for these developments the application of cement bonded wood composites as structural sandwich panels illustrates the extent of the interrelationships involved in the development of complex system solutions to increase resource efficiency (*Fig. 1*).

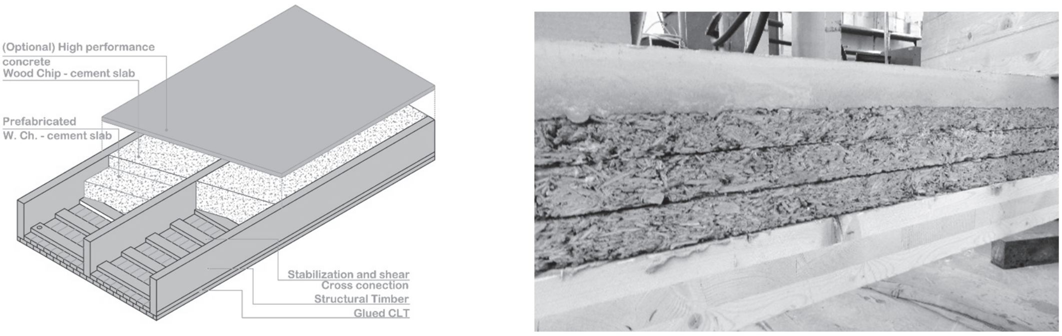

Fig. 1: Lightweight wood-concrete floor element

The following stages were proposed to achieve relevant results compatible to industrial applications:

- ⇨ Development and optimization of wood light-weight concrete using recycled wood particles and new additives, strength tests and evaluation of the physical properties of the lightweight wood-concrete,
- ⇨ Design of structural components made of lightweight concrete connected to timber sections, analysis of the experimental results to develop design concepts,
- ⇨ Evaluation of the thermal and sound insulation behavior,
- ⇨ Fire resistance by explorative tests,
- ⇨ Optimization of the manufacturing methods,
- ⇨ Studies regarding the ecological impact.

In order to recognize the potential for future market implementation and to demonstrate the competiveness of the developed multi-layer systems, the economic feasibility and ecological impact of the most performing structural elements were analyzed in several case studies [1]. Four different variants of floor elements were examined. From the ecological point of view the lightweight wood-concrete floor elements were examined by two end of life (EOL) scenarios. The comparison represents that the lightweight wood-concrete floor elements are an adequate alternative to the massive timber as well as conventional concrete floor elements.

3. Conclusions

To reach a comparable or higher market share in the multi-story sector timber-based buildings must be economically competitive. The strategies to increase use of timber in multi-story buildings are:

- ⇨ Combination of wood with cheaper, non-combustible mineral materials for cost and fire resistance optimization,
- ⇨ Full use of prefabrication with the goal of reducing erection time,
- ⇨ Increase specific knowledge about timber by professionals, students and builders,
- ⇨ Realize intelligent and attractive pilot projects.

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C5

Green Products

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Environmental improvement of building insulating cladding system

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Keywords:PCMs; Thermal Insulation; Cladding System.

1. Extended Abstract

Cladding systems performances are considered more and more important to determine sustainability values in the construction of a building. In fact, the insulating envelope is the mediating element between outdoor environment and indoor spaces of a building: it is responsible of heat transfer and regulation of energy flows through the wall.
The present work aims to improve the performance of an existing commercial product (PIZ Cladding System) through the use of smart materials called PCMs (Phase Change Materials). These materials have been used for many years in building industry because they are able to store high amounts of heat, which helps decreasing thermal peaks inside buildings and energy consumption used for cooling systems.
The new product developed, aimed at improving insulating properties, is a composite panel made of a cellulose fibre matrix (obtained from recycling processes of cardboard) and PCMs as additives in the mixture.
The environmental improvement of the product obtained with the present research consists in the following features:

- the use of widely available waste products such as cardboards as base material;
- the development of a new smart material which is able to increase the insulation properties in specific and critical conditions through the use of PCMs;
- the achievement of a product which is in turn recyclable, because the presence of PCMs doesn't contrast the recycling of paper to obtain a new insulating panel.

Experiments on composition and productive process have been done in laboratory scale in order to face each outlined aspects. Afterwards tests have been conducted in order to verify the

effectiveness of the processed solutions. Finally comparison between cellulose samples and perlite panels actually employed in PIZ Cladding System has come to the conclusion that the new composite material developed represents a valid alternative for the sustainable improvement of the product.
The improvement process starts form the choice of recyclable materials with insulating properties like cellulose fibres, with the aim to find a solution for the cardboard scraps over-collection problem. The enhancement of product lifetime through the maintenance of material resistance properties has been faced with the selection of specific additives which also allow further recycling process. The implementation of insulating properties has been achieved with the addition of PCMs whose operating principles has the effect to reduce the energy consumption of buildings.
All the underlined aspects have been validated by laboratory tests and numerical values. Density, flexural strength, thermal conductivity and conductance of the new composite material developed resulted comparable to those of perlite actually employed in PIZ Cladding System (Table 1).

Table 1: Comparison between perlite and cellulose fibre panel

Material	Thermal conductivity (W/mK)	Density (kg/m^3)	Flexural strength (kPa)
Expanded perlite panel with cellulose fibre	0.050	145	282.95
Pourous panel of cellulose fibre and PCMs	0.052	180	170.75
Perforated panel of cellulose fibre and PCMs	0.055	215	375.80
Expanded perlite panel	0.060	260	650.50
Compact panel of cellulose fibre and PCMs	0.063	215	390.25

In order to evaluate the thermal insulation in dynamic condition a thermal test has been done. A thermostatic chamber has been constructed and temperature variation of typical summer days has been reproduced switching a lamp inside it. Samples of insulating material have been placed on the perimeter wall and, using a heat flows probe, the insulating capacity of each panel has been compared. Calculating the area under the thermal flows curves (Fig.1), it has been possible to compare the amount of thermal energy which passes through the panel in a definite period time. The new product gives better results in dynamic conditions thanks to the thermal storage effect of PCMs which help to reduce the heat transfer when temperature reaches high typical summer values. Those thermal tests suggest that PCMs could be effective for the reduction of cooling systems energy consumption during summer periods.

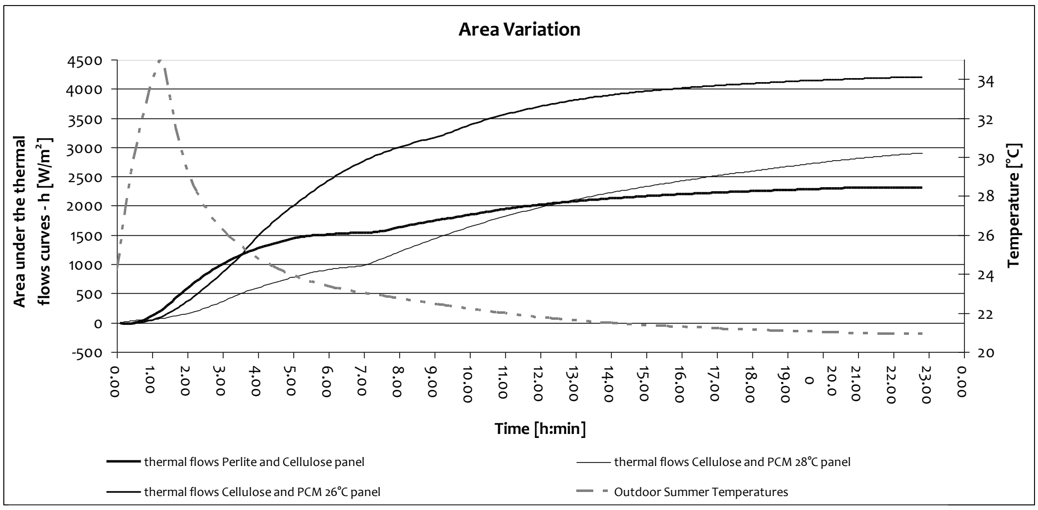

Fig. 1: Area variation under thermal flows curves

2. Acknowledgements

Authors gratefully acknowledge support from “Piz S.r.l.”, “Ghelfi Ondulati S.p.A” and Regione Lombardia for the project “Naturalmente”.

The environmental footprint of plastic pipe systems within the built environment

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Short Summary

The conclusions of the EPD studies carried out till 2012 show that when considering all the categories of the LCA, the average environmental impact of Plastic pipe systems in general are lower than of comparable other materials. The CO^2 footprint which is the best known parameter and environmental impact in the LCA is as well lower than of comparable other materials.

Key words: Plastic pipe systems, life cycle assessment (LCA), environmental product declaration (EPD), European sector approach, sustainable construction and housing.

1. About TEPPFA

TEPPFA stands for The European Plastic Pipes and Fittings Association. It is a trade association representing the key manufacturers and national associations of plastic pipe systems.
Plastics are very young materials. The first polymers were explored or developed within the last 100 years and their use for pipe production has an even shorter history. Plastic and plastic pipe industry is not an innovative industry but it is the innovation itself. The environmentally conscious thinking and acting are the essence of our economic area.

1.1 Our goal

As early as the European Commission gave the Mandate to CEN for creation of a Technical Committee dealing with the environmental aspects of building products and the built environment TEPPFA has also started using the results of this CEN/TC 350 parallel to the development of relevant standards (e.g. prEN 15804, etc.).
In the full paper and the presentation you may catch this early waking looking for the two legs of abiotic depletion. Yes, our studies contain only the combined value of fossil and non-fossil elements of abiotic depletion coming from the fact that in the drafts of EN 15804 this was the case.
The initiative aims to measure the environmental impact of plastic pipe systems throughout their entire life cycle (including the raw material extraction and production, the manufacturing process, the transport, the installation, the use and the end of life disposal).

2. Development of EPDs

TEPPFA has developed an environmental programme with the aim of covering all application areas where its members are interested. The program started in 2008 and is running even today. The companies producing plastic pipes and fittings provide their data. Then the LCA is done by Vito and it is reviewed by Denkstatt.

3. Plastic pipe applications & detailed CO^2 footprints studied:

3.1 Sewage and drainage applications (non-pressure):

- PVC-U solid wall sewer pipe system [12]
- PVC-U multilayer (foamed core) sewer pipe system [13]
- PVC-U multilayer (core of foam and recyclates) sewer pipe system [14]
- PP structured (twin) wall sewer pipe system [15]
- PP solid wall sewer pipe system [20]**
- PP structured wall multilayer sewer pipe system [20]**

3.2 Water and gas distribution applications (under pressure):

- PE water pipe system [8]
- PVC – U water pipe system [9]
- PVC – O, MRS 31,5 MPa, water pipe system [10]
- PVC – O, MRS 45 MPa, water pipe system [11]
- PE gas pipe system [19]**
- PE water pipe system installed by directional drilling technology **

3.3 Soil and waste applications in the building (non-pressure):

- PP pipe system [6]
- PVC-U pipe system [7]
- PP low noise pipe system [18]**
- PVC-U low noise pipe system [18]**

3.4 Plumbing, hot & cold applications in the building (pressure):

- PEX solid wall pipe system [16]
- Polymer, aluminium, polymer multilayer pipe system [17]
- PP-R pipe system [21]
- PB-1 pipe system**

(** In preparation)

The second part of the presentation gives the details of the environmental impacts especially the CO2 emission of plastic piping systems from cradle to grave.

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-(pr)EN 15804: Sustainability of construction works – Environmental product declarations – core rules for the product category of construction products (draft, 2008);

SB13 Graz – Extended Abstract

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Extended Abstract

The project Symbio2 is the research and development of a hybrid façade system that uses the concept of symbiosis of building systems with the controlled and regulated production of microalgae on the building façade. The research explores the behaviour of thin flat panel microalgae photo bioreactors in the configuration of a double skin façade where aerolic and fluid exchanges between the building and the photo bioreactors are optimized [4], [5], [6]. The purpose of the research is to demonstrate the economic and technical feasibility of this new approach to producing microalgae.

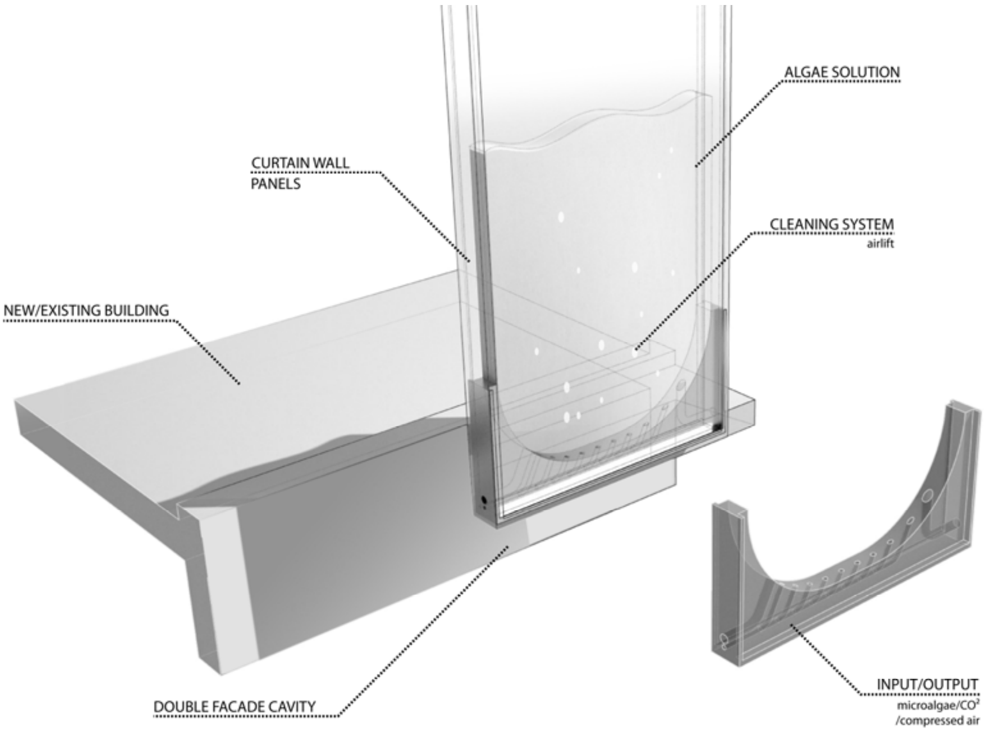

Fig. 1: Breakdown of Photobioreactor Façade System

A demonstrator project on an industrial building in Nantes, France is under development. The host building a waste incineration plant will be used to test the new system in symbiosis with its existing operations. Although the host building is an industrial building the configuration is designed to enable comparison and validation of different building types such as residential and commercial.

Based on the latest development in solar photobioreactor modeling ([1], [2], [3]), a techno-economic model has been developed that measures the impact of the façade design on microalgal production and the energy performance of the building and balances it with both the investment costs, operational costs and the return on investment from microalgal production to understand what are the drivers to making the system feasible.

Thin flat panel photobioreactors were found to maximize light exposure. By placing the photobioreactors only on southern, south eastern and south western facades solar gain is maximized on the microalgae thus maximizing production. The microalgae absorb all the solar gains preventing it from penetrating the building so thus acts as a natural brise soleil. The double skin façade system facilitates the thermal regulation of the microalgae and the building, which have similar needs, but also bring the traditional benefits of the configuration such as natural ventilation and solar optimization.

The research also shows the benefits of this new system in reducing the embodied energy and water in comparison to the existing highly inefficient "raceway" production systems and more modern tubular systems. The research also has identified specific high value micro-algae that require similar temperatures for growth to that of humans inside the building to maximize the symbiosis between the two. The choice of microalgae is based on the current capital costs of implementing and operating the system in line with typical building costs.

The technico-economic analysis reveals that the development and eventual mass production of such façade systems will enlarge the choice of microalgae that are feasible techno economically. Symbiosis also involved several environmental benefits, including the reduction of the urban heat island, CO2 absorption, O2 production and phytoremediation. The reduction of the capital costs of the system is the biggest driver to ensuring the feasibility of implementing such systems.

Keywords: Photobioreactor, microalgae, facade, farming, symbiosis

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A Proposal for the Information Needed with Respect to BRCW7: *Sustainable Use of Natural Resources*

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Short summary

For ease of use by industry, the lead indicator should be a combined resource score that incorporates both the quantities and residual lives of the abiotic, fossil fuels, biotic and secondary resources used in a product. Water use should be reported as a separate indicator, as pressure on this resource varies geographically. EN 1990 sets the minimum design working lives for various types of structure and if a particular component of a structure is not expected to achieve the intended working life, then the life cycle analysis should take into account the impacts of replacement. If the term ‘environmentally compatible’ is taken to mean that a structure does not release or emit significant levels of dangerous substances, this is already covered by BRCW3: *Hygiene, Health and the Environment.*

Keywords: Construction Products Regulation**,** BRCW7, resource indicators, sustainability, fossil fuels, abiotic resources, biotic resources, water.

1. Introduction

The Construction Products Regulation has introduced a new Basic Requirement for Construction Works (BRCW7) on the topic of the sustainable use of natural resources. At present there is no guidance at the European level on how producers should implement BRCW7 and provide the relevant information. The basic rule is that a producer is only obliged to provide information if there is a notified regulation requiring this information; in all other cases they may use the ‘no-performance determined’ option. At present there are few, if any, relevant notified regulations but this may change in the future. The expectation is that the requirement for information on BRCW7 will be driven by specifier demand.

2. Implementation of BRCW7

With BRCW7 the most important words in the construction Products Regulation are in the text before the list and they are ‘*the use of natural resources is sustained*’ and this requires the indicators to include measures of both quantity and scarcity of resources employed. Such an indicator has been developed [1] and it is described in outline in the full paper.

2.1 Re-use and recyclability

Most construction products are recyclable at the end of their life. Metals have a high intrinsic value and, as a consequence, a high recycling rate but with lower value recyclable products, such as brick, concrete and plasterboard, the recycling rate is linked to the level of market intervention.

2.2 Durability

EN 1990 defines minimum design working lives for different types of structures. If the declaration of performance or the technical specification indicates that a component of a structure is unlikely to achieve the intended working life, the life-cycle analysis should include the impacts of replacement, including the resources required for such replacement.

2.3 Environmentally compatible

The exact intent of the bullet point '*Use of environmentally compatible raw and secondary materials in the construction works'* is more subjective. Our interpretation of this wording is that there are two points within the one phrase. The first is that the materials used should be environmentally compatible and this is taken to mean that they do not release or emit significant levels of dangerous substances during construction, during the in-use phase or during the end of life phase. This aspect of performance is already covered by BRCW3: *Hygiene, health and the environment*. A series of amendments to product mandates have been or are being issued by the European Commission that requires the producer to provide information on the potential release or emission of dangerous substances if the product is to be placed on a market with a notified regulation. The same approach may be used to provide information to satisfy non-notified regulations and customer requests for information. Consequently, this aspect of performance is already adequately covered and further information under BRCW7 is not needed.

The second point relates to the use of secondary materials. Secondary materials may be by-products of industrial processes, e.g. fly ash from burning coal to produce electricity, or recycled materials. The lead indicator described in the full paper takes into account the use of secondary materials.

3. Resource Indicators in EN 15804

CEN/TC350 is pushing strongly to have its suite of indicators used as the measure of satisfying BRCW7. CEN/TC350 has no product specific indicators for the social and economic pillars of sustainability. Without such indicators, it is likely to be concluded that bio-fuel is the answer to energy needs and this is likely to have a devastating effect on the food supply/price in third world countries and the loss of habitat to native people.

4. Lead Indicator: Combined Resource Score

The University of Dundee has developed a methodology for combining 11 of the EN 15804 indicators into a single 'Combined Resource Score', which is based on the concept of residual life (as is the abiotic depletion potential). Residual life should not be regarded as a 'tablet of stone' but the best current estimate and it is accepted that these values must be periodically reviewed and updated.

5. Main Conclusion

Information on the sustainable use of natural resources (BRCW7) is best provided using a Combined Resource Score that encompasses 11 of the 12 resource indicators given in EN 15804.

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C6

Green Products

Chair: Ronald Rovers
Zuyd University, Nederlands

A Comparative Analysis of Life Cycle Impact Assessment Methods for Building Materials

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Short Summary

Life Cycle Impact Assessment (LCIA) is a phase of the Life Cycle Assessment that aims to evaluate the magnitude and significance of the environmental impacts of a product system throughout the life cycle of the product. LCIA is the weakest but the most important phase of the method due to uncertainties of the components and approach differences between methods.

Spatial differentiations are effective in evaluating and determining the significance of environmental impacts. Therefore, most countries have created LCIA methods aimed at assessing their own environmental situations. In addition, some countries have created LCA tools that evaluate the environmental impacts of building materials and developed LCIA methods. There are different approaches between LCIA methods. One of the important differences is the point that environmental categories evaluated quantitatively in the system. Accordingly, midpoint, endpoint, and methods, which combine two approaches, have been developed. The methods are also different in specific aspects, such as the quantity and the concept of selected impact categories, the environmental models developed for the characterization, normalization and weighting factors.

This study aimed to evaluate and compare current LCIA methods for building materials such as BEES, Bre- Environmental Profiles, BPIC / ICIP, ATHENA Impact Estimator, BEPAS and BELES. These comparisons are based on the ISO 14040 standard framework. As a result of the study, differences in the methods are seen in the selected impact categories and category numbers, the point which environmental categories evaluated quantitatively, selected category indicators and models, normalization factors and weighting methods. This study emphasizes that continent or country specific LCIA methods for building materials need to be created.

Keywords:Life cycle impact assessment methods; building materials; environment; locality

1. Introduction

High production quantities of the building materials in the building construction and the use of them in a wide area in the world make the environmental impacts of the building materials important. Not only properties, types, application conditions and performance of the building materials but also the environmental effects should be known by the architects.

2. Discussion and conclusions

Most of the methods evaluated in the scope of the study are based on midpoint approach methods. Advantages of using midpoint approach are the reduction of the uncertainties in the method and possibility to develop a method that combines with midpoint and endpoint approaches.

Considering environmental impacts of building materials, the effects on air and water quality, soil effects besides, the consumption of non-renewable resources becomes important. Different environmental impact categories are assessed in the LCIA methods discussed. Waste, human toxicity, indoor air quality, dust and noise are at least evaluating the environmental impact categories. Formation of odours is not assessed as impact categories in the methods. However, environmental and human health effects of these categories are great in the life cycle of the building materials. Therefore, these environmental impact categories should be considered.

When examined the characterization factor used in the calculation of environmental impacts, there is a consensus for global warming used CO_2 equivalent, for ozone depletion used CFC11 equivalent. However, there is no consensus on globally representative characterization models for regional impact categories. For people who study on building, it is difficult to decide which equivalents are better for the characterization factors. A recent study of Hauschild and his friends can be the source on this issue. Accordingly, baseline model of the IPCC and WMO model are recommended and satisfactory. Other impact categories are evaluated as recommended but in need of some improvements or recommended but to be applied with caution [10].

The amount of emissions per person per year is mostly used as normalization factor in LCIA methods. Geographic and time coverage are important in order to calculate the factors. For LCIA of building materials, it is necessary to determine the importance degree of impact categories for a region or a country. Panel method is mostly used in these methods. The disadvantage of the distance to target method is that weighting coefficient may change depending on the policy of countries. Only one method uses willing to pay method. Use of this method depends on the determination of economic values of the selected environmental damages for LCIA methods.

Potential environmental impacts and the importance of particular impacts can be quite significant between the countries or regions. The life cycle processes can vary considerably from country to country, as can the types of fuel used, the source of raw materials, transportation distances, and the relevance of specific impact categories. The most accurate findings are usually obtained where product, process, technology, and local data for a building material being studied is used.

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Product Design Aspects of Agro-fibers Biocomposites for Architectural Applications

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Extended Abstract

Biocomposites are composed of natural fibers combined by a bio-based matrix created from renewable resources, like linseed oils, or natural fibers combined with an oil-based matrix or artificial fibers bonded with a bio-based matrix. In this paper, biocomposites applied and meant are those green biocomposites composed of natural fibers and bio-based matrices. The authors here discuss the agro-fibers biocomposites where fibers applied are short natural agro-fibers, retrieved from agricultural residues resources, bonded with bio-based matrices retrieved and manufactured from annual plant origins that can't be directed towards the feedstock industries.

Agricultural fibers, from which agro-fibers are retrieved, are those natural fibers that are left over after the production of crops whether cereal crops, fruits, vegetables or nuts. The main interest in such annual crops' agriculture is the seed/fruit itself and not the residues left over after harvesting. That's why huge quantities of such residues are so often burnt after re-using relatively small amounts of them in conventional applications. On the other hand, and as the problems of conventional limited usages of stalks, straws,…etc aren't completely been solved, fiber application industries are in great thirst to new available and cheap fiber types. Paper, furniture as well as fiber reinforced composites are accordingly examples of industries that can have a great advantage from applying such fiber sources. Therefore, the highest agricultural residue worldwide, cereal straw, is here applied as an agro-fiber source to manufacture composites that are usable for architectural applications investigating higher standards of desired architectural designs, unlike the classic un-attractive straw baling systems applications in architecture.

Using agro-fibres and applying them in the form of biocomposites, utilizing bio-based matrices based on renewable resources, can offer the opportunity to produce safe formaldehyde-free materials for interiors, hence reaching the highly recommended VOC-free interior air quality. Applying cheap and available natural fibers retrieved from the agricultural residues source would offer not only an environmental balance together with a society awareness reflection, but would also open a new market for biocomposites materials with lower prices and acceptable performances.

The relationship between ecological products based on biocomposites and their applications' potentials in the architectural field is of a critical and crucial nature. Such ecological products reflect the main aim of reducing production emissions, resources consumption and providing more sustainability aspects that are urgently needed in all industrial fields, especially in the architectural and building ones. Product development especially in such a field should not only focus on the material properties, but also on the architectural design aspects and the methodology of achieving this design using the available production technologies, making good use of the materials workability and characteristics.

Agricultural fibers' application in architecture is not a new discovered issue, but was already in use since the pheronic ancient Egyptian era when the rice straw was mixed with mud to form bricks

that were used to build regular housing. In contemporary architecture, agro-fibres are re-discovered and re-applied, but still in limited applications. The hidden reason might be the un-attractive straw bales' look that still appears directly in our minds when talking about agricultural residues, making their applications next to their other technical difficulties, handling problems and aesthetic limitations still un-desired from lots of end-users worldwide.

Therefore, it's discussed here within this paper another method of agro-fibres appliance to reach a much higher architectonic design value and appearance, depending on renewable based matrices that can bind the agro-fibres in the desired forms, surface finishings and colors, reflecting their eco-logical nature to the end-user, according to the required design. In this case, and with extra further investigations, such products can compete with and replace existing fossil-plastics and wooden products which are already present in the contemporary architectural-products' markets, those which are applied in the same target applications like cladding, partitions, acoustic panels, …etc.

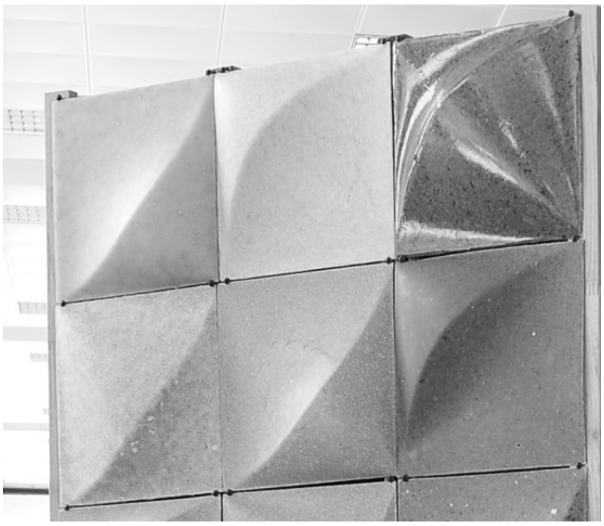

Fig.1: 'TraShell' - from cereal straw, organic ash and bio-resin.Photo: B. Miklautsch

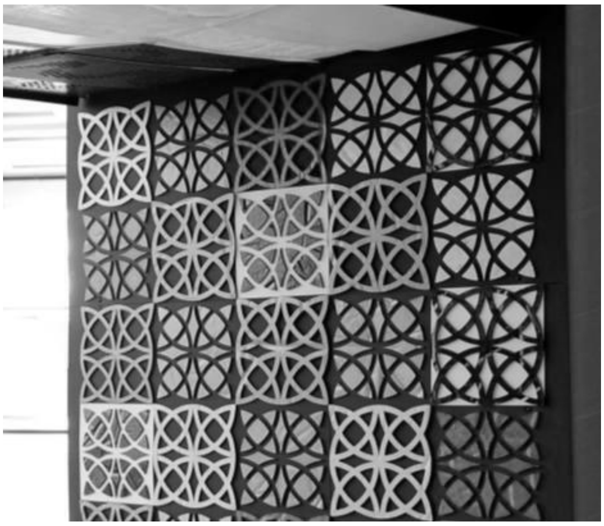

Fig. 2: 'BiOrnament' – from rice straw, bio-resin and natural pigments. Photo: B. Miklautsch

Throughout the paper two product designs are thoroughly discussed, which were manufactured as mock-ups to scale 1:1, (Figs.1-2). The products were manufactured using linseed oil-based epoxy resins, binding short natural agro- cereal straw fibers. Through these designs, higher levels of ar-chitectonic design requirements were investigated represented in formability and processed to reach special desired designs like free-form panels and laser-cut oriental-designed plates. The manufactured products are appropriate in interiors' as well as exteriors' applications. Mechanical testing showed comparable stiffness values with existing non-structural materials available in local markets that are applied in interior applications. This reveals the potential of replacing existing conventional materials with renewable-resourced products based on agro-fibers and bio-based matrices. Further experimentations and designs should be proceeded by architects, designers and material engineers to reveal more attractive applications possibilities from agro-fibers.

Keywords:Biocomposites, Product Design, Ecological architectural products, Natural fiber compo-sites, Agricultural residues, Agro-fibers.

Challenging ETICS

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Short Summary
The results from the investigation of the question whether insulating elements from components of the ETICS can be produced with sufficient static properties due to a new support structure as defined by wInterface to be produced as facade elements in a individualized industrial series production provide a new and significant solution to the challenge of deconstructing ETICS according to the Regulation (EU) No 305/2011 basic requirement for construction works No. 5, 6 and furthermost 7 Sustainable use of natural resources [1] which now has come into force.

Keywords: ETICS, ETIC, TICS, WDVS, Regulation (EU) No 305/2011, thermal refurbishment, EIFS, prefabricated cladding system, large panel system,

1. Introduction
Only under the condition of static characteristics sufficient to guarantee functionality and usability the sensible use of individualized industrial series production of ETICS cladding panels on the basis of modern imaging methods of measurement can be made possible. The use of computer-based production technology enables economic and ecologic optimization over the entire manufacturing process. Conventional ETICS is fixed to the wall, thus does not meet the EU Regulation, which also prescribes the process at the end of use to be considered.

2. ETICS insulation elements

2.1 The wInterface system:
wInterface has defined a novel load-bearing structure for ETICS elements wInterface along with a method of manufacturing, which allows a customized industrial series production of precisely fitting ETICS façade elements. They can be built from accredited components of ETICS on the basis of insulation materials such as EPS, mineral wool, PUR / PIR or wood fibreboards. Thus the whole wood frame construction of elements as examined in the research program Haus der Zukunft can be replaced by wood fibreboards when using the load-bearing structure of the wInterface elements.

2.2 Ensuring functionality and usability
Static sufficient properties will be stated in this work, only when functionality and usability are demonstrated by the fact that under normal loading as wind suction on the order of 1,000 N/m², the deflection of the ETICS elements remains limited to the length-dependent maximum value of L/200 and that extraordinary loads such as wind suction on the order of 2,500 N/m² and more do not lead to fracture of the ETICS elements or their mounting system.

3. Computational models of the deflection
Two computational models were developed to predict the behaviour of the elements under load:

one based on a total cross-section method and one based on composite materials. Both methods give similar results for the expected deformation for the relevant loads (1,000 N/m²). For thinner elements with an insulation thickness of 120 mm, the total cross-section method gives about half as large values as the composite method. For thicker elements with an insulation thickness of approximately 200 mm the same values arise in both methods.

4. Testing

4.1 Deflection

For the wind pressure tests 20 specimen 2,000 by 1,500 mm were manufactured in ten different designs concerning parameters of their inner structure, where certain parameters have been varied. Each parameter is represented in two "extreme" values. The parameters: Adhesives: Cement vs. Dispersion | Bars: with vs without bars made from adhesive | thickness of Insulation 120 mm vs 200 mm | Insulation material: EPS boards vs mineral wool (boards and plates)

4.2 Pull out tests

Based on the ETAG 017 32 specimens were made in total. In these test elements different variants of anchors (standard dowels, helical dowels, and threaded rods) were used. The samples were clamped on a tensile testing machine and a force-distance curve was recorded. The specimens for the pull out test are 400 x 400 mm wide and have thickness of 160 mm.

5. Results

5.1 Failure Limits

The results obtained in the wind pressure tests have not only met but far exceeded the expectations. The experiments have shown that the elements have less deflection than predicted by the models and beyond are also close to indestructible. It was examined that the test bed could not keep up the pressure at a load between 3,500 N/m² and 4,000 N/m². All but one elements have left the test bed intact. For comparison, this burden is equivalent to a heavy storm.

5.2 Verification of computational models

The values at GQS are in the thin components as mentioned about half the size of the values of VW. However, the measured values in these components at the higher loads showed larger values as predicted by GQS. Thus VW provides higher values for safeness for the dimensioning.

5.3 Pull out tests

The pull out tests have shown that the extraction forces already can be coped with standard dowels directly mounted in the insulation material (variant 1), which are sufficient in areas with low wind load. For increased wind loads the dowels can be either combined with the bars or the number of dowel per square meter can be increased.

6. Discussion

The static examinations show that a minimum total thickness of the elements should be kept above 150mm and that a maximum span of the elements of H max = 3,000 mm can be achieved. Even simple alternatives when brought in bond with the adhesive layer achieve better results than ETICS dowels. Thus the fastening system can be reduced of dowels and rails using joint profiles that operate with a two-stage sealing system. This also simplifies the manufacturing process by eliminating the substructure, while allowing joint profiles to fix the insulation during the curing of the adhesive.

7. Conclusion

The investigations carried out on ETICS elements have shown that insulating elements from components of the ETICS can be produced that have static properties that ensure the maintenance of functionality and usability even under extreme conditions. Thus ETICS elements can be prefabricated, which are suitable to be mounted as the exterior wall insulation for use in thermal renovation and new construction. Due to their possibility of disassembly also the basic requirement for construction works No. 5, 6, and 7 of the Regulation (EU) No 305/can be met.

Mesuring the U_g-value of window glazing

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Short Summary

A mobile sensor for measuring the U_g-value of window glazing was developed and tested. The sensor allows short measurement times of few minutes and a high accuracy. The sensor covers the whole range of U_g-values between 0.5 W/(m^{2}K) and 4 W/(m^{2}K), which is typical for glazing found in the building stock. A first prototype of the sensor was produced and tested in the laboratory as well as in field tests. A commercialization of the sensor is planned.

Keywords: U_g-value; measurement device; window glazing; energy-efficient buildings.

1. Introduction

Windows are an energy sensitive part of the building façade. However, after a window is incorporated into the façade, it is very difficult to determine the thermal insulation value of the glazing, especially if no product information about the glazing used is available. There are some existing methods to measure the U_g-value of a glazing, like simple tools (e.g. www.fensterglas-test.de) that give more a rule of thumb than an exact value, or laboratory measurements that give an exact value, but where the glazing has to be dismantled and transported to the measuring facility. A measurement device for the U_g-value that gives fast and accurate results and can be used on-site is not state-of-the-art.

2. Results

A mobile sensor for measuring the U_g-value was developed and tested within the frame of the project „Development of a new evaluation tool to determine the energy savings potential of window refurbishment including effects of glazing, frame and connection“ [1]. The sensor consists of two half-shells that are put onto the two sides of the glazing to be measured. One side of the glazing then could be heated up and the temperature signals on the two sides are measured (Figure 1). Finally, an analysis software transfers the transient temperature signals into the U_g-value of the glazing. The analysis software also converts the measured U_g-value to standardized conditions, so that the results obtained with the sensor are unaffected by environmental conditions and directly comparable to the U_g-values given by the producers.

A first prototype of the sensor was built and tested in the laboratory as well as in field tests (Figure 2). The results are very promising, giving a high accuracy with measuring times of about 10 minutes for double glazing and about 20 minutes for triple glazing. The sensor works with vertical (facade) as well as inclined glazing (roof windows).

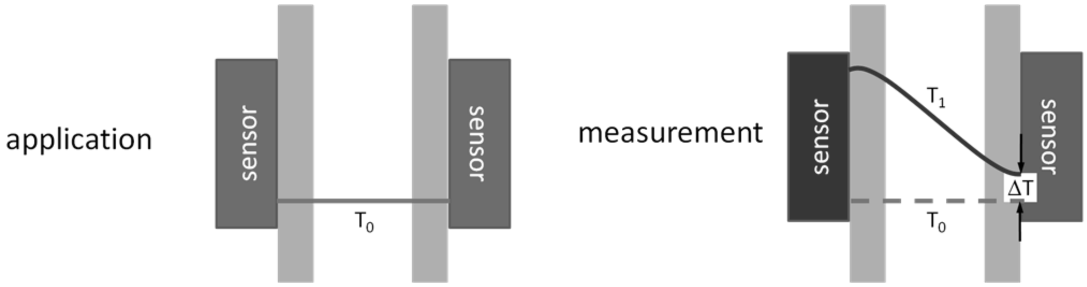

Figure 1: Application and measuring principle of the U_g-value sensor.

Figure 2: First prototype of the U_g-value sensor (left) and field test with anti-fall guard (right).

3. Conclusions

The newly developed mobile sensor allows fast and accurate measurements of the U_g-value on-site:

- measuring time few minutes,
- measuring accuracy about ± 10% or ± 0.1 W/(m^2K) whichever is higher,
- also suitable for inclined glazing (roof windows).

A commercialization of the sensor is planned by the company Netzsch. It should be available end of this year.

4. Acknowledgements

This research was carried out as part of the project “Development of a new evaluation tool to determine the energy savings potential of window refurbishment including effects of glazing, frame and connection” and was funded by the German Federal Ministry of Economics and Technology by resolution of the German Federal Parliament.

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Identification of building materials influence on robustness and uncertainty of single houses LCA.

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Short Summary

The current studies highlight the problem related to the robustness and reliability of LCA. The main scope of this work is the identification of the building materials that influenced most the environmental performances of houses, and the building materials that influenced most the uncertainties of the environmental performances of houses. To do so, a statistical methodology is applied to 16 single houses.

Keywords: Building life cycle assessment, sensitivity and uncertainty analysis

1. Introduction

The assessment of environmental performances of buildings is now commonly based on a life cycle approach. The current studies highlight the problem related to the robustness and reliability of LCA. Calculation of building LCA conveys uncertainties due to: calculation model, data used into calculation and LCA user's level of practice. This study only concerns by the uncertainties related to the data used for calculation. The reliability and robustness of results in building sector is most complex than the other industrial sectors, not only due to the complexity of building but also due to their very long service life that makes this sector unique in comparison to other complex products. This induces large difficulties on how to assess the whole life-cycle of building due to the facts that the energy during the use phase as well as its nature will drastically change during the next 50 years. The service life of building materials and elements can be lower than the building itself due to the factor that can be classified in failure, dissatisfaction and change in consumer needs. The building project will pass in different stages and also in different stakeholders, so the necessary amount of materials needed for the construction will be an uncertain parameter. Uncertainties in the environmental product declaration (EPD) are also controlled by the same type of uncertainties than for other industrial sectors: environmental database quality, technological variation between materials' production plant, distance of transportation, different methods used for the demolition of materials etc. Due to these uncertainties and variability of database the results of LCA in building sector are not robust and reliable. For the building sector two main problems require urgent solutions: the minimisation of the environmental impacts and the minimisation of the uncertainties of the database used for calculation.

2. Methodology

A possible solution is the identification of materials that most influences the environmental performances of building and identification of materials that most influences the uncertainties of the environmental performance building.
To do so we have to perform the contribution analysis that consists the sensitivity and uncertainty analysis. The purpose of sensitivity analysis is to identify and focus on key data and assumptions that have most influence on a result. It can be used to simplify data collection and analysis without compromising the robustness of a result or to identify crucial data that must be thoroughly investigated. The minimisation of the inputs value with most contribution into a result will drastically minimize the value of output. Parallel to sensitivity analysis is uncertainty analysis. The uncertainty analysis is used for the identification of the inputs variables that most influence the uncertainties of output result. The minimisation of the uncertainties of these inputs will drastically minimize the uncertainties of output.

3. Study and results

The methodology described is applied in 16 houses with different structure typologies, located in France. The environmental impact of each building material is based on values from the French environmental products declaration (EPD) available in INIES database. The variability due to these inputs variables comes from the fact that for the same material or elements there are different EPDs supplied by different producers. In the case where different EPDs were available, the mean and standard deviation is calculated, and in the case where only one EPD was available, it isn't consider any types of variability. The mean for the mass of material is considered that defined in the project and the standard deviation is calculated using a ratio for the coefficient of variation equal to 12% that corresponds approximately ±30% of uncertainty about the mean value. The mean and standard deviation for the number of use of material during the service life of building are calculated using different references. The results of the sensitivity and uncertainty analysis are presented for a decomposition of houses projects in building materials and elements.

4. Conclusions and perspectives

This paper is focused on the calculation of contribution of the building materials to the single houses LCA, and the contribution of their uncertainties to the uncertainties of the single houses LCA. To do so, the methodology used is based on sensitivity and uncertainty analysis which identified the parameters having small contribution to the output and small contribution to the uncertainty of output, the parameters having small contribution to the output and large contribution to the uncertainty of output, the parameters having large contribution to the output and small contribution to the uncertainty of the output and the parameters having large contribution to the output and large contribution to the uncertainty. Previous studies have been working with Monte Carlo techniques that are relatively computationally heavy to conduct and is time consuming. The methodology is applied in 16 single houses for the global warming potential indicator. Four groups of materials are identified for a cut off equal to 10%. This study can be useful for stakeholders, on presenting the materials which affect the robustness of single houses LCA such is the plaster and material that have most negative impact to the environment such is the rock wool. In this study we have identified the four groups of materials, but further work is needed, in particular with the value of cut off. Due to its value the classification of materials will change because its value can change from a study to another.
A possible perspective of this study is the minimisation of the uncertainties of the materials in the third and fourth group. Another is the research of factors that minimize the environmental performances of materials of second and fourth group.

D1

Energy

Chair: Guillaume Habert
ETH Zurich, Switzerland

Assessment of the relevance of "embodied energy" in the building stock of the city of Zurich

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Extended Abstract

The building stock is one of the most important energy consumers worldwide. Different building stock models (BSM) have been developed in order to investigate the potentials of energy-efficiency and changes in energy supply in the building stock. In this context and on behalf of the city of Zurich a life cycle-based building stock model has been developed to assess the greenhouse gas emissions as well as the primary energy reduction potential from the building sector to achieve the so-called goals of the "2000 Watt and 1 ton CO2 per capita society" by the year 2050 [1], [2]. However, building stock models often have important shortcomings since they merely focus on the heating (and sometimes cooling and other electricity) energy demand in the use phase, neglecting the "embodied energy" demand (called "grey energy" in the Swiss context) of construction materials, building technologies and energy carriers. According to the target values of the SIA Efficiency Path Energy (Merkblatt 2040) and the target values for 2000 Watt areas (Guidelines) not only the operating energy has to be considered but also the "embodied energy" of building materials in order to achieve the objectives of the 2000 Watt society.
The goal of the project described in this paper is to provide an estimation of the embodied energy associated to the construction and renovation activities in the building park in the city of Zurich. Calculations are based, both technically and in terms of model scenarios, on the parameters chosen in the "Energy Concept 2050, the Zurich City" (EC 2050) [3]. For three scenarios (see below) relevant construction and renovation activities have been quantified and an ecological assessment has been carried out based on the underlying construction processes and associated material flows. The results are presented as gray greenhouse gas emissions (GHG), gray non-renewable primary energy demand (PEnr), total gray primary energy demand (PEtot) and gray environmental impact points (UBP) (following the Swiss Ecological Scarcity concept). The term "gray environmental impacts" is used in this report for the benefit of the reader-friendliness representative for the four outcome indicators under consideration.
In this study, the following steps have been carried out:

- A quantification of the gray energy through new construction and renovation activities differentiated by constructions elements in time from 2010 to 2050 for three scenario variants.
  1. A reference scenario (Ref. sc.) represents a moderate development of energy efficiency.
  2. An efficiency scenario (Eff. Sc.) reflects a profound effect of strict policies promoting high energy efficiency (electricity and heat) and the use of renewable energies in the building stock.
  3. An ecological efficiency scenario (Eco-eff. sc.) assumes along with improving energy efficiency also increased diffusion of design and energetic refurbishment measurements and building elements and construction materials with lower material intensity and a lower content of gray environmental impacts (GHG, PE, UBP).

- A comparison of the gray environmental impacts due to construction and renovation activities compared to the cumulative energy demand (CED) for space heating, hot water and electricity based applications.
- A discussion on the feasibility of the “routine integration” of the gray environmental impacts into the BSM and the methodology of the temporal allocation of gray environmental impacts.

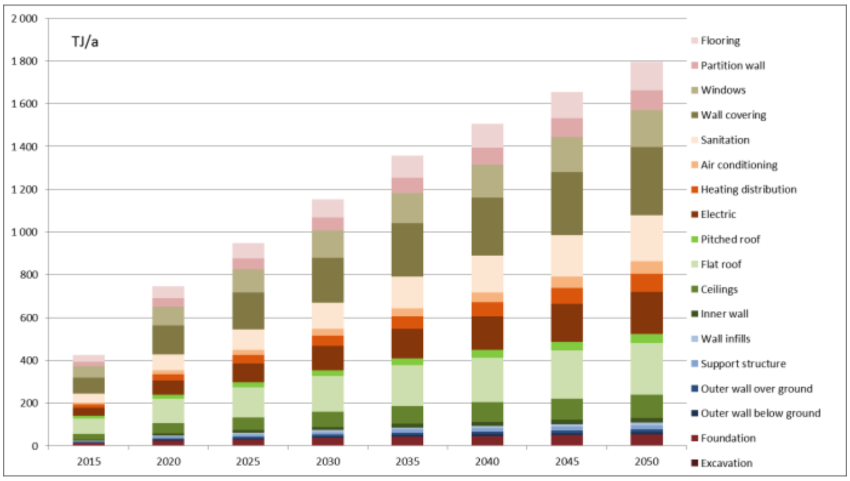

Fig 1. Embodied energy in TJ/a for the reference scenario, (Life expectancy according to TEP/Wallbaum)

The embodied energy in Zurich building stock by building new construction and renovation cumulates to TJ 1’796 (Ref. sc., Fig 1.), TJ 2’270 (Eff. sc.) and TJ 2’304 (Eco-eff. sc.) in 2050. The differentiation by construction element reveals interesting findings, for instance the high importance of flat roofs, electrical appliances, heating distribution, air conditioning, sanitation and wall covering that are often excluded in current environmental assessments. This findings need to be discussed more in detail but obviously the considered life expectancy as well as the high environmental factors of certain construction materials have a significant influence on the overall results. The efficiency scenario leads to higher embodied energy values as the reference scenario mainly because of the high material intensity of building envelopes of high energetic standards. Interesting enough, the eco- efficiency sc. leads to the highest embodied energy values. This can be explained by a much higher energetic standard that is assumed in both efficiency sc. and the increased amount of wood that is considered in the Eco-eff. sc. Some wooden building elements have a lower life expectancy than other construction materials and the currently used building material specific embodied energy values, e.g. provided in the KBOB construction material- list, seem to be too high.

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Keywords
Building stock; modelling; gray energy; 2000 watt society; embodied energy

The Energy Sufficiency Path: Basics for Residential Buildings

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Short Summary

Three strategies are needed for the implementation of the ambitious 2000-Watt Society sustainability programme: efficiency, consistency and sufficiency. The 'SIA Energy Efficiency Path' [1] is an instrument that demonstrates that the set goals can be achieved by efficiency and the use of renewable energy sources. Standard values are assumed for space consumption and user behaviour. Fundamental information for sufficiency in the use of energy is still not available.
Sufficiency entails that demands be moderate and restrained. Although technical measures are the most important factors in the field of efficiency and consistency, man and his attitudes and actions are the central point for sufficiency. In this study, the fundamentals for quantifying the sufficiency potential of residential activities will be developed. In this case, we assume moderate sufficiency.

The most important parameters are living space, user behaviour (warm water consumption, electrical devices) and day-to-day mobility (distance, method of transport). The potential for sufficiency is surprisingly high: compared with today's typical behaviour, moderate sufficiency attitudes could almost halve both primary energy consumption and greenhouse gas emissions.

Keywords: sufficiency, eco-sufficiency, residential buildings, rebound effect, user behaviour, living space, 2000-Watt Society, SIA Energy Efficiency Path

1. Context and Scope

In Switzerland the energy demands of new buildings by square metre have fallen sharply owing to advanced standards and regulations, and even the renewal rate of existing buildings is increasing slowly. In parallel, however, in the field of buildings, a significant part of the gains in efficiency is offset by elevated consumption. The living space per person is rising continuously, which has a negative effect on total energy consumption and the emissions of greenhouse gases. Starting from the assumption that this trend will continue in the future, it is at least questionable whether the turnaround in energy policy with new technologies and efficiency measures alone is possible. Although the parameters and the influence of different measures are well known in the area of energy efficiency, the basics are still missing in the area of sufficiency.
In this study, the potential for reducing primary energy and greenhouse gas emissions should be demonstrated; these can be determined by measures of sufficiency and which actors are responsible for them. New construction and refurbishment of residential buildings are considered.

2. Results

The potential for the reduction of primary energy consumption and greenhouse gas emissions by moderate sufficiency behaviour is considerable. If the identified sufficiency areas—variable living space per person, variable user behaviour during operation and mobility—are superimposed, the result is a considerable sufficiency potential:
Even in an efficient building with equipment of the best efficiency rating and energy-efficient cars, moderate sufficiency can reduce primary energy consumption and greenhouse gas emissions by approximately 50%.

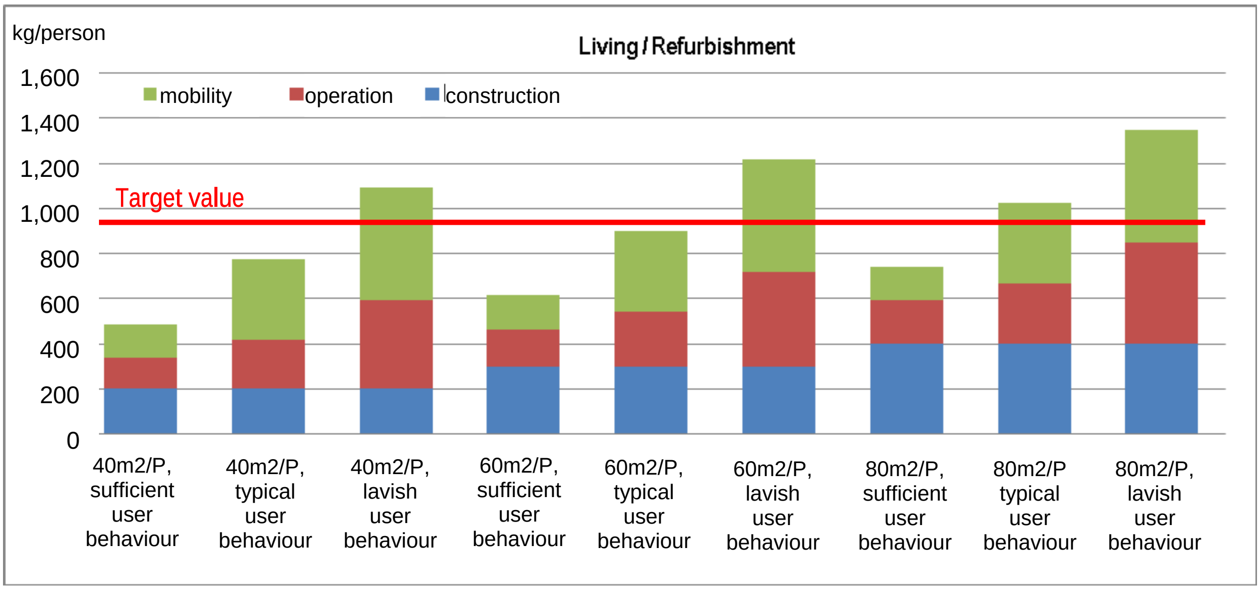

Fig. 4: Greenhouse gas emissions per person with variable living space per person and variable user behaviour in operation and mobility for a refurbished living space in the core of a city with good public transport access and an efficient building with efficient operating facilities, equipment and vehicle fleet.

3. Discussion / Perspectives

This study [2] has been able to describe moderate sufficiency behaviour for residential buildings and to quantify the different reduction potentials between primary energy and greenhouse gas emissions. This represents an important step towards an objectification of the discussion about sufficiency and its necessary extent. It also allows for an appreciation of the already planned and implemented steps building owners and administrations are taking towards sufficiency. Finally, the study allows users to compare their own behaviour with that of a typical household, a moderately sufficient household and a lavish household.

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Residential High-Rises without the usage of Air-Conditioning in Tropical and Subtropical Regions

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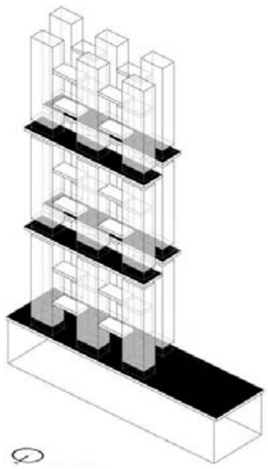
Keywords: Low Energy, Residential High Rises, Air-Conditioning, Living Comfort, Energy-Consumption, The MET WOHA Architects, Opening Requirements, Cross Ventilation, Floor Plan Configuration, Façade Structures, Building Typologies.

Extended Abstract

The extent of construction activity in Asia is at once both fascinating and terrifying. The demand for living space in the metropolitan centres has brought a construction boom for high-rise apartment buildings on a scale never seen before. In the conurbations of e. g. South Western China (among others Pearl River Delta, Hainan) there is also a damp subtropical climate. Inside the buildings the wish is for a pleasant living climate with 50% relative humidity and temperatures of 22 degrees Celsius. Out of doors humidity and temperature levels are virtually double this. As a result air conditioning is in general use for regulating the indoor climate of apartments. These electrical units with their exhaust air not only heat up further the urban spaces, which are already overheated with their sealed surfaces (40% of the air conditioning energy is given off as heat), but they need three times more energy for cooling and the achievement of a comfortable indoor temperature than is needed by a heating system for comfort in cold climatic regions. "Most tropical high-rise housing in developing countries replicate cold-climate models, with sealed facades and total reliance on air-conditioning and mechanical Ventilation." [1]
The 150 million inhabitants of the South Western China coastal region need yearly 3.000 Mega kWh input of energy [2] to keep their homes cool. According to forecasts, Chinese cities can expect to see annual growth rates in future of a million people a year flowing in from the rural areas . Not only will the urban population grow, but the energy needed for cooling is set to virtually double by 2050 [3]. This growth forecast represents a massive climate and energy challenge.

Is it possible to entirely abolish energy-consuming air conditioning systems and simultaneously maintain a high living quality, a comfortable atmosphere and sufficient natural light in a high density living environment? To find answers to this question, the paper will use 3 completed case studies: "The MET" residential high-riser in Bangkok designed by WOHA Architects Singapore,
the "URBAN TULOU" in Guangzhou designed by URBANUS Architects China and the traditional 400 years old Tulou in the Fujian Region in China. The possibilities of abolishing a/c, will appear in building analyses, interviews with experts and conclusions from detected (measured) acoustic decibel, temperature, thermal mass and wind speed. The substantial questions are: Which existing knowledge and which architectural strategies must be combined and modified to create the optimal system in respect to building energy consumption and low carbon sustainability? What is their impact in terms of architectural design? How will these conditions influence the building typologies, floor plans and detailed openings in housing construction? The paper will clarify the challenges in the design processes to realize those typologies, façade structures and opening details in tropical and subtropical conditions.



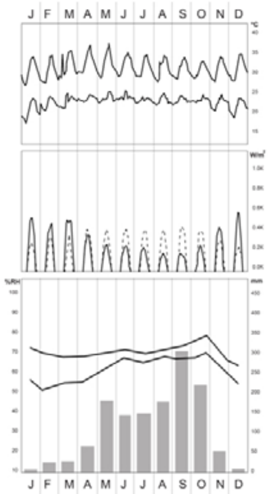


Fig. 1. Integration of Community Decks the MET, Fig.2. Weather Bangkok, Fig. 3. Integration of Greenery the MET, © WOHA Pte Ltd and Dr. Nirmal Kishnani (1,2,3)

Natural ventilation enables a renunciation of air conditioning. This requires a closer investigation of the following three levels of the building:

1. The specific porous building and facade structure of the residential buildings.
2. The floor plan configuration, which must facilitate cross ventilation.
3. The openings must meet numerous requirements and comply with external influences.

The problematizing standards of the openings can be added up to within one window. However, this requires openings that meet all these needs simultaneously. The requirements of noise, air filtering, opening cross-section, as well as sun and rain protection must therefore be equally achieved upon this single opening.

The idea of returning to the passive natural air conditioning is currently difficult to implement among tropical and subtropical cities. The electricity prices are low, facilitating a relatively affordable operation of the refrigeration systems. Air conditionings are easy to get and easy to install. Mostly these are assembled already in advance by the client or operator of the building, since this adds up to the expectations of the patronage.

Mistakenly, the air conditioning seems to present the only assumable answer to the external factors of heat, humidity, noise, and air pollution. The air conditioning is a deeply-rooted standard that meets the need of comfort in a self-evident and simple manner. Surprisingly, the floor plan conceptualizations and openings of older residential properties in hot and humid regions contain functioning cross ventilations without air conditioning. The invention of the decentralised air conditioning has changed the types of housing in the last 50 years thoroughly. We need to focus on and prove the assumption that the adaptation and reinterpretation of traditional housing typologies for new residential buildings aspires to a realization of the living comfort in a sustainable way. The shown Case Studies had become pioneer projects in its own right, representing architectural innovation in tropical and subtropical regions.

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Graphics

(1) Graphic: Integration of community decks, © Dr. Nirmal Kishnani, KISHNANI, N. Dr. "Greening Asia, Emerging Principles for Sustainable Architecture", FuturArc (BCI Asia) Singapore, pp. 263, 2012, ISBN 978-981-07-0116-1

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(3) Graphic: Integration of Greenery the MET, © WOHA Pte Ltd and Dr. Nirmal Kishnani
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Criteria For Low Energy Buildings

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Short Summary

The Recast of the Directive on the Energy Performance of Buildings (the EPB Directive) came into force on 9 June 2010. EU member states should until 9 June 2012, publish the relevant laws and administrative regulations necessary to implement its provisions. European regulatory efforts towards increasing energy efficiency of buildings are focusing on a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements. Such requirements should be the first step into low or zero energy buildings.

In this paper the consideration on different indicators for requirements of low energy and nearly zero energy buildings are presented. The scope of the paper is to show that none of the buildings system (like hybrid or natural ventilation) can be excluded from using in such buildings. This conclusion is crucial for integrated energy design process as designer should not be limited to specific number of systems solutions.

Keywords: Low energy buildings; energy criteria; LCC

1. Introduction

Directive 31/2010/EU [1] requires the introduction of nearly zero-energy buildings but does not specify a minimum or maximum harmonized requirements and detailed guidance framework procedure for calculating the energy performance of building. Member states have to define what that means exactly for them.

The requirements for nearly zero energy building consist of several specific requirements. These include primary energy and useful energy, as well as the tightness of the building and in the case of non-residential buildings useful energy for cooling. Each indicator adopted for the requirements has its advantages and disadvantages, which should be know when deciding to choice it. Poland in the proposal of the new requirements for buildings plans to introduce partial requirements and primary energy requirements.

In the paper the calculation of three systems are presented (natural ventilation, DCV ventilation and mechanical ventilation with heat recovery). It was shown that, the choice of indicator for requirements should include not only the useful energy (heat), but also electricity (heater) and other non-energy operating costs (filters). The correct ratio is multi-dimensional, and its range depends on the used assumptions.

2. The paradox of useful energy ratio - case study

In order to show the paradox of using in the requirements the useful energy the calculation of the energy demand for ventilation in the single family house were provided. Natural ventilation is unpredictable and in many situations is not working. Demand controlled ventilation (DCV) eliminates the disadvantages of natural ventilation, making it works regardless of weather conditions, and also by the ability to control ventilation can adjust the air flow in each room to the needs of users. In the paper the comparison of energy demand for mechanical ventilation with heat recovery and DCV ventilation is given.

The results of primary energy and total operation cost of mechanical ventilation with heat recovery are presented in Table 1 and in Table 2 the similar data are presented for DCV ventilation.

Table 1: The primary energy and total operation cost of mechanical ventilation with heat recovery

Parameter	Heat	Electricity	Total
Primary energy [kWh/a]	1.1*1616	3*1314	5720
Cost [PLN/a]	1616*0.20	1314*0.54	1032.76

Table 2: The primary energy and total operation cost of DCV ventilation

Parameter	Heat	Electricity	Total
Primary energy [kWh/a]	1.1*4902	3*88	5655
Cost [PLN/a]	4902*0.20	88*0.54	1027.92

The presented analysis of energy demand of different ventilation systems done on the basis of existing legislation and the given assumptions indicates a significant disadvantage for determining energy standard of buildings in units of useful energy. Forcing investors to use mechanical ventilation leads to some savings during heating period, but that decision has consequences related to the consumption of electricity during whole year. The estimation of the operation cost of mechanical ventilation does not include: the cost of filters replacement and electricity consumption of the heater to defrost the heat exchanger or to heat the inlet air. This is important in the case of high-performance heat exchangers (eg 85% such as that above).

3. Conclusions

On the basis of the considerations, the choice of indicator for requirements should include not only the useful energy (heat), but also electricity (heater) and other non-energy operating costs (filters). The correct ratio is multi-dimensional, and its range depends on the used assumptions.

As it was presented in the analysis the total primary energy demand can be higher for systems with lower energy demand for heating (DCV ventilation vs. mechanical ventilation with heat recovery). In some cases the additional energy demand for electricity for fan can provide higher primary energy demand for whole building. Also the operational cost are higher in the case of mechanical ventilation with heat recovery. It must be stated that in the cost calculation only energy cost were taken into account.

The given consideration shows that the estimation of energy requirement can not be done using only one indicator eg.: useful, final or primary energy. Such approch may leads to excluding some systems that can be other than recomended.

Part of the work presented in this paper has been done under the IEE/11/989/SI2.615952 project called MaTrID (Market Transformation Towards Nearly Zero Energy Buildings Through Widespread Use of Integrated Energy Design).

Where is the embodied CO_2 of buildings mainly located? Analysis of different types of construction and various views of the results

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Abstract

Purpose

A set of four buildings, consisting of different types of construction, is being analysed in a Life Cycle Assessment (LCA). The aim of this study is to address one essential challenge in LCAs of buildings, namely the presentation of the LCA results in a way that clearly provides valuable information for the architect, with regard to which building elements are the main contributors to the overall embodied carbon emissions of a building over its entire lifetime

Approach

The results are presented by virtually “cutting” the buildings in two different ways, focusing not only on the building as a whole, incorporating all its various materials, but also on the individual impact of each building element (floor, ceilings, external walls, etc.) on the one hand, and on the impact of a predefined standard enclosed floor space (e.g. basement space, typical floor space, roof space) on the other.

The first virtual cutting approach aims at breaking down the total kg CO_2eq of each building to the functional unit of 1 m² of general floor space (in this case the energy reference area) for 1 year of the building’s lifetime. This approach is commonly utilized for LCAs of buildings and facilitates a general comparison of the four buildings by levelling out the huge differences in building sizes. It is, however, not the best way of showing clearly where exactly the main contributors to the final result are situated within the building. When looking at a building from an architect’s point of view, there is no such thing as a general 1 m^2 of floor space to which the overall building emission results could be meaningfully allocated. Instead, each storey has its individual contributors to the final result. The floor element, for instance, only contributes to the lowest building storey, while the roof element normally only covers the top storey. Furthermore, the exterior door is usually on ground floor level, while external and internal walls are found on all storeys.

The second approach aims at systematically defining four typical storeys within a building (basement, ground floor, upper floor and loft) by their specific characteristics. The carbon emissions are then calculated for 1 m² of this specific floor space and 1 year of the building’s lifetime. The objective of this second approach is to clarify the interrelations of the different individual parts of the buildings within their overall functional context, while at the same time allowing for a meaningful presentation and interpretation of their respective impacts with regard to embodied carbon emissions.

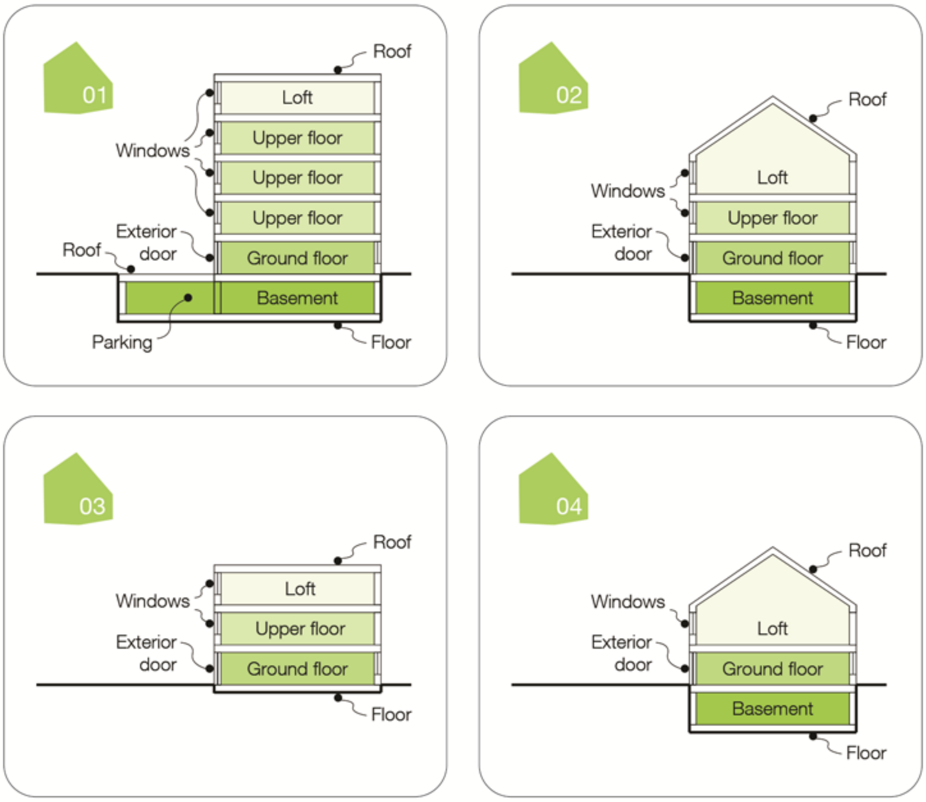

Fig. 1 Schematic view of the floor space characterisations for the virtual cutting approach 2

Findings

Different perspectives and levels of detail are covered in the critical impact evaluation of each building, giving a thorough and comprehensible answer to the question of where its embodied CO_2 is primarily located. While the first functional unit can be used in order to get a broad view of the embodied carbon emissions of the various building elements of the whole building, the second functional unit facilitates a more sophisticated allocation of the results, with regard to the anticipated location of the most relevant elements per storey. It can be observed that the second virtual cutting approach shows fewer individual differences and a more generic distribution of the carbon emission results of the four buildings compared with the results of the first cutting approach. Furthermore, using the second approach, the embodied emissions of an average square metre of basement, ground floor, upper floor and loft with a minimum and maximum deviation from the mean value can be determined. As the buildings within the depicted set exhibit a high level of variety with regard to their construction types and the embodied carbon emissions of their individual building elements, the rather high degree of homogeneity of the results as displayed by the second virtual cutting approach is especially remarkable.

Originality / value

It was demonstrated that by schematically cutting the buildings on the basis of only a few simple conceptual assumptions about the specifications of each storey, a consistent comparison of a set of diverse buildings is feasible, and that quite similar results can be generated from the direct comparison of the same storey of the various buildings. Furthermore, determining the impact of a standard storey of basement, ground floor, upper floor and loft can help architects and planners to quickly evaluate the performance of their building design by using these values as benchmarks, enabling them to localize which storey and which building elements bear the highest optimization potential for their specific project.

Keywords: buildings; carbon emissions; different types of construction; different perspectives

D2

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Zero Carbon Village

Energy self-sufficiency, Modular Prefabrication and Sustainable Building Materials

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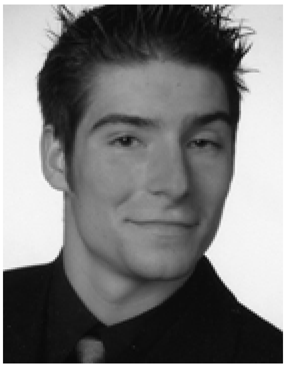

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Short Summary

Zero Carbon in the building industry is a goal that can be reached by focusing on energy- and resource-efficient solutions and by utilising renewable resources both for building materials and energy supply. The project *Zero Carbon Village* has developed solutions in three strands of development and is planning to implement them in a residential settlement:

1. Efficient modular prefabrication of building and service modules in a *virtual factory*
2. Highly energy-efficient and sustainable building materials (straw bales)
3. Energy self-sufficiency: buildings shall be supplied with renewable thermal energy

Keywords: Renewable building materials; renewable energy; life cycle analysis; life cycle design; sustainable systems for buildings

1. Introduction

A relatively large percentage of energy and resource consumption occurs in the building sector [1]. This concerns production of building materials, construction of buildings and also energy consumption within the buildings. These problems can be tackled by efficient prefabrication, sustainable building materials and an energy concept based on renewable energy sources.

2. Modular Prefabrication

In the field of industrial prefabrication, manufacturing processes of building components and modules are standardised so that the finished parts are aligned to each other. Therefore the construction time on the building site can be shortened, material waste reduced and assembly faults avoided. Continuation of modularisation should encompass the manufacturing of compatible elements for building envelope, housing technology as well as appliances.

2.1 Virtual factory

In the concept of *virtual factory* single elements or building parts are produced in a decentralised way by a network of SMEs (small and medium enterprises) around the key trades builder/carpenter. Logistics and marketing on the other hand are performed by a central umbrella organisation to increase efficiency and competitiveness. Individual enterprises thus can continue to work in their own domain and region, but realise major projects together with the other partners.

3. Sustainable Building Materials

Highly energy-efficient and sustainable building materials based on renewable resources, such as straw bales, have been proven to be functional, and show a very low primary energy demand (PEI) and positive effect for the CO_2 balance of the building [2;3;4]. With the Austrian Technical Approval (ÖTZ) in 2010, the functionality of straw bales as an insulation material has been certified [5]. There are several variants for wall construction using wood and straw as construction materials. A first variant consists of whole modules which have been prefabricated and filled with insulation material in the factory. A second option is to prefabricate individual elements and then let SMEs of the virtual factory assemble them on the construction site. Disposal of materials, renewable or non-renewable, should always be the last option (*cascades-principle*).

4. Energy self-sufficiency

In conventional energy systems in households, most appliances are operated by electricity although they actually provide thermal energy services. In contrast to this, in the Zero Carbon Village all thermal appliances like washing mashine, refrigerator or dishwasher are operated by thermal energy, thus reducing consumption of electrical energy by up to 80% compared to the median consumption of Austrian households [6]. Photovoltaic panels and thermal solar collectors are foreseen to cover the electric and thermal energy demand. However, due to imbalanced radiation over the year, especially in winter, a biomass back-up system is necessary to cover the thermal energy demand, using e.g. logs or wood pellets. Technologies for the production of both thermal and electrical energy, such as micro-CHPs, are an optimal supplement for solar collectors and photovoltaic systems in winter seasons.

5. Discussion and conclusion

The three strands: modular prefabrication, sustainable building materials, and energy self-sufficiency, each show high potential for reducing primary energy demand. For implementation and further replication on a larger scale, they have to be combined while taking into account urban development aspects. Building density, number of stories, A/V (surface area/volume) ratio and building orientation are factors that influence the heating energy demand and which are relevant for integration into the urban environment.

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Wood in Carbon Efficient Constructions

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Keywords: Sustainability, carbon efficient constructions, Life Cycle Assessment (LCA), carbon footprint, wooden buildings

1. Introduction

This paper is based on the findings of the European €CO2 project and its Austrian part EcoTimber. Both projects focus on defining the carbon footprint and primary energy balances of wooden products and houses during their full life cycle. The project consortium consists of 20 participating research organisations and companies from Finland, Sweden, Germany, Italy and Austria. The €CO2 project started in November 2010 and ended in March 2013, while EcoTimber will finish in September 2013 [1].

2. Methodological considerations

Life cycle assessment (LCA) concentrated on three environmental impact categories, namely greenhouse gas emissions, carbon storage and primary energy. LCA of construction works can be carried out on two levels: product level and building level. The project covered LCAs for wood products and buildings. Life cycle phases were defined and represented according to EN 15804 and EN 15978 [2, 3]. Generic and specific data for materials and processes have been combined. Methodological discussions within the project aimed at the definition of functional units, allocation, service life of products, building elements and whole buildings, system boundaries, energy supply, carbon storage in building elements and consideration of substitution and end-of-life scenarios (see e.g. [4]). A book published on the results of the project provides detailed information on each of these issues.[1]

3. Life cycle analysis on product and building level

For the following products life cycle inventory data was collected: Cross laminated timber (CLT), windows, doors, internal doors, glued laminated timber (GLULAM), wooden floors, solid wood boards and cellulose fibre. Data for production of these products was collected directly from manufacturers by questionnaires and plant visits. The LCA calculations were carried out using Simapro LCA software and Ecoinvent database.

Case studies on building LCAs were carried out in all participating countries. The production phase A1-3 and an observation period of 50 years were considered by all partners. The aim of the Austrian case studies was to analyse primary energy input and CO_2-emissions over

[1] The book was not yet published at the time this paper was facilitated. Information on this publication will be available from the project website and directly from the authors.

the life cycle of very energy efficient residential buildings (Passive Houses and Nearly Zero Energy Buildings – NZEB). Three existing wooden buildings, one multi-storey building (MFB), one row house (RH) and one single family house (SFH) have been chosen for this analysis. The buildings are supplied by different heating systems. For all three buildings different parameters have been modified to analyse the effect on the LCA results. Variations include different construction and energy supply systems, building concepts and service life. The figure shows an example for the assessment results: a comparison of the carbon footprint per phases of life cycle for the three case study buildings.

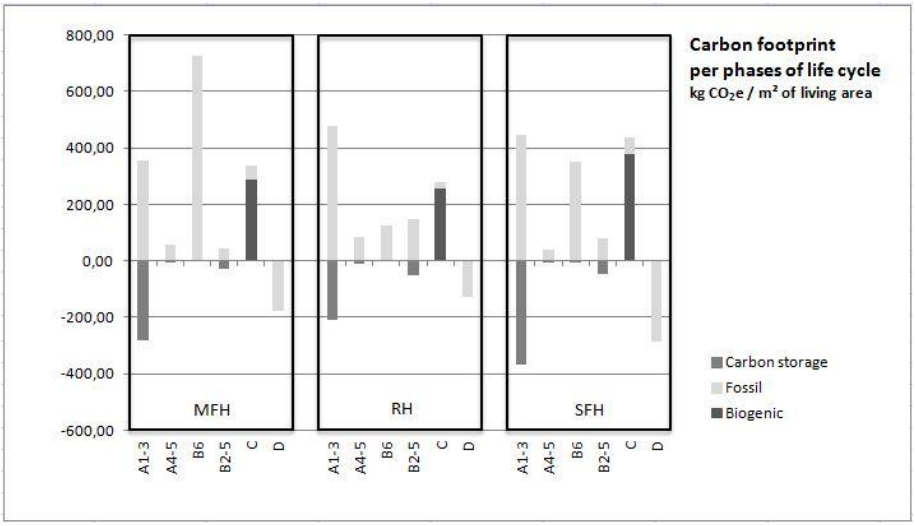

Figure: Carbon footprint per phases of life cycle (assumed service life of 50 years) for the three case study buildings (own analysis)

4. Conclusions

The following lessons have been learned from the Austrian LCA building case studies:

- Energy recovery from wooden residues can be a remarkable benefit for choosing wood for construction material. Nevertheless methodological discussions on how to balance these benefits (e.g. on substitution of fossil fuels) and on how to account for the temporal carbon storage effect of buildings should not be neglected.
- Generally, massive wood construction systems result into largest amounts of residues and bio-energy potential.
- High density architecture is more energy and carbon efficient than single family houses. Wood constructions in the multi-storey buildings should therefore be increased. Further research covering non-residential buildings would be beneficial.
- There will be a shift in the lifecycle carbon efficiency of buildings from use phase to production phase. This is because buildings require less energy for their operation.
- Including all building service installations with their ancillary materials may be very time-consuming and include large uncertainties. Further research is necessary to better cover the environmental impacts of building service installations.

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Greenhouse gas emission from construction process of multi-story wooden buildings

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Short Summary

The purpose of this study is to investigate environmental impact for construction process of wood-based building. Detailed data collection from construction work is conducted on three multi-story wooden buildings. Greenhouse gas (GHG) emission value is calculated for production stage (material production and construction) and operation stage of the buildings, and a ratio of the emission from construction process is observed. The results present that construction phase holds about 20-30% of GHG emission in the production stage. In addition, it is shown that material production phase, construction phase and operation phase of the buildings account for approximately 16-35%, 6-10% and 55-78% of the total GHG emission, respectively. Based on the results, feature of the impact for wood-based construction and an issue regarding the data collection are discussed. This study demonstrates a relevance of construction process in a life cycle assessment of buildings.

Keywords: Life cycle assessment, Building construction, Wood-based building, Greenhouse gas emission

1. Objective

Recently some researches have indicated that construction process should not be underestimated in a life cycle assessment (LCA) of a building [1-4]. The objective of this study is to review environmental impact of construction process. Detailed data collection from construction process of reference buildings is conducted.

2. Methodology

Greenhouse gas (GHG) emission value for material production, construction, and use phase of three multi-story wood-based residential buildings are assessed, and a ratio of the emission from construction process is observed. According to normative standard EN15978 [5], the studied life cycle phases are defined as module A1-3, A4-5 and B6, respectively. All calculations are conducted with Ecoinvent database V2.2. [6]. Functional unit is one m^2 of living area.

3. Results and Discussion

Figure 1 shows GHG emission for the module A and B6 for the three reference buildings. The module A1-3, A4-5 and B6 account for 16-35%, 6-10% and 55-78% of the total GHG emission, respectively. It is remarkable that the construction stage holds up to 10% of the total sorely.

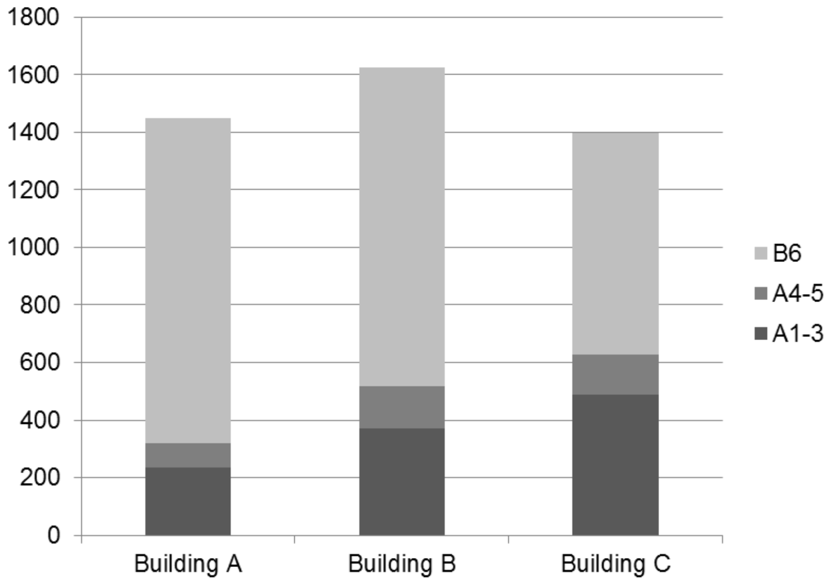

Fig. 1: GHG emission for the module A1-3, A4-5 and B6 (kgCO_2-eq./m^2)

Naturally the share is increasing for the building with lower operational energy demand. This result will change when other life cycle phases are included in the assessment to some extent. However, the ratio of the module A will also increase when the excluded construction materials and works (e.g. foundation and building services) are incorporated. Since the reference buildings are not high energy standard building, this result deserved to consider further.

4. Conclusion

GHG emission for the product, construction and use stage of the three reference wood-based buildings are assessed. The results show that the construction stage has relevant impact and especially transportation process is significant to mitigate GHG emission from the process.

Although an optimization of the construction phase may not have critical effect on overall life cycle impact of a building, it would have a major impact at an industrial (aggregated) level. The environmental impact of the process should be known to enable to optimize it for constructors and designers. Further study is required in order to collect sufficient samples and pile up the experience in order to set a practicable and reliable assessment method for the construction stage.

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Recycling and End-of-Life scenarios for timber structures

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Abstract

In consideration of sustainable buildings, closing life cycle loops becomes more and more important. Up to now reuse and recycling is taken rarely into account in building processes. With rising consumption of wood for energetic use recycling of material becomes more important.
Up to now there are various studies in EU market ([1], [2], [3]), which quantify the usage of wood in market shares. Explicit calculations on recycling of wooden material in the building sector have not yet been done. In general the demand for reclaimed wood products in the building sector will rise due to the fact that the thermal use of wood is the last option in the cascade of use. The preferred option has to be the reuse and the recycling of reclaimed wood. On this option the refinement of reclaimed wood for innovative products as well as the broadening and enhancement of the cascades of reuse and recycling is strongly needed for the timber construction industry. Long-term and resource efficient use of wood from premium quality (like laminated wood, plywood, timber frame construction) is necessary to ensure sustainable construction with wood. In the process of planning new wooden construction the dismantling and reuse / recycling of the products has to be considered too.
This article also shows different recycling scenarios for waste wood management due to the contamination problem of particular fractions. The different waste wood fractions in strength, scale and size will tolerate certain processing options with an emerging range of recycling products.

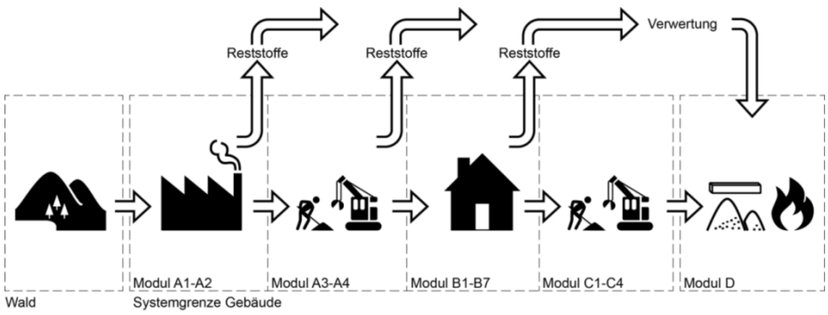

Fig. 2: residues from wood production in different phases of lifecycle

Aim is a realistic estimation of theoretical scenarios for end of life and their influence on planning processes as well as the influence on life cycle assessment according to EN 15978. In this paper outcomes of the woodwisdom-net research project ECO2– wood in carbon efficient construction – as well as calculations on wood consumption of wide-span timber structures and investigated case

studies on a very detailed level are brought together to show the state of art and theories to improve resource efficient usage of wood. In another approach the total demolition of an old wooden house in the Alps was evaluated. It is a typical example for a long-used construction with numerous repair intervals, changes, and additions. This leads to a wide variety of fractions and often to a contamination of wood from preservatives. The fractions of the demolished house mainly consist of small bits and pieces dedicated to different recycling options than wide span structures. The different waste wood fractions in strength, scale, and size will tolerate certain processing options with an emerging range of recycling products.
A better management of its renewable resources supports the material supply of the wood sector to ensure a long-term availability of solid wood products at reasonable prices. This will allow preservation and also gain market shares now and in the future.

Keywords: Life cycle; end of life; reuse; recycling; timber structures; ECO2-project

Regulation of displacement ventilation systems combined with surface heating/cooling in passive house office model rooms

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Short Summary

Thermal comfort and indoor air conditions have been studied in model passive house office spaces comparing several heating, cooling and ventilation concepts. Thermal building simulation and computational fluid dynamics (CFD) simulations have been coupled to building and system simulation.
Results indicate that

- regulation of heating and cooling ceilings and floors require considerable heating/cooling capacities in passive house office conditions
- displacement ventilation gives leeway to decreasing ventilation volumina below the level assumed for mixed ventilation

Keywords: Passive house building standard; office buildings; displacement ventilation; surface cooling/heating.

Introduction

Thermal and hygienic comfort problems and increased energy consumption may occur in office spaces built according to the passive house building standard. Systematic studies on appropriate parameter combinations for office space design have therefore been the aim of a major project [1, 2, 3, 4]. From a follow-up study this contribution selects two topics

- regulation strategies for heating and cooling ceilings and floors
- potential of displacement ventilation for decreasing ventilation volumina below the level assumed for mixed ventilation

Methodology

Thermal comfort has been assessed according to ISO EN 7730. Air quality has been estimated according to EN 13779:2008 as CO_2 concentration of indoor air with classes IDA 1 to 4 referring to CO_2 concentrations ranging from < 800 ppm to < 1900 ppm CO_2. Using model spaces, several heating cooling and ventilation concepts have been studied. Systems compared include thermally activated ceilings, plaster ceiling cooling/heating, suspended overhead cooling/heating panels, and underfloor cooling/heating – differing in their levels of thermal inertness resp. in cooling/heating capacities.

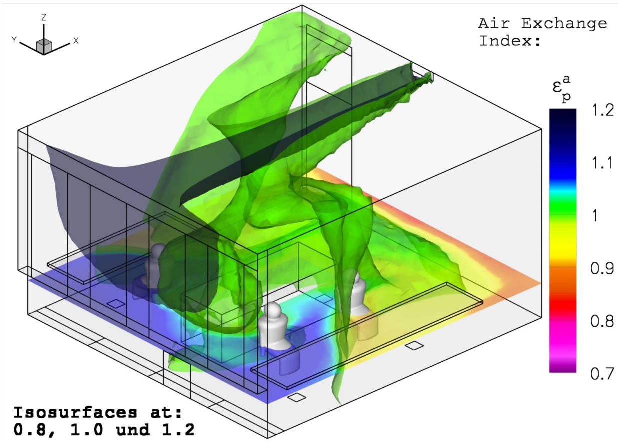

Fig 1. Model office space showing 3 seated persons, furniture and isosurfaces of air exchange index.

Building and system simulations are carried out by TRNSYS-TUD [1, 2]. For the transient, nonisothermal and turbulent indoor airflow simulation, the Finite Element Computational Fluid Dynamics (CFD) code ParallelNS is applied [3]. Both programs are coupled via PVM (Parallel Virtual Machine [4]) to a calculation system.

Results, discussion

Passive house office conditions are characterised by low heat losses but high heat gains from occupants, electrical equipment and lighting. Such heat gains develop quickly in the morning, vary with varying room occupation and thus disapear in the late afternoon. Quick responses by heating and cooling facilities are required to achieve constant – and avoid rising – temperature levels during the day.
Lowering ventilation rates by 15 % (center) still ensures lower CO_2 concentration at 0.6 m height than in the case of mixed ventilation at standard ventilation rates. Lower ventilations rates are especially welcome in winter conditions when low relative humidity of indoor air tends to cause comfort problems in passive house environments [1, 3].

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D3

Integrated Design Process

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Sustainability in Competitions: New German Federal System to verify the Qualities of Sustainability in Planning Competitions (SNAP)

Short Summary

With the establishment of sustainability requirements for public buildings as well as buildings in the private sector new demands on planners and the planning processes in Germany have arisen. These new quality requirements have to be integrated in architectural competitions. Therefore the new instrument “Classification for Sustainability Requirements in Planning Competitions” (SNAP) has been developed.

Keywords

assessment system for sustainable building (BNB) of German government; architectural competition; new tool; sustainable requirements for competitions

Extented Abstract

With the establishment of sustainability requirements for public buildings as well as buildings in the private sector new demands on planners and the planning processes in Germany have arisen.

For example, with the introduction of the new “Guideline for Sustainable Building” [1] and the “Assessment System for Sustainable Building” (BNB) [2] for federal construction measures in May 2012, the higher quality standard "Silver acc. to BNB" has to be adhered for all new office buildings. Similar higher quality requirements could also soon be defined for renovation measures in office buildings or for new schools or laboratory buildings for the public sector. In addition there is a steadily growing demand from private investors and developers for certain categories of buildings for building certifications.

Concerning the planning processes we have thereby to ask ourselves how these new quality requirements on buildings can be integrated in established competition proceedings. For this purpose, an international research project was carried out commissioned by the Federal Ministry of Transport Building and Urban Development (BMVBS) under the title "sustainability requirements in competition proceedings". The practical results are now available as follows:

BMVBS publication "Classification for Sustainability Requirements in Architectural Competitions" (SNAP)
This brochure summarizes for all parties – competition organisers, participating planners, jurors, coordinators, experts - the key recommendations of the "Classification for Sustainability Requirements in Planning Competitions" (SNAP).

Excel tool for the assessment of sustainability qualities in competition entries
With its simple and user-friendly menu system assessments on the following aspects of sustainability can be carried out:

functionality
(infrastructure provision; public accessibility; disabled access; communication-promoting areas and spaces)

comfort and health
(safety; sound insulation; daylight; indoor climate)

economy
(floor space efficiency; flexibility of use; life-cycle costs)

resources and energy
(sealing of land; building materials; energy demand; covering energy demand)

User instructions for SNAP instrument
The structure and operation of the Excel tool are explained in detail in this brochure.

comprehensive final report with an explanation of the methodology and documentation of the discussion in the accompanying expert panel

With the SNAP instrument we now have since January 2013 a new instrument at our disposal. On the one hand SNAP deals with the complex holistic demands of sustainable building in the context of planning competitions, but on the other hand it can be applied practically and without a large investment of time for all parties involved, so that the acceptance of the actors in competitions is ensured.

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Debating economic performance aspects of buildings in the context of sustainability assessments


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Summary

Assessing buildings' contribution to sustainable development requires taking into account economic performance aspects as well. Therefore, it is being discussed on a national, European and international level how economic performance aspects can be integrated into sustainability assessments of buildings and which criteria and indicators are appropriate in this regard. The present paper critically examines the current state of respective standardisation activities, assessment practice as well as possible criteria and indicators. In addition, the paper highlights and discusses open questions and problems which are associated with the attempt of evaluating the economic performance of buildings within the context of sustainability assessments.

Keywords: sustainable buildings, economic performance, valuation, cost, economic value, risk

1. Introduction

In contrast to the assessment of environmental- and health-related aspects, the evaluation of economic performance aspects within the context of sustainability assessments of buildings does not yet have a history of decades of experiences. This discussion is just beginning. As a consequence, within existing systems and tools for assessing and certifying the sustainability of buildings, economic performance aspects are only partly taken into account.

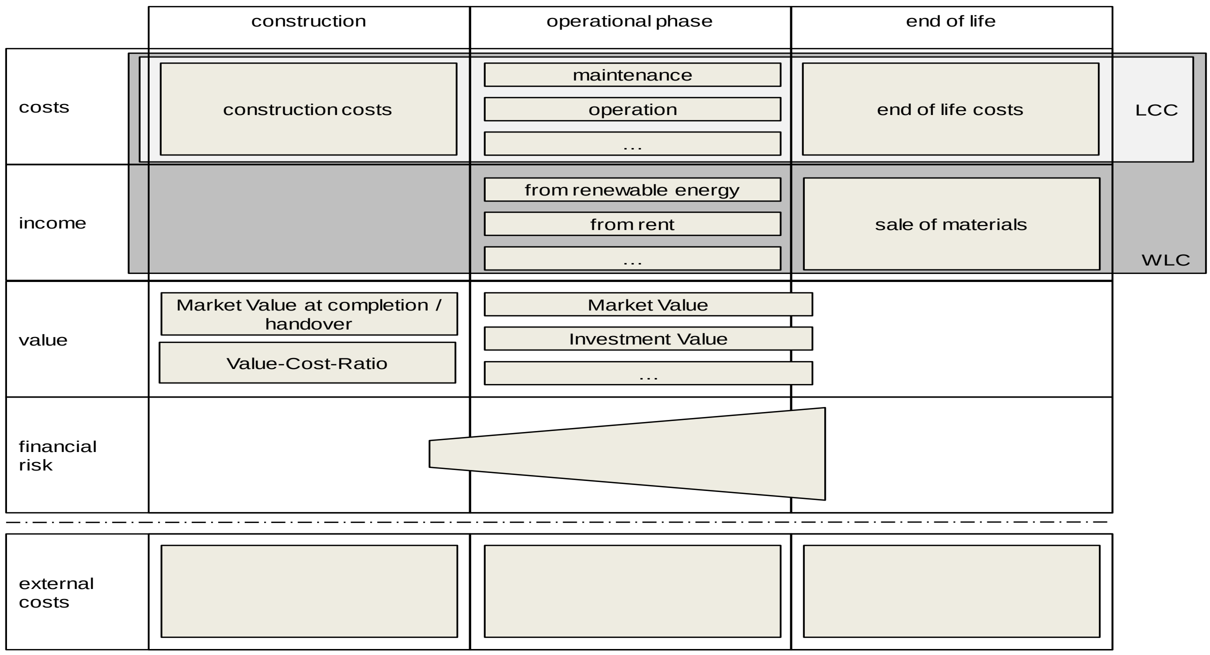
The aim of the present paper therefore lies in examining and discussing fundamental questions relating to the description and assessment of a building's economic performance, to possible criteria and indicators as well as to scopes of action and possible solutions. Particularly, the following questions are addressed within the present paper:

- Which overall areas and goals of protection lend themselves for deducing economic performance requirements?
- What is an appropriate perspective for assessing economic performance aspects – a societal perspective and/or the perspective of individual actors and market participants such as owners, tenants, banks, investors, public authorities, etc.?
- What are the differences and commonalities between a specific economic appraisal tailored to the needs of one single actor and a broader, generic assessment of a building's economic performance?
- What are key areas of concern/interest and how can these be reflected through criteria and partial indicators?
- If one accepts the proposition that economic performance aspects are already (or to be more precise: should be) an integral part of sustainability assessments, how is it then possible to evaluate interrelationships and interdependencies between a building's degree of sustainability and its economic value? Is there a loop and/or a circular argument?
- What are the interrelationships between the formerly distinct disciplines of sustainability assessments of buildings and property valuation?

2. Economic performance criteria and indicators

The following Figure 1 summarizes possible criteria/indicators which are critically discussed in the present paper and which could be used for evaluating economic performance aspects of buildings within the context of sustainability assessments.

Figure 1: *Economic performance criteria / indicators along the building life cycle*



3. Summary

This paper shows that any attempt to evaluate economic performance aspects of buildings within the scope of sustainability assessments reveals a range of unsolved questions and problems which have not yet been sufficiently discussed within national and international research communities. The authors' attempt was not to solve these questions and problems but to highlight them in order to stimulate scientific discussion and debate on these important issues.

The paper has also revealed that two formerly distinct disciplines (i.e. sustainability assessment of buildings and property valuation) are now converging and rely heavily on each other. On the one hand, sustainability assessments of buildings increasingly rely on concepts (Market Value) and methods (income/investment valuation method) originally developed by the valuation profession in order to be able to appropriately describe and asses the economic performance of buildings. On the other hand, the valuation profession increasingly relies on sustainability related information in order to be able to appropriately estimate the economic value of buildings. As such, it appears advisable for both disciplines not to attempt to "reinvent the wheel" but to rely on and make clear reference to the terminology, standards, norms, and definitions which have already been developed and applied within the respective other discipline. This requires dialogue and cooperation between the key representatives and professional bodies of these disciplines.

The interaction between sustainability and quality in building – systemic approach and case study buildings

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Abstract

Today sustainability has gained a growing acceptance in the building sector and is seen as a trendsetting part of buildings. On the other hand building processes up until now have (still only) been evaluated through differences in price and marked by the handling of failures and insufficiencies in the construction and erection of buildings. Positive effects of better building quality have not been widely identified.

This paper examines the interaction between and the impact of aspects of sustainability and the criteria of quality in buildings through a sensitivity model and evaluates it through case studies.

Firstly the elastic terms of quality in the building context and sustainability are discussed. A sensitivity analysis is produced in order to work out the importance of each aspect and to show their various interactions.

Therefore twenty variables are deduced from the firm establishment of the terms, which matter most for this topic. They constitute the set of variables for a sensitivity analysis from Vester. With the sensitivity analysis an impact matrix and an effect system are elaborated to emphasise the critical variables for the processes and variables which matter most.

On these results and for closer inspection of the correlations, sustainable buildings, which are recognised as exemplary representatives, are examined to identify the underlying principals. Processes behind planning and erection of each building were observed critically. The results of the building analysis are then contrasted with the results of the (previous) sensitivity analysis.

An effect system for the creation of sustainable buildings is developed as a cybernetic model. In this model it is outlined which prerequisites are required to develop sustainable buildings.

Aspects, which generate high impact for the whole system, are emphasised and starting points for improvements elaborated.

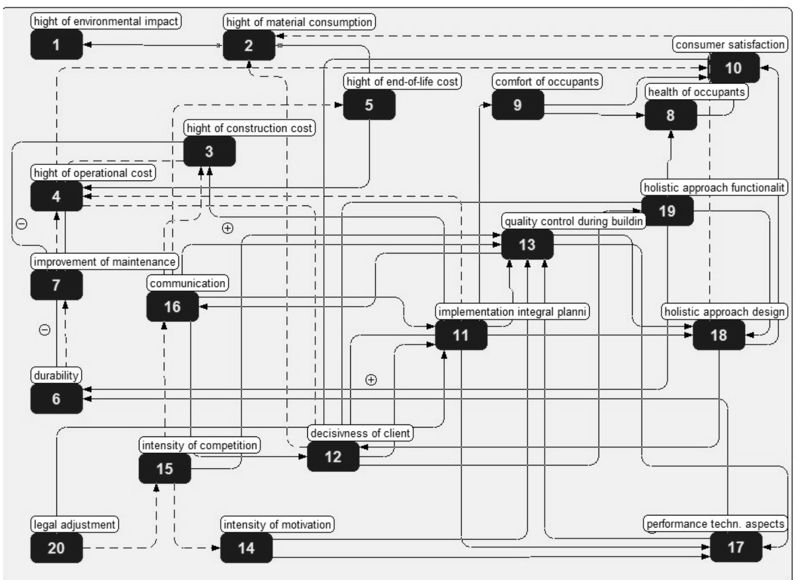

Fig. 1: effect system of interactions between sustainability and quality in buildings

Through the cybernetic model many interactions between sustainability and quality in buildings are shown. True sustainable buildings can only evolve from stronger interactions between the separate disciplines. The first step is to understand the interdependencies and interactions between the variables and then to develop the main factors so that the system changes with the lowest input.
In reaching sustainable buildings, design with its complex dependencies has to regain a central position. Client behaviour as well as quality of construction work on site are also fundamental. Motivation of planners and builders and communication between them is highly important.
More training for all parts of the building sector in these issues is necessary. A honest culture of teamwork for the best result rather than only the economic success is fundamental.

Keywords: sustainability; quality in buildings; sensitivity analysis; interaction

The impact of sustainability issues on real estate project development processes

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Short Summary

The object of this paper is to present a method to include aspects of sustainability in the various stages of project development and the processes involved in real estate development. To that end, the criteria for the certification of office and administrative buildings according to the Austrian Society for Sustainable Real Estate (ÖGNI) are analyzed and their influence is examined. Then an analysis of an ideal development process is carried out to see whether sustainability criteria can be implemented and the temporal and causal correlation between sustainability certification and project development processes are described using a matrix. As a result the authors have adapted the project development process to include all aspects necessary in their opinion for the sustainability certification of office and administrative buildings according to ÖGNI / DGNB standards.

Keywords: Project development, project development process, sustainability, ÖGNI, certification systems, real estate industry

Extended Abstract

The concept of sustainability and the challenges it involves for us and future generations has become more and more important in recent years. As a result, "sustainability" has become a megatrend. Megatrends can be defined as tendencies in society and business that have an impact on the lives and the economy of future generations. Therefore it is logical that aspects of sustainability have become a big influence in the real estate industry as well. A survey by Jones Lang La Salle has revealed that sustainability will have the highest strategic priority for 83% of real estates professionals in the next ten years.
Sustainability certificates play a decisive role in this context and are becoming more and more important, as only a building that has a certificate (label) will be considered a sustainable building by the general public.

We can only call real estate development sustainable if the following prerequisites are met:

- cost-efficient,
- ecofriendly,

- resource saving and
- optimum integration in the socio-cultural environment.

Taking its entire life-cycle into account, this should guarantee that a sustainable building is of higher long-term value to communities, investors, owners and users.

Our analysis of project development processes goes to show that they do not include the implementation of sustainability criteria in the individual phases of the process or only deal with them cursorily. Therefore it is easily possible that real estate projects fail to meet sustainability objectives. Therefore it is necessary to formulate a new, ideal project development process which includes and guarantees the criteria the authors believe to be necessary to obtain a sustainability certificate.

Figure 1 shows a new process resulting from the considerations above, the "accompanying process of sustainability management", for all stages of project development in an intermediate sense. The important element here is that "information" is condensed during the individual phases, which then has to be analyzed and assessed several times with regard to sustainability to obtain a certificate.

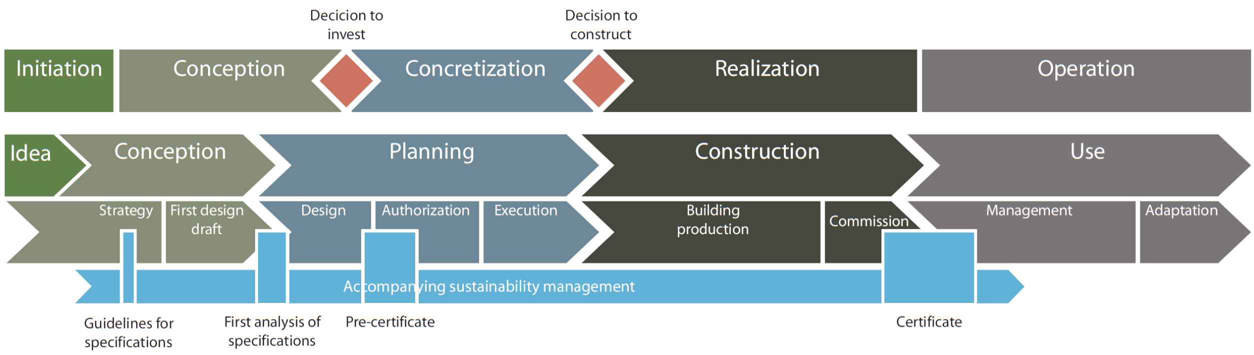

Figure 1: Accompanying process of sustainability management during the stages of project development

This approach contributes to implementing a holistic view of project development to prevent that the sustainability requirements of a building are not only considered in the limited fields of planning, construction and operation.

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Nearly zero energy target integration in public design tenders

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Short Summary
The paper in the beginning clarifies what the nearly Zero Energy Building (nZEB) means and what the advantages of an Integration Energy Design (IED) process are.Afterwards, it shows two local experiences about nearly zero energy target integration in two different public design tenders procedures.The first experience regards a restricted design competition which aims at finding the best design proposal within a restricted number of projects. While the second experience regards a negotiated design tender which just aims at selecting the design team will design the new public building. Results show how to integrate, require and evaluate the results of different tender procedures, advantages to use IED process.

Keywords: nZEB, IED, public design tender.

1. Introduction
The Directive 2010/31/EU [1] invited public authorities to develop plans to increase the number of nZEBs. This paper proposes a way to increase the number of nZEBs including the zero energy balance target within public design tenders for new buildings (or for building renovation) and pushing the design teams to follow an IED process. The paper shows two local experiences about energy performance requirements integration into public tenders.

2. Integrated Energy Design process (IED)
One of the key approaches suggested is the enhancement of the decision making process through an Integrated Energy Design. The IED is a multidisciplinary, collaborative process that analyses the whole building process and integrates different aspects and knowledge during all phases of development of the building. The main advantage of the IED is that the design decisions can be taken when the cost of design changes does not influence the overall construction cost.

3. Nearly Zero Energy Buildings
The presented design tenders include the nearly ZEB concept, such as introduced by EPBD recast 2010 and defined within the international project“IEA SHC Task 40–ECBCS Annex52: Towards Net Zero Energy Solar Buildings”. The nZEB requirements part included in design tenders consists of energy performance indicators (energy balance, heating/cooling/electric demand, IEQ level, etc.), energy calculation methods (tools and methods) and evaluation methods (ranking procedures through assignment of points and weighted sum).

4. Alpine huts design competition
The first experience related to three new alpine huts, for which the design competition is now closed, was realized in collaboration with the Province of Bolzano. When the collaboration with the Province started, the public design tender was already published. The nZEB target was added during a later phase of the design tender publication, and the energy concept has

not been considered in the definition of ranking. Therefore, the nZEB target was not mandatory and the energy design section included in the tender was just considered as guidelines for the design teams. Nevertheless, simplified tools were also provided in the tender to support design teams to develop an energy strategy. Even though the ranking method did not consider explicitly the energy concept, EURAC evaluated each project from the energy point of view and the Provincial Committee could take into account such evaluations. Despite some design proposals had no energy concept description, the energy requirements seem to influence the design concept: compact building shape, solar optimized orientation of building surfaces and energy functional indoor space layout characterize most of the design proposals.

5. Negotiated tender to design a new elementary school

This second experience is part of the Affirmative Integrated energy Design Action project activities. The AIDA, financed through the IEE programme, aims at setting up strategies to support local authorities in pursuing this target.Thanks to AIDA support we collaborated with the Municipality of Merano in drawing up a public tender for design service for a new elementary school complete of the integration of the nZEB target as a necessary energy requirement. This kind of tender, called Negotiated tender aims to select the design team will design the new building. An energy section added to the public tender, explains what nZEB means, by defining the energy balance calculation method, metric and weighting factors, physical boundaries of the building system [2], and requires to manage the design time through an IED process. This energy guidelines section supports the design team to enhance energy performance issues and to develop an energy strategy well integrated into the architectural concept. The ranking method considers explicitly the energy concept and assigns points to design proposals depending on criteria to achieve nZEB target. The tender deadline is the 22nd of May 2013.

6. Conclusions

The tenders procedures analysed have different timing and objectives. Both procedures include energy guidelines about energy performance indicators, energy balance calculation method, ranking criteria and IED process management guidelines. The different objective of the tender procedures has influenced the way energy performance requirements are included into the tender. In the first case, the design competition, is necessary to support the participants supplying simplified tools to calculate the energy balance in the same way, in order to compare energy performances. While in the second case, the negotiated tender, is necessary to introduce energy guidelines that will be used in a second time from the winning design team. In both cases the IED process is considered a necessary approach to increase the quality of the design proposal, from aesthetic, functional, energy efficiency and economic point of view.

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D4

Sustainable Assessment

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Realising Blue Buildings? - Life Cycle Management as an integrated management philosophy for blue building projects

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A new focus for Blue Buildings

The core question to be discussed seems to be rather basic but difficult: What is a sustainable success of a building? Green buildings reached already a high standard of ecological and technical know-how integrated. Blue buildings suffer from a missing common understanding. They are assimilated with the optimized Life Cycle Costs. Every company would not be satisfied if its economic success was only measured at the expenditure. You have to take the earnings into account too. In future a holistic statement on the long-term success of a building needs to integrate Life Cycle Costing on the one hand which covers the total investments and on the other hand earnings out of rental income and sale proceeds over the Life Cycle. Sustainable success can then be defined as the optimized mix of minimizing the (Life Cycle) costs and maximizing the value of the building.

Keywords: Life Cycle Management; Blue building; value and earnings, controlling of sustainablity.

1. Requirements of Blue Buildings

In construction project management the main goal was to realize a project in the shortest time, at minimum (investment) costs and in the best quality. Today buildings demand to be "green" and "blue" what means to be ecological and economical sustainable. Already the project development faces these new challenges and the change of behaviour of investors and users which occur out of a rising consciousness on the relevance of the operation phase and its costs.

The main question is how to realise the ideas of blue building. What are the main aspects and criteria of blue buildings and what management issues do we have to focus on? The management philosophy Life Cycle Management in construction is the sustainable way to cope with these new requirements. The core skills of professional construction project management have to be extended with expert knowledge of life cycle oriented design and build.

2. Efficient ways to Blue Buildings

Out of the practical experience these five Life Cycle Management aspects lead to blue buildings.

(1) **Focus on life cycle costs instead of investment costs and additionally have the value and the earnings in mind as basis for all relevant decisions**
A deeper view on the economic approach of sustainability shows that with the determination of Life Cycle Costs already the impact of the whole life cycle is taken into account. That seems to

be sufficient. But sustainability should lead us further to a holistic approach which includes the perspective of investment and earning out of the recovery of the property. There might be economic advantages, if an investor invests more investment costs and even more life cycle costs, if the earnings increase bigger. It will be discussed which investments make sense in a long term examination.

(2) Use systematically experiences out of the operation phase during project development and design and integrate the learnings in the organisation and in design & construction contracts.
The basically clear demand for optimal use of experience from later phases turns out to be a real organizational challenge and a challenge in defining the contracts for all participants in regard to its actual implementation.
The Integrated Planning Team offers a solution-oriented approach. There at a very early stage the entire planning (design) is carried out by a team that involves not only an architect and a structural engineer, but in particular also consultants in the areas of building services engineering, electrical engineering, energy technology, building physics, acoustics, façade construction and depending on the type of project further specialists. A key role is transferred to the Facility Management Consultant who provides the experience from operating.

(3) Develop a maintenance program for the 2nd and 3rd Life Cycle in early project phases to enlarge the lifespan and integrate the requirements in the building concept and design.
A maintenance program is an important tool to optimize the investments for maintenance, repair, overhauling and services. If the focus is on a 2nd and 3rd Life Cycle (that means 60-90 years) and not only on 20-30 years, the importance of maintenance - including alteration - is evident. The experience shows that with this new view the design process and the questions, that have to be answered, have to be modified.

(4) Apply (long-term) Opportunity and Risk Management in the whole project development process for a continuous project optimization.
Active Risk Management allows identifying risks early and ensures in the implementation of measures to avoid and reduce risks in sufficient time. Life Cycle Management considers not only risks during planning and construction but also during operating and alteration. Opportunity Management ensures that optimization and cost-reducing potentials are efficiently utilized.

(5) Controlling Systems for sustainability to ensure the concept of blue building is realized effectively
Sustainability and the blue building philosophy is part of the objectives of most real estate projects nowadays. To ensure that this is not just an add-on in the marketing brochure controlling tools are necessary. To achieve sustainable buildings the implementation of controlling tools in all phases of the life cycle is essential. The paper presents successful examples of controlling.

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Benchmarking of DGNB-Certified Buildings in Austria

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Short Summary

Since 2010 the Sustainable building certification system DGNB is in use In Austria. The Austrian Sustainable Building Council (ÖGNI) was founded in 2009, cooperates with DGNB-Gemany and adapted the German certification system for sustainable buildings to Austrian conditions [1]. This paper focuses on the results of sustainable building certifications in Austria in order to obtain benchmarks for the future development of the assessment system. The certification body of ÖGNI controls the quality of the submitted building audits. In a third party conformity evaluation, the conformity with the documentation guidelines and the certification system is verified. Meanwhile, about 50 buildings were certified by ÖGNI.

This paper presents the results of the first building certifications. Several certified office buildings are presented. A statistical analysis of the results of all evaluation criteria was performed and evaluated anonymously. The analysis shows which criteria achieved high and low assessment results. Conclusions concerning further development of the evaluation system are derived. Special emphasis is laid on benchmarks for ecological and technical criteria. Furthermore recommendations for a higher transparency of the results are made.

Keywords: ÖGNI; DGNB; Sustainable building certification; Benchmarking

1. Introduction

The DGNB/ÖGNI Certificate is a transparent and comprehensible rating system, which is based on the CEN/TC350 approach. It defines the performance of buildings in a comprehensive way – with 5 plus 1 topics, and enables auditors to conduct an evaluation systematically and independently. The building's performance, by reaching a defined degree of performance, is assigned a bronze, silver or gold award. Furthermore, grades are given for the total performance of the building as well as for the individual topics.

The DGNB/ÖGNI certification scheme criteria-set includes five weighted topics (main criteria groups): Ecological Quality (22.5%), Economic Quality (22.5%), Socio-functional Quality (22.5%), Technical Quality (22.5%), Quality of Process (10%) and one additionally not weighted, separately evaluated topic – Quality of the Location [2].

Each of these topics is divided into several assessment criteria. For instance, the Global Warming Potential, Total Primary Energy Demands and Proportion of Renewable Primary Energy, Thermal Comfort in Winter and Summer or Energetic and Moisture Proofing Quality of the Building's Shell are considered for the evaluation of a building. For each criterion, measurable target values are defined, and a maximum of 10 points can be assigned. The measuring methods for each criterion are clearly defined.

2. Methodology

The objective of this investigation was to learn from the first certified buildings for the development of the assessment system. Meanwhile, about 50 buildings were certified by ÖGNI and an update of the assessment system is developed currently. Therefore the results of DGNB/ÖGNI certificated buildings have been analysed in order to derive conclusions for a fine-tuning of the criteria set and the benchmarks.

The investigation includes 18 certified offices buildings that had been certified between 2010 and 2013. Data has been derived from ÖGNI and the results are presented anonymously. For each criterion the results are presented in ascending order and additionally the arithmetical mean value of all 18 buildings is shown.

3. Results and conclusions

In average relatively high results were achieved for most of all criteria groups and many criteria. Single results generally vary a lot for nearly all criteria and that proves that the assessment methodology is generally very suitable.

For many buildings in the introductory phase of DGNB-Certification in Austria the decision for a Certification was made relatively late in the project stage. Therefore some criteria of process quality couldn't be influenced or improved. The results for process quality showed the biggest variations. It is assumed, that future certifications together with early decisions should show higher values for process quality.

Most of the buildings achieved relatively high results for the criteria concerning environmental life cycle assessment (LCA), especially concerning for the combined criterion "Total Primary Energy Demand and Share of Renewable Primary Energy". Meanwhile, in the updated German DGNB system, this combined criterion is split into two separate assessments. The new structure of the German DGNB system will be adopted in Austria as well and the benchmarks for "Share of Renewable Primary Energy" will be adjusted to Austrian objectives considering the high share of renewables in the Austrian electricity mix.

For the update of the Austrian system the results of the LCA are currently analysed more in detail in order to adjust the benchmarks. Many buildings achieved better LCA results than the target values, but the amount of this overshooting has no influences on the results. It is recommended to improve the target values or to introduce bonus points for overshooting the target values. This also concerns the criterion "Life Cycle Costs".

Further adjustments should be investigated concerning the criteria "Quality of Contractors and Prequalification" and "Conditions for Optimal Use and Management" because these criteria of process quality showed very high results and small variations.

Overall the analysis showed that the DGNB-methodology is very suitable to point out individual properties of buildings that are significant for sustainable development. Therefore it is a very powerful tool to quantify and illustrate building characteristics. It is recommended to show the results of all criteria in order to increase the transparency and information content of the DGNB-certificate.

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SB13 Graz - Extended Abstract

Achieve Sustainability in Laboratory Buildings on different Ways – Building, Equipment and User Behavior

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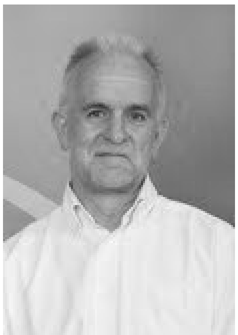
Sustainability is in the focus of many global entities and organizations. Pushed by architectural influence the majority focus on the design of buildings. In terms of life cycle, impact of laboratory process and user behavior, as well as technical equipment such as plug-in-units, seem not to be considered seriously.[1]
Certification systems for laboratory buildings barely are covered by design criteria usually used for office or industrial buildings. They are dominated by an outstanding use of energy no matter if electricity , gases, demineralized water or any other services. A laboratory may have inline pipe network of more than fifteen media.
The presentation will clearly show that a mix of topics only can achieve sustainability. Laboratory apparatus have a major influence and enable users to achieve sustainability on a high scale, provided it offers energy saving, safety and other sustainable design features. No matter how sustainable the building might be, energy consumption, work flow and influence by the laboratory process impressively dominate the impact in regard to sustainable aspects. Increasing number of plug-ins either multiply those effects.
The major doctrine must be furthermore: Safety beats any other category in the sustainability evaluating system, e.g. reduction of air exchange rates shall only be achieved after a proper risk assessment. The humans and their needs and wellbeing are much important for efficiency and research output. By those means lab designers have to keep an eye on comfort, communication options and individual situations of the users. Therefore lab planners need to be educated in safety strategies either. The general and major use of supply air in a lab building for dilution and evacuation of hazardous substances and gases is changing the character of the purpose of air ventilation. On the other side limitations in regard to air velocity because of comfort aspects are to be considered as well.
For sure sustainability hardly can be achieved in a non sustainable building with non sustainable equipment and instruments, but it is easy to operate a building with a high sustainability assessment in a not sustainable way. Users have the key to operate the building in accordance with the sustainable design criteria.
Once the building is occupied, daily monitoring of the bench marks by submetering, permanent control if the goal is still on the screen and sustainability strategies are aligned to short term change of the lab processes, will help to operate for long term the unity building-lab process-user on a level that is verified with a certification system.
Life cycle cost and assessment of the building is important but operators shall know that it makes sense only if the process and its LCC caused by inevitable equipment and plug-in-units are considered also. Impact of the plug-in-units must cause an own sustainability certification system in order to succeed with the paradigm shift towards more sustainability.

[1] [1] EGBERT DITTRICH *“Handbuch für nachhaltige Laboratorien”*. Berlin 2012,ISBN 978 3 503 13053 5

Presenter will give an overview upon the EGNATON CERT initiative including PCRs and EPDs – a certification system for laboratory apparatus and equipment.
The learning lesson is to bring the different categories of sustainability in a balance which follows a global standard in order to provide transparency and acceptance. If entities, public bodies and authorities will not agree upon consensual assessments and the meaning of sustainability differs there is no option to penetrate sustainability to private and public life.
By those means sustainability must be defined in a new way for laboratory buildings and shall be understood in a holistic view.
Some important issue is: Our modern society expects that the industry in general provides sustainable products, substances and processes for the future. By those means research has a clear order which can be achieved only in sustainable buildings and work environment. As a surgeon will not succeed a surgery in a grubby operation theatre, researchers need a sustainable environment to develop sustainable results.

Keywords: Certification; Laboratories; LCC; Plug-in-Units; Sustainability; User Behavior; Ventilation; Safety

Time Valued Life Cycle Greenhouse Gas Emissions from Buildings



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Short Summary

The UK has adopted legally binding carbon emission reduction targets of 34% by 2020 and 80% by 2050 (measured against the 1990 baseline). Emissions from buildings consist of both operational (Oc), produced during use, and embodied (Ec), produced during manufacture of materials and during construction. Oc occurs over the lifetime of a building whereas the bulk of Ec occurs at the start of a building's life. A time value for emissions could influence the decision making process when it comes to comparing mitigation measures which have benefits that occur at different times. An equation is proposed, which weights emissions according to when they occur during the building life cycle, and which effectively increases Ec as a proportion of the total, suggesting that reducing Ec is likely to be more beneficial, in terms of climate change, for most new buildings.

Keywords: Carbon, CO_2, emissions, time value, embodied, operational, discount, life cycle, weighting.

1. Introduction

Global temperatures are expected to rise by between 1.1 and 6.4°C by the end of this century, depending, to a large extent, on the quantity of anthropogenic greenhouse gases (GHG) emitted in to the atmosphere from now onwards. The UK along with many other countries has adopted a target limit of 2°C of warming, which requires global GHG emissions to peak by 2020, and has adopted legally binding carbon reduction targets of 34% by 2020 and 80% by 2050 (measured against the 1990 baseline).

Buildings are responsible for both operational emissions (Oc), produced during use, and embodied, emissions (Ec), produced during manufacture of materials and during construction. To date most effort has focused on reducing operational emissions but it will not be possible to reach reduction targets by reducing Oc alone and substantial reductions in Ec will also be required. One of the main differences between the two is that Oc occurs over the lifetime of a building, whereas the bulk of Ec occurs at the start of a building's life. Therefore, an important issue that needs to be addressed is whether emissions avoided now are more beneficial than emissions avoided in the future.

Time related issues considered in this paper are: the urgency of the need to achieve large emissions reductions by 2020 and 2050; the reduced cost of mitigation measures the earlier effective action is taken; future decarbonisation of energy supply and more energy efficient building equipment; delayed emissions and the relationship between emissions and atmospheric concentrations over time.

2. A time value factor

Factors are derived for the three issues, a discount factor, a decarb factor and a delay factor, which are then combined to produce an overall time value factor (TVF). Figure 1 shows these factors, together with a proposed close fit curve for the combined factor.

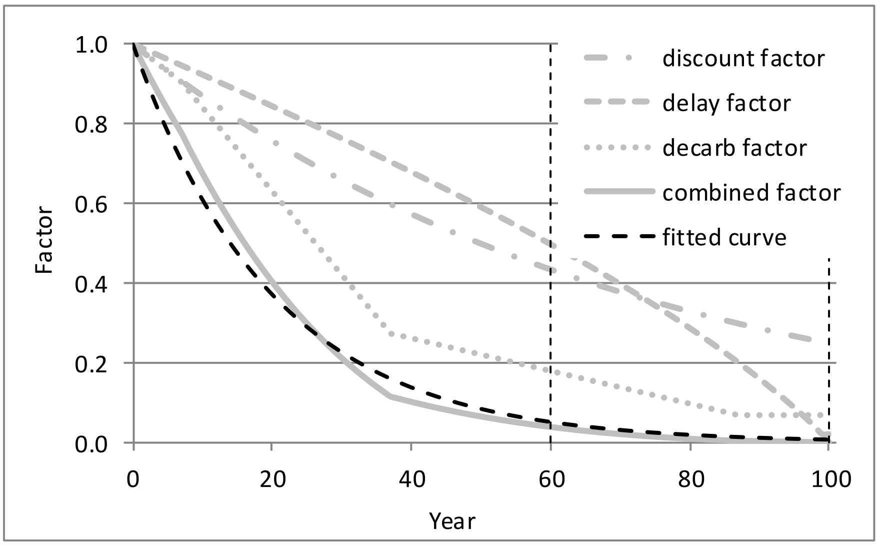

Fig.1: Combined factors for emissions occurring in the future

The close fit curve proposed here is represented by Equation 1

$$Weighting\ factor = \sum_{n=1}^{n} x_n e^{-0.0495n} \tag{1}$$

where n is each year in which emissions occur and x is the proportion of total emissions occurring in any year n.

Assuming equal emissions per year, the overall ‘net present value’ (NPV) of Oc for a given period is the area under the combined fitted curve for that period multiplied by the annual emission. For periods 0 to 60 years and 0 to 100 years the overall NPVs are approximately 32% and 20% of the unfactored emissions.

3. Conclusions

It seems likely that substantial reductions in both Oc and Ec from new buildings will be required to meet the UK emissions targets. The proposed TVF put forward for discussion and comment in this paper is described by Equation 1. A TVF of this type could be a useful tool for assessing and prioritising building options to achieve the most beneficial overall GHG emissions outcome, for example when making comparisons between embodied and operational emissions.

A time value for emissions has implications for life cycle assessment methods used for evaluating embodied emissions for materials, products and complete buildings. Factored ‘end of life’ emissions have a much reduced influence and this suggests that ‘cradle to grave’ assessments may give very similar results to ‘cradle to site’ assessments. If this is the case, embodied carbon calculations using very much simpler ‘cradle to site’ assessments could be justified.

When taken at face value, Oc usually appears to dominate and is the focus of reduction strategies. However, when appropriate allowances are made for future scenarios, reducing Ec is likely to be more beneficial, in terms of climate change, for most new buildings. Thus giving higher priority to Ec reductions is likely to result in a bigger positive impact on climate change and mitigation costs.

The influence of structural design on the sustainability assessment of building constructions

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Short Summary

The assessment of structural design is regularly not implemented in certification systems. Thereby construction details can exert an enormous influence on the (technical) sustainability of a whole building. This paper describes the development of an evaluation model that allows the assessment of building constructions due to their technical/functional sustainability. Aspects such as maintenance, disassembly, dismantling and recycling are implemented in the tool. The practical test of the evaluation model was based on selected buildings and showed the strengths and weaknesses of the tool.

Keywords: sustainability, building evaluation, building certification, building construction, structural design, technical sustainability, certification system

1. Introduction and background information

Actual discussions about strengthens and weaknesses of different structural designs are influenced by the paradigm of sustainable development. 2004 the European Commission mandated the “Development of standardised methods for the assessment of the integrated environmental performance of buildings”. This suite of standards will influence planning, construction and operation of buildings as well as their demolition. Beside the environmental, economic and sociocultural dimension the consideration of the technical and functional performance over the entire life cycle of buildings is a basis for the assessment.

Meanwhile numerous methods for the assessment of sustainability are available, but the technical performance is often ignored. While a structural Due Diligence offers a snapshot of the condition of a building, building certifications describe the integrated building performance over the whole life cycle, although there is a lack of structural design and its effects on the building performance in the assessment.

Current real estate assessments methods forecast the market behaviour on a monetary level, but are not able to comprehend life cycle aspects. Anyway the interest in certified buildings is steadily growing because they let expect a higher return on investment. Normally certification systems are ex-post-assessments and not developed (at the moment) to be applied during the planning process.
The comparison of commonly used certification systems in Europe and the associated literature displayed that an advanced consideration of structural design didn’t happen. Thereof the approach of implementing structural design in the assessment was defined as a main topic of this paper.

2. Methodology

An evaluation tool was developed that is based on the structure of DGNB/ÖGNI and this allows to evaluate construction details including building materials and fasteners. Content and system boundaries focus only on the technical quality of a construction. Essentially for the development of the assessment model was to ensure the applicability on a component level and to facilitate the evaluation of component layers and joining techniques.

This resulted in the adaption of existing evaluation criteria and in the development of new criteria with new assessment indicators, which were the basis for the evaluation model.

As part of the practical test of the model three buildings of the Graz University of Technology have been analysed, evaluated and compared with each other. These buildings differed in their of construction, in their building method but the thing they had in common was their usage – buildings with administrative use as departments. In the front of the assessment there have been aspects of maintenance, disassembly, separation and recycling. The scheme of the developed evaluation tool is shown in figure 1 for two adapted criteria.

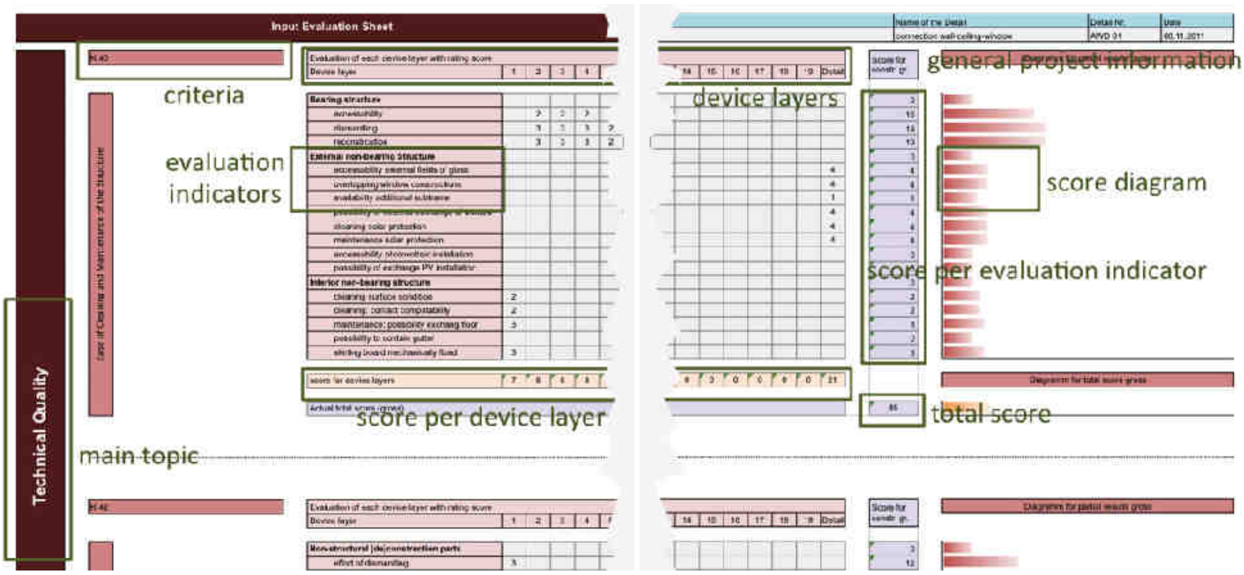

Fig. 1: Overview evaluation matrix for criterion K40

After evaluating three specific construction details (roof detail, connection wall-ceiling-window and basement) of each building, these constructions were compared with each other regarding their construction design (separability, ability for maintenance…) and their recycling costs.

3. Results and conclusions

The test showed that the model allows both a detailed and a quick review. The weighting can be adjusted individually so that single component layers can be highlighted in view of their importance. The evaluation matrix can be used both as a decision support system for planners (designers), product manufactures and producers as well as implemented into the DGNB/ÖGNI certification system. For this purpose further development is still needed.

The costing for dismantling is very difficult to calculate. The current method in practice, an estimated fixed rate, should not normally remain. In the future dismantling-friendly construction will allow to dismantle parts of a building recycling oriented and to separate single variant, which makes it possible to gain significantly higher added value out of the construction waste.

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D5

Blue Buildings

Chair: Maristela Silva
Federal University of Espirito Santo, Brazil

Development of LCA Tool for Use in Initial Stage of Housing Design Based on Endpoint Modeling of Residents

Part. 1 Examination of Assessment Framework

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Short Summary

In this study, we develop an integrated endpoint-type LCA tool for the initial stage of housing design. In this part of the study, we adopt the Japanese version of Life-cycle Impact assessment based on Endpoint modeling (LIME2) and examine the associated assessment framework for the case of a detached house.

Keywords: life-cycle assessment; based on endpoint modeling; housing; initial stage of design; human health

1. Introduction

Characterization and integrated LCA tools have been previously developed for detached houses in Japan; however, there is a need for an integrated endpoint-type LCA tool , that could comprehensively assess the direct influence of building safety and comfort on residents, as well as the cost-effectiveness of buildings at a local or personal level. Such a tool has the potential to be used as a communication tool for architects and their clients to determine the direction of housing design in the initial stages. In this study, we develop an integrated endpoint-type LCA tool for the initial stage of housing design. In this part of the study, we adopt the Japanese version of Life-cycle Impact assessment based on Endpoint modeling (LIME2) and examine the associated assessment framework for a detached house.

This proposed LCA tool considers existing earthquake risk management and human health risk assessment methods, such as disability-adjusted life years (DALY) proposed by the World Health Organization (WHO), and a function to estimate this is embedded in the method. DALY can estimate the decrease in lifespan resulting from harm to human health. However, it cannot estimate the increase in lifespan caused by improvements in human health. Incorporating improvements in human health into this tool will remain a challenge for the future.

2. Assessment framework

Based on LIME2, protected objects, category endpoint and influence region is set. Assessment framework in this study is shown in figure 1.

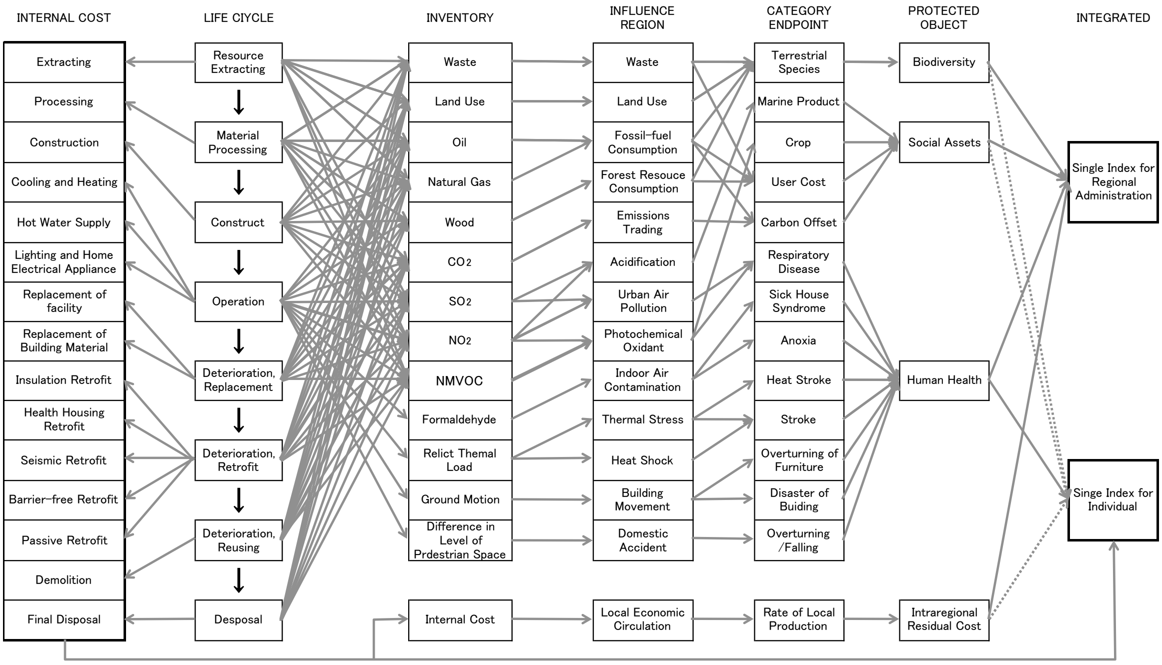

Figure 1: Assessment framework used in this study

3. Evaluation of assessment framework by case study

The cost was calculated for a case study using the assessment framework of LIME2 and the results were analyzed to examine the efficacy of the assessment framework.

A result of the full-cost assessment is shown in figure 2. Before the basic design, multiple housing types can be considered to decide on the best option. This figure shows that operational costs are highest. It is thought that a full-cost assessment would encourage the client to choose housing using the cost-effectiveness estimate from the LCA.

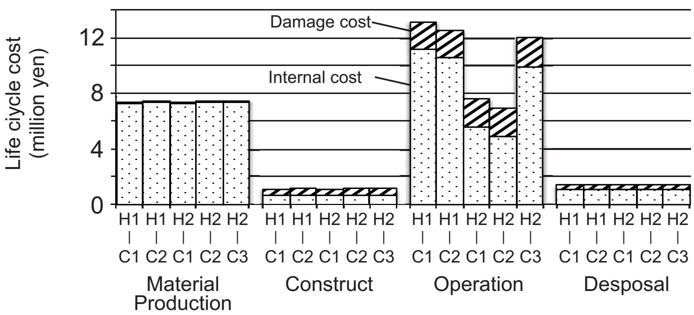

Figure 2: Full-cost assessment

4. Conclusion

In this part of the study, we have proposed a new housing LCA tool that can comprehensively assess potential damage to residents, and we have tested the assessment framework in this tool. We carried out a case study to confirm the utility of this tool. According to the case study, the overall trend of the results showed that operational costs were the highest costs.

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Contribution of plastics to the sustainability of buildings

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Summary

The contribution of plastics towards more sustainable buildings is covered from a full life cycle perspective, taking into account the three pillars of sustainable development. Environmental impacts of manufacturing are weighed against contributions in saving resources. Economic aspects are discussed in terms of the life cycle costs. A few social considerations are developed, such as health and safety of workers and users, and convenience afforded to the user.

Keywords: Plastic; life-cycle; eco-profile; insulation; windows; piping

1. Introduction

In the EU, more than 20 % of the plastics raw materials go into long life building applications, i.e. about 10 million tonnes/ year. Plastics are used in thermal insulation, window frames, shutters, piping systems, cables and cable ducts, roofing membranes, floor coverings, interior decoration, fitted furniture, fencing and decking. Photovoltaic cells and solar panels also rely on plastics.

2. Environmental information, benefits and impacts

PlasticsEurope first launched its Eco-profile Programme almost 20 years ago. There are now more than 70 detailed Eco-profile reports freely available, covering the environmental impacts and resource use of all major plastic materials. They include datasets from cradle to factory gate [1] and are an invaluable data resource for LCA studies. In line with the standards developed by CEN TC 350, Environmental Product Declarations are now being derived from these eco-profiles.

Efficient heat insulation is essential for reducing energy consumption. Combining thermal insulation with triple glazed windows can reduce energy consumption by up to 80%. All insulation materials have strong and weak features; no material is best in all applications. Any insulation level can be achieved by increasing product thickness; it is therefore more useful to assess the merits of various materials on other properties. It is worth mentioning however that the energy saved over the life time of plastic insulation compared to the energy used for its production exceeds 200:1 [2].

Plastics afford the desired insulation performance with thinner products than most competing materials. This allows optimum use of space, a key feature especially in renovation. Plastic insulation materials are also durable and maintenance free, contributing to resource efficiency.

Plastic waste is estimated to range between 0.1 % and 2% of construction and demolition waste arising in the EU [3], but the amounts will be growing in future, requiring careful consideration.

Insulation products are difficult to recycle, being often contaminated by other materials. On the other hand, almost 105,000 t of profiles and 24,000 t of pipes were recycled in 2011 as part of the schemes funded by the PVC industry [4]. In Europe more than half of plastics building and construction waste is now being diverted from landfill through recycling or energy recovery.

3. Economic efficiency

The Total Cost of Ownership methodology is an economic analysis adding up the costs borne by the owner or user over the entire life of the product. It has been applied to window profiles, water mains and sewage pipes, as well as flooring [5]. The TCO of plastic pipes is for example the lowest among the materials commonly used. Installation is the main cause of such differences for sewage pipes. In the case of water mains, it is due to purchase and use costs.

4. Social aspects

Construction products have to comply with stringent fire safety regulations. Plastics are combustible, like e.g. wood, and in some cases it is necessary to add flame retardants in order to achieve the required level of fire safety, taking care to ensure consumer and environmental protection.

Rigid products are more difficult to handle than flexible ones and are more prone to deformation, requiring special care during installation. The light weight and flexibility of plastic products contributes to easy and safe installation.

Volatile organic compounds (VOC) account for about 8 % of the total Indoor air quality related burden of disease. The main VOC contributors are paints and furniture. An assessment of the sources of exposure concluded that building materials account for about 0.2 % of total burden [6].

Plastic products are generally smooth, easy to clean, which helps maintaining a high level of hygiene at home, in health care facilities, etc. They require neither painting, nor chemical cleaning, thus preventing exposure of workers and occupants to potentially hazardous chemicals, as well as emissions to the environment. Durability, minimum maintenance needs and easy cleaning are major contributors to the convenience of users.

5. Conclusion

The criteria discussed overlap to a large extent with those used by building rating systems. Rating systems based on a broad spectrum of environmental, economic and social criteria should be welcomed, provided they are based on the entire life cycle of the building, and rely on risk assessments rather than discriminating substances based on hazard. Eco-labels should follow the same principles. This holistic view is the only one capable of correctly assessing buildings, components, and materials they are made of. The diversity and complexity of the building industry requires such a broad perspective. Its environmental, economic and social importance deserves the effort.

6. References

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Relevance of the recycling potential (module D) in building LCA: A case study on the retrofitting of a house in Seraing

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Short Summary

Following EN 15978, the informative module D allows crediting a building for the recycling potential of its materials and the exported energy. Whereas the relevance of this module has largely been associated with the environmental assessment of metals so far, it is not clear to what extent module D is relevant in the life cycle assessment (LCA) of buildings. In this paper a building renovation case study is considered to investigate and discuss the implications of including module D in a building LCA. The results initiate a discussion on the controversial module D and illustrate the potential effects of this module compared to the rest of the life cycle.

Keywords: Life Cycle Analysis (LCA); Recycling; Module D; Renovation; Environmental Assessment; Building LCA; LCA Methodology; Cradle to Grave; System Boundary

1. Introduction

According to the European standards concerning the sustainability of construction works EN 15804 and EN 15978, a building's life cycle information is organized along three major life cycle stages: (A) the product and construction process stage, (B) the use stage and (C) the end of life stage. However, for the building assessment information, the standard identifies an additional optional life cycle stage (D) describing the benefits and loads beyond the building life cycle. This stage, also called module D, allows crediting a building for the recycling potential of its materials and the exported energy. In this paper a building renovation case study is considered to investigate and discuss the implications of including module D in a building LCA.

Within the research project Reno 2020 a 4-storey high multi-family house in the region of Seraing (Belgium), including 3 apartments and a commercial space, has been renovated deeply in order to meet the current needs and standards in terms of comfort, space and energy requirements. As the project included quite some materials that are recyclable, the benefits and loads beyond the building life cycle were calculated in a cradle-to-grave LCA, including module D.

2. Results

First, the results reveal that the highest environmental impacts are related to the energy use during the occupancy phase of the building, which is in line with several other building LCA studies. However, for buildings with a better thermal performance (such as passive houses or nearly zero energy buildings) and for new constructions (with a larger of amount of materials used for the building), the relative importance of the use phase will become smaller and the decisions taken at material level will become more significant. Seen the focus of the paper, the analysis and discussion focuses on the impacts of the materials.

At the material level, the largest impacts result from the production stage. The impacts resulting from module D are in the same order of magnitude as the impacts of the replacements, and are significantly larger that the impacts related to the transport, construction and end of life of the materials. More specifically, the results show that the potential benefits from recycling the materials are considerably high for both the roof and the windows and doors (see figure). For the roof, 98% of the avoided impacts are related to the high use of steel. Also for the windows, the majority of the avoided impacts can be linked to the high recyclability of aluminium (98% of module D impacts). The high recyclability of the glass panes (with 70% recycling rate) represents only a small part of the module D impact. The impacts reported in module D for the other building elements are rather small (see figure) because of the non or low recyclability of the materials, or because of the low benefits related to the recycling process (e.g. concrete, bricks).

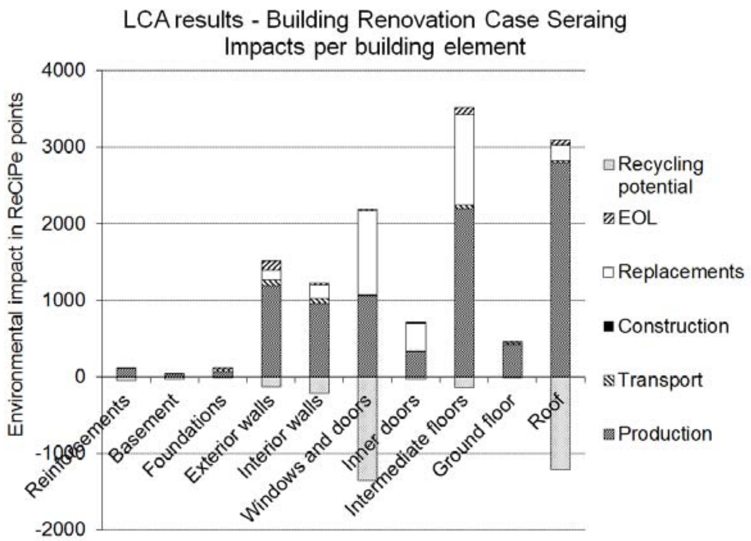

Fig. 1: Environmental impact of the materials over their life cycle, according to the different building elements, with indication of recycling potential (module D).

3. Conclusions

The present study reveals that the consideration of module D in a building LCA is possible and can be relevant. It suggests that, even though module D is stated to be optional, it can provide some relevant additional information concerning the recycling of materials at the end of life and can represent a significant part of the total building impact. For the presented case, the impacts related to module D are larger than those related to transportation, construction and end of life. However, the case also shows that the impacts being reported in module D are strongly related to the use of metals in the building. Analyses ate the material level reveal that materials with high recycling rates do not necessarily relate to high (avoided) impacts in module D. Therefore, one should be conscious that module D reports only on certain environmental impacts and does not necessarily provide the whole recycling story.

Based on this study, we can state that module D will show a considerable impact for buildings containing a large amount of metals, but these results cannot be generalized to other buildings without further investigation. Research on the recycling impacts of different types of materials is desirable to get a more holistic view on the value of module D at building scale.

4. Acknowledgements

This research has been made possible thanks to the Walloon Government by funding the research project “Reno 2020” and the Brussels Institute for Research and Innovation by funding the “Technological Support for Sustainable Construction and Development”.

Decision making processes in sustainable refurbishment projects for public administration

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Short Summary

Most existing real estate portfolio management systems lay their focus on tangible assessment criteria, leaving the value of a building for a corporation in terms of user satisfaction or support of the core business aside. Therefore M.O.O.CON developed a holistic portfolio management system which enables the user to base portfolio decisions on an analy sis of all organizational, technical and economical factors. This leads to feasible allocated resources on refurbishment projects that support achieving an organization's goals. The early planning phases of sustainable refurbishment projects are efficiently supported by assessing life cycle costing parameters for project alternatives. This method was successfully adopted from the federal province of Vorarlberg, which holds more than 120 buildings within their portfolio.

Keywords: Portfolio management, sustainable refurbishment, corporate, life cycle costing

1. Extended Abstract

While enthusiastic self-imposed code of practices as well as EU directives (EPBD – energy performance of buildings directive) demand that Austrian federal states and municipalities apply high modernization standards when refurbishing their existing building stock, public administration faces a wide array of challenges.
Considering budgetary limits of federal states and governments, a four step methodology was developed that helps public administration to successfully tackle energy efficient retrofitting projects within their existing building portfolio while focusing on a rational and transparent decision making process.
This work presents a method that allows policy makers to first evaluate their existing building stock and identify leverage points before heading into complex and costly refurbishment projects. Stated procedure, which ought to be implemented in accordance with public officials, follows four steps:

1. Developing Criteria for portfolio evaluation
2. Evaluating the existing building stock
3. Compilation of specific strategy for each object
4. Initiating sustainable refurbishment project based on specific object strategy and analyzing project's life cycle costs – see figure 1.

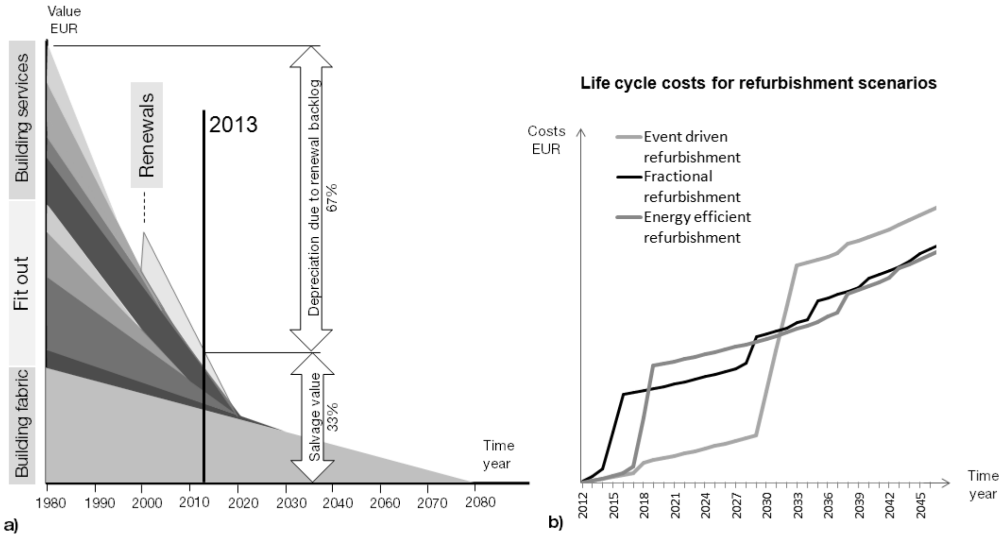

Fig. 1: Life cycle analysis for three refurbishment scenarios

1.1 Conclusion

Before concentrating on certain refurbishment projects within a given building stock, first an evaluation of the entire building portfolio allows the efficient allocation of resources. Most existing real estate portfolio management systems lay their focus on tangible assessment criteria, leaving the value of a building for a corporation in terms of user satisfaction or support of the core business aside. Therefore new portfolio management tools and methods need to be fully customized for public administration that manages buildings for own usage.
This allows a holistic and evidence based approach that support an informed decision making process. When an object strategy is derived, life cycle costing guarantees the continuous controlling of initially set goals of a developed portfolio strategy.

LCC tools and their early involvement in the planning phases of refurbishment projects undoubtedly support the planning and decision making process about procedures that account for more than only investment costs: building operation costs e.g. energy, maintenance and cleaning need to be considered when evaluating possible refurbishment scenarios (figure 1). Life cycle costing offers true costs for project alternatives and distinguishes between supposedly efficient looking scenarios and ones that do offer real benefits and advantages for the user, the organization and the environment over a building’s entire life cycle.

D6

Life Cycle Assessment

Chair: Viola John
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The need for a comprehensive and consistent approach in sustainability assessment of buildings - the EC Product Environmental Footprint

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Short Summary

To date a proliferation of sustainability claims in architecture is noticed with a main focus on energy during the use stage of buildings. Although this is highly relevant, a more comprehensive life cycle approach is needed to support decision making in order not to overlook relevant environmental burdens such as respiratory effects and land use. As a base for addressing the current confusion in the market, the Product Environmental Footprint (PEF) was developed and has recently been adopted by the European Commission. This method provides specific guidance for comprehensive, robust and consistent environmental assessment of products. It is based on four main principles: (1) multi-criteria, (2) life cycle thinking, (3) consistency and (4) ensuring maximally physically representative modeling. This paper presents the PEF in the specific context of buildings.

Keywords: Labelling, Life Cycle Assessment, Multi-criteria approach, Product Environmental Footprint, Sustainable Buildings.

Extended abstract

Although the construction sector contributes to socioeconomic development, it also induces important environmental impacts due to its energy consumption, solid waste generation, global greenhouse gas emissions, adverse health effects, environmental damage, resource depletion and land use [1], [2]. It is thus a relevant sector for reducing its environmental impact and hence an increased interest in sustainable building is noticed in the last decades. In this context, there is a proliferation of sustainability claims of buildings to date with a major focus on energy and related CO_2 and on the building use stage. By limiting the focus to a single environmental impact and/or a single life cycle stage, there is however a potential risk of burden shifting to other impact categories and/or other life cycle stages [1], [3]. In a response to that, more holistic evaluation methods have appeared such as the Leadership in Energy and Environmental Design (LEED) rating system [4], the BRE Environmental Assessment Method (BREEAM) [5] and the German Sustainable Building Council (DGNB) [6] system. These methods are more holistic because they include other life cycle stages than the use stage and consider other impacts in addition to global warming (multi-criteria).

Although methods such as LEED, BREEAM and the DGNB system have clearly their strengths in terms of comprehensiveness and awareness raising, they also show some weaknesses. They consist of a subjective weighting of credits assigned to a list of measures, covering different issues such as energy use, material choice and water efficiency; and are thus rating-based methods (also referred to as qualitative methods). The most important need for improvement identified is the consistency and rigidness of the methods for the determination of the environmental benefits assigned to each building measure and the relative importance of each of the measures. A more consistent and comprehensive Life Cycle Assessment (LCA) based (quantitative) method is hence recommended. Consistency over the different building types, but also over the different EU Member States would be beneficial in terms of transparency and comparability. It would moreover be advantageous for the assessors to have a consistent method in different building locations in terms of time and money. The Product Environmental Footprint (PEF) method exactly aims at providing such a consistent, LCA based, clear and actionable guidance. The PEF method has been developed by the Joint Research Centre (JRC) of the European Commission (EC) in close cooperation with the Directorate General for the Environment (DG ENV). It was recently published as an annex of the recommendation linked to the Communication "*Building the Single Market for Green Products - Facilitating better information on the environmental performance of products and organisations*" [7], [8]. The aim of the PEF is to bring comparable and reliable environmental information in order to build confidence and to provide the basis for addressing the current confusion of sustainability claims which is not only noticed in the building sector.

The PEF method is an LCA based method to calculate the environmental performance of a product with the overarching purpose of seeking to reduce its environmental impacts taking into account supply chain activities (from extraction of raw materials, through production and use, to final waste management). The PEF method provides guidance for modelling the environmental impact of the flows of material, energy and the emissions and waste streams throughout a product's life cycle. The PEF Guide has a high level of prescriptiveness and hence a low level of flexibility. This is seen as essential in order to obtain consistent and comparable results. The PEF Guide provides for example strict guidelines regarding the data quality, allocation, EoL allocation, cut-off, impact assessment, biogenic carbon removals and emissions, temporary carbon storage and nomenclature. The PEF method is comprehensive and includes 14 impact categories, prescribing the midpoint models, related indicators and characterisation factors to be used. This is in contrast with many other currently available footprinting methods which in general allow the user to choose out of a range of possibilities and focus on a single impact category.

The next step forward consists of developing Product Environmental Footprint Category Rules (PEFCRs) for buildings and construction products in order to increase consistency, reproducibility, relevance and comparability of their assessment. PEFCRs should moreover reduce the time and efforts needed to conduct a PEF study by limiting the scope in terms of relevant processes/life cycle stages and environmental impact categories. An alignment with the CEN standard EN15804 should be envisaged when developing PEFCRs of construction products.

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A modular LCA database adapted to different user needs during the building design process

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Long Abstract

LCA is widely recognized as the most relevant tool to evaluate building environmental impacts [1]. However, its use is still facing limitations which make it restricted to experts and researchers. Over the last few years, many works and initiatives have focused on methodologies and user-friendly tools to spread building LCA practice and ease its understanding [2],[3],[4],[5], encouraged by the growing interest for this method as a tool to achieve a more sustainable development [6]. However, few works have tried to adapt the tools to the specific needs of the different building stakeholders. The objective of our work is to make LCA more accessible to non-experts willing to assess their building projects at different stages. Depending on the goal and scope of the study, data, methods, calculation rules, etc. within LCA tools have to be adjusted. All these adjustments require advanced knowledge in order to ensure proper representativeness, respects of certification schemes requirements, etc.

A complete building LCA is not a simple aggregation of LCA of component and construction materials and has to consider other contributors. However, the component and building product contributor is still the most time consuming to describe and inherently difficult to assess. Because of this time consumption and this tool specialization, the evolution from eco-design to performance evaluation of building environmental quality is still limited. Also, LCA tools are often more specifically oriented towards one objective and then one construction project stage [7]. To promote the holistic approach, tools must provide a real continuum. This is particularly important since eco-designing should not be considered as a simple variation comparison but also as a first evaluation to reach a specific performance level. To ensure this continuum, the use of different study types as described in the European project, EeBGuide [8] is showing a growing interest. To summarize, the three study types, screening, simplified and complete, are proposed with appropriate stage of completeness and exactness in the description [9], leading to different result levels matching particular goals. To do so, scalable description systems are foreseen as one solution to be embedded within LCA tools [10]. A scalable description system will offer a way to consider smaller entities within a whole assembly, avoiding getting into the detail when not needed. Such an assembly is then considered as a "macro-component". Coupled to the scalability, the selection between both generic data (representing a whole set of products, by a weighted average for example) and specific data (representing a particular commercial reference) allows the users to evolve from aggregated and highly generic building parts to specific compound by compound description.

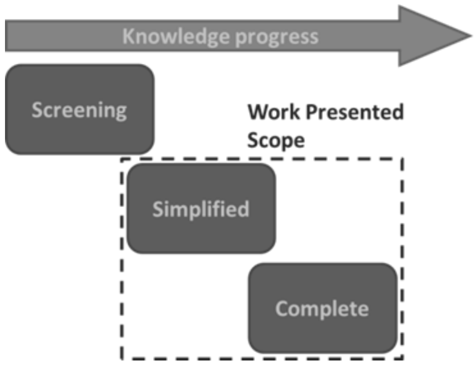

Figure 1: Positioning of this study within the three study types as exposed in the EeBGuide project *vs.* the project knowledge progress

Figure 1 makes appear the scope of our work relatively to the three study types presented in the EeBGuide project. More particularly, this whole study is focused on the building materials/products contributor. Also, the presented approach is restricted to the "simplified" and "complete" types, it could be further extended to "screening" with some evolutions partially exposed all along this paper.

Our work focused on developing such a database based on the modular principle, implementing it on an existing LCA tool (ELODIE), and validating its use for different types of studies. This paper provides an exhaustive description of the approach at different scales, supported by case studies that show its relevance and consistency depending on the considered goal and scope. They will illustrate the distances between results from LCA of early design eco-conception and final certification results or existing building models. Particularly, we focus on three utmost-interest points for practicers: reproducibility, accuracy and time-saving potential. The investigated approach is dedicated to further facilitate the deployment of LCA amongst non-expert users. Integration of such an approach in building LCA tools could facilitate the decision making at the first steps of a building project, when the potential influence of design on costs and environmental impacts is the highest.

Keywords

Sustainable building; LCA; Environmental impacts; Macro-component; Generic data.

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System and scenario choices in the life cycle assessment of a building – changing impacts of the environmental profile

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Short Summary

A case study life cycle assessment (LCA) on an office building is performed to investigate how the setting of free parameters (from the CEN/TC 350 standards) influences the results of the building's LCA in the DGNB certification scheme for sustainable buildings. The parameters concern the reference study period and the energy supply scenarios. Furthermore, a set of toxicological impact categories are included in the assessment to test whether the toxicological impact potentials follow the same trends as the impact categories already included in the DGNB methodology

Keywords: building LCA, reference study period, energy scenarios, impact categories, DGNB

1. Introduction

Both the European CEN/TC 350 standards on Sustainability of Construction Works and the DGNB International certification scheme for sustainable buildings make use of the LCA methodology to evaluate the environmental sustainability of a building. Whereas the CEN/TC 350 standards present a broad framework for the evaluation of sustainability, the DGNB International is a concise recipe for the evaluation process, complete with system boundary settings and benchmark values. In this sense, the DGNB International scheme serves as (one of many possible) translations of the CEN/TC 350 standards into an applicable scheme for sustainability evaluation.

Important system and scenario settings for the LCA in the DGNB International are:

- The choice of reference study period. For office buildings, 50 years
- The choice of energy supply for the building's use stage. Set as European averages
- The choice of impact categories. Toxicological impact categories are not included

These system and scenario choices of the DGNB scheme were questioned in the Danish adaptation process of the certification scheme and the case study was performed in order to explore the environmental impacts of the choices.

2. The case study

The case building is a low energy building (Danish 2015-standards) and the headquarters of a larger Danish company. The building was assessed using the DGNB simplified LCA methodology, including the life cycle stages of production (material extraction, transport, manufacturing), use (operational energy use, material replacements) and EoL (waste processing, disposal, reuse recycling and recovery potentials)

The following scenarios were tested:

Table 1. Scenarios and parameters assessed in the case study

	Scenario 1 Reference	Scenario 2 Long reference study period	Scenario 3 Danish energy	Scenario 4 Forecast energy supply
Study period	50 years	100 years	50 years	50 years
Electricity	EU-25 grid mix	EU-25 grid mix	Danish grid mix, 2010	Danish grid mix, average 2010-2060
Heating	District heating (100% natural gas)	District heating (100% natural gas)	Danish district heating mix, 2010	Danish district heating mix, average 2010-2060

Figure 1 presents the scenario results of the case building LCA as differences in impact potentials for scenarios 2-4 relative to scenario 1.

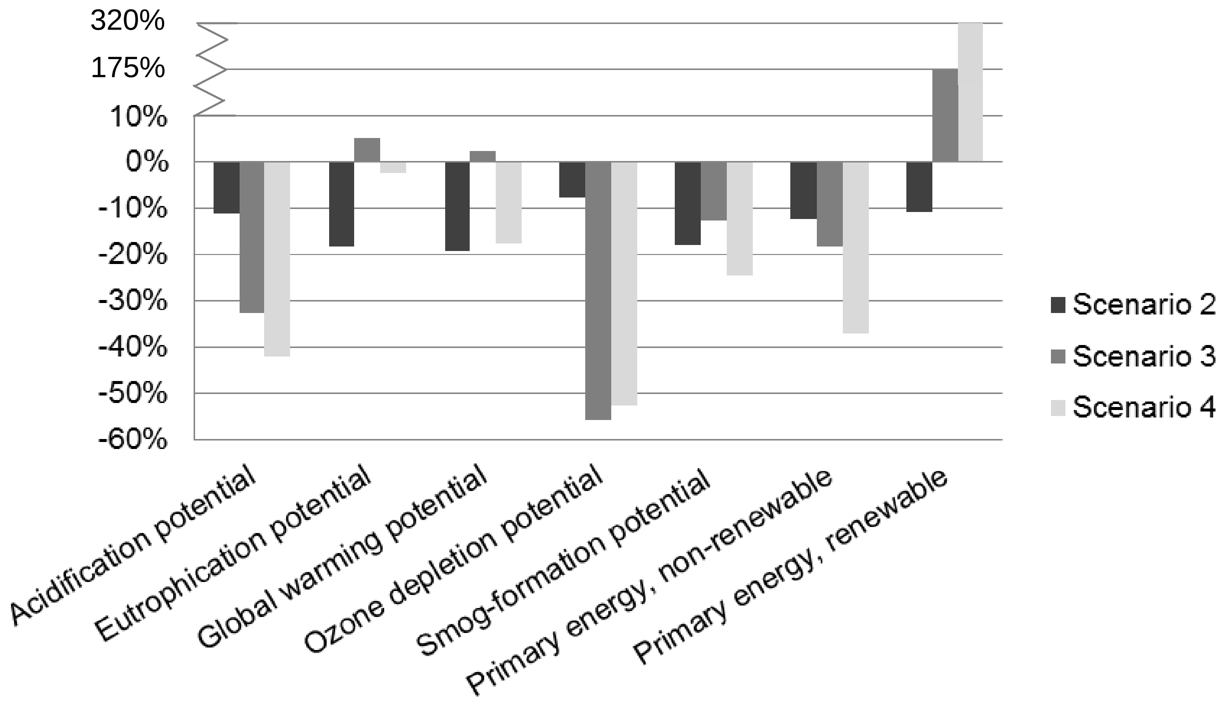

Fig 1. Differences in impacts potentials per m^2/year for scenario 2, 3 and 4 relative to scenario 1

3. Conclusion

The results of the case study illustrate how impact results change up to 20 % from a 50 year study period to a 100 year study period. A study period of 100 years can properly justify the use of long-lasting materials but increases the uncertainty of the scenarios on energy input and replacement.

National or local data on energy production should be preferred to regional data, so as to give a more correct picture of the actual environmental effects of the building. This approach is already being followed in the Danish DGNB adaptation process. The use of dynamic energy scenario modelling may prove to provide results which come closer to the actual situation of the building. However, the uncertainties connected with this kind of projections can be considerable.

The contributions from the life cycle stages to the toxicological impact categories do not follow the trends found in the other impact categories. The inclusion of toxicological impact categories thus widens the perspective of the environmental profile of the building. In practice however, it will be difficult to include the toxicological impact potentials as part of the certifications scheme, because the background data is not readily available.

Trends in Building & Construction Life Cycle Assessment

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Summary

Life Cycle Assessment (LCA) based Environmental Product Declarations increasingly become a default communication format for construction product manufacturers – e.g. based on the new EN 15804 standard [1]. In sustainable building certification schemes, particularly in those of the DGNB and its partner organizations across Europe, e.g. ÖGNI in Austria, LCA of buildings is well established as default mechanism [2, 3]. In both areas – product LCA for EPDs and building LCA for certification – the method has matured from research into daily application and planners increasingly use LCA for decision support during the planning process.
This in turn raises the question: What future developments can we expect for LCA in the construction sector?
This article indicates different upcoming developments in LCA that are either already under way – yet not necessarily generally visible – or that are likely to come. Some developments indicate increasing harmonization of calculation methods, e.g. across Europe. The European research project “EeBGuide”, for instance, yielded a comprehensive set of guidelines and provisions to uniformly conduct LCA studies in the construction sector [4].
Other developments include the assessment of new environmental aspects such as scarcity of abiotic resources, water consumption, land use, biodiversity or toxicity, always covering a product’s or building’s life cycle.
But also the improvement of LCA for use in the planner’s daily work reflects a visible trend in the field of LCA. This includes simplified methods for building LCA and automatic connections of LCA models and software to planning tools. The link of LCA to decision support in building planning – e.g. by identifying major drivers for environmental impacts of building, reported through LCA – forms another basis for future LCA-developments.
The article outlines which trends are in sight and the need for research activities in the different fields is mentioned. Focus of those discussions hereby lies on the need for pragmatic implementations of new developments into the practical use of LCA.

Life Cycle Assessment as a method to investigate the environmental performance of products and technical systems is well established in the building and construction sector. LCA already serves to assess buildings and construction products in building certification systems and for Environmental Product Categories.

Upcoming developments include, among others, increasing efforts to harmonize the method and the integration of the method into political agendas and legislation. However, the continued development of the method of LCA should hereby not be forgotten. A number of subjects for further development can be identified and should be pursued. These fields leave wide open spaces for research activities, which are often tasks for consortia of several involved stakeholders.
Some of the research fields are described: understanding benchmarks for buildings and the relevance of certain planning decisions is necessary to improve the use of LCA as planning tool and for certification. In that context, the development of justified simplification approaches is also essential to improve the method's use for planners. And finally, the development of indicators to address the information demand is necessary work.
For all new developments, two things should also be kept in mind: LCA is a method to support decisions of one kind or another, it is never an end to itself. As LCA is relevant for decision making in numerous situations, it is a method that must provide meaningful answers and if the intention is – as it is the case in the construction sector – to have planners and building practitioners to work with LCA, then the method must be provided in a way that is useful for those who should use LCA. Researchers working to improve and advance LCA should always keep this in mind and should always assure that their work is not only scientifically sound and innovative, but also helpful for those, who are intended to use LCA.

Keywords: Life Cycle Assessment; Environmental Product Declarations (EPD); Building Certification; EeBGuide; Future Developments.

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Life Cycle Assessments and the Austrian Construction Sector

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Introduction

Sustainability assessments quantify impacts and aspects in order to analyse the environmental, economic and social performance of products and services.

EN 15643 states the methodology of Life Cycle Assessment (LCA) as one of the most efficient possibilities to determine environmental impacts and aspects based on transparent data and an extensive life cycle analysis.

In recent years the application of the LCA methodology increased intensively within the construction sector. On the level of construction products LCA established as an effective option to demonstrate environmental impacts of single products with a tendency to Environmental Product Declarations (EPD), which offer a high credibility due to their independent verification. The rising number of building certification systems increases the need of LCAs for the building construction. In contrast regarding built infrastructure the LCA methodology was applied marginal so far and mainly on research level.

This paper analyses and compares the application of LCAs within the Austrian and international construction sector. It is shown, which potentials exist on national and international level, and which gaps need to be filled in the upcoming years especially with regard to built infrastructure. Finally suggestions for further LCA-based research and development projects, which should focus on the applicability and the future profit for the Austrian construction sector, are made.

Conclusions

General improvement of ecological construction assessments

The ecological assessment of building products and constructions is an important part for proceeding to a sustainable society. By now a large scope of tools, such as standards, are available to state an ecological footprint of products in several stages to the final building. But there are some problems that interfere the wide application of ecological evaluation.

- Lack of comparability and usability due to different systems and parameters in the evaluation of environmental performance. This shows that ideal characteristics are still not found. This gap must be closed in future.

- Uncertainty of background data due to unclear raw data and arbitrarily set system limits. Studies on the same topic often lead to completely different findings. Such contrary results must be avoided by better raw data and a better conformability.

- Significance regarding the whole building must be displayed. The focus must be set on the parts with the highest impact on the environment. Hence the main focus of further research works must be set on the detection of the essential products and processes of constructions.

- Period of validity due to daily changing background data. There is still a special need for a definition of the validity of an ecological evaluation.

If these aspects could be more clearly in the future the acceptance and application of decision makers would probably be higher. In addition also the other constituents of sustainability – beneath ecology - should be kept in mind. The social and macroeconomic benefits of constructions are often not easy to evaluate, but of extreme importance. Thus, the ecological evaluation must always be set into relation of all these parts.

Austrian EPD program for building products

In the last years a board of Austrian research institutes prepared the start-up of an Austrian EPD platform for building products by developing the basic documents needed for an EPD program:

- Basic document for the preparation of an EPD
- General rules for the LCA part of the EPD
- Analysis guidelines for emissions to air and environment

By the beginning of July the Austrian EPD program will start his operational work, so the first EPDs can be submitted for verification and publication.

The Austrian EPD grogram should then build the base for a bottom up approach leading to Life Cycle Assessments of buildings, built infrastructure and building components utilizing datasets representing the Austrian situation. This can be seen as first step towards stable characteristics for ecological assessments within the Austrian building sector.

Research need for infrastructure buildings

Within the construction industry infrastructure buildings are much less analysed regarding to their ecological impact than other buildings. The high potential for further research in this field is based on the following properties of infrastructure buildings:

- Long lifetimes
- High consumption of materials
- Enormous Impact of utilisation phase
- Influence of maintenance strategies
- Social end macro-economical side effects

The road LCA studies carried out in Germany, Switzerland and The US demonstrated the necessity of an ecological study analysing at least Austrian highway constructions regarding their environmental characteristics in order to build the ecological base for a future sustainability assessment tool such as NISTRA or Greenroads.

Furthermore, there should be a focus on LCA studies and sustainability assessments of further civil engineering structures such as railways, tunnels, power plants, etc. where the overall ecological consequences of the situation with and without the project need to be compared.

Posters

Renovation strategies for ageing society

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Short Summary

The specific building stock of Red Vienna represents 16% of total Viennese housing stock [1]. This stock is of significant cultural value, as a monument of an era, which determined the worldwide unique Viennese housing policy. Moreover, it represents a high social value, still bearing a large ratio in provision of affordable housing. The stock is more than 50 years old and in need of refurbishment and adaptation to the modern housing requirements. These are determined through the trends such as ageing society, increasing of housing areas [2] and of user comfort. On the other hand, the issues such as scarceness of resources and energy and minimisation of emissions must be considered in refurbishment process.
This paper presents a case study carried out on a specific housing block of the Red Vienna period. In the course of research, the economic (life cycle costing and yields), ecologic (CO_2 emissions) and socio-cultural impacts (monument protection, accessibility, assisted living) of several refurbishment variants were evaluated through quantitative and qualitative analysis. The research points out the large potentials in structural refurbishment of building stock for development of assisted living models, which prove to be substantially more cost efficient than the institutional care, providing a better comfort for the inhabitants, and also the necessary social mix through trans-generation housing in the social housing facilities.

Keywords: Life Cycle Costs, Social Housing, Assisted Living, Thermal Refurbishment, Sustainability Criteria

Towards research model

For the evaluation of refurbishment strategies by the means of sustainability criteria, a case study methodology was chosen. As specific reference object a housing estate “Elderschhof” in second Viennese district (erected in the years 1931 to 1932, owned by the federal state Vienna and administered by Wiener Wohnen) was chosen. In the first step, several refurbishment strategies were compiled:

Table 1: Summary reconstruction strategies

Reconstruction strategies	A Thermal refurbishment	B Barrier-free ground floor	C Installation of elevators and stairlifts	D Stairlifts
Starting Position	Existing building 2011	Existing building 2011	Existing building 2011 - without elevators	Existing building 2011- without elevators
Thermal reconstruction	X	X	X	X
Technical modernisation			Elevators, stairlifts	stairlifts
Modification in apartments on ground floor		Furnishing category A and universal accessibility	Furnishing category A and universal accessibility	Furnishing category A and universal accessibility

In further steps, the thermal refurbishment represented through variations of façade-insulation - systems was evaluated for life-cycle costs (LCC) [3] and the life-cycle analysis (LCA) [3].
For the thermal refurbishment of facades following variants were examined:

- Modernisation of the façade without thermal insulation measures (without TIM)
- Exterior thermal insulation composite system EPS (ETICS EPS)
- Exterior thermal insulation system mineral wool (ETICS MW)
- Thermal insulation plaster (TIP)
- Interior insulation (II)
- Vacuum insulation panel (VIP)

Finally, the developed thermal and structural refurbishment measurements were evaluated upon the sustainability criteria: economic (LCC, capital strain of rental income) [3], ecologic (CO_2 emissions) [3] and socio-cultural (monument protection, accessibility, assisted living); through qualitative analysis. The structural refurbishment strategies were compared to the gross expenses of public authorities [4] for various nursing services.

Conclusion

The study implies large potentials of existing stock for care at home, instead of much more cost intensive institutional care; reinforcing the value of stock as social capital. The comparison of the life-cycle costs concerning a structural refurbishment with the gross expenses of the public authorities points out, that nursing expenses are a multiple of the life-cycle costs caused by a structural refurbishment for accessibility in an existing building. In terms of thermal refurbishment, due to the large energy consumption during the operation, the most preferred measure is the holistic refurbishment (complete envelope) through the highest energy and CO_2 saving potential. The façade options with low potential of heating demand reduction have, despite the positive sustainable performance concerning production and maintenance, high economic and ecological life-cycle values (cumulated over 50 years), which cannot be neutralised by the positive monument conservation effects. In terms of lifecycle costs and achieved energy and CO_2 savings the ETICS EPS refurbishment variant shows the best performance over the period of 50 years, however is not compatible in terms of monument protection. As alternative, the interior insulation, causing higher ecological impact and higher skills in application, can be taken in account. The qualitative evaluation of the structural refurbishment and exploration of the potentials for providing the appropriate housing for aging society proves variant D (disclaims the use of existing elevators, but instead installs the stair lifts and enables the barrier-free living of the ground floor) as the optimal variant, both in terms of LCC as in social criteria for affordable housing (low heating costs and rent).

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GENDER PERSPECTIVES ON THE DESIGN AND OPTIMISATION OF HIGHLY ENERGY EFFICIENT BUILDINGS

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Keywords: Gender mainstreaming; user behavior; planning tools; holistic planning approaches; highly energy efficient buildings

This conference contribution presents a study tackling user behaviour and consumer aspects in highly energy efficient buildings taking into account social, ethnical, and especially gender-related aspects, and analyses the building design concept in comparison with the actual energy consumption. The interdisciplinary project team applies new socio-scientific methods to develop innovative solutions for influencing user behaviour, which undergo trial runs in selected buildings. Results will contribute to improving communication measures, design process and product development in order to tap the full potential of energy savings due to user behaviour.

According to the EU-project „BEHAVE“ (http://www.energy-behave.net/) more than 50% of energy savings are due to changes of energy consumption related user behaviour. The development towards plus-energy-buildings (buildings which produce more energy than what occupants consume) causes a change in the role of consumers: consumers turn to active stakeholders, because their way of using the building will be decisive whether the building actually achieves plus-energy status, or not. It is a precondition to fully understand the motivations and options for actions of consumers, in order to tap the full potential of energy savings related with user behaviour. In this regard, gender-specific aspects have not been considered so far.

The study presented is based on the deep analysis of new and existing buildings which comply with ambitious energy-related criteria and belong to a broad range of building typologies (multi-unit residential buildings, office buildings, schools and kindergartens, educational campus). The interdisciplinary project team applies new socio-scientific methods to develop innovative solutions for influencing user behaviour, which undergo trial runs in selected buildings. The project team investigates the process starting with the early design phase and ending with the present operation of the building. First results will be analysed, and serve as the point of departure for developing innovative solutions and measures to address user behaviour in terms of energy consumption reduction. Selected measures undergo a trial run in selected buildings. Focus is on gender and diversity aspects.

Results will contribute to improving communication measures, design process and product development in order to tap the full potential of energy savings due to user behaviour:
Design process and building construction: Lessons learnt will serve to improve stakeholder involvement during building design. Results will contribute to improve communication and information measures during building operation. Design guidelines: Results provide input to specify standard user-behaviour profiles which are used during building design. Product development: Results will provide information especially for improving building services components and house automation. Stakeholders are actively involved in the project to sensitize them for gender-related issues.

Cost optimal levels for envelope components in residential building renovation – Rainha Dona Leonor neighbourhood case study

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Short Summary

The present work aimed to study the cost optimal solutions for buildings elements in a case study, representative of the Portuguese buildings stock. The results come from the comparison between the analysed solutions' energy savings and costs.

Keywords: Building's renovation, cost-optimal, Energy Efficiency

1. Introduction

Due to the increase of the energy consumption in buildings, energy efficiency has become an important issue, when it comes to buildings' construction or renovation. In last years The European Commission is making efforts in order to help technicians in the construction/renovation to turn buildings more energy efficient. This comes from the fact that buildings are responsible for 40% of the primary energy, which makes them an important target for reducing carbon emissions [1].
In 2010 there was the EPBD recast [2]. After the recast and in order to clarify some of the changes, the European Commission released the Commission Delegated Regulation Nº244/2012 that establishes a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings or its elements [3].
In Portugal most of the building stock has already more than twenty years old and have poor energy efficiency due to old constructive solutions [4]. Thirty percent of the national building stock needs renovation [5]. To check the potential of renovation in a Portugal one case study was analysed. This case study represents the national building stock, in a certain period of time.
The building is part of an Oporto city social housing neighbourhood and is currently into renovation process and has already some energy improvements in its envelope.
The base solution included insulation in all the elements apart from the floor and was the base for comparing the renovation measures into analysis.

2. Methodology

To understand what is the impact of this improvements is necessary to determine the energy needs, for heating and cooling. The DHW weren't part of the analysis purpose.
The energy needs were calculated based in the Portuguese thermal regulation (RCCTE) [6] in accordance with ISO- 13790. The renovation measures included different insulation materials and different positions in the building's element. The analysis was made in a private perspective, which means the global costs include the initial investments, energy costs and maintenance, considering the discount rates. The carbon emissions costs are excluded. The balance between the energy

needs' reduction and the lowest costs gave the cost-optimal solution for each building element, for a thirty years building's life cycle. The elements' cost-optimal solutions were also analysed with different heating/cooling systems.

3. Results and conclusion

The analysed solutions are better than the applied ones which are the common renovation measures in the Portuguese market. Table 1 summarises the cost optimal solutions.
It was considered the existence of an air gap underneath the floor slab. This first results were obtained considering an electric heater for heating and an air conditioned for cooling. This are the reference solutions defined in the Portuguese thermal regulation.
Table 2 shows the results using the cost optimal solutions when varying the heating/cooling systems.

Table 1 Summary of the most profitable solution on each buildings' element

Element	Wall	Roof	Window	Floor
Most profitable solution	*EPS in the inside + plasterboards	Keep the existing on + *RW/GW + Asphalt shingle	PVC frames	*RW underneath the floor slab

*EPS - Expanded Polistyren; RW – Rock Wool; GW – Glass Wool

Table 2 Summary of the cost optimal solutions with different heating/cooling systems

Equipment	Wall	Roof	Window	Floor
Electric heater and cooler	120mm *EPS	120mm *RW	PVC 4+16+6 100% Argon	140mm*RW
Gas boiler	120mm *EPS	100mm *RW	PVC 4+16+6 100% Argon	60mm *RW
Heat Pump	80mm *EPS	80mm *GW	PVC 4+16+6	40mm *RW

The cost optimal solution are all better than the actual solution.
More efficient heating/cooling systems allow thinner insulation thicknesses. The only element that didn't have insulation was the floor, therefore, it suffered greater impact in the energy reductions. Despite being a reference building, the results can't be entirely applied to another buildings, from the same time scale as this one, because it has a particular situation involving the floor.

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Building Envelope Retrofits for Improved Energy Performance and Thermal Comfort in Detached Houses in Serbia

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Keywords: retrofit; building envelope; energy efficiency; overheating; house.

Introduction

State-of-the-art studies indicate that the biggest energy saving potential in Serbia lies in the residential sector. Most of the existing residential buildings in the country characterize poor thermal properties of building envelopes. Retrofit strategies which are applied in recent years vary from value retention to partial renovation. Energy conservation, inner comfort and summer overheating are concerns for the households in Serbia, where more than 2/3 of the population lives in houses. In order to improve energy efficiency and thermal comfort in detached houses in Serbia, appropriate retrofit strategies have to be considered. We conduct our research to evaluate energy saving potential, cost-effectiveness and thermal comfort during the summer of three retrofit solutions for a representative house in Serbia.

Methodology

A case study research was employed as a primary methodology, while simulation in relation to experimental research (defined by Groat, 2002) was the most dominant research tactic. Two simulation tools were used: (1) Euro-WAEBED for calculating heating demands and (2) GEBA for summer conditions estimation. The representative model of the detached house from 1970's was simulated in Belgrade. Our model was selected from a database of typical housing designs from 70's and 80's in Serbia. This is because more than 60% of total housing stock in Serbia emerged in the period 1960-1990. Proposed retrofit solutions improved thermal properties of building envelope by insulating external building components and by replacing old doors and windows.

Results

Three building-envelope retrofits were evaluated from the socio/economical/environmental point of view. The results derived from the simulations depict applied retrofit measures by following parameters: (1) energy savings; (2) cost-effectiveness; (3) inner comfort in summer. The representative house showed good energy saving potential. With three variants of building envelope retrofits, we achieved the energy savings from 34% to 72% (Figure 1.). The effective retrofit for detached houses in Serbia has to take into account critical summer conditions. Changes in inner comfort under different renovation scenarios are shown in Figure 2.

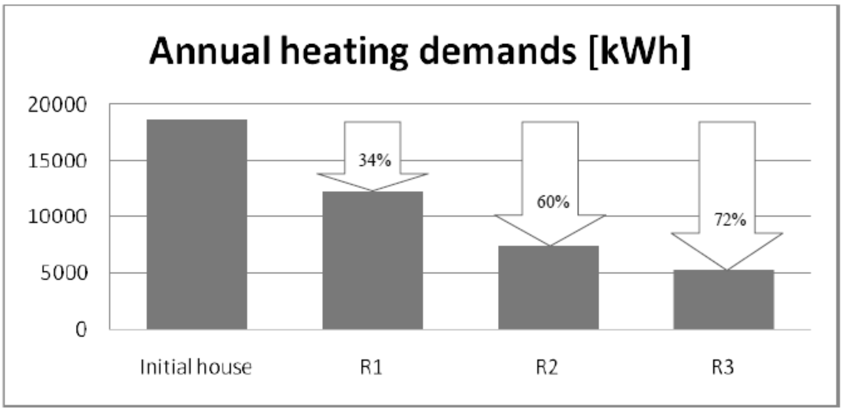

Fig. 1. Comparison on the annual energy savings for the house

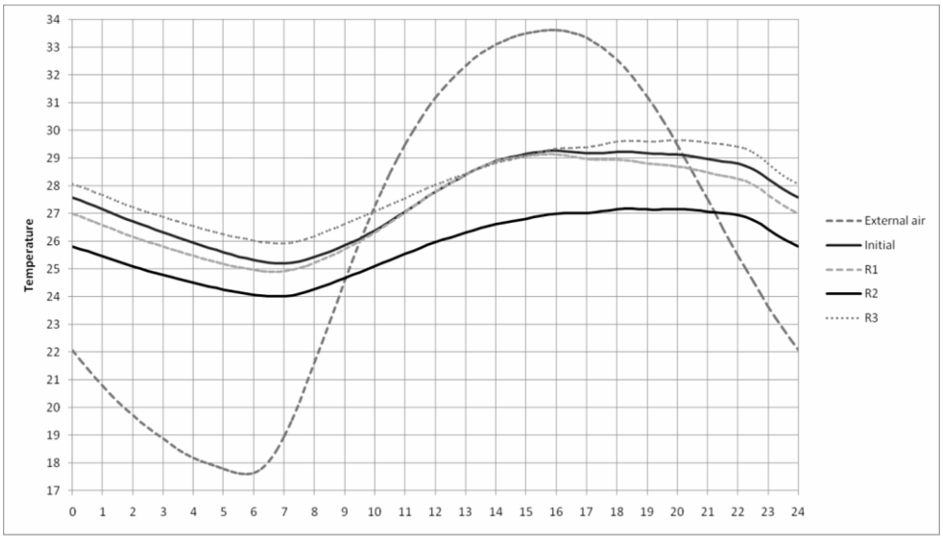

Fig. 2. Inner temperatures in the living room on the 15. July

Considering analyzed retrofit scenarios, we propose the most appropriate solution for the detached house in Serbia. Because our chosen model regards numerous similar detached houses in the country, the outcome could be used as a first step for refurbishment of these houses. We may recommend that for the refurbishment, house owners and planners do similar economical and non-economical assessment and chose appropriate retrofit measures for a particular house.

Proposed retrofit strategies could be applied trough partial or comprehensive renovation of the typical detached houses in Serbia. We especially address the social/economic/environmental issues, because are of particular importance for the tenants who invest in retrofitting.

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Life cycle assessment of wooden building systems for façade retrofitting

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Extended abstract

The building sector is a crucial sector for a sustainable development. It accounts for a large amount of land use, energy and water consumption, air pollution and impact on climate change. In order to reduce the energy consumption of existing buildings, the ‘EFFINOV Bois' research program, a French National Research Agency (ANR) project, suggests to bring industrialised technological solutions using wood systems. These wood based multifunctional complexes can be used within the framework of retrofitting of facades. The project aims to analyse the potentials of using a light framed wooden structure renovation technique on an existing heavy structured façade. To measure and to demonstrate the environmental progress obtained after the installation of the developed solutions, an environmental analysis has been conducted in a rigorous, quantitative, and comprehensive approach based on Life Cycle Assessment (LCA). LCA is a standardized methodology (ISO 14040 and 14044 standards) based on a quantified inventory of impacts sources such as material, water and energy consumption, waste generation and discharges of pollutants in water, air, and soil. From this inventory from cradle to grave, environmental impact indicators are computed according to NF P01-010, the French standard for environmental building products declaration.

In this study, environmental impacts of the building before and after renovation have been estimated with ELODIE, the building LCA tool developed by the French Building Institute CSTB. The environmental benefit of the renovation solutions has been calculated by making the difference between impacts of the building renovation solutions (materials production, transport, construction, use and end-of-life) and reduced impacts of lower energy consumption during the renovated building lifetime. Four renovation solutions have been developed: low cost, high thermal performance (HTP), very high thermal performance (VHTP) and all-wood. To connect these solutions to the existing building, two types of support were considered: a facade connection (FC) or a ground connection (GC). All solutions have been adapted to an existing university building for simulation. Three types of building use have been considered for energy consumptions modelling: public assembly building (PAB), tertiary building and housing building.

In order to compare the impacts of renovation solutions developed with those of non renovated building, 27 cases have been studied:

Table 1: Studied cases

Building without renovation	BAP	Tertiary	Housing
Building after renovation, facade connection	BAP low cost	Tertiary low cost	Housing low cost
	BAP HTP	Tertiary HTP	Housing HTP
	BAP VHTP	Tertiary VHTP	Housing VHTP
	BAP All wood	Tertiary All wood	Housing All wood
Building after renovation, ground connection	BAP low cost	Tertiary low cost	Housing low cost
	BAP HTP	Tertiary HTP	Housing HTP
	BAP VHTP	Tertiary VHTP	Housing VHTP
	BAP All wood	Tertiary All wood	Housing All wood

For the buildings without renovation, the study is limited to the heating energy consumption for the building use for a period of 50 years. For renovation solutions, the assessment includes the heating energy consumption and the production, transport to pre-fabrication site, construction, use and end-of-life of the renovation materials.The renovated materials are:

- Precast wood walls with window,
- Connecting elements between the walls,
- Junction materials between wall and soil for the ground connection,
- Insulation of the floor and the roof.

The common elements between the existing buildings and the renovated buildings are not considered in this study.

Four key themes of the French “Grenelle of Environment” have been studied: energy (non renewable and renewable energy consumption), climate change, water and waste (non-hazardous, hazardous and inert waste). The renovation life time considered is 50 years.

The renovation solutions developed decrease renewable energy consumption, non-renewable energy consumption, climate change, water consumption and hazardous waste. However they increase non hazardous waste and inert waste, but the amount of renovation waste has to be relativized compared to waste of the whole existing building disposal, not considered here.

For example, the figure 1 presents the results for climate change.

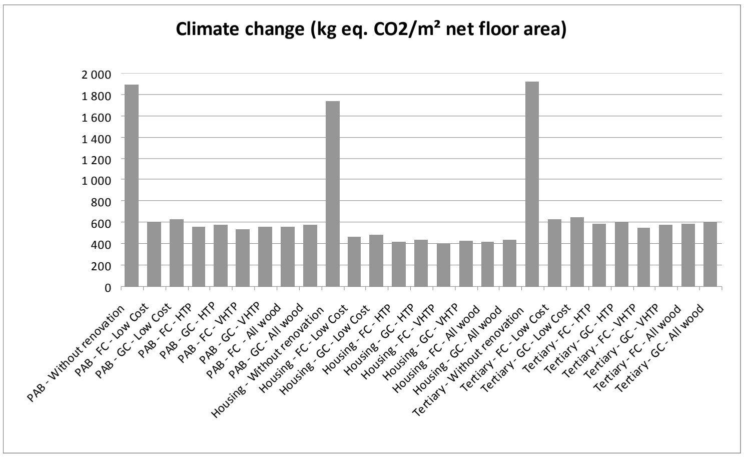

Fig. 1: Climate change results

Thanks to LCA methodology, this study showed that the impacts reduction due to energy saves is much more important than impacts of the facade components for most indicators, considering additional materials life cycle, assembling on the pre-fabrication site, transport to construction site, construction and energy consumption saves. There is no significant gap between low cost, High Thermal Performance, Very high Thermal Performance and all-wood solutions, and between facade connection and ground connection. This is due to the too small differences in composition and thermal performance between the wooden solutions developed compared to the important energy saves of the building renovation.

Keywords: Life cycle assessment, wood, building rehabilitation, environmental impacts.

Co-Benefits in Building Retrofit – Methodology proposal, tool development and a case-study demonstration

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Short Summary

The existing building stock presents relevant opportunities for actions to deal with climate change [1] and to move towards a more sustainable relation with our planet [2], but the decision making process for its renovation keeps hampered by the evaluation of building renovation measures that only considers the direct costs, disregarding other relevant benefits and thus, significantly underestimates the full value of improving and reusing buildings, in local and global economies.

This study identifies a broader scope of effects that arise from building renovation and proposes a methodology and a tool for their quantification and integration in the decision making process in order to assist owners and promoters in the definition of the most appropriate renovation measures. The application of the methodology and the developed tool to a case study allowed to confirm the relevance of the non-financial benefits in the final evaluations, proving that not only economic criteria should be considered.

An enormous influence of the categories related to the social aspects was demonstrated, as well as to the environmental parameters, clearly showing that these parameters can change the ranking between the tested renovation packages.

Keywords: Co-benefits; Sustainability; Building renovation; Multi-criteria analysis

1. Introduction

Although existing buildings represent a huge potential [3], it has been found hard to fully exploit, mainly because of the evaluation of building renovation measures that only considers the energy savings and the costs, disregarding other relevant benefits and thus, significantly underestimating the full value of improvement and re-use of buildings [4]. In fact, building renovation has several side effects often yielding substantial benefits which can be felt not only at a financial level, but also in the environmental and social dimensions [5]. These side effects can be felt at the building level [6] by the building owner or user, but also at the society level [7].

A methodology and a tool to support building renovation operations were developed, enabling comparative analysis of different renovation alternatives in a holistic perspective in order to integrate the global benefits and co-benefits of building renovation in the decision making process. The tool is intended to assist owners and promoters in the definition of the most appropriate renovation measures and allows the use of 34 different criteria that covers economic, environmental and social aspects, combined through the use of multi-criteria analysis.

2. Methodology and application of REHABILI-Tool to a study case

The methodology for the integration of co-benefits in the decision process and for the development of the tool to support the decision process evolved through four essential steps, namely the identification of the benefits and co-benefits related to a building renovation (based on the analysis of a set of methodologies for building sustainability certification and several studies on the evaluation of the benefits of existing buildings renovation [8, 9, 10]), the assessment and quantification of each, their weighting and ranking, and finally the selection of the multi-criteria analysis tool ('GREY Relational Analysis' [11] approach).

Within the case study analysis, three scenarios for building renovation were evaluated, namely a Base scenario with renovation measures corresponding to the usual measures being used nowadays in current building renovation in Portugal, a Best practice scenario where the package of measures used correspond to the best practice currently available in the market, including the use of on-site renewables, and a Maintenance scenario in which the original performance of the building was kept, and only maintenance and conservation measures were implemented.

3. Conclusions

The study presents a method for integrating the benefits and co-benefits of building renovation in a decision process and it was recognized the ability of multi-criteria analysis in dealing with this type of assessment. With regard to results, the relevance of the co-benefits in the final evaluations has been showed. It was determined the enormous influence of the categories related to the social and environmental aspects in the final standings of each alternative, more specifically in the Best practice scenario, in which by adding to its rating the social and environmental criteria enabled this to be the solution with the highest overall score.

These observations allow confirming that apparently less attractive solutions in financial terms can globally be the most effective and adjusted to the building under consideration. This option for solutions with better performance leads to better ratings in social and environmental dimensions, but also to lower usage costs and higher property values justifying higher initial investments.

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BIPV-Standard Module for Large Scale Halls

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Development of a standardized BIPV module for large-scale halls with thermal insulation function

The new targets set by the EU for the building sector such as the EU-Directive on Energy Performance of Buildings (EPBD) open a new field for research and development activities which should focus on giving the best cost-effective innovative solutions in order to reduce the energy consumption in buildings. This contributes to an increase of the market potential for BIPV products and calls for a reduction of the energy needs for heating and cooling of the buildings.

A study run by EPIA estimates that 40% of the total energy demand in Europe could be supplied by roof and façade PV installations. This means an installed capacity of over 1500 GW with an annual electricity production of 1400 TWh [1]. Taking into account these numbers and perspectives the actual growth of the BIPV market is still too low. For example, in Germany, the installed BIPV capacity in 2009 was 1.6 % of the PV capacity installed [2]. One of the barriers preventing this market to develop faster is the absence of standardized products as they are known and used in the building sector. The actual needs of the building industry demand new PV products with integrated thermal insulation systems in order to lower the energy consumption of the building. As a first approach to the development of standardized BIPV products, this project focuses on the design and construction of a standard product for a specific building category.

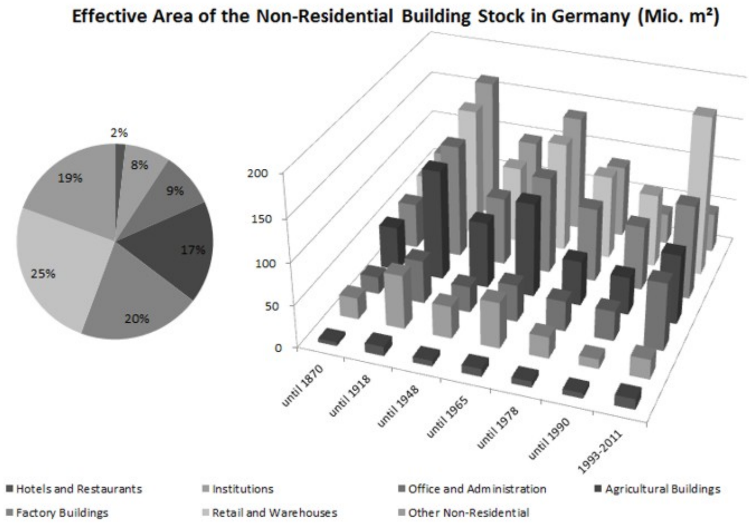

Fig. 1: Effective area of non-residential buildings in Germany [3], [4].

Non-residential buildings and especially industry halls with heating and cooling demand represent a large share of the potential market. In Fig. 1 it is shown that these building categories represent a 45% of the effective area of the non-residential building stock in Germany. A recent study on energy efficiency in halls states that the usable net surface of heated hall buildings in Germany is estimated to be between 508 and 625 million m^2 for the building period 1960-2009 [5]. As a first approach, the total façade surface can be estimated to be of around 400 million m^2 (based on a standard hall for South, East and West facades), which could mean a total installed capacity of 60.000 MWp. Due to shading and other issues, only a fraction of this area would be appropriate for BIPV.

One approach to reduce costs in the building sector is the standardization of products, which helps improve the quality and reliability of the product. The goal of this project is to develop a Building Integrated Photovoltaics (BIPV) façade multifunctional product which could be used for both retrofitting and new construction. Simplicity of construction and cost-effectiveness are to be kept in focus. A first sketch and prototype of the module is to be developed. Studies are to be run regarding the most suitable measures of the product and the insulation material to be used taking into account costs and energy saving potential.

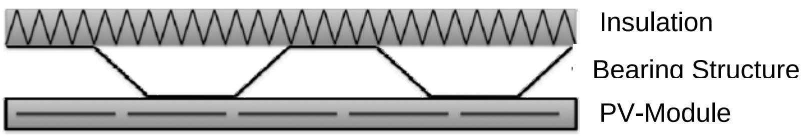

Fig. 2: First draft of a standard BIPV Module with thermal insulation

The development of a standard product as well as the added thermal characteristics is expected to contribute to scale up the BIPV market. This is also supported by the increased demand on energy savings for buildings established by the EU- Directive on Energy Performance of Buildings (EPBD). The standardization of products and regulations regarding BIPV plays an important role when trying to widen the market. Several problems, such as the absence of standard test for mechanical loads, or the impossibility to achieve the required Fire Class for some products are still a barrier. It is important to further invest in the research and development of these technologies due to their large potential. Lifetime and feasibility of the products are another main factor, because of their expected longer lifetime. They require a big initial investment being profitable only in the long term. Therefore, analysis and tests that guarantee the operability of the systems are still needed.

Keywords: Building Integrated Photovoltaics (BIPV); thermal insulation; industrial halls; cost-effectiveness; standard module; lifetime.

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Prefabricated Retrofit Facade System – a Systemized Building Construction Detailing

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Abstract

In comparison to a demolition of existing buildings with severe technical deficits, usually the retrofitting of buildings is more effective in order to prepare them for low energy consumption and new necessities as communication and media connection or HVAC-installation (Heat, Ventilation and Air-Conditioning). Prefabricated retrofit solutions are developed throughout Europe to enable higher levels of industrialization in building envelope modernization and hence additionally improvements in energy efficiency. Five years of experience and a reasonable number of demonstrations done with timber-based element system (TES) facades show tendencies for best-practice building construction.
This paper focuses on the jointing between single façade elements and the connection of those elements to the existing building. Being a crucial construction detail within the TES-facade, the joint area shall meet various requirements and challenges:

While the horizontal load mainly from wind shall be anchored into the existing building, the vertical load from the self-weight of the TES-facade shall be conducted through the timber frame into a foundation system at the foot of the façade. To equalize the unevenness of the existing wall surface a coupling beam, on which the TES-element is mounted, is necessary. The cavity between TES-Element and existing building needs to be filled and sealed. Fire-safety requirements have to be met not only for a non-loadbearing part of an exterior wall, but also fire and smoke spread in and on the façade have to be taken in account, especially in higher building classes. Thermal bridges and convection have to be prevented. Diffusion safety with a vapor retardant layer and diffusion openness influences the construction of the element joint as much as an obligatory second continuous water-carrying layer and driving rain protection to ensure durability and a low risk of moisture damage.

Figure 1: Mounting a TES-Element [gumpp&maier]

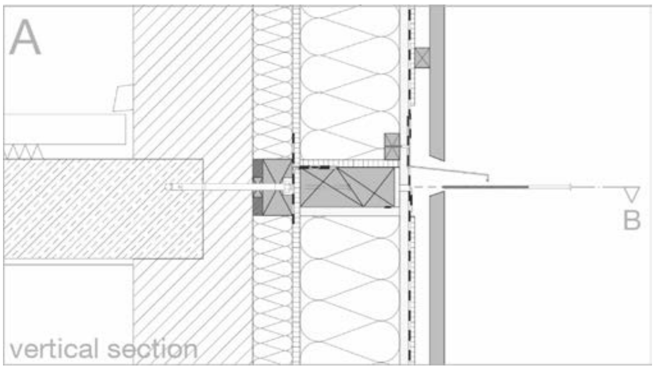

Figure 2: TES horizontal joint Vertical

All requirements have to be in line with the efficiency of the production effort, for example by the universal jointing solution, standard window assembly, and the mounting work. Through the precise connectability and an element to element butt joint, the up 3 ton weighting elements are easily positioned and fixed.

Keywords: Energy efficiency, refurbishment, façade construction, timber construction, prefabrication, fire safety, building envelope.

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Assessment of Double Skin Façade Technologies for Office Refurbishments in the United Kingdom

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Short Summary

There is a growing tendency towards use of Double-Skin Façades (DSFs) for office buildings in Europe. The potentialities this technology has range from acting as thermal buffer to innovative application of natural ventilation. It is still a developing research field identifying what are the most determinant architectural parameters for optimal uses of DSF. This research focuses on applying DSFs to refurbishment of buildings, which has a bigger market than new builds. Knowledge on how to select suitable DSF systems for refurbishments is scarce due to the additional constraints of existing buildings thus narrowing the number of options.

This paper reports the initial findings of the first stage of a comprehensive research, with the aim to establish an assessment methodology and a tool to identify suitable DSF systems for the refurbishment of office buildings in the UK. The assessment methodology proposed here identifies a group of suitable DSF technologies for each of the UK office types identified. The tool has been tested with real refurbishments case studies, which showed coherent and consistent results.

Keywords: Double Skin Façade; Office Buildings; Refurbishment.

1. Introduction

The major challenge for the UK government to meet the greenhouse gases (GHG) target is to reduce the emissions related to the energy consumption of existing buildings. Since the building façade represents the physical barrier between the indoor and outdoor environments, its improvement has been shown to be one of the most effective ways to enhance the indoor environmental quality and to reduce energy consumption [1]. Within façade's improvements, there is a growing tendency of applying an additional glazed skin to the existing façade - what forms a Double Skin Façade (DSF). However, parameters which influence double-skin façade's performance in refurbishments are many and information on their design is scarce. This paper aimed to establish an assessment methodology and a tool to identify suitable DSF systems for the refurbishment of office buildings in the UK. The assessment methodology and the related tool proposed here have been tested by means of case studies.

2. Main body of work

To assess the suitability of DSFs for office refurbishments in the UK, two different analyses are to be conducted. Firstly, the state of the UK office stock is to be investigated to determine whether or not existing buildings may adopt these technologies. Secondly, the performances in temperate climates need to be reviewed to prove the environmental benefits DSF systems are capable of. This acquired knowledge forms the basis for the proposed methodology, enabling to identify suitable solutions which can help the UK to meet the GHG targets.

2.1 UK office building stock

Two-thirds of offices in the UK are mainly constituted of cellular and open plan spaces [2] with structures suitable to the application of Double-Skin Façades. In terms of age, around 80% of them were built before 1990 [3] with U-values double, if not triple, than current practice. Therefore, due to their age, their poor thermal performance and the different lifespans of elements and components (i.e. the load bearing structure and the façade) most of those buildings will be refurbished in the coming years.

2.2 Double Skin Façades technologies

Double Skin Façade technologies have greatly evolved over time and it is a growing research field to identify what the key architectural parameters are and to establish their influence on DSFs' performance. A glazed double skin façade is a heterogeneous system made of an external glass skin and the actual building façade separated by an air cavity which acts as a thermal buffer zone and as a natural/mechanical ventilation channel. In temperate climates these technologies, when carefully designed, seem to have been capable of significantly improving the building performance with energy reductions as high as 67% [4].

2.3 DSF systems for refurbishments

Existing constraints such as location of the building, its conditions and characteristics, etc. make refurbishments more challenging than new constructions. In case of applying double-skin façades the difficulty is even higher due to the careful design this technology requires to exploit its full potentialities. Additionally, the huge number of possible DSF systems often confuses the making of optimal choice. Therefore an assessment methodology has been designed and an evaluation tool developed according to the current state of the UK building stock. Results led to identifying groups of DSF systems suitable to each UK office type. These findings have been validated by means of case studies, showing coherent results with what has been done in real refurbishments.

3. Conclusion and future work

This research has reviewed the current state of the office stock in the UK and indicated that the majority of it is suitable for the application of Double Skin Façades. Due to the absence of existing knowledge about suitable DSF systems for refurbishments, an assessment methodology has been successfully developed. Initial tests of the proposed tool on completed projects indicated coherent and consistent results but additional improvements to be implemented have already been identified. This research has contributed towards the deeper understanding of DSF in the context of their application in office refurbishments. The assessment tool developed to identify the system options, although basic in its current form, is a stepping-stone towards the building up of a knowledge base to support the wider and more appropriate use of DSF for sustainable refurbishments.

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Characterization and Classification of the Energy Performance of Facades According to Climate and Location

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Short Summary

We are in the process of developing an energy assessment tool for residential property within the framework of the SHERIFF (Hybrid and Economic System for the Flexible Comprehensive Rehabilitation of Facades) Research Project, funded by the Spanish Ministry of Economy and Competitiveness and part of the INNPACTO Program. This tool will help to make decisions about how to rehabilitate buildings in Spain. For its development, we have studied the following topics: typologies of existing enclosures, weather conditions and the most appropriate improvement actions to apply on the facade.

Keywords: Rehabilitation, Assessment, Facade, Method, and Bioclimatic.

1. Introduction

Based on previous studies, [1, 2] this research is limited to the period between 1950 and 1980 in the Community of Madrid, Spain. A selection of neighbourhoods has been made based on the amount of buildings built during that time and their state of conservation. The most representative type of residential buildings of each neighbourhood has been chosen and building information for each property has been requested to the relevant administrative entities. A two hundred independent building inventory has been created, collecting information about multiple building enclosure typologies. This inventory has been summarised into the following typologies: six different classes of opaque enclosure construction, two types of window construction and three different sun protection typologies.

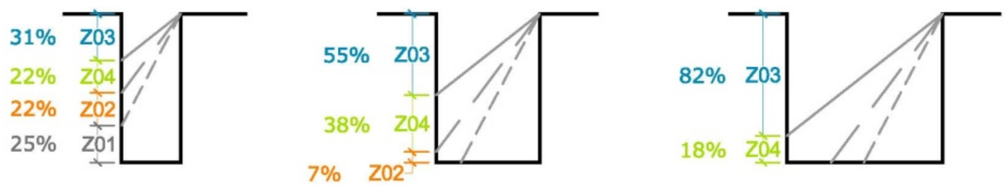
2. Actions on the envelope

2.1 Strategies to improve the energy performance in the facade according to latitude

Weather conditions, guidelines and representative sections of the city street have been studied, allowing the appropriate action's definition appropriate action as (previously) defined to be applied on the enclosure. The facade has been divided into four specific areas:

- Z01 (Zone 01) Null zone, where no solar radiation is received during the year.
- Z02 (Zone 02) Sun protection zone, which must be protected from excessive solar radiation to prevent solar gains (overhangs, louvres, blinds, slats, etc.).
- Z03 (Zone 03) Solar gain zone, which can take advantage of the solar collection strategy. Prevention of heat loss is needed (greenhouse, trombe wall, thermal inertia, etc.).
- Z04 (Zone 04) Flexible zone, which requires both solar gain and sun protection (for example moveable sun protections).

Figure 1 shows an example (percentage of facade for each zone type) of determining the most appropriate actions on the east facade, in Madrid, latitude 40º.



T01 T02 T03

Fig. 1: Sections type T01, T02 and T03; Legend: ___Winter, __ __Autung/Spring, _ _ _Summer

2.2 Action requirement according to the Spanish Technical Building Code (CTE)

We have verified the summarized inventory according to a theoretical transmittance of facades previously catalogued, which has been compared with the transmittances required by the CTE 2006 (still in effect), the CTE 2013 (draft document) and a proposal for improvement of the latter by 25%. These last data have been made taking into account that the European Standards are already establishing the steps that will be needed to get zero energy buildings. The purpose of this comparison was to evaluate the requirements needed for each type of facade according to its corresponding climate zone. Although this comparison has been made for all the areas of Spain established in the CTE, this study only shows region D, corresponding to Madrid.

Table 1: Transmittance comparisons: theoretical transmittance, CTE 2006 transmittance and CTE 2013 transmittance.

	Region D			
	Thermal transmittance of the facades (W/m2 K)			
Cataloguing summary	Theoretical	CTE 2006	CTE 2013	Improvement proposal by 25%
One-foot-thick solid face brick wall	2.21	0.86	0.66	0.50
Half-foot-thick solid face brick wall + 5cm air chamber + 4cm hollow brick	1.49			
	Thermal transmittance of the frames (W/m2 K)			
Metal frames	5.70	3.50	2.70	2.03
	Thermal transmittance of the glazing (W/m2 K)			
Double glazing	3.30	3.50	2.70	2.03

3. Conclusions

The selection of the study period and neighbourhoods has allowed us to develop a detailed analysis in order to catalogue the most common facade types. Knowing the composition of the facades and their cataloguing allows the thermal behaviour of the building to be established in order to make a proposal to improve according to the existing buildings.
Studying the weather conditions has allowed the identification of the specific rehabilitation actions for each CTE climate zone, for the windows (the openings) and for the facade enclosures catalogued (the opaque part).

4. References

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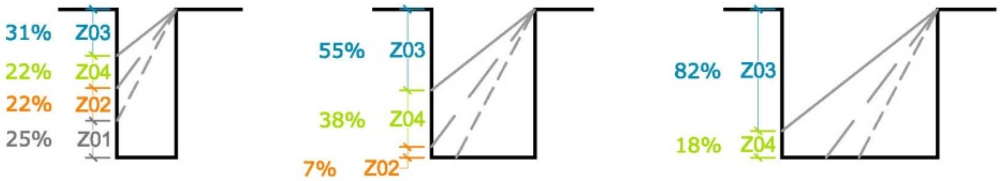

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Evaluating the energy savings potential of window refurbishment

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Short Summary

A saleable software was created for the evaluation of built-in windows and the savings effect to be attained by building in new windows. With the help of the program Uwin the energy savings can be prognosticated in case of refurbishing by consultations with suppliers of windows, facades and glazing. The program starts with guideline values which can be adjusted and refined step by step. The calculated energy savings are indicated in kWh/m² as final energy (as QE in kWh/m²a). According to the operation of the rapid access field the result can be issued with or without heat loss by airing as well as with or without solar gain. The program anticipates that the window is protected from insolation by lateral and horizontal components. It also anticipates that there is a building opposite.

Keywords:window; refurbishment; energy savings potential; energy-efficient buildings.

1. Introduction

Windows are an energy sensitive part of the building façade. In case of a planned window refurbishment however, it is often difficult to evaluate the energy savings potential of such a measure, especially if no product information about the glazing and frame used is available.

2. Results

Within the frame of the project „Development of a new evaluation tool to determine the energy savings potential of window refurbishment including effects of glazing, frame and connection" [1], a new software tool was developed to help evaluate the energetic state of windows in a building. If the thermal properties of glazing and frame are not known, the software tool relies on databases that link the year of manufacture with corresponding U-values. In addition, the condition of seals and connections between window frame and façade can be taken into account. Due to the sophisticated calculation algorithms that are based on prevailing standards, the tool gives reliable data for energy demand and CO_2-emissions of the current window situation and compares them to different refurbishment scenarios.

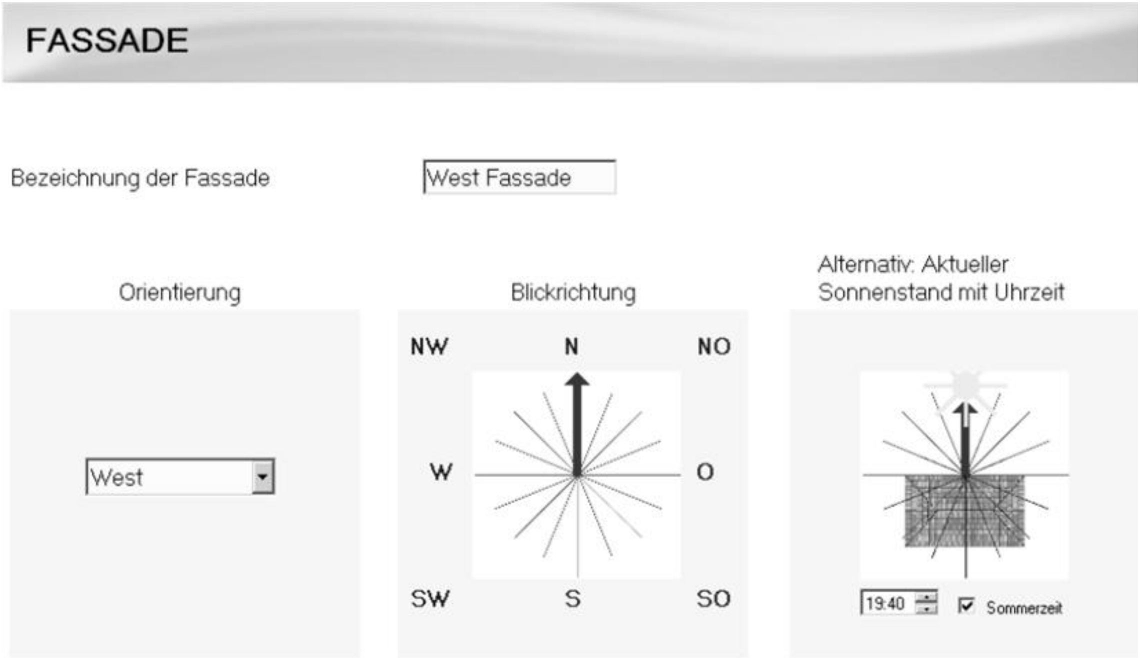

Figure 1: Example of an intuitively operable input screen for selecting the façade orientation.

3. Conclusions

The newly developed evaluation tool allows an easy and reliable calculation of the energy savings potential of a window refurbishment. The tool can be used as a quick method to give a first estimation, but also allows a detailed evaluation including effects like solar gains and ventilation heat losses.

4. Acknowledgements

This research was carried out as part of the project “Development of a new evaluation tool to determine the energy savings potential of window refurbishment including effects of glazing, frame and connection” and was funded by the German Federal Ministry of Economics and Technology by resolution of the German Federal Parliament.

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Monitoring results of PCM-systems for room cooling

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Short Summary

Two different cooling systems with PCM – a sun protection system and a ventilated cooling ceiling – were installed in some office rooms and monitored during summer 2010. The thermal behaviour of the systems was measured and compared to an identical reference room without cooling system. To avoid any interference from the users and to get defined boundary conditions, the measurements were performed on weekends with electrical heaters to simulate internal gains. With each of the PCM systems, the maximum operative room temperature could be reduced by 1-2°C, while a reduction of 2-4°C could be achieved with both systems together. The regeneration of the PCM by night-time ventilation only was a problem.

Keywords: Phase Change Material (PCM); latent heat storage; room cooling; energy-efficient buildings; thermal comfort.

1. Introduction

Phase change materials (PCM) offer a promising alternative to conventional cooling systems. The passive nature of the latent heat storage process allows a high potential for energy efficient systems, especially if combined with some kind of free cooling to regenerate the PCM during the night. Two such systems – a sun protection system with PCM [1] and a ventilated cooling ceiling with PCM - were installed in some office rooms and were monitored during summer 2010. One office room was equipped with the PCM sun protection system, one with the ventilated cooling ceiling with PCM, and one with both systems. The thermal behaviour of the systems was measured and compared to an identical reference room without cooling system. The measurements were carried out in a funded project [2].

2. Results

It was found, that the behavior of the room users (ventilation habit, use of blinds) significantly influenced the measurement results. Due to this, the measurements were carried out without inhabitants (on holidays and weekends) and electrical heaters were used to simulate internal gains. All other parameters, like the position of blinds and windows, were kept identical in all of the rooms. The measurements showed a significant cooling potential for the PCM systems. Each of the systems reduced the maximum operative room temperature by 1-2°C compared to the reference room, while a reduction of 2-4°C could be achieved in the room with both systems together.
The regeneration of the PCM during the night turned out to be problematic. Even in nights with outside air temperatures of as low as 16°C, the PCM often could not be regenerated by tilted windows. In the rooms with the ventilated cooling ceilings, the forced air flow of the ventilation

systems enhanced the regeneration process.

Figure 1: Installation of the PCM-boards in the ventilated cooling ceiling (left) and built-in sun protection system with PCM (right).

3. Conclusions

PCM systems for room cooling can reduce the maximum operative room temperatures significantly, thus improving the thermal comfort of the inhabitants. However, the regeneration of such systems could be problematic in German climate if no active components, like ventilation systems or chillers, are used.

4. Acknowledgements

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Cost-effective and high performance renovation of existing residential multi-family buildings in three European countries

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Extended Abstract

The built environment is a central aspect of daily human life. Building processes are also among the most cost intensive processes that we come into contact with. As for residential buildings, many people take 20 or 30 years, or even more, to pay back their home loans. Refurbishment of buildings is seen as a possible major contribution to lowering the impact of buildings on the environment [1] while being, ideally, economically promising and keeping the social identity of our built environment. On the other hand, regulations are often centered on the sustainability of new buildings [2], and there is a lack of regulations tailored to refurbishment [3]. At the same time existing buildings are seen as a key factor in local identity, and as a hub of socio-ecological development [4].

The EU funded BEEM-UP project (Building Energy Efficiency for Massive market UPtake) [5] has the goal to demonstrate the economic, social and technical feasibility of retrofitting initiatives for a 75 percent reduction in energy consumption in existing buildings, and lay the ground for massive market uptake. BEEM-UP involves key expertise to implement and demonstrate innovative building and energy management approaches with the overall aim to improve energy efficiency in existing buildings and obtain better indoor comfort conditions in three ambitious retrofitting projects. The main emphasis is placed on the economic and ecological life cycle assessment and comparison of the different projects and applied measurements in Sweden, the Netherlands and France. All projects are large-scale residential buildings with a focus on social housing, apartments and flats. All three sites are representative examples in the respective countries of building cohorts that are due for refurbishment.

One of the main goals of the BEEM-UP project is to compare the refurbishment approaches of the different countries, and to provide an exchange regarding related problems and solutions. For this purpose an ecological as well as life cycle cost assessment has been carried out for all three sites. For each site six refurbishment scenarios have been defined through intensive consultations with the building owners and other stakeholders, for instance tenants or tenant representatives. First preliminary results indicate that it is economically and technologically feasible to achieve 75 percent reductions in energy consumption for the existing building stock.

However, these preliminary findings point to institutional and social impediments that may not lead to massive market uptake in the social housing real estate community. Social housing institutions face distinct regulations and economic constraints, which can inhibit their uptake of energy retrofit policies [6]. On the one hand, national and EU wide policies nudge building owners towards basic energy-efficiency measures. On the other hand, institutional factors historically embedded into the social housing framework like rent controls and governmental rent subsidies inhibit a more equitable distribution of refurbishment costs between tenants and building owners. Moreover, discounted third-party capital is limited and subsidies at the national and local levels cannot

support the level of refurbishments needed across the housing stock.
However, there is economic value in energy-efficiency refurbishments of the building stock. An increasing number of studies document increased transaction values for buildings that are relatively more energy-efficient [7,8]. However, BEEM-Up has shed light on other sources of value at the property level. Namely, firms that have developed the product, process and organizational innovations associated with energy-efficiency retrofits could be financially more nimble and efficient in their housing portfolio relative to their non-innovative peers. In addition, there are more ways than transaction value and rental income to see the financial benefits of energy-efficiency. Alternate sources of income from renewable energy and even less explored financial benefits from taxation and depreciation that are currently linked to energy-efficiency investments are another source of savings for energy-efficiency that is far less explored. Thus, political and economic capital is required to shift institutions and firms towards an innovation mind-set to meet the needs of an ecologically improved building stock.

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Keywords

Retrofitting; social housing; energy consumption; energy efficiency; LCA; LCC; economic performance

Innovative modernization of historic buildings – pilot schemes in Vienna

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Extended Abstract

Historic buildings from the late 19th and early 20th century **(era of promoterism)**, so called "Gründerzeit" buildings with typically decorated façades represent a essential portion of the building stock for example in Vienna. The project cluster "Gründerzeit with future **prospects**" started in 2009 aims the modernization of historical buildings in a systematic and holistic way using innovative technical and organisational solutions.

Initiated activities within this flagship project contain:

- basic research about technical, economical and legal issues
- developing transferable concepts as well as innovative technical and organisational solutions for renovating historical buildings,
- create feasibility studies for pilot projects
- implementing the concepts and solutions within four innovative pilot projects (including documentation and monitoring)
- dissemination of the results to owners and property managers, planers, architects, representatives of the building sector

The pilot projects are designed to show how technical, economic and social barriers coming up while restoring historical buildings in an innovative fashion can be overcome. The pilot projects are located within the City of Vienna and cover a variety of historical buildings. The main innovations are to ensure the high quality of restoration by using passive house components (mechanical ventilation systems, high quality insulation, possibly also from the inside), newly developed windows as well as the systematic implementation of innovative climate neutral systems for HVAC.

The actual status and first results of the pilot projects are shown in the following description. Further project information, feasibility studies and monitoring results of the demonstration sites are available on the project website www.gruenderzeitplus.at.

Pilot project **Wißgrill Alley** [completed December 2010]	Pilot project **Kaiser Street** [will be completed in May 2013]	Pilot project **David's Corner** [start of construction work 2012]
Factor-8-Modernization and efficient attic floor construction 	Modernization of a monument-protected building 	Modernization of three historical buildings located next to each other 
• Modernization of the building shell and reduction of thermal bridges • Installation of efficient and comfortable ventilation systems • Efficient heating system: combination of central wood pellet heating and solar thermal collectors which are integrated into the façade • Installation of PV	• Internal insulation with capillary-active material • Detailes Monitorin of ther internal insulation at different cross-sections • Modernization of the windows in line with monument-protection • Installation of efficient and comfortable ventilation systems with heat recovery • Static and thermal modernization of the roof structure	• joint development of all three objects • Installation of a district heating system and solar thermal collectors (across-buildings) • Installation of efficient and comfortable ventilation systems • Thermal optimizations and Re-designing of the façade • Redesigning of the residential layout plans • Accessibility for the entire building
• The satisfaction of the occupants is evaluated • Results of the last two years energy monitoring are analysed	• Construction work finished in July 2013 • energy monitoring started in August 2013	• detailed planning is completed • Construction work will be finished in September 2014

Energy Demand Calculations – View from Above

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Short Summary

Paper deals with energy demand calculations based on stochastic principles. This allows for the use in very early stage of the design, because there is not necessary to wait for complete set of input data. At the same time, such calculations can be used for quick analysis of larger group of building having their main parameters within given range. Overall tendencies, possibilities of refurbishment etc. can be evaluated from the calculated results.

Keywords: Integrated building design, energy demand calculations, stochastic approach

1. Introduction

In principle, at least two different approaches in calculation and interpretation of theoretical energy demand of buildings can be identified. For the first approach, very detailed multi-zone and dynamic models are used, with the best possible description of all parameters, detailed information on building use, local climatic data etc. for one studied building. This is very useful especially for research on new technical systems, for analysis of measured data and for detailed performance estimation. Large amount of input data is needed.

At the same time, it seems to be necessary to have an instrument allowing the observation of the problem "from above" by slightly simplified calculation, but for larger group of buildings. This approach is suitable for overall assessments, for studies on tendencies in particular typological group of buildings, for setting of targets and policy making. Such approach can be used as a real design supporting tool as well – advantageously in one package from the very early stage of the design to final delivery of the project.

2. Procedure and input data

The core model remains in all studied cases identical, based on usual procedure according to international standard. The calculations using steady state monthly method are repeated automatically for large amount of combination of input data (typically several hundred up to thousands). Stochastic principles for selection of input data and for expression of the results are used [1].

In general, all input data can be set in different modes:
- exact value, if available,
- reference to standard or legislative requirements (upper limit or lower limit, as interval),
- most realistic default values created automatically within the software tool.

The results are expressed in the form of statistic evaluation of all calculations done for generated data sets (overall distribution, minimum and maximum for 90% of results, mean value, probability of reaching usual targets). A sensitivity analysis can be used for “fine-tuning” in the next step of the building design.

3. Example

Fig.1 brings overall information on apartment buildings with the built volume 5 000 m^3 – 8 000 m^3) having required value of thermal transmittance [2] by all building components. No data about building geometry was known. Different information was available on heat recovery from ventilation air and about number of inhabitants.

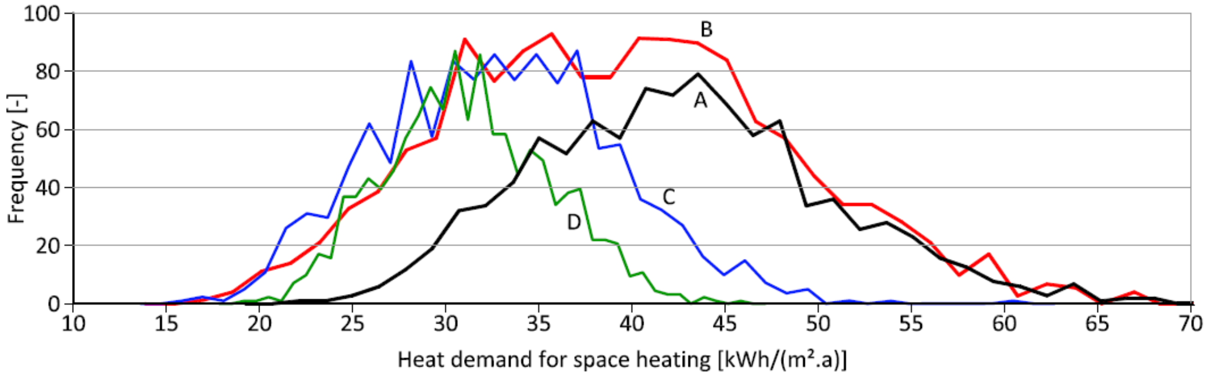

Fig.1 Comparison of heat demand for space heating of middle size apartment buildings with required values of thermal transmittance [2]. In cases A, B, C no information about building geometry, orientation, compactness, fenestration ratio, shading and number of inhabitants was available. Following values were considered more exactly in case D: Built volume 6500 m^3, number of inhabitant 45. Overall efficiency of heat recovery from ventilation air was considered as follows: A no recovery, B no information about heat recovery available which means the efficiency varies from 0 % to 70 %, C and D: efficiency 70 % exactly.

4. Conclusion

The described method has a potential for further development. For educational purposes and for wider use a computer tool with simple dialog via internet was already prepared [3]. It enables quick evaluation of space heat demand, in each case based on 1000 combination of input data for studied apartment building (or group of buildings). Similar approach could be effectively used during evaluation of applications for public support of energy advanced solutions. This approach was used [4] for overall estimation of total costs (investment + operation costs in 30 years) for apartment buildings in the discussion about cost-optimum level requirements [5].

Acknowledgements

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CESBA – a collective initiative for the new building culture in Europe

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Short Summary

CESBA „Common European Sustainable Building Assessment“ is a collective initiative for the new building culture in Europe. To reach the EU2020 goals a common, regional adaptable, mass-oriented approach is needed. CESBA delivers a framework for this highly political course. CESBA is a bottom up policy harmonization process by project partners from several transnational EU-projects. Join CESBA on http://wiki.cesba.eu/.

Keywords: CESBA, building culture, building assessment, Europe, bottom up process, open source, NENA-Network

1. CESBA – a collective initiative for the new building culture in Europe

The building sector is a cornerstone of the EU climate protection program and has an important role to play in the achievement of the Europe2020 strategy, in particular in relation with the initiative “Resource efficient Europe”.

Further buildings play a central role in our societies, providing places to live, work or enjoy leisure activities. They are the basis of our urban environment, impacting the social, economic and ecologic aspects of our lives. Indeed, our health, comfort and safety as well as our economy and our natural environment are strongly connected with the construction sector activities.

Building culture is not only defined by the sum of certain quality indicators. The processes including certification, training and assisting services along the whole building life-cycle are significant parts too. However, the plethora and mismatch of building regulations at EU and national levels leads to considerable administrative burdens, confusions among the actors and to a very fragmented sustainable construction market.

A new building culture integrates not only experts but all stakeholders, from the users to the politician, from the big companies to the single family house owner. It is a mass-movement towards nearly zero emission buildings in Europe.

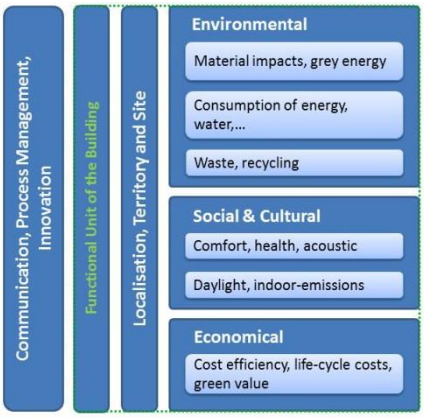
2. CESBA – Common European Sustainable Building Assessment

The development and implementation of new standards require synergic actions and initiatives. Current building assessment tools not only have variable elements including structure analysis, assessment methodology, and the identification of variable impact issues but also use different scoring methodologies. This lack of conformity makes comparison of results difficult. A harmonization is needed.

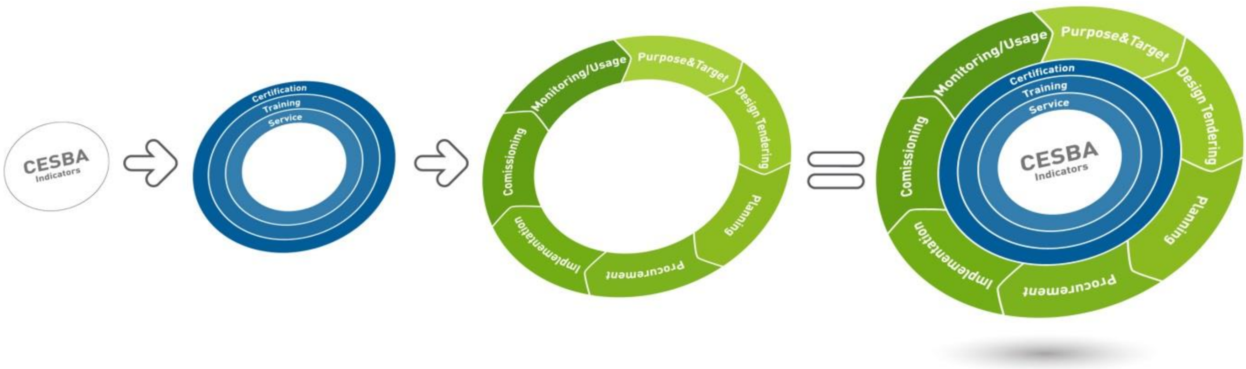
The participation of the civil society is essential in the bottom-up approach of generating common mass-oriented, open-source building sustainability assessment guidelines as well as in the establishment of building standards for the constructing of building stock itself. The system of analysis that describes the sustainability quality of buildings must be transparent to the layman.
As Europe is a mélange of regional building cultures European buildings standards must be open to regional needs and circumstances.

CESBA discuss and unites following aspects of future building culture:

1. Quality indicators to measure the quality of the building processes and the achieved quality standards. These indicators consolidated in the following framework, which goes along with the suggestion done by CEN/TC 350 and 6 European projects:



2. Integration of all aspects of the building life cycle: Services, Trainings and Certification processes for all aspects along the building life cycle. Purpose and target setting, design tendering, Planning, Procurement, Implementation, Commissioning, Monitoring / Usage.



3. Next steps for CESBA:

1. Defining and collecting front runner projects and activities in all parts of CESBA, establishing an open source knowledge-hub - http://wiki.cesba.eu/.
2. Holding follow up meetings and open exchange among all stakeholders – common CESBA Sprint Workshop http://www.cabee.eu/events/
3. Structuring the collective process (CESBA task force, regional CESBA contact points)
4. Further political engagement of all kind of stakeholders including civil society
5. Promotion and collaboration activities: Join CESBA! - http://wiki.cesba.eu/

Human Scientific Factors to Enhance Life Cycle Sustainability of Housings

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Keywords: life cycle sustainability; housing; human quality; housing psychology; housing physiology; housing theory; housing quality analysis

Introduction and Correlation

The presented work is dealing with psychological and physiological contributions to enhance the performance of blue, green or smart housings and dwellings.

Initially there is one main causal connection to be considered: The higher the human quality of residential buildings the longer and more intensively they will be occupied on average. Usually the by far biggest amount of resources (building materials, products as well as energy and transport) has to be spent during constructing or reconstructing buildings respectively during demolishing and building new. The longer the period of occupation, which means the longer the period between constructing and reconstructing or demolishing the higher generally the impact on life cycle sustainability.
The main difficulty of this conclusion reveals by trying to catch the central terms: How can "human housing quality" or "humanity" be defined, analysed, and optimized (especially also in advance, before erecting the building)?

Main task
Based on scientific research results the main goal of the work is to define ways of enhancing the life cycle sustainability of housings by considering the human quality factors.
A further task is to explain the thesis that sustainability without humanity is an insufficient goal and with regard to housing structures hardly realizable.

Within the paper a scientific methodology will be presented which is able to analyse precisely the human quality of housing projects. It comprises all essential factors which are relevant for the performance and acceptance of buildings from a human perspective. The topic will be explained in the form of real projects and respective research results.

Context
The influence of the factor "humanity" on sustainability is enormous but highly complex and for certain reasons one of the most non-realized so far.
Housing psychology is dealing with human nature, needs, behaviour and healthiness. There are strong psycho-logical connections between building structures and human beings. This logic used to be as relevant and sound as physical conclusions, too.

Research Report Part I: Housing Theory and Science

The basic research in this part consisted in finding a scientific theoretical conception which has been able to define the term "human housing quality" precisely. A further applied research part consisted in the finding of an appropriate and highly sophisticated methodology, which is able to analyse housing projects from a human scientific perspective.
The following main steps have been carried out during the research project (overview):

1. First the human habitat system had to be defined in whole and its characteristics in detail (*meta-theoretical level*).
2. The complete spectrum of relations and exchange processes which are connecting the human being and his habitat (housing environment) had to be defined systematically and as far as they are relevant for housing (*theoretical level with interdisciplinary linkages*). In combination with that all those general human needs had to be defined that are directed to the habitat.
3. The whole conception had to be examined theoretically as well as empirically (*empirical level*).

Research Report Part II: Examples and Analyses

The ongoing practical research is illustrated with the aid of 3 examples:
(1) "Pruitt Igoe" - the most unsustainable housing complex in history
(2) "Terrace-house-settlement": Sustainability despite energetic / thermic deficits?
(3) Cohousing project: Social plus ecological sustainability?
These three examples are just meant to offer a short insight for a better understanding of the topic.

Conclusions and Resume

Potential Impact on Sustainable Housing Practice

By means of the respective methodology for analyses we are able to check out the potential housing/living quality of buildings and residential areas in detail and **in advance**.
This leads us to one major goal: it becomes possible to carry out analyses on a scientific and systematic basis **before** the building is erected and occupied, still **during the stage of planning!**

Afterwards we are able to return to the main task and to answer the initial question:
How can we enhance the human quality of housings and settlements and therefore also their sustainability?
- By using this sophisticated methodology of analysis during planning and hand in hand with planning.
- By using this methodology of analysis before reconstructing a housing complex, remodelling a building, or redeveloping a whole housing settlement.

Finally optimization of habitation quality as well as reduction of deficits become possible. By a clear and detailed definition of the specific qualities of an object, such analyses could support avoidance of deficiencies and provide the basis for various improvements concerning the human-related aspects.

Sustainability plus Benefit to the Inhabitants

The research results could provide contributions to increase sustainability on three levels

- ecological sustainability: prolonging the life-cycle endurance of buildings; reduction of dispersed settlements, urban sprawl, etc.
- social sustainability: increase of human housing quality, living and social quality, etc.
- and also economic sustainability: higher occupation rate, higher quality for equal price, etc.

The benefits are on principle valid for all forms of housing, i.e. the high-budget as well as the low-budget segment. With the latter there are even much more improvements necessary and possible.

OPEN HOUSE: Common European methodology for assessing building sustainability

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Extended Abstract

Sustainable construction is a relatively new concept that aims at integrating the objectives of sustainable development into the construction activities. Multiple methodologies and approaches for assessing building sustainability at international, European and national level are being used. However most of them form part of national initiatives and consequently are only used at national level. Also, many of these assessment methodologies are conceptually developed without user-friendly applications, thus not meeting the industry needs of responding to manageable steps in practice.

ACCIONA Infrastructures as coordinator and Fraunhofer as chair of the Scientific and Technical Committee lead the European project OPEN HOUSE (OH) financed by the European Commission within the seventh Framework Programme (FP7). The project aims to develop and to implement a common European transparent building assessment methodology, complementing the existing ones, for planning and constructing sustainable buildings by means of an open approach and technical platform. The methodology was developed on the basis of existing systems, international initiatives and European standards with a view to harmonizing building assessment. The first version of the OPEN HOUSE methodology is composed of 56 indicators classified in six categories: Environmental Quality, Economic Quality, Social/Functional Quality, Technical characteristics, Process Quality and The Location. Regarding the score, for each sub-indicator a maximum of 100 points can be achieved: the baseline of 10 points is obtained by fulfilling the standard of the specific EU country – the maximum by achieving best practices towards sustainability goals (e.g. targets of the EU in 2020).

OPEN HOUSE methodology was implemented in 68 buildings used as case studies distributed in 35 European countries in order to assess the applicability of the methodology and to gather constructive feedback to improve it. Two kinds of assessments were conducted during the case studies: Basic & Quick Sustainability Assessment (the evaluation of the building performance is based on assumptions) and Complete Sustainability Assessment (the evaluation of the building performance is based on detailed documentation). The assessment of the case studies was done thanks to a user-friendly online tool developed during the project (http://oh.building-21.net/).

This paper focuses on the first analysis of the feedback from case studies. The results from the feedback reveal that the OH online assessment tool is user-friendly and facilitates the building assessment.

The OPEN HOUSE methodology was seen as holistic and covering all aspects of sustainability. Some aspects to be improved from the methodology were the time needed to assess the building and the data requirements in some indicators.

The methodology was considered as highly applicable to office buildings and flexible enough to be applied to other building types (educational or cultural buildings). When the assessment was done during the planning phase, there were certain uncertainties about the final concept of the building and this difficult the assessment of some indicators. In some case studies in which the assessment was done in existing buildings it was difficult to get information about the planning process or the building materials. For each category, it seems that case studies located in the same country achieved a similar score. If we consider that these buildings are representative of the best local practices, their performance can be used to scale the local reference values. However, more than 2 case studies per country are needed for precise benchmarking.

On the basis of the feedback analysis, this first version of the OH methodology will be refined in order to establish a European reference point for building sustainability labelling.

Keywords: OPEN HOUSE; Building Sustainability Assessment; Assessment tool; Case studies.

Development of a Performance Based Evaluation Method for Carbon Management of Existing Building in Egypt

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Keywords: Carbon management; Existing Buildings; Performance Based Evaluation;

1. Short Summary

The need to de-carbonize existing buildings with the use of various renovation approaches is on the rise. This paper reviews the key drivers in the literature and describes a performance based evaluation method to assist in the decision making to renovate existing buildings. A base case of an existing apartment building was used to demonstrate the effectiveness of a proposed evaluation method. The result of the study recommends the inclusion of the key drivers and proposes a method to quantify the performance of the proposed renovation scenarios and provides the owner with a decision making method to minimize carbon impacts associated with the renovation and operation of the existing buildings in the future.

2. Introduction

With energy efficiency and carbon emissions growing in importance in recent years, more detailed exploration into the sources of carbon emissions can be seen in recent research work. Looking at the close relationship between energy consumption and carbon emissions, energy consumption can be used as a rough indicator as to the carbon emissions - where renewable resources are not the main source of energy. Statistics show that an estimate of 40 percent of total energy consumption worldwide goes into the building and construction industry [1]; therefore, the building sector is a significant contributor of carbon as well as other emissions [2]. On a building level, the most commonly used mode of energy accounting in buildings is calculated either though energy analysis or using guidelines set by the ISO (International Standardization Organization) for Life-Cycle Assessment (LCA)[3]. Using LCA to determine the impact of a building on the environment involves accounting for and calculating all the energy processes revolving in and around the production, maintenance, demolition and running costs of the analysed building. These processes are generally divided into two distinct categories: embodied energy processes and operational energy processes; the energy products of which sum up to the total life-cycle energy of a building.

Although the overall impact of a building cannot be assessed solely on either embodied energy or operational energy on its own; the study and optimization of each of the two sub-components has the potential to explore the factors affecting each and eventually reaching a compromise. Therefore as can be clearly deduced, the study of embodied energy has notable reason for slowly gaining importance and becoming a topic of further research. However, while studies have been conducted in many countries worldwide; the localized analysis of embodied energy in the building industry in Egypt remains a topic of discussion. An important point to note as discussed by Haynes[4] is the separation between embodied energy and embodied carbon. The distinction is important since a comparison of embodied energies of two buildings might show that one has higher energy content than the other. However energy content alone should not be considered as an indicator to its impact on the environment, as the very same building with higher embodied energy may be of a clean renewable source whereas that of the building with lower energy may be based off of fossil fuels-having overall a greater environmental impact.

Locally in Egypt, where the current supply for energy is in need of expansion in order to cover the growing energy demands, a reduction of embodied carbon content through the replacement of current energy sources with clean renewable energy would be of significant impact in the construction sector. Based on energy reports from 2009 published by the Energy Information Administration under the Department of Energy [5]; Egypt's main sources of energy were oil and natural gas accounting for 47 and 48 percent of the country's total energy consumption respectively. Such a high reliance on fossil fuels indicates a high level of embodied carbon since not only will transportation be based on fossil fuels, but also nearly all other processes including material extraction and/ or manufacturing, processing and then later assembly, maintenance and disassembly would all rely on carbon-embedded energy sources as well.

3. Research approach

In order to begin work in this field, it was first necessary to conduct a general literature review both internationally as well as locally in order to determine the local lags in research. Based on this research it was decided that a localized framework for the calculation of embodied energy in existing buildings in Egypt was the area of work most needed to suit both markets of design and construction. This was concluded as further research and the optimization of construction materials, alternative construction systems or even transportation processes to reduce embodied energy totals would be reliant on the former establishment of a fixed framework or calculation methodology; and thus must be established beforehand. In absence of comparative studies locally, a residential apartment building case study was selected to calculate the total embodied energy of the building and compare it to similar building worldwide. This case-study was intended to act as a prototype for the calculation of embodied energy of a building; acting as an initial benchmark to introduce embodied energy calculation in the local research market. A performance based approach is proposed (Fig.1) and a set of conclusions and future areas of research to advance this work were documented.

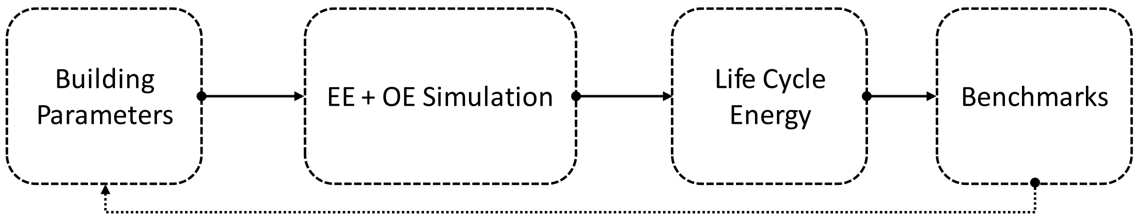

Fig.1: PBE approach

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Better understanding and modelling of user behaviour in (nearly) zero energy buildings

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Short Summary

Employees and staff influence building operation in various ways. The subjective opinions and resulting behaviour of users are not only determined by 'objective' comfort parameters (temperature, draught), but depend decisively on social aspects [1,2]. What makes the user of a building satisfied with his physical working environment?

Parameters, which determine comfort related behaviour and user satisfaction, can be found on personal and organisational level. Two main factors influencing user satisfaction and behaviour are: (1) Individual possibilities to control work environment and comfort, e.g. can users influence operating parameters of the technical systems? (2) Information on the building and its operation, e.g. do users have the feeling that their concerns and complains are taken seriously, do they feel involved in the energy performance of the building?

To get an overview of the social and psychological factors that play a role in the context of the built environment in office buildings, a questionnaire was created by author Magdalena Wicher. The findings should provide an indication for the social interrelation of the agents and thus be integrated in an agent based model (ABM).

The questionnaire about the social and psychological factors affecting satisfaction in office buildings has been distributed through an online tool (unipark) in Austrian buildings that are designed as lowest energy buildings and with plus-energy building techniques. It has also been used to analyze a low-energy high-rise office building in Graz, Austria, which will be the reference for the ABM. The questionnaire is online-based and was created in the form of a post-occupancy evaluation. POE surveys are a common instrument for assessing user satisfaction in buildings and to evaluate the indoor thermal comfort [3,4].

The questionnaire contains several items on staff's behavior in non-comfortable indoor conditions which allows to analyze the effects of user behavior on energy consumption of the building. Among these it also provides input data concerning the comfort of occupants for an agent based modelling (ABM) of the user behaviour.

Agent-based modelling (ABM) is a simulation methodology that can account for the interaction between agents, e.g. the exchange of informational messages between individuals in an network can be modelled and how this exchange affects changes in behaviour [5]. ABM has attracted wide interests in the social sciences because it is particularly able to reflect the relationship between human behaviour and factors present in the environment that can influence human behaviour.

Agent-based modelling also plays an upcoming role in environmental psychology. The simulation of the complex interaction of humans and their social and physical environment is characterised by the complexity of the involved factors and processes [6].

The activities of the staff of a high rise office building in Graz to realize their personal thermal comfort conditions are the starting point for the ABM. Persons are assumed to be comfortable if indoor conditions are within the “comfortable” region of the comfort diagram according to the PMV/PPD-model of ISO 7730. A list of possible activities to alter the thermal comfort variables is available, among others: turning on the central heating system, opening the door of the own room to the corridor, opening the window next to the own working place, turning on a fan on the own desk, change one’s clothing.

Persons like to talk about thermal comfort and thermal variables in the office, in specific if conditions prevailing are on the brink of the comfort region. People also talk about their activities to reach the comfort region. So chats among colleagues are the relevant occupants’ interactions that are taken into account. Agents will act, if the limit of their accepted operative temperature/ humidity/ draught region is reached. Colleagues acting the same way will improve the conditions. Colleagues counteracting will worsen the situation.

It is the goal of the ABM to model the collective effect of user activities. Questions of interest are: To what extent can an “average user” be defined? Is the “average user” always (in all temperature domains) the same? Are there any indications for clustering of user behaviour? When do agents act? When do agents communicate? A first simple model will provide stochastic communication within the same room, an advanced model will let agents communicate with all other agents according to a „friend“-relationship (same project, same room, same preferred comfort range).

The agent based simulation could further be used to draw conclusions of the building’s operational energy use. The suitability of the model of agent based social simulation of user behaviour for the context of (nearly) zero energy office and service buildings is tested.

Keywords: User behaviour; nearly zero energy office buildings; quantitative social research; agent based modelling

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Timber in the City

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Abstract

In recent years, the so-called long-term environmental sustainable CLT (cross-laminated timber) building system has been a topic of great interest for multi-storey apartment buildings. This system can be an alternative to current reinforced concrete building systems and it offers great advantages in cost, speed and carbon reduction, while opening many questions in the design field.
In this paper, we present innovative student design projects for mid-rise buildings made of CLT. The presented projects are a part of the master studio “Timber in the City – Red Hook”, held at TU Graz, Faculty of Architecture in the summer semester 2013. The first objective of the project was to investigate the possibilities for design using scale models, in combination with parametric design and engineering. The second objective was to define an innovative and interactive facade system as a sustainable design element.

Keywords: timber, mid-rise building, sustainable building system

1. Introduction

In the last few years, there has been a rapid and noticeable development of CLT building systems for multi-storey apartment buildings. The height of constructed multi-storey apartment buildings is closely linked to the building codes and building insurance in individual countries, and it varies between three floors in Austria to thirty floors in Sweden.

2. CLT in Multi-Story Buildings

The reason for the rapid development of the CLT structural system and the establishment of related building codes is associated with climate change and multiple benefits of CLT, such as structural and environmental behaviour. From a structural point of view, its benefits concern mechanical properties across to advantages during assembly, which also influences, the financial benefit of this product.

Cross Laminated Timber panels can be produced in a factory environment with different surface qualities, which means the material is faster to use and build on site and therefore highly cost-effective. This process delivers an alternative to concrete and steel that can withstand the same pressure as prefabricated concrete [1]. A part of the fabrication process is CNC milling, with the opening and guides for installation milled for each individual panel From an enviromental point of view, wood is naturally CO_2 neutral and energy efficient in every respect. For example, by using CLT one ten-storey building reduces CO_2 equivalent emissions by more than 1,200 tonnes when compared to concrete and steel [2].

The largest influence on the final price of CLT buildings is determined by the price of the raw material and labor costs, which vary extremely across countries. On the one hand, the price of the raw material wood for such buildings is 10% higher than the price of the material for massive constructions like concrete or brick. On the other hand, however, prefabricated CLT panels increase productivity by lowering labor requirements and facilitating assembly. This decreases the total building costs about 40% compared to the same buildings built with reinforced concrete [2].

3. Challenges in timber

The master studio “Timber in the City – Red Hook” held in the summer semester 2013 had the aim to investigate the possibilities to use timber technology as the primary structure or part in a hybrid building structure for mid-rise buildings The first objective of the studio was to define parametric design tools to include static calculations in the early stage of the design process. The second objective was the definition of an innovative and interactive facade system as a sustainable design element.

4. Conclusions

Many prejudices about wood as a building material in contemporary architectural practice have led to concrete and steel being the most frequently used materials in the construction of multi-storey buildings. These materials and buildings significantly contribute to large volumes of CO_2 output and climate change. A current challenge concerns the promotion of alternative materials for this type of buildings. Many initiatives worldwide promote multi-storey buildings constructed of wood, which is indicative of a desire to change the situation.

The possibilities of designing multi-storey buildings made of timber are poorly studied, and through our studio “Timber in the City” we tried to evaluate the formal potential of this material. As an analysis of the students’ work, it can be concluded that architectural design with timber offers a great potential and the use of different systems such as CLT, laminated wood or Kielstieg combined with concrete or steel offers up to a 90% better CO_2 balance than standard buildings. The question how the building industry and markets perceive timber buildings is still strongly related to financial interest and safety standards.

5. Acknowledgements

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Criteria of Mobility for Sustainable Buildings

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Short Summary

Part of the research project “life cycle improvement of the building quality” (“LQG”) is the comparison of sustainable building certification systems. This study describes the differences concerning infrastructure and mobility in several building certification systems for residential buildings: klima:aktiv, TQB, DGNB, MINERGIE-ECO®, LEED and BREEAM. It demonstrates how these systems deal with the aspects of mobility and where the deficiencies are. Infrastructure and mobility is treated differently in all the systems. Some system boundaries simply ignore aspects of mobility for building declarations in order to do it correct in a “scientific way”. Thinking in a holistic way, from the point of sustainability it is clear that a “passive house” or “plus energy house” does not really work if you need lots of energy for mobility by using this building. A building depends completely from the site, because it is never changed. Therefore the system boundaries have to be extended from the building itself to the urban settlement.

Keywords: Certification systems, mobility, system boundaries

1. Introduction

National and international building certification systems have crucial parts in quality assurance and optimization of buildings. Thereby criteria of urban building and qualities of buildings are inspected by the University of Applied Sciences Upper Austria during the project “life cycle improvement of the building quality” (“LQG” – Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden, 2008-2013). Are we permitted to refer to a “passive house” or “plus energy buildings” as such, if mobility becomes a grave factor for the energy consumption of a building due to the building’s site? Should the energy demand respectively the energy consumption be assessed without mobility factors anyway? Nowadays, the term “total energy balance” should not ignore basic holistic coherences under the guise of “clean scientific separation”.

2. Urban building aspects and criteria in building certification systems

Commencing with a comfortable indoor air quality the aim of a high user satisfaction can also be improved by building structures and location factors. Criteria for mobility respectively infrastructure figure a high importance in these aspects, whereas mobility factors are not only defined by the motorised private transport. The problems of urban sprawl, environmental pollution and daily traffic jams will intensify due to the Austrian trend from 577 cars per 1,000 inhabitants at present to 680 cars per 1,000 inhabitants in 2021 [1]. Hence, urban and traffic planner demand the first priority for the public transport facilities over the motorised private transport as well as safe foot and cycle paths and connections with private and public green spaces. A previous research project exposed an approximate compliance of the requirements of energy-efficient and ecological urban construction and the parameter for child- and family-friendly urban construction: the “house in Green” is not identical with the child-friendly construction, but moderate concentrated building structures [2].

For the comparison only the criteria catalogues for residential buildings are used intentionally. klima:aktiv defines the quality of infrastructure by distances to public transport stops, food supply, etc. as well as foot and cycle paths and cycle storage possibilities. The mobility factors are listed in the category “Planung und Ausführung” (Planning and Execution). The percentage of the category planning amounts to 8.93 %, taking into account that only 38.7 % deal with site and mobility factors. TQB and klima:aktiv are nearly identical, but TQB divided the requirements into several more detailed criteria. Depending on the distance to the factors e.g. connection to the public transport or quality of the local supply, leisure facilities and social infrastructure points are assigned. Moreover, the safety of access routes and biking facilities are rated. The DGNB system takes an exceptional position in comparison with the other systems, because site and mobility factors are assessed in a separate category, which does not influence the total evaluation. The site factor of the MINERGIE ECO®, expandabilities, is listed in the category "Gebäudekonzeption" (building concept) and does not have any real influence (1.16 %) on the total result. Mobility factors are missing, although the Swiss leaflet SIA 2039, which is based on the 2,000 Watt Society, would provide a scientific basis. Criteria concerning site and mobility in LEED for Homes are evaluated in the categories Location & Linkages and Sustainable Sites. "Community Resources" has a percentage of 2.2 % of the total weighting and assesses the distances to public facilities. "Compact Development", which rates the amount of dwelling units per acre (4,046 m^2) of buildable land, attends with 2.9 % to the total evaluation. In category 1 of the certification system BREEAM Code for Sustainable Homes "Energy and CO_2-Emissions" the criterion "Cycle Storage" influences the total result with 4.1 % [3].

3. Discussion and conclusion

Building certification systems serve as quality assurance and quality optimization of buildings. Criteria for energy efficiency are treated broadly coherent at least in Europe, whereas criteria for site and mobility are viewed different. In DGNB mobility criteria are not included in the overall assessment, which can be referred as a historic mistake. Holistic orientated assessments do have to consider these factors, because the system boundaries redeploy off buildings to urban planning dimensions. The Austrian systems klima:aktiv and TQB already set detailed parameters for accurate ratings as distances to public transport connections or to local supplies. The gap of a missing scientific basis is filled by the leaflet SIA 2039 (*Fig. 1*), which covers the building-induced mobility in the energetic overall consideration. Consequently, the leaflet and its calculation tool is currently the state-of-art tool for the interface of mobility and immobility. As a result of the comparison, all building certification systems have to be reworked until they achieve an ideal mixture of all aspects of mobility and until all their requirements are easily comprehensible and reasonable.

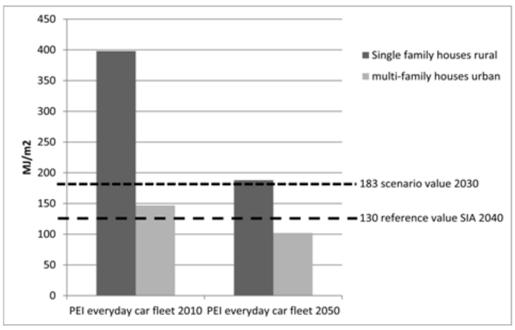

Fig. 1: Results of SIA 2039 comparing urban and rural area and car fleets of 2010 and 2050. The PEI requirements of SIA 2040 can only be achieved in the urban area with the car fleet of 2050 [4].

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High Performance Buildings Quality Assessment

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Short Summary

The “Database Quality” follows the initial idea that a holistic improvement of the quality of buildings over their entire life cycle can be achieved by adding quality assurance methods with one aim in mind, the contentment of the user of a building. Building certification systems are one possibility to get a higher level of quality performance [1]. From one partner in the project – FH Wels – a lot of quality assurance methods from different certification tools were tested. These studies are put into the comprehensive guideline. The guideline is structured on the life cycle of a building and contains defined time slots, where decisions are necessary and what information will be helpful for a decision maker. The focus of the common database will lie on facts, which have to be estimated during the planning of the building. This comprehensive guideline is placed in an internet portal, which gives quick access to the scientific data that will be presented online.

Keywords: Building certification systems, Quality assurance

1. Introduction

As part of the research project “life cycle improvement of the building quality” (“Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden – LQG”) a database is created. This is done to increase the approachability of the information provided and to spread the background and knowledge further. Especially landowners who plan to build a house should know about the ecological impact and life cycle data. The usual interest concerns mainly investment costs and time as well as creating the building according to the owner’s wishes. Particularly quality over the whole life cycle is an argument that applies scientists and house owners [2]. With the Austrian Research Promotion Agency (Forschungsförderungsgesellschaft – FFG) financing the project, it runs for five years but ends in October 2013. Five Austrian Universities work together with six industry partners and the main output beside the database is a comprehensive guideline.

2. Database of Quality

The layout of the homepage is divided in columns and lines in form of a dynamic matrix. The first line indicates six different levels of knowledge, starting with the first section which lists five different phases of the life cycle of a building. Beginning with the concept and the planning before the implementation is listed. The last two phases concern the utilization as well as the deconstruction. The second level deepens already into the different issues of the building’s life cycle. The other columns continue deepening the knowledge and so level 5 contains a variety of master and bachelor thesis [3].

The Database of Quality is filled with issues according to the relevant work package of each university involved in the project. The project management in addition to the development and the realization of the database is done by the FH Tirol Kufstein beside quality assurance energy efficiency and life cycle costing. The main topics of the FH Burgenland Pinkafeld are life cycle analyses and the database of quantity. Parallel the FH Kärnten Spittal contemplates life cycle costs among a tool for the early planning phase. From Graz the LCA and LCC of facade elements come with a test in a concrete application. The FH Upper Austria Campus Wels is responsible for quality assurance particularly tools concerning energy efficiency, building biology, occupant satisfaction together with processing the database [3].

One of the most ambitious aim of projects is the well-being of occupants. Because of the complex opportunity to measure satisfaction, this issue often is neglected. Every person experiences heat and cold differently what leads to very personal results.

Fig. 4: Pyramid of Quality of Buildings [4]

Figure four indicates the building optimisation assembled with energy optimisation, building biology and ecology along with quality assurance [4]. With a questionnaire the satisfaction of house owners was requested. Several accommodation units were consulted and a ranking list with the most important facts was disposed. Beside the air quality, the acoustic conditions and the temperature also the current health was observed. Moreover the energy savings, safety, design and offers of public transport were scrutinised [5].

3. Discussion and Conclusions

Up to now the database of quality has reached a certain grade of complexity and is already publicly available. With the adjustment according to the life cycle of a building the ordinary user can handle is easily and find one's way. For experts especially the deeper levels provide general reference work. To improve further development the database is verified by the industrial partners, who experience it in commercial practice. Especially the spread competences of the different universities of applied science secure a diverse knowledge and approach [3].

With all the research done pursuant to the project "life cycle improvement of the building quality" ("Lebenszyklusorientierte Qualitätsoptimierung von Gebäuden – LQG") the network called "University of Applied Science_network_building" ("FH_Netzwerk_Bau") is an established partner. Beside declaration tools for buildings particularly life cycle costs and life cycle assessment can be comprehensively advised.

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Assessment of an Office Building in Serbia by New Proposed Methodology - „OPEN HOUSE“

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Short Summary

The Construction Cluster „DUNDJER“ participates in the 7th FP European project entitled OPEN HOUSE (7th FP ENV - 2009.3.1.5.2). The overall objective of OPEN HOUSE is to develop and to implement a common European transparent building assessment methodology, complementing the existing ones, for planning and constructing sustainable buildings by means of an open approach and technical platform. OPEN HOUSE will develop a transparent approach able to emerge collectively in an open way across the EU. This approach will be communicated to all stakeholders and their interaction and influence on the methodology will be assured in a democratic way. The baseline will be existing standards (both CEN/TC 350 and ISO TC59/SC17), the EPBD Directive and its national transpositions and methodologies for assessing building sustainability at international, European and national level. This paper deals with practical assessment of an office building after reconstruction in Serbia.

Keywords: building assessment, sustainable building, european norms, ecologic building, energy efficiency, location

1. Introduction

Open house project involves 11 countries of the EU and the Western Balkans. Active partner at the project (FP7-ENV 2009) is a Construction Cluster Dundjer from Nis.

Basics methodology consists of the following assessment:

- environmental quality,
- social-functional quality,
- economic quality,
- technical characteristics,
- process quality (design and construction),
- the position of the building (location).

2. Project description

The case-study building hosts J.P. “Razvoj” (Public/Municipality Enterprise “Razvoj”). The Eterprise supports urban development of Municipality Knjaževac, and controls public investments, including design of major projects and objects. The Enterprise takes part in regional development and supports research in collaboration with research institutions, usually with University of Niš.
The building is located in the downtown of city Knjaževac, in pedestrian zone, close to main administrative municipality institutions. Face of the building is west-southwest oriented, without shadowing obstacles. The view from the building front side is to the small city central park and river Timok. The building has 3 main floors and an attic. In the 3rd floor are located offices, and in attic small conference hall, which is used also as a design studio for working team consultations.
The reconstruction of building was accomplished in the year 2005, with steady improvemen especially in energy consumption. This is the only office building with heating/cooling system based on heat pump. In addition, there is design of using solar energy (PV system) on the south oriented part of the roof. The design draft for using PV solar energy shows ability for using 200 m^2 (roof area) for PV panels. After completing, it would enable saving up to 15-20% of total energy consumtion.
Modeling the thermal energy balance of buildings is recently a challenging task for local architects and engineers. Directive EPBD (2002/91/ES) is recently enforced by local Energy Law, but in the time of building design and construction, the elements of design like glazing areas or windows thermal characteristics, the climate zone, the orientation, and the type of construction (e.g. high or low thermal inertia) have not been considered in a way to optimize their thermal contribution to the whole building’s energy balance. The measuring system, necessary for proper assessment and improvement, has to be realized in near future.
All the sustainability aspects (environmental, social/functional, economic, technical, process, location), are assessed “as is”, according to given scale. For Economic Quality assessment, the bill of quantities is now out of date, due to unrealistic prices of some materials and works, and using some not any longer used materials (with not standardized quality) and equipment with not strictly defined efficiency, and, finally, local rate of inflation (over 10 %). Sensitivity analysis, being considerable politically dependent, is even more complex, and somehow rather unpredictable.
It is worthy to mention that this building was chosen, it seems, occasionally, and not as an example of good practice. The building is located in underdeveloped part of Serbia with all consequences to quality of building and, consequently, building sustainability. But, it is, in a way, representative case of construction technology in southeast Serbia.

Fig. 1: **Case study building**

Building Type
Office

Building Phase
In use
Date of Completion: 2005

Building Characteristics
Total Floor Area: 340 m^2
Number of stories: 3

Address
Street Kej Dimitrija Tucovica 30
City Knjazevac
COUNTRY Serbia

Case study: Green family house in Slovenia, from planning until certification

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Short Summary

Case study of the real life example where individual low-energy building in Maribor, Slovenija has been carefully planed, built, supervised and certified as low energy building. Consultants for sustainable construction where tightly involved in all stages from the very beginning of building design. Blower test and thermography have been used not only for the proof of sustainability for the completed building, but also for the quality checking during the building process. All phases have been well documented from planning via on site measurements until the acquisition of grants by Slovenian Eco Found. Also similarity and differences of sustainable building sector in Slovenia and Austrian region Styria has been discussed.

Keywords: green building, certification, eco subvention, real life example

1. Green buildings in Slovenia, past and present

1.1 Comparison Slovenia vs. Styria

Despite Slovenia and Styria are comparable on forest coverage (over 50%), the share of the wooden building is significant higher in Styria then in Slovenia where over 80% of the new buildings are classical massive buildings. That means more difficulties to reach low energy (LE) and passive house (PH) standards and more embedded energy in the buildings.
When Slovenia has joined EU a number of European directives came into force also in the field of sustainable buildings. System of lending and granting subsidies has been successfully established for the construction of NEH and PH facilities through Slovenian Eco Found.

1.2 Design of LE and PH buildings

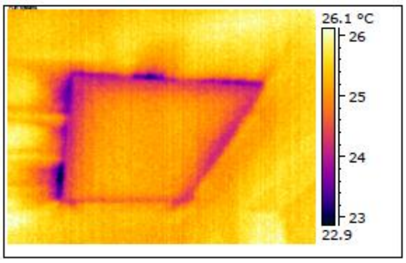
Professional basis for making well-insulated buildings in Slovenia are given with the norms and regulations. The main one is PURES and associated technical guidance TSG-1-004: 2010 [1] both from 2010. Based on those regulations variety of software solutions for building physics calculations (Archimaid FIBRAN, Energija 2010-Knauf, Building Physics 4.0 URSA, etc..) has been offered for free mainly by our main insulating materials companies.
Darmstadt Passivhaus Institut guidelines and PHPP software are used in planning and building of LE and PH buildings. Main low-energy criteria is computational energy consumption for heating (<25kWh/m^{2}a for LE and <15kWh/m^{2}a for PH. Additional demand is the minimal air tightness of the building that should be: <1.0 h^{-1} for LE and <0.6 h^{-1} for PH. Controlled ventilation is mandatory.

1.3 Slovenian Eco Fund

Eco Fund, the Slovenian Environmental Public Fund is operating under the jurisdiction of the Ministry of Agriculture and the Environment. Data from the annual report of the Eco Fund [5] shows that the average annual Eco Fund subsidizes the construction of approximately 80 individual buildings (the LE or PH implementation) with around 1,000,000 EUR. Eco Fund support only LE and PH buildings and the value of subvention diverse from type of building.

2. Role of SB experts during design and building process

Involving of SB experts in all phases is essential. Also all stakeholders must cooperate and have in mind the goal of low energy consumption. A control measurement with thermo camera and blower door test has been executed to discover weak points as for example bad sealing around otherwise PH certified attic door (Fig. 1) before final works. Weaknesses revealed by the measurements have been corrected before the final measurement, certification and the occupation of the residents.



3. Observed residential family building in Maribor

The observed building in Maribor, Slovenia comprises of four floors, including basement, ground floor, first floor and attic with external dimensions 9.10 m × 10.10 m. The netto area of the accommodation is 257m^2 and heating and hot water prepare is covered by a 8kW heat pump air / water and controlled ventilation with heat recovery is performed centrally from piping floors. The outer wall, which is essentially clay hollow brick POROTHERM system DRYFIX thickness of 25cm, 20cm are surrounded by the EPS insulation λ = 0.032 W/mK. The building is heated by floor heating system to all floors. Special attention has been paid to the implementation of the air-tightness of the building. Certification and founding has been successful.

4. Conclusion

Subsidiaries of the eco fund do not cover all extra cost of LE or even PH building, but they can certainly help in decision and osveščanju

Benefits of LE and PH are not only in the lower cost of living and higher life quality in those buildings but also in long-term sustainability of our society.

Such a construction is forcing us in the detailed planning and execution, the side effect is certainly a more enjoyable house to stay. Extra effort and more attention in the design stage without extra cost can ensure a comfortable stay in many years of the life cycle of the building.

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[4] Photo archive: Benedikt Boršič, www.gb-hisa.si, Veronika Leski, IB LESKI, Knittelfeld (Avstrija), www.gbc-net.com
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Improving comfort condition in the building

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Abstract

Appropriate energy efficiency and conservation strategies are essential for establishing optimal thermal comfort conditions in the buildings. In this regard, the building envelope has a major influence, and must be taken into consideration. In this study, the hourly variation of thermal comfort parameters of a building in Rasht (Iran), in warm seasons, is analyzed with Energyplus software. The walls of this building are made of horizontal hollow bricks, with a complementary thermal insulating layer from inside or outside. Natural ventilation based on the level of thermal comfort conditions has also been taken into consideration. The results make clear that high thermal inertia of the building envelope and natural ventilation with appropriate night purge sequence increase the thermal comfort level in all the floors of the building.

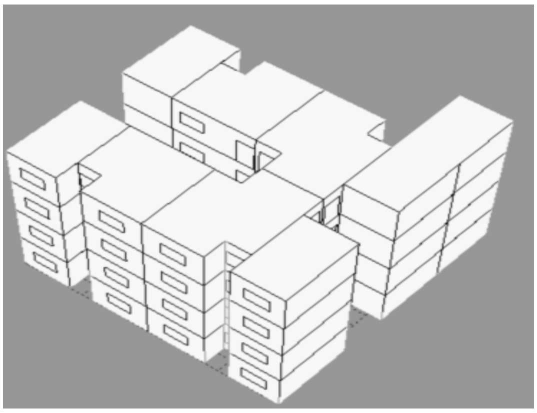
Keywords:*Comfort condition; Building construction; Natural Ventilation; Thermal insulation.*

1. Introduction

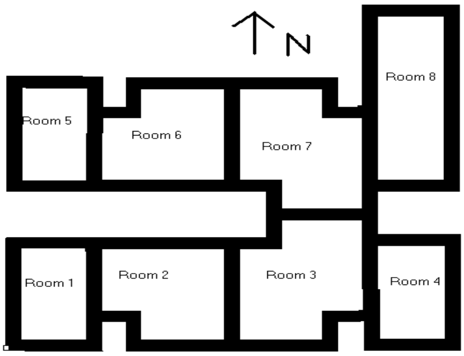
The thermal comfort depends on many parameters, such as the activity rate of persons, the indoor temperature, relative humidity, air speed and the temperature of surfaces surrounding the indoor space. In this paper, the hourly effect of using the thermal insulation and hollow bricks in the building external envelope exposed to natural ventilation at night, based on the level of thermal comfort conditions has been investigated for Rasht (IRAN). The simulation has been performed using Energyplus software in warm seasons. The thermal comfort has been investigated in two configurations: a) The effects of using thermal insulation and hollow bricks in external building, envelope on thermal comfort condition in sedentary and low activity rate condition, b) The effects of using natural ventilation in the building on thermal comfort condition in sedentary and low activity rate condition,

2. The procedure

The building energy simulation program Energyplus™ was used in present study to predict the thermal comfort in a building in Rasht. Energyplus™ (version 1.2.3.031) is made available by the Lawrence Berkley Laboratory in USA. [1]. Thermal comfort of a typical residential building including 4 floors has been evaluated by computer simulation. In this building, each floor has 4 similar zones (Fig. 1). First, the hourly inside temperature has been obtained using simulation by Energyplus software. Afterwards, the thermal comfort has been calculated, based on method explained in the ISO 7730[2]. The people are assumed to wear summer dress and the hourly thermal comfort has been calculated in several air speed configurations, for sedentary and low rate activity, from the 5th (May) to the 10th (September) month. Also, during natural ventilation period with windows wide open, from 10:00 at night to 9:00 in the morning, the air change is assumed to reach 3 volumes per hour. The rest of the time, air change rate is taken equal to 1. Table 1 shows Combinations of different models that are compared. In some models used insulation. All models have been simulated in different indoor air speed conditions: 0.5, 1, 1/5 and 2 m/s, for sedentary and low activity rate. The variation of the air speed can be provided using ceiling fans.



(a)

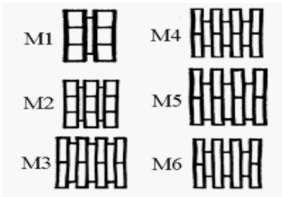


(b)

Fig. 1: Plan of the building (a) Isometric view, (b) Top view

Table 3: All models

Case(model)	Type of Block	Insulation used	Air Change
1 (Reference)	clay block	-	1
2	clay block	-	3
3	M1	-	1
4	M2	-	1
5	M3	-	1
6	M4	-	1
7	M5	-	1
8	M6	-	1
9	clay block	In the External Wall 5 cm	1
10	clay block	In the End Roof 10 cm	1
11	M1	-	3
12	M2	-	3
13	M3	-	3
14	clay block	In the External Wall 5 cm	3
15	clay block	In the External Wall 5 cm and End Roof 10 cm	1
16	clay block	In the External Wall 5 cm and End Roof 10 cm	3
17	clay block	In the End Roof 10 cm	3



3. Results and discussion

In this paper, the hourly effect of using the thermal insulation, with hollow brick external walls, accompanied with natural night ventilation, based on the level of thermal comfort conditions has been investigated. Based on the results, the following conclusion remark can be formulated:

1- The best thermal comfort condition is achieved in the first floor of the building, in rooms 6, 7, 2, 3, 5, 4, 8 and 1 (descending order).

2- In cases without night ventilation and without air speed increase, changing the building construction material of the reference building has not a noticeable effect on the thermal comfort condition (maximum 4%), despite the increase of the build cost.

3- In case with night ventilation, without air speed increase, changing the building construction of the reference building has a more noticeable effect on the thermal comfort condition (4 to 11%).

4- In case without night ventilation, with air speed increase, the thermal comfort change is more noticeable (about 10 to 65% in all month).

5- The change of activity level, from low activity to sedentary, leads to a more noticeable change of the thermal comfort.

In consequence, using night ventilation with ceiling fans (to increase air speed) is suggested to improve the thermal comfort condition. This change is cost effective, and can be suggested for new and existing buildings in Rasht and other regions with similar climate.

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Integration of Zero Energy Standards into Student Accommodation: Demonstrated through a Case Study of Lancaster University Residences in the UK

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Summary

The paper aims at the possibilities of converting the student accommodation of University of Lancaster (UK) into zero energy building. The analysis has been carried out on the typical student accommodation unit and an evaluation has been completed on the amount of energy saved, carbon emission reduction and energy produced by renewable sources. The paper also provides results of a study of climatic conditions of Lancaster and its influence in the design, based on which zero energy building techniques have been used to make the building energy efficient. In the study, the thermal efficiency, daylight factors, artificial lighting and energy production are considered to make the units sustainable. Series of computer simulations have been completed on the unit to assess the impact of thermal insulation on space temperature and energy uses, window openings to admit in the required light and use of solar collectors to produce energy. This particular building and site has been selected as it could become the template of student accommodation in the UK. As per statistics, there has been an increase in the demand for student accommodation with the increased flow of foreign students coming to the UK. This phenomenon has forced mainly university to expand their accommodation infrastructure and the University in conjunction with the University Partnerships Programme who were able to develop accommodation with standards of Ecohomes. The study looks at the possibility of achieving zero energy standards for the Ecohomes so that it could be used as design template to build greener student accommodation around the country to answer the demand.

Keywords:Eco Residences, Zero Energy Building, Student Accommodation, Building Simulation, Photovoltaic Cells, Energy Consumption

A Study on Assessment Methodology to Measure Carbon Reduction Potentials of Recycling Building Materials considering Avoided Impacts

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Short Summary

This is a basic study on developing an assessment technique to objectively measure environmental loads of recycling building materials throughout their life cycle. At present, the building materials industry does not have any detailed procedures and standards necessary in estimating greenhouse gas emission caused by manufacturing and utilization of products developed using waste materials as ingredients. Therefore, it is necessary to develop an assessment methodology with which to measure in advance the environmental loads that can be lowered at waste recycling.

Keywords: Carbon emission reduction; Life Cycle Assessment; Environmental impacts; Avoided Impacts; Recycling Building materials.

1. Objectives and Scope

Recycling building materials are produced using mainly waste and, thus, the ratio of natural resources content is low. As much as so, different assessment scenarios must be applied to measuring environmental impacts by life cycle and a methodology to estimate carbon dioxide emission according to each scenario must be established in detail. This study aims at proposing a life-cycle assessment method to quantitatively assess environmental impacts of recycling building materials by each stage, such as manufacturing, use and disposal of building materials made using recycled materials.
Although there can be various methods of quantitatively assessing environmental performance depending on the points of view, this study uses an analysis method based on $LCCO_2$ (Life Cycle CO_2) in relation to climate change agreements, which are emerging as an international issue. Building materials undergo numerous processes during their life cycle, ranging from production and use to disposal.

2. Proposal for measuring CO_2 reduction

In life cycle assessment, a model to explain the flow of resources and energy within the ecosystem is basically divided into environmental sphere and technical sphere. The system boundaries for life cycle environmental impact assessment on a target are generally limited to the acts of processing, construction, utilization and disposal that take place within technical sphere. Environmental impacts are calculated by collecting the relevant data and applying the corresponding LCI DB by each input substance.
However, in case a waste substance discharged within specific system boundaries inside technical sphere, such as recycling building materials, is processed and utilized as a recycling resource or biomass within another system boundaries, it is necessary to add a new circulatory sphere so that to explain the phenomenon of a cyclic closing that takes place within technical sphere. As for recycling resources, collection and disposal of the resources take place within technical sphere. Accordingly, by expanding system boundaries to include collection and disposal of materials, both

carbon reduction occurring in the stage of collection and potential environmental load reduction occurring in the stage of disposal must be taken into consideration.
In this study, the avoided impacts by resource recycling, potential carbon reduction in the stage of materials collection and the potential carbon reduction in the stage of disposal were expressed as reduction potential, sequestration potential and recycling potential respectively.

3. Conclusions

A. **Production stage:** The sources of carbon emission activity in production stage include raw materials for production, energy collection, manufacturing process and transportation of raw materials and energy. If raw materials are the source of carbon absorption, according to the carbon reduction effect generated by carbon sink, the amount of carbon emission can be lo wered as much as the amount of absorbed carbon.
B. **Construction stage:** The sources of carbon emission activity in construction stage are largely divided into activity to transport building products to a construction site and activity to assemble the building products using construction equipment. The amount of carbon emissions is calculated by adding emission amounts caused by each activity.
C. **Use and maintenance stage:** The sources of carbon emission activity in application stage are divided into an activity to use building products and an activity to repair the products in o rder to maintain their performance during the period of use. The amount of carbon emission generated by the application of building products can be calculated based on the amount of energy use. And the amount of carbon emission generated by maintenance activities can be calculated by estimating repair cycle based on the product lifespan in comparison to total a pplication period and then multiplying the repair cycle with the amount of product input in the initial phase.
D. **Disposal and recycling stage:** The amount of carbon emission generated by disposal of b uilding products is calculated by adding the amounts of emission from dismantling the products and recycling activities, and then deducting the amount of carbon r eduction resulted from production of natural resources that are substituted with reused or re cycled materials.

4. Acknowledgement

The work presented in this paper is a part of the study on the Construction Technology Innovation Project (project number 11-Technology Innovation-F04) which has been funded by the Ministry of Land, Transportation and Maritime Affairs.

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Using MFA for the performance economy: a case study of industrial storage

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Keywords : Performance economy; Material Flow Analysis (MFA); Life Cycle Assessment (LCA); Industrial storage; Product-Service System (PSS).

1. Introduction

Sustainability requires development of new economic frameworks and business models for a better management of materials and energy. For example, the performance economy offers new function-based business models instead of product-based business models. Performance economy can be applied by companies through dematerialization of their offers and rental of a service. In this case, companies keep ownership of materials involved in the service provision over their life cycle, which gives a strong incentive to optimize resource efficiency.
Industrial storage is a sector in which performance economy has been developed for a long time. Serge Ferrari Company was interested to assess the environmental impact of different storage solutions.

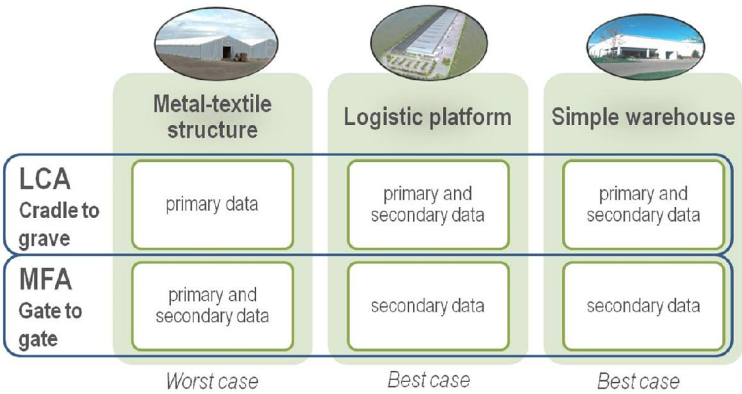

Fig.1: Storage solution analysed in the project

2. Methodology

This study aims to quantify environmental impacts of performance economy by comparing the rental of metal-textile storage structures with classic storage solutions. To take into account the management of materials and the reuse cycles (e.g. logistics, stock management), a materials and energy flow analysis (MFA) is carried out, using Umberto® tool. Based on representative demand profiles, various use scenarios are analysed. A Life Cycle Assessment (LCA) is then carried out to compare this service provision with plausible alternatives.

The rental of metal-textile structures needs a material management of parts (storage, repair, reuse loops ...). According to this complexity, Material and Energy Flow Analysis has been carried out in order to evaluate “gate to gate” results of this system. Then, Life Cycle Inventories have been used to add upstream and downstream flow and going to a “cradle to grave” Life Cycle Assessment.

Comparison between different storage solutions shows that over five environmental indicators, the rental of metal-textile storage structures can have a lower environmental impact than classic storage solutions (logistic platform and warehouse).

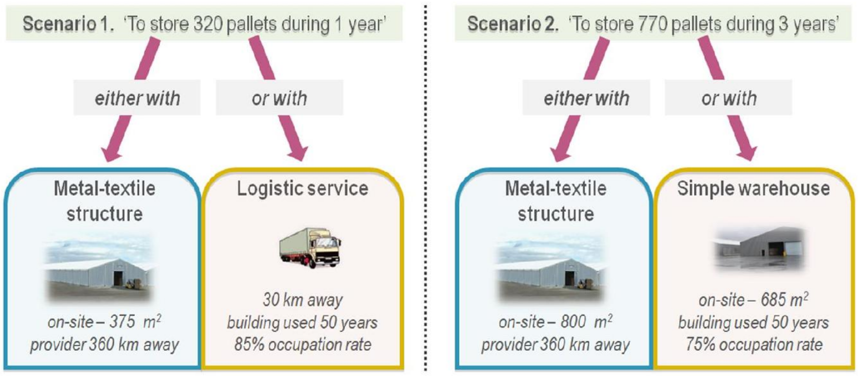

Fig.2 : Scenarios analysed for industrial storage solutions comparison

3. Results

Thanks to its lightness and the reuse of materials, as well as the design modularity, metal-textile structures could lower environmental impact for industrial storage and could bring flexibility and reactivity compared to classic storage systems.

Environmental performances are mainly due to:
- The lightness: reduction of material input per unit of service
- The proximity: reduction of pallet transport by truck
- The modularity: adaptation of storage solution volume (no oversize needed)
- The efficient management of material (wastes reduction): reusing, repairing, remanufacturing and finally recycling

Thanks to the modularity, metal-textile structure can be adapted to non standard pallets, unlike logistic platform which are efficient for standard pallets (storage on racks). Metal-textile structure is also a solution which manages the risk of material obsolescence by reusing materials in another place where there is a storage need. In the case of classic warehouse or logistic platform, if there is no longer storage need at proximity, the building becomes obsolete and most of materials involved in the building will not be used in another building.

4. Conclusion

This project shows some environmental benefits of technical textiles in one specific application but these types of textiles have many applications (like frontage protection, dividing wall, etc.)
Metal-textile structures show interesting properties like:
- Obsolescence risk management: unlike a simple warehouse or logistic platform, there is no risk of obsolescence - can be disassembled and used in another place.
- Proximity: can be assembled on-site where the need of storage is required.
- Modularity: can be adapted to merchandise that have to be stored.

However, metal textile structures are not always better than other solutions on an environmental point of view. When the storage need is far from the metal-textile structure supplier and when the storage time is low, environmental burdens per unit of service due to transport, assembly and disassembly of the structure is high.

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Identification of climate neutral buildings using LCA – Case studies from the project ÖKOPLUS-KOMPLEX

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Short Summary

The paper summarizes main findings of the Austrian research project “ÖKOPLUS-KOMPLEX”, which investigated technical, ecological and economic pre-conditions for the implementation of plus energy and climate neutral building concepts. The paper focuses on the results concerning the technologies, which can be used to produce more energy on the buildings surface than needed by its residents in the operation phase, how life cycle assessment (LCA) was used to determine climate neutrality of the building, and the impact of setting different system boundaries on the results.

Keywords: Plus energy building, climate neutral building life cycle assessment (LCA) greenhouse gas emissions

1. Extended Abstract

Passive Houses, Low Energy Buildings, Nearly Zero Energy Buildings, Net Zero Energy Buildings, Zero Emission Buildings, Climate Neutral Buildings, Blue Buildings or Plus Energy Houses. A whole variety of different terms and concepts are currently buzzing around in the building sector. For some of these concepts a common understanding exists, at least on national levels.
The Austrian research project “ÖKOPLUS-KOMPLEX” looked into the concepts of Plus Energy Buildings and Climate Neutral Buildings. The technical, ecological and economic requirements for the implementation of these building concepts were investigated.

The potential to produce energy from the building surface (e.g. roof and walls) was analyzed and compared to the energy needed by building’s residents. The analysis was based on already existing buildings with a high energy standard (low energy building, passive house) and was made at the following scales: three single family homes, one multi-story building, an event-building and a housing complex.

Using life cycle assessment (LCA) a greenhouse gas (GHG) balance for the investigated buildings was prepared. Based on the results of the LCA it was determined if the building concept is able to reach the status of “climate neutrality”. If more energy was produced on the buildings surface than needed by its residents the benefits on greenhouse gas (GHG) emissions by replacing energy generation from fossil resources were determined. If the GHG emission benefits were the same -

or even higher - than the GHG emissions linked to the buildings life cycle (construction, operation, and demolition phase) the building reached climate neutrality.

The paper summarizes the main findings of the project concerning the technologies, which can be used to produce more energy on the buildings surface than needed by its residents in the operation phase, how LCA was used to determine climate neutrality of the building, and the impact of setting different system boundaries on the results.

2. Acknowledgement

The work for this paper was conducted in the Austrian project “ÖKOPLUS KOMPLEX – Untersuchung der energetischen und ökologischen Voraussetzungen zur Errichtung und Nutzung von Plusenergiehäusern und –verbänden” which was carried out within the framework of the programme “Haus der Zukunft Plus”.

3. Project Team

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RESOURCES – Institut für Wasser, Energie und Nachhaltigkeit

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Sustainability issues in the valuation process of project developments

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Short Summary

This paper presents a system to incorporate the economic benefits of sustainability into the valuation of real estate project developments. The impact is provided through the consideration of quantified sustainable qualities of buildings in the determination of the interest rate in the valuation process. Furthermore, it highlights the added value that sustainable features and the relevant certification systems bring to a project development. Using a catalogue of parameters, key parameters are identified for the specific project development to be valuated. These parameters are then quantified by means of distribution functions and checked for interdependencies. This analysis, and with it the results of a sustainability valuation, are incorporated into the calculation of the market value and the Internal Rate of Return. Results are communicated according to the input data through distribution functions. The valuation system makes investment decisions easier to understand and emphasises the positive impact that sustainable features can have on the economic success of real estate projects.

Keywords: project development, sustainability, valuation, real estate industry, certification systems, profitability, integral

Extended Abstract

Over the last few years the principle of sustainability has established itself in the real estate industry and become a significant quality feature for properties. Nevertheless, for investors the economic success of a property is of greatest importance. The foundations for this success are laid at the start of a project. Issues addressed during this development phase include the basis for decision making and, with it, the valuation of projects in the design phase. Therefore, this paper not only aims to develop a valuation system for property developments but also to establish a positive correlation between the sustainability and the economic success of a project. The impact is provided through the consideration of quantified sustainable qualities of buildings in the determination of the interest rate in the valuation process. Regarding a property's sustainable features, the question is how these can be integrated at an early stage into project planning and brought in line with the economic aspects.
The following quote clearly illustrates the importance of sustainable building:

Sustainable building means ... constructing and preserving buildings which, instead of being an inherited liability, will prove to be an asset for generations to come. [1, p. 221]

Sustainability certificates have been developed as tools for measuring and comparing sustainability features. From these various certificates the ÖGNI/DGNB system was selected as the basis for our valuation model.
The valuation model, which allows a quantitative consideration of sustainable features of buildings, comprises two phases, as shown in Fig. 1.

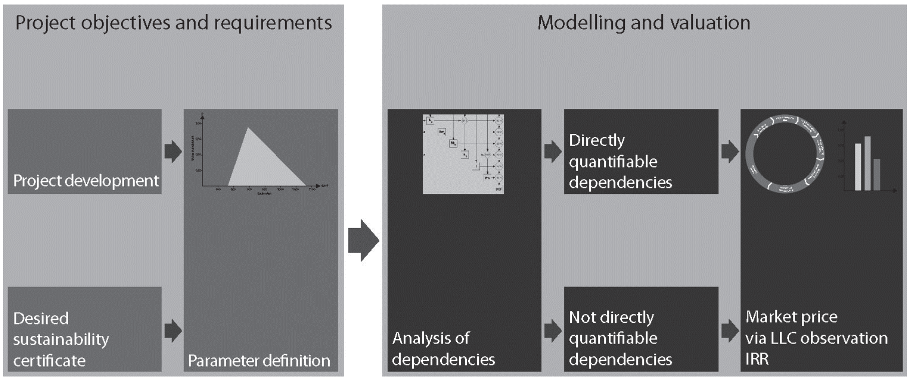

Fig. 1: Valuation process taking into account sustainability criteria

In the first phase the project objectives and requirements are defined. These are then used to select the most important parameters for that specific project from a range of parameters analysed in the paper. This is followed by the essential step of quantifying the input parameters through distribution functions. In the second phase the parameters are analysed for dependencies (divided into directly quantifiable and non-directly quantifiable dependencies), which then are incorporated into the determination of the discount interest rate as risk-minimising influencing factors. The final step is to calculate the market price and the Internal Rate of Return as distribution functions using an adapted DCF method via a Monte Carlo simulation. The system was validated using a practical example and tested for practicability.
The limitations of this valuation system become apparent in the necessary task of creating forecasts. Therefore the system should be used only as a basis for drawing comparisons. Furthermore, the valuation of design aspects is another topic which is almost entirely excluded from the model. It is also not possible to evaluate the social effects of project developments or the impact they have on urban development.
The method developed in this paper represents a practical valuation tool that can be used in all phases of real estate project development, right through to the final design phase. For decision makers this tool significantly improves the process of investment decision making through the consideration of sustainable features and a probabilistic approach and, as a result, the optimisation process. One key advantage of the tool in practical situations is that it creates a highly transparent system that is easy to understand, especially for investors and financing institutions. Through the paper it was also possible to highlight how fulfilling sustainability adds value to a project development. All in all, this valuation system can make a significant contribution to risk management in project developments.

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Non-state market driven governance in the Green Building sector

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Extended Abstract

Third party certification as a contribution to non-state market driven governance represents an increasing share in the real-estate sector. The role of NGOs and the linkages with industry are of interest for this study. For the Austrian real-estate market the ÖGNI (Österreichische Gesellschaft für Nachhaltige Immobilienwirtschaft) was identified as a key player in providing certain certification schemes (DGNB, blueCARD) for the Austrian market. This study addresses the role of ÖGNI in the Vienna real-estate market and puts a more detailed focus on members and auditors as part of the stakeholders to identify innovative impulses in the Vienna real-estate market to analyse the linkages between economy, politics, and society. The real estate sector is the economic sector that contributes in many ways negatively to the environment and society (e.g. inefficient use of materials, water, land, etc.) and with this dynamism can therefore be seen as one of the major threats to sustainability in the future. There are a lot of critical voices among scholars which alert us that such industry dominated environments are mainly serving the market while neglecting public interests. In order to fill this gap between public and private interest one can think of examples that show why it is necessary to create networks managed by non-governmental organizations (NGOs). Consequently the role of different kinds of organizations in fostering sustainable development has become a broad field in governance related research. Within this research the role of NGOs as governance actors for sustainable development is becoming increasingly relevant. Since NGOs are involved in processes aimed at raising quality standards in different areas, e.g., forestry management (Forest Stewardship Council (FSC)) and marine protection (Marine Stewardship Council (MSC)), the scientific community can build upon a growing empirical basis.

The study investigates the dynamic development in the green building market in Austria and specifically in Vienna by focusing on the non-state market driven environmental governance processes led by green building councils. The overall goal of this study is to identify innovative trends in Vienna's real estate market that have been activated by the Austrian Green Building Council (ÖGNI) by implementing the German certification system for sustainable buildings (DGNB). In order to fulfil this goal the study was designed to investigate if and how this organisation, as an independent and external organisation for the real estate market, contributes to non-state market driven governance. Focusing on the members and networks of ÖGNI the study describes its third-party role and its ability to act as a bridging institution between the state, the market, and the public.

Following a case study approach the study is embedded in a conceptual framework that provides the basis for analysis. The empirical part was preceded by an extensive literature and Internet research on ÖGNI. A questionnaire was designed together with the management of ÖGNI, who supported the research team with data from their members and auditors database. As a result of the initial research it was decided to interview the auditors as well. For the online survey, ÖGNI has provided the research team with a list of 239 email addresses. 206 people were contacted and received an invitation to an online survey. A total of 90 people completed the questionnaire. 27 people were exclusively members, 30 auditors and 33 auditors, who are also members of the ÖGNI. This corresponds to a response rate of 43.7%. Questions for the members include the history of the accession and the use of the member network for professional purposes as well as

the satisfaction with their membership and the overall perception of ÖGNI. The specific questions for auditors also refer to the history of education as a DGNB auditor, working as an auditor, satisfaction with the support from ÖGNI, as well as an assessment of the market potential for certifying buildings in Austria. Furthermore, there is a respective set of questions, which includes general questions for both groups about their social background. Parallel to the online survey, the research team decided to create a list of project participants of those buildings in Vienna certified by the DGNB certification system.

The analysis provided evidence for the suspected value of membership to ÖGNI. The members use ÖGNI as a networking platform, where they are primarily focused on networks in the context of their own profession. This can be clearly seen as an advantage, since the network activity has direct relevance in developing a sustainable building industry. Moreover, the members who participated in the survey largely come from industry. It can be stated that ÖGNI provides a platform for the exchange of industry-specific activities and is described by its members as a valuable networking instrument as also reflected in the literature on non-state market-driven governance.

The increased media presence of ÖGNI is well perceived by its members, who feel themselves represented in the framework. The real estate market moves more and more towards sustainability and related activities are demand driven from the customer (investor) side. The active public relations are seen as an awareness instrument that is used in the entire real estate industry. An additional strength is the third party certification. It is described as a long term investment by investors and customers (owners) are demanding certificates as found in interviews with auditors.

One weakness generally refers to the information provided and in particular to the lack of structure of this information. It can be subsumed that ÖGNI provides information, but too much in terms of volume, or in an unstructured way. The second identified weakness relates to the certification system. According to the members it could be improved in order to optimize the process. The DGNB certification system however provides ample space for improvement and sees itself as a learning tool.

An issue that was rated ambivalently is transparency. The result shows that transparency is a sensitive topic that is barely recognised by individuals, because transparency has been called both strength and a weakness. It can also be associated with excessive information or the lack of structure of this information, as this may also lead to a non-transparent process.

The general opinion in relation to the work of the ÖGNI has been very positive. Two major areas were considered separately - the organization and the certification. The assessment of the organization clearly shows that the ÖGNI has a clear focus on Austria and especially Vienna. Most DGNB certified buildings are located in Vienna and the city is also seen as having great potential in improving the quantity of DGNB certified buildings. Vienna will establish a leading role in the sustainable office sector in the near future leading to a headquarters function in Austria driving the market towards sustainability. This is a beneficial effect due to the institutionalization of ÖGNI as stated by respondents. The certification system is clearly perceived as a market benefit. The type of certification (bronze, silver, gold) has not provided any disadvantages due to lack of experience over longer periods. Further analyzes after having implemented the system for a longer peiod would be needed in order to make more profound predictions towards the different types of certification. There is wide consensus that deciding whether a building certificate is sought or not, will be determined solely by the project participants and will thus be a market-driven decision, which is not controlled by any political action (policy push). Since ÖGNI in its capacity as a third party institution awards and promotes the development of sustainable construction, one can speak of an existing non-state market-driven governance regime, which in its actions and engagements supports the overall policy framework without being a political decision maker.

Socioeconomic logical attributes to complement LCA results in building material selection in Brazil

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Short Summary

Observed throughout entire life cycles, these factors are the incentives and the inhibitors of potential environmental improvement. However, LCA has traditionally focused on environmental aspects, and even ISO 14040:2006 limits the analysis to environmental effects. This paper aims at using the set of socioeconomic subcategories, proposed by UNEP's guidelines for social LCA, as logical attributes to assist design decision-making processes regarding choices of construction materials. The validity of the attributes in the Brazilian construction sector is evaluated, considering information availability. These attributes are expected to complement and enlighten ranking of alternatives beyond environmental evaluation or when it is not enough to establish a clear ranking between them. Targeted materials and systems will be those associated to the highest life cycle environmentally impacts based upon previous studies of a sample of typical practice Brazilian buildings. Considering the current embryonic stage of Brazilian LCA studies and of consideration of social and economic aspects worldwide, this paper expects to enhance the discussion on integrated life cycle accounting of multidimensional sustainability aspects, and to add practicality to data that are usually perceived as too specific to be properly used by designers and contractors.

Keywords: Life Cycle Assessment (LCA); social; economic; building materials; life cycle indicators; life cycle attributes.

1. Introduction

Observed throughout entire life cycles, socioeconomic factors are the incentives and the inhibitors of potential environmental improvement. However, Life Cycle Assessment (LCA) has traditionally focused on environmental aspects, and even ISO 14040:2006 limits the analysis to environmental effects. According to [1], recommendations based on LCA do not address possible trade-offs between environmental protection and socioeconomic concerns, which raises questions about LCA's ability to support actual decision-making in companies aiming for sustainability. In an effort to take a step towards SLCA standardization, UNEP/SETAC Life Cycle Initiative published the Guidelines for Social Life Cycle Assessment of Products [2], aiming to provide a framework to assess social impacts across product life cycles.

The insertion of socioeconomic aspects on building activities can be common when aiming to assess financial viability of different project choices. However, when considering construction performance in a life cycle perspective, companies usually fail to take into consideration the performance of all of their supply chain contributors. Life cycle studies in Brazil still struggle with the lack of inventory data, which diminishes researchers and designers ability to produce and use, respectively, reliable life cycle results. With SLCA and LCC the main obstacles remain the same.

Aiming at providing more complete and thorough results to aid designers' decision making processes, the present article *(i)* proposes a set of socioeconomic attributes, based on

UNEP/SETAC published guidelines [2] and *(ii)* evaluates the viability of such attributes through a survey of sustainability reports of different Brazilian companies that produce building materials with highest contribution to a building's environmental load.

2. Methodological approach

In order to assess the feasibility of using the UNEP/SETAC proposed subcategories as attributes, main production companies' sustainability reports have been analyzed. The attributes were evaluated within companies that produce 12 materials/component, which were listed in previous studies as top contributors to the building's embodied energy and carbon. The studied typology was basically low-rise, low window-to-wall ratio, reinforced concrete-framed, masonry façade and partitions, and ceramic or metallic roofing buildings. The four cases comprised one integrated service center; one police-training center; and two school buildings. Results obtained showed that the ranking was composed by: Portland cement, ready mixed concrete, ceramic brick, steel rebar, PVC tubes and conduits, sawn timber, sawn roundwood, roof steel structure, ceramic tile, plywood, hydrated lime and adhesive mortar. Results are presented for each material/component or production sector, indicating to which extent the information regarding the selected attributes is available, and later the scope is enlarged to assess information availability related to each stakeholder category, considering all top 12 materials/component.

3. Final remarks

Brazilian historical deficiency in data availability creates many obstacles to LCA experts to provide reliable and thorough results. Within the national building sector, specifically, many academic efforts have been observed to create databases and aid designers' in project choices, but showing wide methodological variation. However, the current protectionist policy of many companies in relation to their internal processes data observed in Brazil characterizes a scenario in which researchers many times have their hands tied when it comes to providing truly trustworthy and strong life cycle results. Considering the mentioned situation, performing a complete Social Life Cycle Assessment consists in a great challenge for the Brazilian construction sector.

Results showed that companies with higher market breadth and, consequently, more industrialized processes, disclose more complete sustainability reports, usually in compliance with GRI's guidelines. Smaller companies, in almost all cases, have not published any sort of reports. In the case of wood and ceramics, the informal nature of their production in Brazil implies in a significant lack of information. In such cases, to assure social and economic responsibility, it is important to create suppliers' ratification projects. Steel stood out as the material with more information available, probably due to the aggregation of large manufacturers in a national association, which impels companies to disclose results, and even to improve their production processes, considering the opportunity to increase competitiveness. Finally, results highlighted that, in the current data availability status, the use of impact subcategories exclusively as logical attributes could aid in the process of inserting social and economic evaluations in the construction sector. Some product categories, however, would be harmed in the decision-making procedures due to failure in reporting adequacy of final producers or along the respective supply chains.

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Indicators to Support Sustainability and Performance-Based Selection of Structural Frame Alternatives in Concrete: Validation at Typical Floor and Superstructure Levels

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Short Summary

Life cycle-based studies have shown structural frames and envelopes as major contributors to buildings environmental loads. Given the difficulty to insert life-cycle assessment (LCA) in daily routine of structural design practices, this paper presents a set of LCA-and-LCC-based indicators that integrates functional, environmental and economic performance requirements. The goal is to allow proper design decision-making support and a broader, life-cycle, sustainability evaluation of concrete structural frames. Using a case study approach, it focuses on different concrete building flooring systems to show the indicators application feasibility at typical floor and whole superstructure levels.

Keywords: sustainability; indicators; LCA; LCC; structural frame; concrete flooring system; performance requirement.

1. Introduction

Research initiatives for new generations of sustainable buildings assessments state that buildings sustainability level should always be described using indicators [1]. They should be relevant, measurable and adequate to the analysis [2], whilst remaining objective and providing traceable results [3]. The work carried out in the past decade within the "Construction and City Related Sustainability Indicators"- CRISP network provided a comprehensive indicators' database for the building sector. However, further studies of this network concluded that considerable additional work was still required to achieve indicator systems that could be widely used to support successful adoption of the performance approach to buildings design and construction [4].

Environmental, economic and social performances are all important dimensions to make a good sustainability assessment at the building level. However, advancement in all three dimensions of the sustainability tripod is not equally balanced. Literature review has pointed out many unsolved difficulties regarding integration of social aspects to environmental life-cycle assessment [6]. Thus, considering the complete absence of data in this regard in Brazil, this work is dedicated to the study of structural systems typically used in Brazilian residential concrete buildings typology. Other relevant building systems as well as the relation with the other parts of the building and the impacts on the technological system as a whole are beyond the scope of this paper. Therefore, this paper aims at proposing a set of LCA-and LCC-based indicators to evaluate sustainability aspects of concrete structural frames from a life cycle perspective. A case study approach was adopted to investigate its feasibility to compare sustainability performance of different concrete building flooring systems.

2. Approach

The set of functional indicators shown in this paper refers to stability, fire safety and safety in use, flexibility and durability requirements, and is based on ISO and the Brazilian Performance Standards. The selected environmental indicators, primarily resource intensity indicators, are based on ISO/TS 21929-1:2006 mainly associated to resource management. They measure structural frames environmental performance in accordance with ISO 21931-1:2010 methodological guidelines. Life cycle costs and local economy support were the economic indicators considered for this study. Three case studies on structural flooring systems, used in different residential concrete building typologies in the Brazilian coastal area are presented. They comprise low-and medium-rise concrete-framed buildings. Case study 1 has a total built area of 5,829.19 m^2, in 6 floors (24 apartments), with a 27.5cm-thick reinforced concrete waffle slabs with beams. Case study 2 (8,841.37m^2 in 15 floors; 48 apartments) and Case study 3 (4,943.31m^2 in 6 floors; 32 apartments) have 18cm-thick prestressed concrete flat slabs. The structural materials usage was quantified for all three buildings from structural design drawings provided by the local construction company, including labour, which was calculated from reference costs tables (February 2013) available online at the official site of Espírito Santo Public Constructions Institute (IOPES). For each case study, environmental indicators were calculated for two situations: one typical floor and the total superstructure. Foundations were disregarded to isolate the effects of soil's carrying capacity on sizing, and consequently on material consumption. Calculation of LCA-and-LCC-based indicators used Life-365 software for service life prediction and LCC estimate, as well as cradle-to-gate LCA results performed via SimaPro 7.3 for the structural materials designed for the marine environment studied.

3. Results and Conclusions

For the conditions studied, *(i)* prestressed flat slabs showed better economic and functional results than reinforced concrete waffle slabs, which, however, presented the best environmental performance; *(ii)* results confirmed the validity to proceed with the analysis of a typical storey in lieu of the whole building structure; *(iii)* findings revealed that designing by the Brazilian concrete structural design code does not ensure compliance with the recent national performance standard, ABNT NBR 15575:2013, thus, strategies to increase the service life of concrete structures must be considered; and *(iv)* that design life associated to unit of structural area are convenient functional unit descriptors for superstructure as well as floors, ensuring proper comparison among structural components performing same structural function over a given lifespan. Analytic hierarchy process will be applied for relative importance attribution across indicators, to generate single scores to streamline selection. It is expected that this set of indicators, refined by other case studies, evolve to a multidimensional performance framework to support sustainability-oriented concrete structural design decision-making.

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Performance of Domed Roofs using a New Computer Model

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Short Summary

Domed roofs have been adopted by architects and engineers throughout the North Africa and other hot dry areas. However, the solar performance of such forms has rarely been quantitatively studied. In this study, variation of the direct solar radiation (DSR) over domed roofs was estimated and compared with standard horizontal flat roofing used in the typical houses.
A number of investigations have been carried out on domed shapes with varying cross section ratio (height/width) and orientations to study their solar performances. The geographical latitude (30 N) has been chosen to represent the hot region areas. The comparison showed that the use of the domed roofs leads to a significant improvement of indoor space in summer. The height-to-width ratio (Cross Sectional Ratio) has a significant impact on the solar performance

Keywords: Circular Dome, Roofs, Solar Performance, Curved Surface, Direct Solar Radiation.

1. Introduction

Economic buildings can be built in such a way that the structural elements are designed and oriented to take maximum advantage of the local climate (Sanjay et al, 2008). Olgyay [2] and Fathy [3] indicated that the curved roofs can reduce local radiant flux on a rounded surface. As a result, the heat flowing into buildings will be reduced. Bahadori [4] mentioned that domed geometrical structures with vents in their crowns increase natural ventilation through buildings. As a result, the indoor air will not become humid and the mean radiant temperature can be reduced. Gadi [5] reported that about 40% of domed roofs would be reduced from direct solar radiation. According to Vector [6], at noontime, the dome’s performance is always better than that of a horizontal surface.

2. The Geometrical Resemblance

Wang [7] mentioned that the continuous curved surfaces could be approximated using a finite number of small flat planes. Elseragy [8] also explained that it is possible with an acceptable result to undertake calculation of radiation incidence on a large number of infinitesimal tilted planers that resembled the curved forms. In this study, the curved exposed surface has been divided into a number of small flat planers called “elements”, The element can be a horizontal, vertical, or tilted surface; the slope angle for each element is different from the others, depending on the surface curvature of the exposed surface. The solar irradiation on each element depends on its specific orientation and tilt angle, and upon the other common parameters such as the time, latitude, atmospheric conditions and ground reflectivity. The total solar radiation received by the entire exposed surface can be estimated as the sum of the irradiation on the surfaces of all elements.

3. Calculation of direct solar radiation

Several geometric calculations are needed to compute the DSR received by the dome surface: the slope, the area, and the azimuth angle for each grid cell. For area calculation, a simple algorithm was developed to calculate the area of trapezium and triangular elements. The tilt angle for each element on the dome surface is the angle between the element surface and the horizontal plane. the element’s azimuth angle(ξ) for each element depends on the element angle (ψ) and that element's deviation (de) from the x-axis. The performance of the developed simulation program has been validated through comparing its results with the results of three different proven available models.

4. Solar Performance of a Circular Dome.

This section examines the solar performance of circular domes with different curvatures, and compares the received solar radiation on their exposed surfaces to the solar radiation received on the horizontal surface. Due to geometry of a CD, which is fully symmetrical, it is found that the changes of the solar performance of a dome are solely a consequence of the solar elevation angle.

The results show that, as the c*ross sectional ratio* increases the DSR incident on the dome surface decreases. Receiving less DSR during summer may add some credits for employing a domed surface with a higher cross-section ratio. However, it is necessary to keep the loss in the intensity as small as possible in the winter. In summer time, throughout the day there is only one time-period in which horizontal roof receives more DSR than that received by curved roofs. This scenario has not existed in winter time, which created two desirable times during the early-morning and the late-afternoon. Both two periods are similar in that the horizontal surface receives less DSR than the curved surface.

The result showed that the solar performance of circular dome is affected by its curvature in a following way: In summer, the circular dome with the highest ratio performs better than with low ratio at any orientation. In winter, the circular dome with the low cross section ratio is more preferable (receives maximum solar gain) than the circular dome with the highest ratio. In general, the circular dome is desirable in summer. However, the flat surface more efficient in the winter.

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Embodied energy and CO2 emission associated with building construction by using I/O based data and process based data in Japan

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Summary

This study quantifies the embodied energy and embodied CO2 associated with building construction by using energy intensities and CO2 intensities obtained by process analysis and I/O analysis, and compare with each others in Japan.

The energy intensity and CO2 intensity table is calculated, which is based on 2005 I/O tables in Japan. In the intensity table, intensities of energy consumption and CO2 emission are shown as values of MJ and kg-CO2/million Yen, and each values are shown as based on producer's and purchaser's prices. It can be possible to calculate embodied energy and CO2 emissions due to constructions of various buildings.

The process-based data were referred to existing databases in Japan.

In this study, following comparisons are implemented;

・Comparison on energy intensity and CO2 intensity of building materials of the different databases: cement, concrete, steel, glass, glass wool and lumber.

・Comparison on embodied energy and embodied CO2 of building by using different databases: a reinforced concrete office building and a steel frame structure office building.

The energy and CO2 emissions associated construction buildings were calculated by using energy intensity and CO2 intensity obtained by the I/O based analysis and the process based analysis. The results showed that many of intensities by obtained I/O analysis are larger than the intensities by obtained process analysis. The embodied energy and CO2 of office buildings by using I/O analysis are approximately 13% larger as the results of process based analysis.

Keywords: Embodied energy; Process based database; I/O based database

Life Cycle Assessment of Mega Event Buildings - Case Study National Stadium Warsaw

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Short Summary

The demand to identify and evaluate the environmental impact of mega-event buildings such as sports facilities is growing progressively. An important part of the evaluation is the life cycle assessment (LCA). With regard to the building typology stadium, guide lines and definitions when considering the entire life cycle are missing. This paper focuses on the specific characteristics of mega-event buildings and discusses how to conduct a LCA based on a case study about the National Stadium Warsaw.

Keywords: Mega-Event Buildings, LCA, Standards and Definitions

1. Introduction

Focusing on the big scale of sports facilities, the mega event buildings for the Olympic Games, European and World Cups have to be mentioned. Whether in London, Sochi, Vancouver, Qatar or Warsaw, points of contact with environmental aspects resulting from mega events are almost unavoidable. Likewise, the desires not to neglect the needs of the environment at these events are growing. Concepts such as Green Goal or the re-use concept as part of the Summer Olympics in London have shown that the interest to implement these events as environmentally friendly as possible is present. Of particular significance are innovative buildings, which usually have the most shares of the impact on the environment.

As planning instrument for the implementation of sustainability aspects, organisation committees of mega events, such as Olympic Games or World Football Championships, are progressively demanding an evaluation of the sustainability performance of the venues. But there is yet no common assessment method including a life cycle approach. Therefore, a comparison of the sustainability of the venues is not possible so far.

2. Life Cycle Assessment of the Building Typology Stadium

As part of the research project "Guidelines for the Assessment of the Sustainable Performance of Buildings of Mega-Events", supported by the BMWi (German Federal Ministry of Economics and Technics) from 2012 to 2013 [1], this paper demonstrates the need for a systematic approach and solid basic rules for the evaluation of the referred building typology.

Focus of the study, on one hand, was on the identification of the characteristics of mega event buildings. On the other hand, as life cycle assessment is an important part of the evaluation of buildings, an LCA was conducted for the National Stadium in Warsaw to demonstrate how to handle the characteristics of Mega-Event buildings. The National Stadium is a multi-purpose venue serving for the European Championship in Poland and Ukraine in January 2012, designed by a planning community of gmp architects, JSK Architekci and schlaich bergermann and partners. For the study, the total construction including the parking ground, the pitch as well as the stadium seats were considered over a life span of 50 years. In the end the results were compared and discussed. According to the discussion, the formulation of common standards and definitions for mega event buildings relating to

- surfaces (e.g. a stadium NGF),
- scope and system boundaries,
- environmental impacts and policies
- lifetime of components of mega event buildings

were pointed out. The establishment of these is inevitable for assessing mega event buildings in the future.

3. Environmental Impact of Mega-Event Buildings

In the project, the results of the LCA for the National Stadium Warsaw were discussed in details. Additionally, a comparison with other studies about the venues of London 2012, as well as the National Stadium in Beijing and the Olympic Stadium in Sydney, was performed.
The following figure shows the impact category global warming potential. The different benchmarks such as surface and roof area as well as seat number were considered. For this purpose, the values of the CO_2 study of the Olympic Delivery Authority have been taken into account. The National Stadium Warsaw shows comparable results to the arenas in London or Sidney. Taking into account the permanent seat capacity into account, which is the most realistic benchmark, Warsaw holds ranks in the middle.

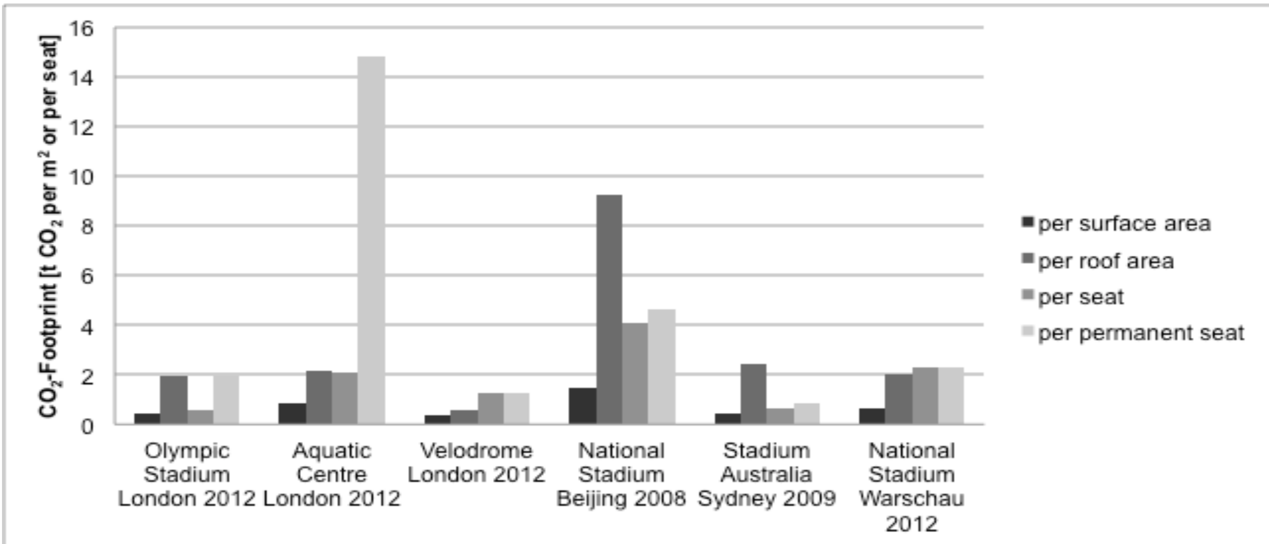

Fig. 1: CO_2-footprint in relation to different benchmarks [in accordance with 2]

To discuss and compare results about different mega event buildings, common standards and definitions are to be established.

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Combining Concepts of Energetic, Environmental and Economic Life Cycle Balance towards an Integrated Life Cycle Approach

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Extended Abstract

The idea: Sustainable construction and refurbishment of buildings requires to know the economic and ecological resources consumed during building life cycle at an early stage of planning, in order to choose the optimized alternative.
It is the aim of the development plan of LEKOECOS to create a simple tool that allows to determine the expected resource consumption over the life cycle of a building. The new tool represents a new model for the life cycle of buildings and is based on the life cycle cost model LEKOS of the Danube University, with main emphasis on costs, and on the ecological assessment tool ECOSOFT of the Austrian Institute for construction and ecology (IBO), with main emphasis on the ecological assessment of construction elements.

The first step is the establishment of a catalogue of economic and environmental basic elements. It is intended that the life cycle model for buildings LEKOECOS allows the combined economical and environmental optimisation already at an early stage of the planning process, at a stage with various possibilities of changes. The calculation of life cycle costs is relevant for users, facility managers and owners of buildings as they have to judge on the long-term affordability of a property or estate. As opposed to that benchmarks like CO_2-equivalents or the Global Warming Potential (GWP) with their optimized values are mainly of relevance for the public sector, e.g. with respect to meeting the target as requested in the frame of the Art.15a B-VG agreement for the reduction of greenhouse gas emissions in the building sector or in the frame of the Kyoto-protocol.

Until now the corresponding analysis for costs or the environmental assessment of construction elements was carried out by a separate analysis using different tools. The combined tool allows for the integrated examination of economic and resource related performance. The tool supports the combined efficient use of financial means and natural resources and thus contributes to the protection of the environment and to the strengthening of the economic competitiveness.

Moreover the following ecological benchmarks may be calculated: global warming potential (GWP), acidity potential (AP), primary content of of renewable and non-renewable energy (PEI e, PEI ne), POCP, EP, OI3-Index (benchmark based on GWP, AP, PEI), indicator for waste disposal (EI). The results of the calculation are presented as an “ecological certificate for buildings”. Evaluation of these ecological parameters is based on the standardised method of LCA (Life Cycle Assessment), systematically determining the environmental impact of products, services or processes during certain stages of their lives or throughout their entire life cycles.

The concept: The tools LEKOS and ECOSOFT start each from a different degree of detail. The life-cycle cost analysis of LEKOS is carried out on an aggregated level whereas ECOSOFT is working on a more detailed level of elements (construction elements and building equipment). In order to combine the two tools it is necessary to define a level of detail that allows to establish a working interface between the two tools. In this way several elements of ECOSOFT were combined in order to represent typical construction elements or building equipment for a defined type of building. At the same time it was necessary to install and maintain the compatibility with the structure of LEKOS. This approach induced for LEKOS the integration of additional data into the system in order to be able to produce the necessary ecological benchmarks.

The catalogue: The catalogue of economical and environmental basic elements is being developed. It comprises typical elements of construction and building equipment (HVAC) for pre-defined types of buildings, that is office buildings, schools, residential buildings and the corresponding cost-data and eco-benchmarks for the construction phase and the operating phase. The catalogue of economical and environmental basic elements represents the database for the calculation model of LEKOECOS.

In the benchmarking of real estates the classification “low”, “medium” and “high” quality of buildings are used in order to allow for the application of the tool without knowledge of details. The qualities “high”, “medium”, “low” are assigned to different concepts of buildings and related costs that are activated when choosing one of the qualities. This approach of classification in the real estate benchmarking is used to determine energy related eco-indicators in LEKOECOS.

Environmental relevance and system boundaries; to define system boundaries, an evaluation of the ecological relevance of the individual products, processes and services of the building life cycle was therefore performed. In essence, each cost position was examined for relevant environmental impacts of various pre-products and sub-processes. The following environmental impacts were taken into account: production of materials and building components, freight and passenger transport, usage of cleaning agents, energy consumption during construction and building operation, waste disposal processes. Alongside the relevant costs, the LEKOECOS model also calculates and displays environmental parameters of cost positions considered environmentally relevant in the procedure, as well as any environmental effects that can be presented with the available data and methods.

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Can form follow energy? – Critical factors in modelling for computational design optimization

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Extended Abstract

The claim, that form can be derived from a desired performance, is quite popular among practitioners of architecture. Nowadays a lot of projects apply computational optimization methods to achieve this goal. The paper deals with the question in how far a form can be derived purely from the performance by an optimizing process, as it is propagated by the slogan "form follows performance" [4]. It is highlighted that the process of defining the computational model always precedes a performance-based generation of a design. Thereby a model is defined, which can generate possible solutions to a given problem (Generative Model – GM). These variants can be searched for the ones which correspond to the performance criteria, defined in the Evaluation Model (EM).
By using a simple case study, the automatic reproduction of the Socrates house, it is shown which factors must be considered when modelling for design optimization and how these factors actually influence the extent a form can be derived from certain performance criteria. The Socrates House represents a very early example of a building form optimized in terms of passive use of solar energy [5]. It can be described by a simple generative model (GM). Two variants are presented to show different ways to create GMs and on the other hand to check whether the results differ depending on the model used. For each of the two GM described above multiple optimization runs were made. A representative selection of the results is shown in Fig. 1.

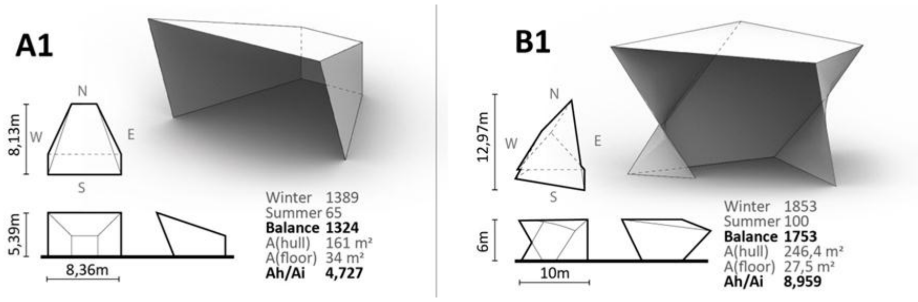

Fig. 1: Different optimal solutions resulting from the two different GM (left: Model A, right: Model B).

The similarities of the optimal solutions generated (high performance, essential shape features of the Socrates house) show that optimization methods in the design of buildings are effective in principle. However, the differences between the results of the two GM shows that creating a GM is an essential step in the application of optimization strategies: Depending on how the model is designed not only the range of variants, but also the solutions resulting from the optimization process changes. Two critical factors for creating a GM are discussed and implications for the use of optimization techniques in the design process are drawn.
When describing this model, a differentiation between metric and topological properties is

necessary. It can be noted that, although important information for variation of the building geometry is defined by the topological properties, most models for performance-based form-optimization only vary the metric properties. In these models, the variation-spectrum is severely limited. Such models are only suitable for solving problems in which many decisions have already been made.
Defining the EM depends on the amount of knowledge used for defining the GM. Here, a distinction was made between weakly and well structured models. Generalizing, we can conclude that in well structured models, the solution of a problem is mostly included in the specifications and in weakly structured models, the solution of a problem is defined by the evaluation criteria. Although weakly structured models require many criteria, they are regarded as more suitable for solving design problems, because the variant-spectrum is not too narrowed in advance.
Concluding we can state that the case study on the reproducibility of the Socrates House demonstrated on the one hand the potential of optimization methods in designing. On the other hand, it made clear that the extent a form can actually be derived from a desired performance depends on the model used to represent the optimization problem. How to build a computational model for performance-based design optimization needs to be decided anew in each particular case, but on thorough considerations of the critical factors described in the article. To what extent a general model for design optimization can be built needs to be investigated in further research.

Acknowledgements:
The present work was part of the research project FOGEB (Research Group Green Efficient Buildings). The project is funded by the Thuringian Ministry of Economy, Labour and Technology from the European Social Fund (ESF).

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Comparative study of energy performance of an institutional building for different façade configurations in Saudi Arabia

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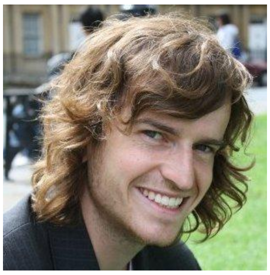
Abstract

Façades not only shape the appearance of building, they also determined the indoor climate, energy consumption and operating costs of a building. This paper aims to examine the energy performance of multi- story buildings by changing the settings on available building façade keeping other parameters constant at standardized values (such as orientation, illumination load, type of HVAC system etc.) in Saudi Arabia. Simulations were carried out for different types of facades. The DesignBuilder 3.0 software was used as a simulation tool for calculating energy consumption of the analyzed building. This paper shows the annual energy performance of the building for typical Saudi Arabian climate. Six different economically available building façade are compared. It is shown that there is a significant effect on energy consumption and cooling load on the change of façade as a result of which utility operational costs are reduced. The study shows that there is the significant drop of 3.92% and 4.80% in total energy and cooling load consumption respectively by opting the façade-II instead of Façade-I. The result of the paper enables to select the optimum alternative of façade configuration; to help decision makers reduce the energy consumption of commercial buildings.

Assessing the severity of workmanship defects using thermography and 2-D and 3-D heat transfer models



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Short Summary

The effectiveness of insulation in reducing heat loss depends to an important extent on the quality of its installation. It is advantageous if the performance of insulation can be checked before construction work is complete so that problems can be rectified before the building is occupied. The research presented in this paper is investigating how thermal imaging techniques (thermography) can be used during the construction of new domestic buildings to assess construction quality and the energy efficiency of the building fabric. Thermal imaging surveys are usually conducted post-construction and so this approach to testing constitutes a novel area of practice. Further insights into the results of a thermal imaging survey can be gained from computational models of heat transfer through the building envelope. The particular focus of the paper is how these virtual models and thermography can be used in a complementary way to diagnose and assess the severity of insulation defects in construction work. This idea is explored through three case studies, which illustrate some practical considerations for the application of thermography during the construction process. The research topic will be of interest to built environment professionals, thermographers and researchers interested in methods of investigating the thermal performance of new housing.

Keywords: infrared thermography; construction quality; workmanship defects; low carbon housing; building fabric performance; residential buildings; energy efficiency; thermal bridges

1. Introduction

If an anomaly is identified in the building fabric using thermography then two questions arise: the cause of the defect and its severity. Two-dimensional (2D) and three-dimensional (3D) heat transfer models can be used to help gain insight into both of these problems. In the paper, three case studies considering the complementary use of heat transfer modelling and thermal imaging are discussed. Together, these case studies explore some practical considerations for the application of thermography during the construction process, including: testing procedures to establish suitable environmental conditions for thermography; assessing the severity of thermal bridges in terms of the effect on building energy performance and also risk of condensation and mould growth; and limitations to the types of defect that can be identified using thermography.

2. Case Study A

For this case study, the THERM software programme has been used to calculate the surface temperatures in the proximity of a defect in a partial-fill masonry cavity wall construction. The additional heat loss resulting from this linear thermal bridge (psi-value) is also calculated. Results indicate that it may not be possible to establish the presence of this defect by a retrospective thermal imaging survey, even though heat loss is four times that of a non-defective construction. In general, the continuity of insulation within a building can be assessed more effectively with thermography when there is less intervening structure between the insulation layer and the internal or external surfaces. Modelling may provide a useful predictor of when to survey.

3. Case Study B

In this case study, thermal images obtained from a building survey are compared with THERM modelling data. A thermal imaging survey carried out at an intermediate stage of construction found lower surface temperatures at the eaves junction. Assessing the severity of the defect indicates there may be a risk of surface condensation and mould growth. Modelling indicates that the thermal performance of the eaves detail could be improved. Comparison between the thermography results and THERM modelling is revealing of how the assumptions underlying design calculations of thermal performance (with insulation placed in perfect contact with the surrounding structure) may bear little relationship to the as-built reality encountered on site.

4. Case Study C

Early-stage checks on the installation of insulation can be carried out using electrical radiant heaters to target heat at an area of the building envelope. To investigate the efficacy of the approach, a full-scale physical model of an external wall has been built to investigate the type of defects that can be identified in timber-frame structures. The results of model testing are compared with predicted surface temperatures calculated using HEAT3. Together, the physical tests and modelling support the following two conclusions: the use of insulation materials with different thermal conductivity within a wall (i.e. substitution of the specified product by an inferior one) is likely to be difficult to detect using a thermal camera; while the presence of air voids within a timber frame structure can be determined relatively easily and quickly using the radiant heating approach.

5. Conclusions

Thermography can be used to obtain feedback from real buildings and improvements in design can be supported by computer modelling, with the lessons from both potentially carried forward to future projects. Some specific ideas explored in the three case studies are summarised below:

- Thermography is a powerful tool for assessing the continuity of insulation in buildings, but there are limitations to the technique related to both the environmental conditions in which a thermal imaging survey is undertaken and the impact of discontinuities in the insulation layer on surface temperatures. The latter point is perhaps not sufficiently acknowledged within existing literature, since it places limitations on the ability to detect certain types of insulation defect.
- The impact of poor design or workmanship on building energy performance can be quantified using computational methods provided some basic information about the problem is known. This is a useful complement to thermography, which is primarily a qualitative diagnostic tool.
- Design calculations typically assume perfect placement of insulation to the adjacent structure. This may be an unrealistic assumption, particularly for details that are awkward to build, and may result in actual performance being considerably less than predicted (as may be revealed by thermal imaging).
- 3D heat transfer models can be used to generate 2D projections of surface temperatures. This enables a direct comparison to be made with thermal images, with the potential for a building to be “calibrated” against this expected thermal pattern.

6. Acknowledgements

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Water and Energy recycling in a Residential Passive House

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Before producing new energy, whether fossil or renewable, or pumping freshwater from groundwater resources, one should look first on how to avoid energy and water consumption and how to optimise the total resource efficiency for both the energy as well as the water sector.

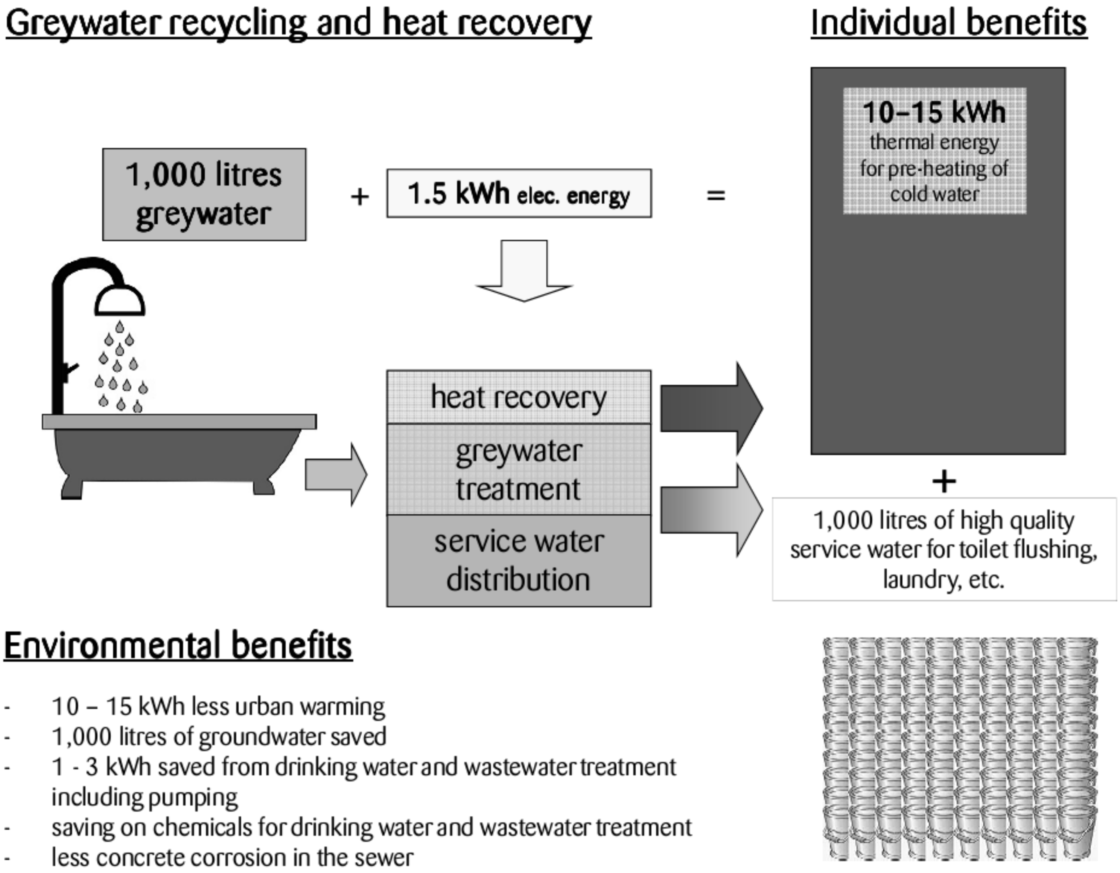
Greywater is a sustainable resource of water and energy. Conventional water supply and wastewater treatment, including pumping and distribution, is a very energy intensive process. The Berlin Water Works supplying a population of about 3.5 million requires as much energy as a city with 280,000 inhabitants [1].

Greywater recycling is one effective tool to improve the efficiency of water use in buildings. Advanced greywater systems have been developed and tested which produce high quality non-potable water (service water) for indoor (toilet flushing, laundry) and outdoor use (gardening, cleaning).

This presentation shows the research results which had been evaluated since March 2011 in a residential passive house in Berlin. The decentralized greywater recycling system in combination with heat recovery gains much more energy than it requires for its operation.

Three cubic metres of greywater from showers and bathtubs are collected daily from a 41-flat passive house (123 tenants), passes a heat exchanger before it undergoes advanced biological treatment in an MBBR (moving bed biofilm reactor) and UV-disinfection to be eventually used as high quality service water for toilet flushing. The heat energy recovered from greywater is used to preheat the cold water before it enters the building's combined heat and power plant (CHP). The biologically treated greywater (BOD_7 < 3 mg/l; turbidity < 1-2 NTU) is fed into the service water network by means of a booster pump. The total electrical demand for heat recovery, greywater treatment and service water distribution is about 1.5 kWh/m³. Treatment is done without the addition of chemicals and at very low maintenance. The space requirement for the combined system is 9 m² and the costs are about 10 €/m² living space including installation and 19% VAT.

During the winter months heat recovery by means of the low-maintenance heat exchangers achieved a coefficient of performance (COP) of ≥ 10. The benefit for the private users in thermal energy savings from 1 m³ of greywater is about 10 kWh/m³ in summer and 15 kWh/m³ in winter, when the potable water exhibits lower temperatures. In addition to obtaining high quality service water which can be used for all non-potable applications (toilet flushing, laundry, irrigation, house cleaning, cooling, etc.), other benefits are also expected as demonstrated in the figure below.



In conclusion, well planned greywater recycling systems can contribute considerably to water and energy savings in buildings and should therefore be marketed in future urban context as sustainable, environmentally friendly and safe technologies.

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SB13 Graz – ELIH-Med Extended Abstract

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Short Summary

ELIH-Med is a Strategic Project co-financed under the MED Programme, focused on the development of energy efficiency policies in Low Income Housing (LIH) in the Mediterranean area based on sustainable building principles and the involvement of residents in the energy retrofit in order to reach the EU2020 objectives.

The main objective of the project is to identify and test, through large scale actions, the feasibility of cost efficient innovative technical solutions and financial mechanisms backed with ERDF which could then be extended taking into account the specificities of the region.

The target is the low income houses because:

- Represent 30 to 40% of Mediterranean households.
- Have poor thermal performance.
- Is a key segment in order to reach EU2020 objectives.
- Are not a focus of traditional and current EE policies.
- Residents have limited access to credit.

A participative process has been used to organize two groups constituted of the relevant stakeholders at a local level:

A) The Territorial Management Group (TMG): Local stakeholders representing the key institutions that deal with energy efficiency and LIH. In charge of analyzing the innovative financial and technical options and monitoring the implementation of the energy retrofit in the selected dwellings.

B) The Pilot Project Participative Group (PPCG): Residents affected by the pilot projects, social workers, social landlords, local associations etc. which express the real life needs and problems that are experienced in the selected buildings, helping the TMG to develop and adjust the Action Plan to the reality of the situation.

In order to carry out the large scale experimentation of the technical and financial solutions analyzed, a total of 420 dwellings have been selected and divided into 10 pilot projects across 6 partner territories. Furthermore, the promotion of intelligent energy management systems at local and regional level will be carried out through the experimentation of multi-energy smart meters in 135 dwellings.

The objectives established for the pilot projects include:

a) A cut in energy consumption of 40%.

b) A decrease in energy expenditure of 20%.

c) An increase of 2 energy grades.

d) An investment for energy retrofitting of less than 30.000 euro per dwelling.

e) Development of strategies and policies that address EE and sustainable building approaches in LIH.

f) Identification of financial and technical mechanisms adapted to LIH, to be deployed in the Mediterranean area.

g) Improve energy consumption habits and reduce energy bills thanks to smart metering.

The partners involved in the project belong to 7 different countries while the pilots will be realized in Italy, France, Spain, Greece, Cyprus, Malta. Slovenia also participate to experimentation but only for the smart metering part.

The experimentation will produce several guidelines related to technical and financial solutions as well as the awareness campaign.

The project has also produced a policy paper which is still under development and which foresees joint capitalization activity with other two projects, such as MARIE and PROFORBIOMED, which are other two projects of the MED program related to energy efficiency and Renewable energy production by biomass. The final document will be endorsed by all the political stakeholders at European, National and regional level.

All the guidelines and the policy paper, as well as other useful information can be found in the project web site: www.elih-med.eu

Keywords:
Energy Efficiency; Low Income Housing; Mediterranean; Smart Metering

Life Cycle Assessment for sustainable buildings during the planning phase

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Short Summary

Since the ecological impact of buildings not only depends on the operational phase but also on the way of demolition and especially the way of construction and used construction materials, the need for tools supporting decision with regard to optimize ecological impact of buildings in an early design phase has become urgent. The approach of this research was to extend the former developed “LZK TOOL” by Hofer and Herzog by this possibility. The used method to aggregate the cost of building by predefined elements has been advanced as for each element also ecological impacts have been calculated. First results show, that this approach provides reliable support for decisions in an early planning phase influencing impacts ecologically and monetarily during the lifetime of a building.

Keywords: LCA, sustainable buildings, early planning phase, LZKTool

1. Introduction

When an architectural competition is undertaken or a building project is in the concept design phase, decisions about facades and energetic concepts - highly influencing the energetic and consequently the economic performance of a building – have to be made. These decisions are based on the experience of architects and its technical consultants. Because proposed solutions are becoming more complex and, due to the technical innovations in the last decades, the possible solutions manifold and difficult to compare, developers need proper support to tackle this task.

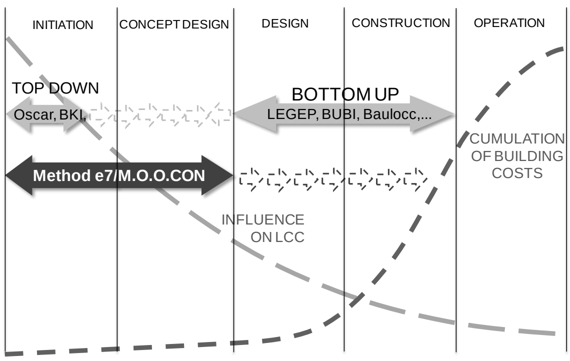

Figure 1. Missing link in models for calculating life cycle costs during the design phase (Source: [1]).

As Developers do usually not have the experience to validate proposed technical solutions, important decisions can’t be made on the basis of hard facts. This uneasiness in the planning process and the urge to receive high security about construction and operation costs, energetic performance and knowledge about the possibilities for a future building certification already during the planning phase, can only be tackled with proper tools.

These tools must deliver more or less accurate figures (costs, energetic and ecological impact) but work with parsimonious input data as most of the construction and building details are not known by that time.

Unfortunately, most of the available tools to calculate indicators for these issues need detailed information of the future building which can't be provided. As outlined in Hofer et.al 2011 [1] and shown in the figure below there is a lack of tools during the conceptual phase of a building.
With the growing pressure for buildings being sustainable and growing importance of building certification, not at least to guarantee high marketability as outlined in Fuerst & Allister [2], it has become more important for developers to receive assurance for a high building quality as early as possible.

2. Method

To calculate the ecological impact in an early planning phase neither a bottom up approach which prerequisites detailed information of a the building nor a top town approach which only can deliver results for the entire building but not parts of it were suitable. Therefore in analogy to the developed "LZK TOOL" described in [1], which is able to calculate in a simple way life cycle costs, the tool has been extended by the possibility of calculating an LCA for a building.

3. Preliminary Results

As the input data does not differ from the input data in the LZK TOOL, LCA calculations for several projects could be undertaken. The projects were proposed by M.O.O.CON and are known under the project titles: WES Smart Campus (Vienna), E+E (upper Austria), Garant (lower Austria), Immorent (Vienna), Windkraft Simonsfeld (lower Austria).

Considering the system boundary, it can be said that for the inventory the approach delivers an acceptable result. Unfortunately, the different impact categories - Primary energy demand (PE), Global warming potential (GWP), Acidification potential (AP), Photochemical Ozone Creation Potential (POCP) –show results with wider variation. While the results for AP, POCP and PE non renewable show results in an acceptable variation the important indicator for the renewable primary energy demand as well as the global warming potential show substantial variations.

Nevertheless, at the given stage of research it can be concluded that the "LZKÖKO Tool" can be used to calculate the ecological impact in an early planning phase. The inventory shows approximately the same results at a variation below +/- 10%. As especially the inventory deals as a fundamental prerequisite for calculating the ecological impact, differences in the impact categories can be tackled and brought to an acceptable level. Current differences in some of the chosen impact categories must be further investigated but first insight anticipate that one of the main obstacles is the use of different databases.

The aim of this research, to support decisions for developer in an early planning phase, has been achieved. The first results show, that the chosen method, aggregating ecological impacts of elements to the ecological impact of a building can be used to give a first indication and support developers decisions.

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In situ U-value measurements for today's Cypriot Houses

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Short Summary

Material thermal properties are essential in calculating thermal energy losses through out a building's shell. Exact values, especially regarding the material thermal transmittance co-efficient, also known as U-value, are critical for the correctness of calculations predicting a building's thermal energy demand, both for heating and cooling, thus enabling engineers in designing, dimensioning and evaluating the building's necessary heating and cooling systems in order to optimize the final building/system integration and maximize efficiency, resulting in decreased consumption. The aim of this study is to establish, under real weather conditions, the thermal characteristics and actual thermal behaviour of typical residential houses in Cyprus.

For this purpose, a wireless web-based monitoring system has been deployed covering 44 different houses, geographically selected all over Cyprus. Construction materials varied amongst each house, resulting in a theoretical U-value range of 0.467 to 1.389 W/m^2K. Calibrated temperature sensors were installed and measurements were conducted at 30-minute intervals for each individual house. The internal house air temperature, the external air temperature, as well as, the internal and external wall surface temperatures, have been continuously monitored for a period of fifteen months.

Processing the above mentioned data has led to the establishment of the mean internal temperature of the typical Cypriot residence and calculation of the U-value for each individual wall, facing north, south, east and west, including the roof, comprising the building envelope. Variations of the calculated U-value of up to 25% for each wall orientation are observed, even though construction materials of each wall remain the same. Furthermore, deviations of up to 30% from the theoretical U-value calculation are also observed.

The utmost aim of this study is to provide experimental evidence and accurate measurements of the thermal characteristics and behaviour of the typical building envelope in Cyprus, providing thus a more accurate tool for the engineering calculations.

Keywords: Heat Losses; Energy; Building Envelope; U-value; Thermal Transmittance co-efficient.

Life Cycle Costing of innovative energy storage systems in buildings

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1. Introduction

It is the goal of the European Union to enhance the energy efficiency of buildings until 2020 and to increase the usage of renewable energy sources for heating, warm water supply and air conditioning. The reason therefore is the amended EU directive for energy-efficient buildings of the year 2010 (EPBD) and many European governments have committed to use more renewable energy sources. With a higher share of renewable energy sources in the electrical and thermal energy supply, the significance of storage systems rises accordingly, because the production and use of renewable thermal and electrical energy in the building may be temporally distinct. The integration of energy storage systems in buildings is a necessary step in order to use renewable energy sources in buildings efficiently.

With the help of energy storage systems, it should be possible to reduce the load of peaks and the exchange with the grid. End users can reduce their energy consumption from the grid and costs equally. To consider and to interpret these aspects, it is necessary to perform life cycle cost considerations for energy storage systems

2. Life Cycle Costing

Life cycle costing analysis is a method to estimate the total costs that occur during the whole lifetime of a product. The costs are considered along the single phases of a product during its life cycle (cradle to grave). That means that all costs of the different life cycle phases, the production stage, the usage and the end-of-life stage are taken into account.

Depending of the perspective the life cycle cost analysis is based on two different methodologies. Depending on the available data, life cycle costs can be determined with the support of the Bottom-Up or the Top-Down method. The Bottom-Up method works out the life cycle costs along the life cycle starting with the production to the cost of the usage and the end-of-life. In comparison, the Top-Down method is used when the production costs are unknown.

In summary it can be said that the goal within the LCC is to identify the utility-maximizing alternative in terms of the maximum economic benefit.

3. Energy storage technologies

Energy storage systems gain due to the increasing use of renewable energy and the time gap between production and demand this form of energy more and more economic and strategic importance. Through their use, the supply and demand of energy is balanced and power peaks are covered. The different energy storage technologies can be differentiated by their storage time, loading and unloading, saved energy (power) or their size and weight.

The use of renewable energy is always combined with a limited aspect of the storage and any energy conversion is associated with energy loss. Renewable, fluctuating energy sources (solar, wind) are usually only temporary and short-term available in abundance at this moment but not directly stored. For storage and later use it must first be converted into a storable form of energy that is associated with losses.

4. Life Cycle Costing of the storage technologies

Within the EU project MESSIB both GHEX and the VRB are connect or integrate into an existing building. The storage technologies have been studied in terms of energy consumption, the exchange with the grid and its utilization during the operating phase. The scenario assessed is based on an office use.

The innovative developments of the ground heat exchanger in the MESSIB project have not lead to energy savings during the operating phase. However the CFM enables to save energy costs over the life cycle. The comparison of scenario A and B of the boreholes shows that the CFM generates larger savings in a ground with a low thermal conductivity. Furthermore, it can be concluded that CFM at a location with high heating and low cooling demand has a greater impact to reduce operating costs than at a location with high cooling and low heating demand.

The innovative development of the VRB with a storage capacity of 6 kWh which is integrated into an office building could only be analyzed based on the energy costs over the life cycle. The comparison of scenario I and II of the VRB shows that in scenario I no costs can be saved with the integration of the VRB. In scenario II it is possible to save energy costs over the considered life cycle but there are still no investment or disposal costs taken into account. But the saved costs will be not high enough to cover the investment and disposal costs for the VRB. For example a lithium battery, which is already available on the market with a comparable storage capacity has investment costs of 10,000 EUR.

When you compare the two innovative developments of the technologies, it can be seen that it is possible to save the most energy costs under certain boundary conditions (no feed-in tariff) with a VRB. Summarizes it can be noted that the boundary conditions (integration and economic parameter) have a great influence on the amount of energy costs savings regardless of the technology.

5. Conclusion

Both technologies allow, under certain conditions, to generate energy costs savings. Decisive boundary conditions are amongst others the political boundary conditions and the setting with the other components of the installation engineering in the building. The feed-in tariff as one political boundary condition has a high impact on how the VRB can generate cost-savings. If the feed-in tariff is too high and the payment of the feed-in electricity makes the integration of a VRB unattractive, this form of energy storage will not be able to enforce in width and apply. Also it is equally important for both technologies to synchronize them on the building, which means that the storage technologies have to be sized in the right way and the other components of the installation engineering (e.g. the PV power plant has to produce enough electricity to charge the battery in all seasons) have to be synchronized with them.

Real-time Energy Simulation for Advanced Building Control

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Short Summary

This paper describes a methodology being developed to combine building energy simulation results with accurate and real sensor & meter data with the purpose of better understanding the relationship between energy simulation and real building operation for better occupant comfort and more efficient operation.

Keywords: Simulation; Building Control; Energy Efficiency; RFID; Occupancy.

1. Extended Abstract

In general, current Building Energy Simulation Tools are used for pre-construction design and comparison of designs rather than a full exact varying representation of reality. To provide the best level of detail full CFD analysis for the entire building would be required. However this is currently by far outside the scope of current computing power and labour efforts for a building energy system. Because these simulation tools are designed for comparison of potential designs and because of the difficulty in predicting occupant behaviour, very often the predicted results do not correlate with the real actual performance when buildings are in operation. Questions arise in relation to occupant comfort when a building space is serviced with a constant level of heating and ventilation. In addition, a cost saving could be realised if intelligent systems know to what level should a building space be heated or cooled.

Real life measures occupancy data from four building spaces in UCC’s Civil Engineering Building have been recorded using a novel RFID system and access control system to develop relevant indicators concerning occupancy levels. Two technologies are used to detect occupancy, proximity card access and RFID detection. A contrast of results from both systems is expected while also using both systems to quantify an exact as possible occupancy level based on scheduled events involving the mentioned rooms.

Results gained from the occupancy detection systems will be utilised as input for commercial building energy simulation tools for the purpose of obtaining a better understanding of real time conditions within the occupied spaces and improving building control of HVAC systems within the experimental building.

From previous project experience a deficit has been encountered whereby the correlation between simulation results and measured data is not entirely accurate. This paper discusses a method of validation, which will provide a means of comparing measured data (e.g. sensors and weather data), and simulated data (e.g. near future simulations).

This method for validation of building simulation results initially involves a comparison of data from building simulation and respective measured sensor readings. From this comparison, value is added from correction of simulation results, and/or input to simulation parameters. Further worth can also be provided by gaining knowledge for creation of simulation profiles which are difficult to predict before construction and operation. Additional value can also be derived from identifying conditions of poor results and other relevant input factors which can be corrected. Simulation data and actual data is available from various campus buildings of University College Cork, Ireland. Simulations are undertaken using readily available commercial products and use practical and straightforward data analysis methods so that results and further development can be implemented by building engineers who may not have extensive IT or coding experience.

This study focusses on UCC's Civil and Environmental Building (CEE) which is located on the main campus of University College Cork. The CEE Superstructure consists of brick walls, concrete ceilings and wood flooring. The windows are wood-framed single glazing. Efforts to upgrade these windows have been refused due to the semi protected nature of the building on the central Victorian style Campus. The building is approximately 2500m^2 consisting of experimental and IT laboratories, offices, seminar rooms, and lecture theatres. Heat is supplied from the University Combined Heat and Power plant through a connection to Campus Distribution System. Within the building a single pipe heating systems exists with cast-iron type radiators. Thermostatic control valves have been retrofitted in most rooms. The building is naturally ventilated with an air handling system installed to ventilate 2 IT Labs only. Lighting consists of Zoned control through presence detection sensors. A moderate upgrade to the building was undertaken in 2009 consisting of:

- Modification of Heating System and Incorporation of Bldg. Control Systems
- Lighting (Fitting Replacement, Appropriate re-wiring, Improved Controls)
- Heat Recovery Ventilation from IT Laboratories

Of particular relevance to this paper is the installation of an occupant tracking system concentrating on 4 key rooms. The occupant tracking includes 2 no. independent systems consisting of;

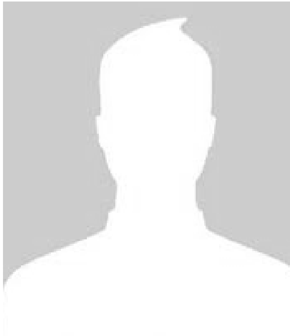
- "Gate Reader" or RFID solution. This solution works with the readers/antennas fixed to the building. Users and inventory items are "tagged" with different forms of either HF or UHF passive RFID-tags. Tracking will be executed on "item"-level. The emphasis is on the integration of "security data" into Building/Energy Management systems. Additionally, we consider aspects of privacy and security in our research.
- Access Control or Proximity Card solution. This can be considered to be a more active solution whereby close proximity to an access control reader is required to gain access to a building or room. In the research described here access control was installed in for key rooms within the research building.

This paper describes a process for providing detailed simulation inputs and results from an accurate and verified BIM model and providing access to a considerable body of building sensor and meter records. The next stage of the process to provide value from comparison and aggregation of this simulated and real data. The comparison concentrated on heating because of the building type and relative cool nature of the Irish climate. The expected result to be derived from this method is to give an indication of quality of simulated data results and provide feedback. If the difference between simulated and real data is too large, steps to improve results will be suggested. In future it is envisioned that automated adjustments may be performed to simulation inputs to correct results.

Furthermore an explicit process of Knowledge Management has been undertaken by turning data (simulation results & measured data) into information (basic comparison of key results) and future plans for creating useful knowledge (improve building operation for key results, energy, comfort and CO2). This will ensure that the process can be clearly documented to allow results to be achieved on other buildings in future.

The procedure described in this paper describes a clear methodology for creation of accurate dynamic simulation and comparison with real measured results with the goal of providing better understanding of building operation for the ultimate goal of improving building control. Whilst detailed post occupancy simulations comparisons to building simulations are difficult due to the lack of data, the tools and building being discussed in this paper provide a rare opportunity to do so.

Energy Efficiency Using Integrated ICT Systems: Business Challenges and Opportunities



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Short Summary

This paper focuses on business challenges and opportunities related to the adoption of integrated ICT system that will be developed in the framework of EU-FP7 CAMPUS-21. CAMPUS-21 aims at identifying opportunities for reduced energy consumption in public buildings and spaces through integration of different building automation systems. The integrated ICT platform will optimise renewable energy use, multiple building systems, optimise indoor air quality and consider occupancy of the building. For the purpose of this study a questionnaire has been developed in accordance with the business Model Canvas as suggested by Osterwalder and Pigneur. Business and contracts related data have been collected from the demo-sites, results have been analysed, discussed and conclusions have been drawn.

Keywords: Integrated ICT Systems, Energy Efficiency, Business Models, CAMPUS-21

1. Introduction

Interconnectivity of building automation systems, data collection, data analysis and automated control requires a holistic integrative approach to the management of the energy used by building systems. Integrated ICT Building Automation Systems can extend the functionality of already installed isolated systems and allow the synergistic usage of different data sources. This can result in reduction of life cycle cost by reduction of energy demand (demand-supply improvement) as well as lower maintenance requirements (increased equipment longevity). This poses significant opportunities for service providers and facility managers to create added value for their clients, to contribute to Corporate Social Responsibility and to enter new markets.

Within the framework of the EU-FP7 project CAMPUS-21, an integrated ICT system will be developed in three European public demo-projects. The aim of the integrated ICT platform is to integrate multiple building systems to optimise energy demand-supply, renewable energy use and indoor air quality. This paper analyses business challenges and opportunities related to successfully adoption of this platform in current businesses. Based on the Business Model Generation approach, introduced by Osterwalder and Pigneur, a questionnaire has been designed. Service providers and owners of the demo-projects provided data on used contract, involved partners, existing HVAC systems, energy purchase, energy generation and financial models. Results have been analysed, discussed and recommendations for business improvement have been given.

2. The Business Model Canvas

For a better understanding of existing business models, the business model canvas of Osterwalder and Pigneur [2010] has been used. This framework consists of nine blocks describing business models and introduces five important approaches to build new or to innovate existing business models. These approaches (resources-driven, offer-driven, customer-driven, finance-driven and multi-epicentres) are based on improving one or more blocks and tracing the changes in the other blocks.

3. Methodology

To answer the research question, a case study research has been performed. The Business Model Generation approach, introduced by Osterwalder and Pigneur, has been used to design a questionnaire. Service providers and owners of the demo-projects provided data on used contract, involved partners, existing HVAC systems, energy purchase, energy generation and financial models. Results have been analysed, discussed and recommendations for business improvement have been given.

4. Discussion and conclusions

Existing business models in the three campuses could characterised as very traditional. The three campuses grew in the course of years where buildings have been built or renovated, HVAC systems have been maintained or replaced, business partners have been changed and Energy Management has been implemented. This change process has resulted in segmented business developments and disjointed business models. This segmentation improved business components but mist a holistic improvement. It is also very important to mention that the three existing business models are driven by price instead of added value in terms of thermal comfort, higher productivity of employees, lower environmental impact and corporate social responsibly by greening products and services. Nowadays, governmental bodies, commercial partners and also the society are focusing in adding more value to their business, low price is only one of these added value strategies. Business models have to take into account making their added value or their performance more visible to their customers. This could be achieved by presenting energy savings in the entrance of the swimming pool or the lodges in the football arena or by surveying employees or students satisfaction after implementing new measurements. In order to make achievements and performance more visible, business models have to consider clearly defined key performance indicators in their contracts.

Besides, business models have to consider a life-cycle cost approach instead of initial cost approach. Energy saving measures needs initial costs while gains are can be achieved in also in the use phase yielding lower life-cycle costs. Energy Service Companies have considered this point very well in their business model. They engage with building owners in energy performance contracts that consider a total cost of ownership approach. They pay the initial costs needed to implement energy saving measures and get paid back through the saving they guarantee during the contract. Energy efficiency could be achieved by implementing technical or ICT solutions. However, users' behaviour is a very important factor in realising good energy performance in the use phase. Users have to be taught how to deal with HVAC systems and to be made partners in achieving efficiency. This could be achieved, when possible, by sharing gains from energy saving or by sharing losses that resulted from their behaviour. Suitable business models Energy Service Contracts or Desigh & Build.

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Comparison of sustainable office façade renovations in the Netherlands

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Short Summary

This paper presents a comparison of different environmental assessment methods in sustainable office façade renovations. The assessment methods applied have both weighted and non-weighted systems to combine energy and material performance. The comparison is based on the south facing facades of three realized office renovations in the Netherlands, and based on the MAXergy method the ‘best’ renovation project has been further developed to minimize environmental impact. In MAXergy, energy and material performance is calculated to the indicator land-time necessary to create the resources. Based on the comparison of environmental assessment methods in this paper and based on the developed façade renovation version, energy focused optimization of office renovation may result in material performance sub optimization emphasizing the need for a joined and non-weighted assessment of energy and materials.

Keywords

sustainable office façade renovation – environmental assessment methods – building envelope – MAXergy

1. Introduction

Energy consumption is increasing worldwide, mainly based on fossil fuels. As fossil fuels are exhaustible resources, methods to lower fossil fuel consumption are investigated elaborately, amongst others in the built environment. Of all energy consumed worldwide 40% takes place in the built environment. Measures being taken might have a positive effect on the operational energy performance of a building and are often implemented in the building envelope, for instance by adding insulation materials. But these measures have an effect on material performance, which might cause a negative effect on the environmental performance of the building. The material performance can be calculated in embodied energy. With respect to operational and embodied energy, it is possible to calculate an offset between the two, and generate insight in the optimum. But only energy calculations do not offer us the complete picture of combined material and energy impact, as for instance availability and depletion of materials is not incorporated in the calculation. Existing sustainability tools, such as BREEAM and the Dutch GreenCalc+, use weighting factors for combining energy and material performance to arrive at a total score. Currently, methods are investigated to combine material and energy performance on an equal scale without weighting. In this paper three methods are applied, one based on a weighting of indicators, one based on embodied and operational energy, and one based on land-time impact. The land-time impact might be an useful indicator to generate insight in the combined impact of both materials and energy performance based on the carrier capacity of the system. In this time-space calculation method, called MAXergy, the time and space necessary to fulfill the energy and the material demand for a certain function in a certain environment can be calculated.

Within the Netherlands, approximately 15% of all office buildings are vacant. This leads to a market driven situation in which the demanding party has a wide selection of possibilities. The costs associated with the energy performance is one of the criteria on which potential tenants decide. A better energy performance lead to less vacancy and higher rents. Besides this aspect, the policy of the Dutch government is to only rent high energy performance office buildings. As a third aspect, there is a tendency of commercial and non-commercial organizations to green their real estate to contribute to a positive impression. Currently, numerous assessment methods to calculate the level of sustainability are applied, such as BREEAM, LEED, CASBEE, SBtool, and Greencalc+. These tools have a number of advantages, such as the distinction in the level of sustainability of a building compared to other buildings, providing a communication tool, encouraging stakeholders to define sustainability requirements, and providing a vehicle for policymaking. In this paper, three assessment methods are applied to compare three different office façade renovation projects in the Netherlands. Based on one of the assessment methods, the ‘best’ office renovation has been further developed to minimize the combined impact of materials and energy.

2. Method

Based on different environmental assessment methods three realized office renovation projects in the Netherlands are compared on their level of sustainability. The assessment methods applied are the Dutch environmental assessment tool Greencalc+, the land impact calculation tool, MAXergy and embodied energy/operational energy calculations based on the program VABI 114 and the ICE database of the University of Bath. The case studies consist of three existing office renovations, where a comparison is made between the situation before and after the renovation related to energy use of the building (operational energy), materials of the facade (embodied energy) and the associated land impact (embodied land).

3. Conclusions and discussion

- The comparison of different assessment methods indicates a large bandwidth of results between the methods and between the projects. In future, a common language should be developed to tackle the difficulties that will arise due to the application of different environmental assessment methods.

- In the Dutch environmental assessment tool Greencalc+ all three renovations score relatively high on sustainability and show comparable total results.

- The embodied energy increased and the operational energy decreased in all three renovations, and in all three cases the cooling load remains the largest energy factor during the technical lifespan of an average office facade (30 years). Based on energy calculations, optimizing energy performance seems logical.

- The embodied land increased in all three renovations, but the results show large differences between the projects. The lowest impact of the WNF building is due to the choices in material application based on renewable materials.

- It can be concluded that material use becomes the determining factor with respect to operational energy in NZEB’s.

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The environmental footprint of plastic pipe systems within the built environment

Short Summary

The European Plastics Pipes and Fittings Association (TEPPFA) deems it important to have an insight into the integral environmental burdens encountered during the life-span of particular plastic pipe system applications within the built environment. With this framework in mind, TEPPFA has set up a project with the Flemish Institute for Technological Research (VITO). The aim of this project is to carry out several life cycle assessment (LCA) studies from the cradle to the grave. The LCAs of several plastic pipe systems outline the various environmental aspects which accompany the pipe systems, from the primary extraction of raw materials up to and including the end of life (EoL) treatment after their reference service life time. To get a better view on the advantages and disadvantages from an environmental point of view of a pipe system in plastic compared to its main competing non-plastic material, LCA comparisons were made. The conclusions of the comparative LCA studies show that the average environmental impact of plastic pipe systems in general are lower than the average environmental impact of piping systems made out of traditional materials.
This paper reports on the LCA of some specific plastic pipe systems with the final aim of providing a clear environmental product declaration (EPD), thus raise the awareness amongst developers, installers and users, of the potential environmental impacts and benefits over the complete life cycle. In addition some comparisons for the environmental impact category global warming (CO2 footprint) are presented and discussed.

Keywords

Plastic pipe systems, life cycle assessment (LCA), environmental product declaration (EPD), European sector approach, sustainable construction and housing.

Cooling concept of the new R&D building of the ZAE Bayern using several thermal energy storage (TES) technologies

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Short Summary

The Bavarian Center for Applied Energy Research (ZAE Bayern) is currently raising the new R&D building “Energy Efficiency Center” [1] (EEC) within a public funded research project. The EEC, which will be finished by June 2013, includes offices, laboratories as well as an Info-center which is open to the public and informs the visitors about the implemented innovative systems and current R&D activities within the funding scheme “Research for Energy Optimized Buildings”.
The overall aim of this project is to demonstrate the compatibility of energy efficiency, user requirements and appealing architecture. The EEC aims to be a technology reference and along with the strong interaction of research, demonstration and dissemination at one place it is supposed to accelerate innovation processes in the field of energy optimized buildings.
Since the EEC is a partial lightweight building with a translucent building envelope and high internal heat gains, an integral, sustainable concept for cooling is required. For this, several new thermal energy storage (TES) technologies are combined. To minimize energy consumption and to ensure thermal comfort for the employees a highly innovative building automation system will regulate and control the interaction of the single systems.

Keywords: PCM; energy storage; cooling concept; energy efficiency; L-DCS

1. Introduction

In view of plans to increase the energy efficiency in the building sector, turning old buildings into energy efficient ones as well as establishing high standards for energy efficiency of new buildings has become notably important in Germany. With growing insights in the field of energy research several new technologies were developed in the past years which promise more energy efficiency in buildings. Anyhow, in the building sector innovations often take many years until being accepted on the market. This means that a great potential of energy savings is still unused.
Based on these facts the main target of the new R&D building EEC for the ZAE Bayern is to combine cutting edge energy efficient technologies, to optimize their interaction and to accelerate their introduction to the market by demonstration. These ambitious goals are promoted by gathering the know-how of the involved research partners from science and industry.
Since the EEC is a lightweight building with a translucent building envelope and high internal heat gains, an integral, sustainable concept for heating and cooling is required.

2. Cooling concept

The cooling concept is mainly based on regenerative and natural cooling strategies, using natural ventilation, Passive Infrared Night Cooling (PINC), Liquid-Desiccant Cooling (L-DCS) and an integrated thermal storage concept. Two fire fighting water tanks with a volume of 100 m³ each are also used as cold water thermal energy storage tanks that are connected to the buildings cooling circuits. The cooling energy for one tank is generated by a conventional compression cooler during night times; this tank is mainly used as a back-up system for process cooling demands. The second tank is connected to the PINC, which is a highly efficient cooling method developed at ZAE Bayern: the water is pumped to the roof at night where it runs freely and is cooled down mainly by radiation exchange with the cold night sky. The cold water is used for the cooling units in the laboratories as well as for the regeneration of the implemented PCM (Phase Changing Material) cooling ceilings in the offices. At daytime, the PCM is cooling the room passively while melting.
During moderate outside weather conditions, the building is naturally ventilated. When the outside air is too hot or too humid, tempered air is supplied by a L-DCS which uses a concentrated hygroscopic salt solution for air dehumidification and an evaporative cooler for cooling. During cold seasons, the system is used for heat recovery and heating. After its completion, the building will undergo a comprehensive long-term monitoring and optimization phase.

3. Conclusions

For the first time, the thermal energy storage systems “PCM”, “PINC” and “L-DCS” are combined in one building in order to improve energy efficiency and to use and analyze synergy effects. In cooperation with the building automation system the thermal energy storage systems have an enormous potential to make the use of thermal energy equipment more effective. Subsequently, large scale energy substitutions are reachable which is important from an economic as well as sustainability perspective. Thermal storage in a building may be decisive for the reduction of cooling loads and temperature increases, but also the achievement of indoor thermal comfort requirements. In the EEC the positive effects of energy storage technologies will be proved, the systems and the interaction among themselves will be optimized and verified through a long term monitoring. Therefore this has the potential to accelerate the innovation processes in the field of energy optimized buildings.

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Refurbishment of a Viennese residential estate to future building standards with a prefabricated façade system and integrated PV

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Short Summary

The recast of the European directive on energy performance of buildings in May 2010 (EPBD, 2010) tightened and added some requirements for new and existing buildings. All member states have to implement national plans to enforce the amount of nearly zero-energy buildings (NZEB) and till 2020 all new buildings have to fulfil this standard [1]. Because of long renovation cycle even existing buildings shall be transformed into nearly zero energy buildings, if major renovation measures are applied.

In the project “B02 enVELOP C - Multifunctional Cover in Refurbishment of Facades and Buildings” a prefabricated renovation system with passive and active modules shall be developed and demonstrated on existing buildings constructed in 1970. Based on an existing passive cardboard insulation system with timber framing, additional active modules with integrated photovoltaic shall be implemented. The photovoltaic cells are integrated into the glass cover of the ventilated façade. A special experimental set-up, developed at the University of Applied Sciences Technikum Wien, should investigate the impact on the natural convective air flow as well as the effect on the insulation properties of the panel.

Keywords: passive house; refurbishment; prefabricated building elements; building integrated renewable energy systems

1. Introduction

Within the project “B02 enVELOP” the gap-solutions system was further developed [2,3]. In the float glass pane photovoltaic cells were integrated partly. Because of the dynamic characteristics of the cardboard comb panel the effects of the photovoltaic cells on the thermal behaviour and the rear ventilation of the panel have to be investigated in detail. The integrated PV cells provide shading on the façade panel partly. Hence the natural convection flow of the rear ventilation is affected. In addition the solar radiation input is reduced and the warming effect in the combs is influenced.

The goal of the experimental investigations was to identify an appropriate layout for the photovoltaic cells to minimize the effect on the functionality of the façade panel. Furthermore the soiling of the inner glass surface should be assessed as the deposit of aerosols and dust is mainly depending on the convection flow. The investigations of the effects of PV cell integration were carried out in the laboratories of the University of Applied Sciences Technikum Wien. For this purpose a special experimental set-up was developed.

An artificial light source consisting of six metal halide lamps, each 1.000 W connection power, was used to irradiate the façade panel. A cross-flow radiator fan was used to simulate exterior wind conditions on the glass surface. Below the test panel a reservoir with aerosol-mist was mounted, which could be filled without any pressure. With the reservoir it was possible to visualise the convection flow throughout the entire width of the panel. The panel was equipped with several sensors and measurement devices [3]:

- **Inlet and outlet temperature:** For the measurement commercial PT100 sensing devices were used and calibrated according to DIN EN 60751. Inlet and outlet temperature were measured with two structurally identical sensing devices each. The results were averaged for interpretation.
- **Temperature in the rear ventilation layer:** The distribution of the temperature in the rear ventilation layer was taken point wise on eleven measurement points. The sensing devices were TESTO thermal flow velocity probes (robust hot bulb). The measured values were logged with the measuring instrument TESTO 480.
- **Velocity of the convection flow:** Similarly the velocity of the convection flow was taken point wise at the same measurement points with TESTO thermal flow velocity probes.
- **Temperature of the outside glass surface:** The temperature on the surface of the glass was taken on the same measurement points and logged with TESTO 435.
- **Thermal flow:** The thermal flow through the panel was measured with two heat flow plates of the company Alhorn and logged with the software LabView.

Consequently the standard panel has to be investigated at first to define a reference for comparison. The photovoltaic cells are commercial mono crystalline cells with a dimension of 15 x 15 cm and an electric output of 4,08 WPEAK. For the experimental set-up the integrated PV cells were not connected to each other and have been in a no-load condition. Thus no electrical energy was produced. Four different PV cell layouts with horizontal and vertical alignment were investigated.

2. Conclusions and outlook

The outdoor measurements under exterior conditions (natural radiation, wind, temperature, etc.) confirm the experimental set-up. The integration of PV cells into the glass cover influences the temperature profile and natural convection flow in the rear ventilation layer to some extend. The lowest influence was observed in PV variant 3. Based on the experimental results the PV cell layout on the façade of the demonstration object should be aligned in horizontal patterns and the density should not exceed one third of the aperture area. It seems feasibly to recommend an additional investigation and apply semi-transparent PV cells. Thus the shading is lower and the effects on temperature, natural convection and thermal flow through the panel could be reduced further.

For the demonstration object a dynamic building simulation will be carried out. Hereby the focus is on thermal comfort in summer time. The adaption possibilities to climate change issues should be analysed using the climate scenarios and the weather data set of the summer season 2003. The results of the measurements are used to fine tune the previous CFD (Computational Fluid Dynamic) simulation and support the development of a TRNSYS type for building simulation.

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LifeCycle Tower – the Natural Change in Urban Architecture

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Short Summary

More than 50% of the world's population today lives in cities and the trend is increasing [1]. The urbanization of the world presents an enormous challenge to the future of mankind. As we move into an era of climate change compounded by either diminishing resources and/or resources that are expected to continue to have extreme price volatility, resource efficiency is a crucial factor.

Global construction industry today accounts for 40% of today's energy, CO2 and resource consumption, and 40% of waste production [2]. In the past, urban architecture has been based predominantly on conventionally produced prototypes with long, complex and resource-intensive construction work. Today, resource efficiency combined with renewable energy and energy efficiency should be part of every community’s planning, projects and budgets and should be considered for all construction projects. Therefore, sustainable construction techniques are of immanent importance. The orientation towards high-rise green buildings that offer many people an urban living environment with environmental and resource-friendly building materials is much more than just a global trend by now.

The changing global construction scene was the trigger that spawned a research project over several years. An extensive research process by knowledge leaders from all professions in the building industry, such as architecture, structural engineering, building physics, building services, process management, marketing etc. resulted in an innovative solution for sustainable construction.

The vision of our product reflects the aim: LifeCycle Tower (LCT) – a skyscraper out of wood [3]. Therefore, we developed a market-ready hybrid timber building system for high-rise buildings up 100 m and 30 stories. Cree as a subsidiary of Rhomberg is set to demonstrate the versatility as well as the feasibility of this modular construction system. Three main objectives were pursued:

1. Large-volume building

As a result of the global trend towards urbanization, efforts were made to develop a solution for use in an urban context. The objective was the development of a high-rise building solution capable of reaching up to 30 stories or 100 m in height.

2. Resource efficiency

The shortage of resources and the associated rising prices of raw materials turn the intelligent use of material goods into an enormous competitive advantage for the building industry. Therefore timber, a renewable and local resource, was chosen as the basis for the development of the new building system. Its reduced "ecological backpack" is only half that of conventional buildings.

Moreover, wood as a material has the potential to improve the CO2 balance by 90% [4] and reduce the weight of the building by 50% [5].

3. System building

A further objective of the research was to develop a standardised universally usable modular system containing a significant proportion of building technical services (heating, cooling, ventilation,…). The individual elements should, as in the automotive industry, be capable of being prefabricated in a factory and modular to the extent required by the client. The concept of serial off-site production was intended to ensure economies of scale, consistently high quality and rapid erection of the building on site.

The first research project "8+" investigated the technical feasibility of buildings in wood construction. The results showed that it was technically feasible (from a structural engineering point of view) to erect buildings 80 metres or more in height. The research did not consider the commercial marketability or the likelihood of obtaining statutory construction approval of the final concept. It was therefore not possible to construct a building based on principles of the "8+" research project.

The second "LifeCycle Tower" research project extended the findings of the "8+" project and developed a new building system modified to suit the requirements of the modern real estate market. Industrial prefabrication and special consideration of fire safety in the design led to the new product becoming ready for the market. The eight-story prototype “LCT ONE” that has been constructed in Dornbirn, Austria and the first customer project IZM being built in Vandans, Austria demonstrate the proof of concept.

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Keywords: cree; life cycle tower; wood; system; building

Concrete Repair Mortar Made of a Waste from Oil Refining Industry

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Short Summary

Awareness that the use of green building materials towards long-term sustainable development includes addressing environmental, performance and economic issues in an integrated way is promoting synergies in waste recycling. Within this scope, this paper addresses the reuse of an oil refining industry waste – the spent fluid catalytic cracking catalysts – in the concrete repair mortars composition.

Keywords: Oil-cracking catalyst; Concrete repair mortars; Waste recycling; Green building materials

1. Introduction

The market demand for concrete repair materials has grown considerably due to: (*i*) deterioration and distress of concrete structures as the age of existing infrastructures is increasing, (*ii*) the understanding that sustainable construction practices includes the ability to extend the structures longevity in order to both continue using embodied energy of construction materials and to reduce demolition wastes, and (*iii*) the need to fulfill mandatory regulations. Moreover, since cement production is a natural resources, an energy as well as a carbon intensive process, repair practices, particularly using green products, reinforce the aforementioned environmental impact mitigation. In this regard, the production of cement based materials, including concrete repair mortars, with partial replacement of cement with other lower carbon material with cementitious properties has been recognized as a lever for greener products manufacture [1]. In addition, if the surrogate material is an industrial by-product – being recycled in the cement based materials composition – there is also a concomitant decrease in landfill disposal of wastes as well as an increase in profits by adding value to a waste. Within this scope, this paper presents results of a study aiming to assess the viability to produce concrete repair mortars incorporating an oil refining waste, the fluid catalytic cracking (wFCC) catalyst.

2. Experimental program

The raw materials used were: commercial Portland cement type CEM I 42,5R (according to EN 197-1 standard); wFCC catalyst originated in a portuguese refinery plant (PETROGAL S.A. company); sand (according to EN 196-1 standard) and SIKAPlast superplasticizer (SP). Repair mortars were prepared using water (w), sand (s), binder (b) and superplasticizer (SP), in a weight ratio (w/s/b/SP) of 0.5/3/1/0.005, respectively. Binders used were plain cement (used as reference) and blended cements formulated by partial replacement of cement with 5, 10 and 15% w/w of wFCC catalyst. Notation adopted for binders identification was, respectively, C100, wFCC5, wFCC10 and wFCC15. Mortars mixing procedure as well as flexural and compressive strengths tests were conducted following EN 196-1 standard procedures. Consistency of fresh mortars (by flow table), modulus of elasticity in compression and water capillary absorption were evaluated as prescribed, respectively, in ASTM C 1437-07, EN 13412 and EN 13057 standards.

3. Results and discussion

Experimental results (Table 1) show that wFCC catalyst incorporation does not have a significant effect neither on mortars flexural strength nor on elastic modulus although their values tend to decrease with the increase of wFCC content. Due to the significant cementitious properties of the wFCC catalyst, the incorporation of up to 10 % of waste on mortars composition leads to a compressive strength enhancement slightly higher than that of the reference mortar, and mortars with 15 % of waste incorporation still exhibit a compressive strength similar to that of the reference mortar [2]. Capillary absorption decreases with the increase of wFCC content in the mortar. Moreover, previous studies on materials manufactured with wFCC catalyst have shown that they do not harm the environment as they comply with environmental requirements [3]. Furthermore, experimental results (Table 1) show that all the assessed properties comply with the requirements set out for all classes (R1 – R2 Noan-Structural; R3 - R4 Structural) of concrete repair mortars as defined by the EN 1504-3 standard.

Table 1 – Results and requirements laid down in EN 1504-3 standard for classes R1 to R4 of concrete repair mortars.

Properties	Experimental results				EN 1504-3 standard requirements			
	C100	wFCC5	wFCC10	wFCC15	R4	R3	R2	R1
Flow table (mm)	223	218	207	188	NR	NR	NR	NR
Flexural strength, 28 days (MPa)	7.9	7.7	7.6	7.5	NR	NR	NR	NR
Compressive strength, 28 days (MPa)	69.5	70.5	71.4	69.2	≥ 45	≥ 25	≥ 15	≥ 10
Elastic Modulus (GPa)	36.3	36.9	35.9	34.1	≥ 20	≥ 15	NR	NR
Capillary absorption coefficient (kg/($m^2h^{0.5}$)	0.34	0.26	0.19	0.14	≤ 0.5	≤ 0.5	≤ 0.5	NR

Legend: NR – No requirement.

4. Conclusions

Major findings in this investigation reveal that there is a large potential to use waste FCC catalyst as a constituent in repair mortars producing novel materials with adequate performance and durability and, concomitantly, making a significant contribution for "greener" construction materials.

5. Acknowledgments

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Biobased Sandwich System for Applications in Architecture

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Short Summary

For years polymer foams have posed an excellent „warm shell“ for buildings. Generally the foam is used for external wall insulation. Yet forming a sandwich from rigid laminates and a quite shear resistant polymer foam core, results in extraordinary stiff elements that provide not only thermal insulation, but a load carrying structure. The sandwich structures sustainability can be raised by combining materials from renewable resources. The sandwich system currently developed in cooperation with our partner from industries C3 House Technologies consists of phenolic foams of varying density and natural fibre reinforced laminates. A phenolic resin matrix provides sufficient fire resistance for the entire sandwich itself, and a high performance thermal insulation. The material system may be employed for compact construction methods. One may also rely on local resources for the laminates. By the selection of fibres and their ratio of mixture in the natural-fibre-fleeces the mechanical properties can be designed according to use. Depending on the pressing technology, the fibre-resin-ratio and the kind of fleece, the elastic modulus of the laminates can be adjusted in a wide range to fit particular applications like external or internal walls.

Keywords: sandwich; biocomposite; lignin; biofoam; bioeconomy; phenolic resin; lignosandwich

1. Introduction

Fibre-reinforced plastics were first used in their own right as a class of construction material in the construction industry in the middle of the 20th century. They enabled architects to construct plane load-bearing, lightweight and dream-like structures with thin walls spanning wide stretches and floral or crystal structures, providing us with a novel type of housing.

Fibre-reinforced plastics are a multifaceted class of construction materials as the most diverse types of fibres as well as thousands of combinations of plastics together provide high-performance materials. Plastics are currently undergoing a period of transition. Oil is no longer the sole means of producing plastics: natural products are undergoing chemical processes and are being offered as bioplastics. Natural fibres are now fulfilling other roles apart from their traditional use as textile fabrics in the clothing and carpet industries. The construction system being developed is based on the combination of new composites, existing findings in the field of lightweight construction using sandwich systems, and sustainable resource and energy saving construction methods that are currently in use.

2. Design & Architecture & Material

A large amount of the heat and energy produced, and thus the consumption of finite gas and oil reserves, goes into heating buildings. The aim of the European Union therefore is to reduce energy consumption by 20% in 2020 by increasing energy efficiency.

Two-thirds of the energy consumed during a buildings service life is put into heating and ventilation. Efficient thermal insulation and the airtightness of the buildings shell would result in great savings. Therefore the idea of the passive house attracted great interest and has served as a shining example in reducing energy consumption. In the passive house energy is mainly reduced by reducing energy losses through transmission and ventilation. This is achieved by effective thermal insulation, the airtightness of the entire building shell and a controlled ventilation of living areas with heat recovery from the outgoing air.

Insulated, airtight structures are constructed of many layers, which do not only exceed the dimensions of the overall structure, but also lead to sources of defects like thermal bridges and leakages. A compact design in which the load bearing structure simultaneously ensures the building physics and provides protection against weathering, can be achieved by the use of a sandwich system. Sandwich systems have been employed for timber and composite structures. Building on these experiences current research aims at materials for energy-saving constructions.

In the ongoing research projects at the Fraunhofer IWM in Halle experience in composite construction is linked with current production standards in construction industry and plastics-processing industry. As a result renewable raw materials are combined in innovative sandwich systems, so called Natural Composite Panels (NCP). These are qualified for applications in architecture and construction industry. Apart from a compact solution for the load bearing structure, the building physics and the protection against weathering, NCPs also offer the advantage of: savings in material due to thin walls, savings in weight and transportation costs thanks to the lightweight design, a high quality owed to the controlled industrial manufacture of the materials, a high degree of prefabrication, good workability, quick installation and yet still provide individual design possibilities. Primarily renewable locally available raw materials are used.

Besides the creative flexibility of the NCP construction system, seen on the illustrations, the innovation in structural design is the joining technique – bonding is appropriate for the material involved and superior to mechanical joining. Elements such as windows and doors can easily be integrated and local overloads, that would generally lead to material being ripped out, like in a bolted connection, can not occur.

The materials used in NCPs are specified according to the current international requirements for load bearing structures and building physics and are designed on in teamwork with the manufacturer, load bearing structure designer and architect (Fig. 1), taking into account manufacturing requirements and the structural design.

Fig 1: Components of the sandwich system (source: C3 House Technologies GmbH)

The combination of raw materials enables the sandwich to be optimally tailored for the respective application. Perspectively, it will be possible to replace part of the petrochemical component (phenolic resin) by lignin as a biobased component, receiving a construction material that consists of 20 – 50% renewable raw materials.

Multi-Linear State Space Model Identification for Large Scale Building Systems

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Short Summary

Many Control Design approaches presuppose the knowledge of a state space description of the system. As in many real and large scale systems the construction of a state space model using analytical equations and rough assumptions is a time consuming process leading most of the times to questionable precision. System simulation software has been developed for several applications over the recent past decades. For this purpose a System Identification approach is proposed in the present paper. The idea of the System Identification from a simulation model using statistical measurements from the simulation output data has been of great interested for optimal control schemes which require accurate and furthermore, agile, simple and practical models to handle. In practice real systems and accurate simulation models, show nonlinear dynamic behavior which concludes to linear approximation-identification models being unsuitable for this purpose. The proposed Multi-Linear State Space Model Identification process is using the idea of mixing signals as weighted contribution factors for the final model behavior. A common Least Square error minimization process is used to minimize the model approximation error.

Keywords: Building, Simulation, SSM, Modeling, System Identification

1. Introduction

This paper copes with the idea of approximating a dynamic state space model of a given system by using off line measurement data, using a common input-output system measurement database.. The proposed strategy introduces state space subdivision and local linearization according to the current system working point - state. Locally referring but globally representative weight functions decide the contribution of each linear subsystem to the final model total dynamic behavior.

Let us consider a general non-linear system which assumes the following dynamics

$$\dot{\chi} = F(\chi, u, w) \tag{1}$$

where $\chi \in \Re^n, u \in \Re^m, w \in \Re^d$ denote the vectors of system states, control inputs and system disturbances, respectively, F is a nonlinear vector function which is assumed to be continuous. Assume that F can be approximated using smooth mixing signals membership functions, so as to have smooth switching between the linear subsystems. The linear sub-systems are derived using a Least Square minimization.

To test the developed system identification algorithm we use a validated building model generated with TRNSYS [1]. This model has been developed during the project PEBBLE (for details see http://www.pebble-fp7.eu/). TRNSYS simulation output and weather data from 2003 are used for the system identification.

The used system identification scheme is based on random excitation. For this reason a simulation schedule is followed in the building simulations to generate proper data for the identification.

2. Results

In our approach we try to identify a multi-linear model for the indoor mean air temperature and humidity ratio, given schedules for ventilation, window opening and blind control, as well as operation of a thermally active building system (floor activation), and the boundary conditions: Outdoor humidity ratio, outdoor temperature, wind speed, wind direction, total solar radiation and office occupancy.

The summary for the identified model is incorporated in Table 1 below. The different Integration Horizons and the according error indicate the ability of the identified model with respect to predictions.

Table 1: Identified model summary of results, for three different state resetting frequencies (different prediction horizons)

Steps (1 Step = 0.25 h)	*prediction Horizon 1*	*prediction Horizon 25 (6.25 h)*	*prediction Horizon 96 (24 h)*
Number of mixing functions	2	3	2
Training Period Error (%)	0.9	4.7	6.6
Validation Period Error (%)	1.1	4.5	14.7

3. Conclusion

The identification of a multi-linear state space model which is viable to describe the thermal dynamics of an office building for the near future – based on (simulation) training data from the past – was successfully demonstrated. In this paper simulation data from a validated TRNSYS model of an office building were used for demonstration, but practically these data may stem from measurement data of a real building. Real building data, describing usual operation of the building, however, might not lead to sufficient excitation, which is needed to obtain a “good” model. The idea of mixing signals as weighted factors for the linear sub-models to form the multi-linear state space model proved to work very well if the current state is updated frequently. As the update frequency increases the modeling error increases significantly, especially for the validation period.

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Storepet – European Project of an Innovative Thermal and Acoustic Insulation Solution for Construction Materials

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Short Summary

The Construction Cluster „DUNDJER“ participates together with number of distinguished research and development organizations in EU, in the 7th FP European project entitled STOREPET (FP7-SME-2011-2, Proposal 286730). STOREPET is a project which goal is develop an innovative thermal and acoustic insulation solution based on phase change materials in building sector. StorePET will be especially designed for lightweight and low thermal mass building envelope structures, as well as for any other residential/commercial/governmental new or refurbishing building projects, with extra insulation and heat storage capacities needs. With a project budget of € 2.4 million, it has been estimated that the new product will produce new streams of revenue worth € 170 million in the materials and energy savings worth above € 300 million. The research is at a moment in progress. One of closing meetings, with presentation of final research results will take place in Niš, Serbia, in the year 2013. The Construction Cluster „DUNDJER“ will have all rights and royalties, including regional production and merchendise.

Key words: building materials, thermal insulation, acoustic insulation, light building constructions, energy efficiency, sustainable building.

1. INTRODUCTION

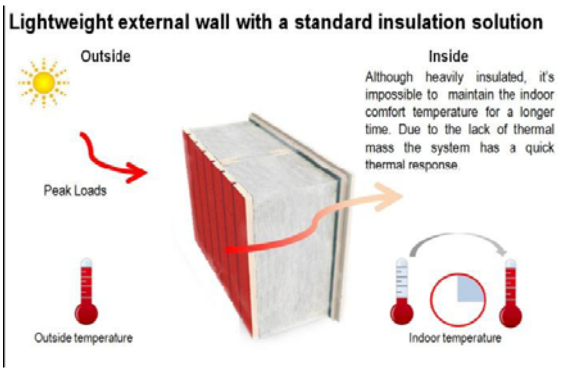
New building strategies addressing climate change effects and reduction of heating/cooling energy are two fundamental issues at EU level. Figures as the 35,000 excess deaths attributed to the last heat wave in the continent in 2003, or 10% of the world’s energy being used just for heating of buildings support European citizen’s concerns and new EU legislation. New national and communitarian stringent directives, together with the economic slump of the construction sector (showing two digit shrinkage rates) have set extremely high challenges to the already weakened companies in the construction sector, especially the SMEs. A market need and a new opportunity for them is researching competitive solutions for thermal and acoustic insulation of light-weighted constructions, a broadly recognized market driver for the next decade. Lightweight constructions represent an economical alternative to traditional buildings, one of whose main drawbacks is the very high energy load needed to keep internal comfort conditions, as they are unable to curb rapid swings of temperature. When compared to heavier weight materials buildings, it’s estimated that to maintain a thermally comfortable temperature range of 18-24°C, low weight materials use between 2 and 3 times the heating and cooling energy needed by a heavy weight material construction.

2. PROJECT DESCRIPTION

The project concept is based upon the fact that outdoor/indoor heat exchanges (which play a significant part of lightweight buildings cooling and heating loads) can be potentially controlled by a new fibre insulation that possesses a thermally active heat storage capacity. During the day, when temperature rises, the peak loads can be largely absorbed by a PCM-enhanced fiber insulation layer, only to be slowly discharged back to the environment later (during the night time, when outside temperature drops), without affecting the interior building energy balance, as it is aided by the presence of an standard low heat transfer fiber insulation layer. This approach will provide a much slower response of the building envelope to daily temperature fluctuations, helping maintaining inside temperature in a comfortable range and thus avoiding the need for extra energy consumptions to accomplish it. Effective levels of indoor comfort will be also guaranteed by the well known fiber materials excellence, when it comes to reduce airborne noise transmission and its superior performance upon controlling the sound resonance in construction cavities.

3. THE PROJECT CONCEPT

The project concept is based upon the fact that outdoor/indoor heat exchanges (which play a significant role in lightweight buildings cooling and heating loads) can be potentially controlled by a new fiber insulation that possesses a thermally active heat storage capacity. During the day, when temperature rises, the peak loads can be largely absorbed by a PCM-enhanced fiber insulation layer, only to be slowly discharged back to the environment later (during the night time, when outside temperature drops), without affecting the interior building energy balance, as it is aided by the presence of an standard low heat transfer fiber insulation layer. This approach will provide much slower response of the building envelope to daily temperature fluctuations, helping maintaining inside temperature in a comfortable range and thus avoiding the need for extra energy consumptions to accomplish it. Effective levels of indoor comfort will be also guaranteed by the well known fiber materials excellence, when it comes to reduce airborne noise transmission and its superior performance upon controlling the sound resonance in construction cavities.



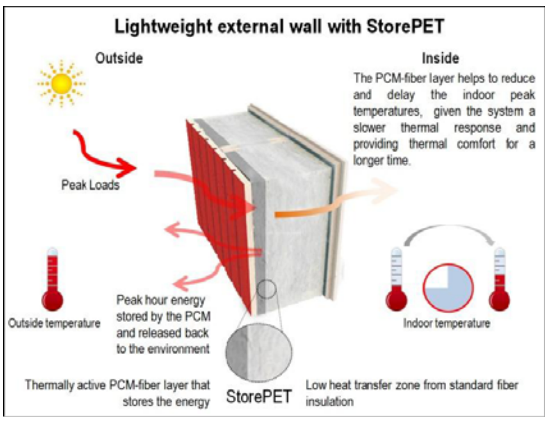


Fig. 1. Standard external insulation solution

Fig. 2. External insulation with StorePET

From the point of view of energy efficiency design, the added value of the PCMs is its extra ability (on top of the thermal resistance) to reduce energy consumption in the building. The figures above show how StorePET solution would significantly reduce inside temperature fluctuation and therefore the needed heating/cooling load to keep temperature constant, in a scenario of high fluctuation of outside temperature (Fig. 2) in comparison with standard insulation (Fig. 1).

Implementing dynamic load-bearing structures on a generic case study

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Short Summary

Nowadays most of the buildings cannot respond efficiently to changing needs of users and society due to the way buildings are designed and constructed. Labour-intensive renovation is often necessary; otherwise demolition of the building will follow. In both cases valuable building materials are lost and new raw materials are needed. Partly therefore, the environmental impact of the building sector is significant.
The need for new buildings materials and the production of waste could be minimized by implementing the time dimension in the design phase, in such way a building can change during its life cycle without ever being an end product. Namely by using compatible components and reversible connections, building components can be added and removed to fulfil new requirements. The removed components can be reused later on in a new configuration.

Therefore, in the context of this paper the impediments of implementing dynamic detailing and the dynamic potential of conventional load bearing structures will be explored. It will be examined how a structure constructed by using a conventional building method (masonry, timber skeleton structure, etc.) can pass into various usage scenarios: expansion, reduction, modifications of the skin, etc. This knowledge will be applied to a generic case study.
By doing this, it will become clear which building method can meet the imposed dynamic conditions and which usage scenarios the load bearing structures can fulfil. These results can be extended to other more specific cases.

Keywords: Generic case study; design for disassembly; detailing; load bearing structure; reuse of building components.

1. Introduction

In this paper the research is clearly defined in terms of building layers: only structural components will be taken into account; because this building layer has the biggest environmental cost compared to other building layers. If the structure can anticipate changing needs, the structure will last longer and its environmental cost will reduce. In a next research phase the building envelope, partitions, etc. should be taking along.

2. Transformable building systems

In this section most conventional building methods are discussed. A summary is given of the mean dynamic properties of existing building systems. However, they need some small adaptations in order to anticipate better changing needs. Solid structures have more freedom if they are single bearing, and all conventional structures would improve their reuse potential by standardizing and making their components compatible. By using steel bolts preassemblies can be made of clay and loam bricks; and they can insure an uncoupling into different building elements.

However, those proposals should be further elaborated both theoretical and practical. It should be examined whether there is actually an environmental benefit in applying those construction systems in the short and the long term and compared to existing systems. For instance, some studies suggest that the environmental costs of using steel bolts will be too high.

3. Determination of possible scenarios

This section describes some possible usage scenarios the load bearing structure should be able to pass into, e.g. expansion and reduction of a basic unit.
The included scenarios are the ones where the structure has a major influence on a possible anticipation. For example, if there is need to build an addition on an existing building, accessible from the base unit, there must be enough space in between the structure to build a staircase in order to access the addition. The scenarios were not included if the structure has little effect on a possible anticipation or if there are too many other boundary conditions beside the structure. For instance, a possible anticipation on a change of function (i.e. residential, commercial, office, and retail) depends on many factors.

4. Implementing building systems

Finally, those scenarios are tested on the original and the improved building systems. It is examined to which extent a particular scenario can occure.

It can be concluded that the proposed adjustments have indeed a dynamic effect compared to existing dynamic building systems. The modified building systems can give easier access to additions; they can extend services; joining of units and changes in the space plan are now possible in already one direction and reductions and changes to the skin are more easy than before for most adapted systems. Moreover, when reusing the components, they provide more form- and dimensional freedom.
However, with or without adjustments, skeleton structures can pass into most usage scenarios more easily than solid structures. But, compared to solid structures, the components are bigger, which give less form- and dimensional freedom in a new configuration.

5. Acknowledgment

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Improving thermal performance of rammed earth walls using expanded clay aggregate

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Short Summary

The buildings with rammed earth walls have a high thermal inertia which, given the climate characteristics of Portugal, improves its thermal behavior. However, it is desirable that the thermal conductivity of the rammed earth were lower.

Compositions were considered soil and expanded clay having the following percentages of expanded clay, 0%, 10%, 15%, 20% and 25%. In order to characterize the different compositions from the point of view of mechanical and thermal performance, cubes were produced with 10 cm edge and assayed in order to calculate its compression resistance and its thermal conductivity. The results showed that the use of this type of building typologies on earth with the incorporation of expanded clay allows to increase your performance by making it possible to adapt this typology needs of today, including the demands of the Portuguese legislation.

Keywords: Rammed earth walls, Energy efficiency, Expanded clay aggregate.

1. Introduction

In Portugal, earth construction, and in particular building incorporating rammed earth or *taipa* walls is common in the Alentejo and Algarve regions. However, the use of this construction technique has gradually fallen into disuse, especially since the mid-20th century. As masters of the art disappear, we risk losing a fund of specialised knowledge required for selecting soil, determining optimum moisture content and implementing the technique itself: the placement and compression of the earth between wooden formworks.

Portuguese regulations governing the thermal performance of buildings (RCCTE – Regulation of Characteristics of Thermal Behaviour of Buildings, the provisions of which are contained in statute law: Decreto-Lei no. 80/2006) set out requirements regarding limits on the nominal consumption of energy during the cool season that are not easy to comply with when using the rammed earth technique.

The aim of this paper is to provide a contribution towards the improvement of the thermal performance of rammed-earth walls by examining techniques for reducing thermal conductivity. This study involved the use of granulated cork, which was mixed in different proportions with soil with a number of different particle sizes in order to gauge how thermal conductivity could be reduced without decreasing too much the compressive strength of the mixture.

2. Thermal and mechanical performance

In order to characterize the different compositions from the point of view of mechanical and thermal performance, cubes were produced with 10 cm edge and assayed in order to calculate its compression resistance and its thermal conductivity.

The compressive strength of samples of soil containing 0%, 10%, 15%, 20% and 25% of expanded clay ranges between 2,6 and 3,1 MPa. These values show a satisfactory level of compressive strength. The standard NZS4297 (1998) considers as acceptable 0,50 MPa. Guerrero and Delgado (2006) classifie as high resistant rammed earth without stabilization which compressive strength is 1,8 MPa. So, the added expanded clay, in the discribed percentages, doesn’t damage the compressive strength of the mixtures.

Thermal conductivity was measured using an ISOMET 2104 device. Values recorded for samples containing different percentages of expanded clay of particle size 2-4 are presented on Table 1. As a result of the addition to soil of different percentages of expanded clay, a significant decrease in thermal conductivity was recorded, from 1.08 W/m.ºC to 0.79 W/m.ºC.

Table 1: Thermal conductivity for samples of soil with expanded clay 2-4 (mean values and standard deviations)

Samples	λ (W/m.ºC)
100% soil	1.08 ± 0.11
Soil + 10 % Expanded Clay 2-4	1.04 ± 0.66
Soil + 15 % Expanded Clay 2-4	0.93 ± 0.15
Soil + 20 % Expanded Clay 2-4	0.94 ± 0.08
Soil + 25 % Expanded Clay 2-4	0.79 ± 0.15

3. Conclusion

According to the Portuguese Regulation on Thermal Performance of Buildings (RCCTE, Decreto-Lei n.º 80/2006), the reference value of the thermal transfer coefficient of the opaque and vertical elements of the exterior envelope in Climatic Zone I_1 (nearly the South of Portugal) is 0.70 W/m^2.°C. Let us compare this with the values obtained as a result of the tests carried out. In order to make this comparison let us determine the thermal transfer coefficient (U) of a rammed earth wall with a thickness of 0.60 m covered with plaster with a thickness of 0.02 m on the inside and outside.

It should be noted that, as a result of the tests performed, a value was obtained for the thermal conductivity of the soil sample equal to 1.08 W/m.°C. In accordance with the methodology described by Santos and Matias (2006), for the rammed-earth wall consisting only of soil and plaster the value U = 1.29 W/m^2.°C was obtained.

With regard to compressive strength, all the solutions tested would show a satisfactory level of compressive strength (Guerrero and Delgado, 2006; NZS4297, 1998), which means soil with 25% expanded clay 2-4 is the best option. The thermal conductivity measured was: λ=0.79 W/m.°C, and the U value of the described wall is: U=1.02 W/m^2.°C. Comparing this with the sample consisting of soil without a thermal insulator, it was found that the thermal transfer coefficient of the option consisting of 75% of soil and 25% of expanded clay aggregate is equal to 79% of the thermal transfer coefficient of the soil sample, thus, a substantial reduction was achieved.

Future Building Performance Factors towards Energy Efficient Travel Plan in Regional Development

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Abstract

Preliminary research shows short coming of Building Performance field of research to measure outdoor performance of building manly EETP factors. Accordingly, this research aimed to Proposing future building performance toward Energy Efficient Travel Plan based on user friendly EETP factors. The research methodology engaged three research phase. ‘Phase I’ was to identify user friendly EETP factors. In this phase after a literature review, fix-format self reporting interview survey was conducted among experts in Travel Plan implementation in Malaysia. ‘Phase II’ was to investigate effective Building performance factors on user friendly EETP, within which literature review conducted on building performances followed by brainstorming with 5 experts in building management field of research. Final phase was to validate purposed building performance towards EETP in a futuristic cross-impact scenario study. In summary, research is concluded to introduce three main out comes, first: list user friendly EETP factors, second: EETP building performance factors and Third: future Building performance factors towards EETP based on futuristic cross-impact analysis. In conclusion, study introduced list of new innovative future building performances including; BCS (Building communication system), BEEM (Building Energy Education Management), EETP (Energy Efficient Travel Plan), BRc.S (Building recycling system), and BAgr. (Building agriculture) investigated as future building performance factors.

Climate:active renewable raw materials (k:a NAWARO)

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Short Summary

Keywords: ecological building materials, renewable resources, natural building materials, insulation, refurbishment, environmental and health impact

Renewable raw materials (RRMs) are agricultural and forestry-produced materials and biogenic rest or waste materials which are not used as food or feeding materials, but are used as raw materials in the industry or as energy sources. Unlike fossil fuels, they renew annually or in a reasonable timeframe. During combustion or composting, RRMs only set free the quantity of CO_2 that they have absorbed from the atmosphere during their growth period. Unlike fossil fuels, they are therefore largely CO_2 neutral under certain conditions. This CO_2-neutrality, however, is at risk, if the current CO_2 storage is affected by the expansion of cultivable acreage for renewable resources, or other greenhouse gases are released into the atmosphere, or the use of artificial fertilizers increases. The sustainability of products from renewable materials is ensured when regional cycles arise with ecologically compatible cultivation.

The **national awareness program climate:active** promotes the material use of renewable raw materials in products, to achieve a better market penetration and acceptance by consumers and users. The objective of this program is to support the sustainable use of renewable raw materials in Austria and to actively push the material use of RRMs.

Since the project is integrated in the climate:active program, the overall goal is the reduction of greenhouse gas (GHG) emissions through substitution of fossil fuels by renewable raw materials in Austria. Assuming that the full market potential of RRM material use can be achieved, the technical CO_2-eq. saving potential is estimated at 326,000 t/a in Austria. To be able to fully exploit this potential, the mere focus on the CO_2-factor is insufficient. Therefore a holistic sustainability assessment of the entire production chain (including sustainable produced raw materials) forms a central point in the argumentation chain.

Direct regional chains from the raw material to the end product are a realistically implementable target mainly **in the building construction area**. Analogous to regionally produced foods, a regional building culture (i.e. preferring construction materials from regional processing) would be part of the added value directly related to the use of renewable materials and to the creation of "green jobs". On the market side the objectives of the program are to:

- Strengthening of regional implementation networks eg. craftsman and salesman associations and refurbishment networks for the use of RRM construction materials
- Acquisition of a larger market share of RRMs in the insulation sector of thermal refurbishments
- Increase of the awareness of already successful products
- Influence over the development of the framework for the use of renewable raw materials (building guidelines, standards ...)
- Initiation of innovative product developments among manufacturers – even cross-industry collaborations are requested
- Initiation of research projects and information about adequate funding opportunities (eco

innovation, FFG)
- Establishment of quality assurance as part of the climate:active program (product label / Eco-label)

The already provided **RRM suitcase** demonstrates the versatility of renewable materials and products in the construction sector. It contains a multitude of construction product samples made of renewable raw materials and gives explanations of its ecological assessment, it´s manufacture, use and characteristics.
Accordingly, the information and illustration samples serve for energy advice, training, education and public relation. Goal of the composition of the suitcase was to integrate some unconventional products to demonstrate the wide range of application possibilities of RRMs. The compilation of the information and documents primarily based on the construction materials are declared on the web platform www.baubook.at. On the website, in-depth information, technical parameters as well as manufacturer and salesman can be found.

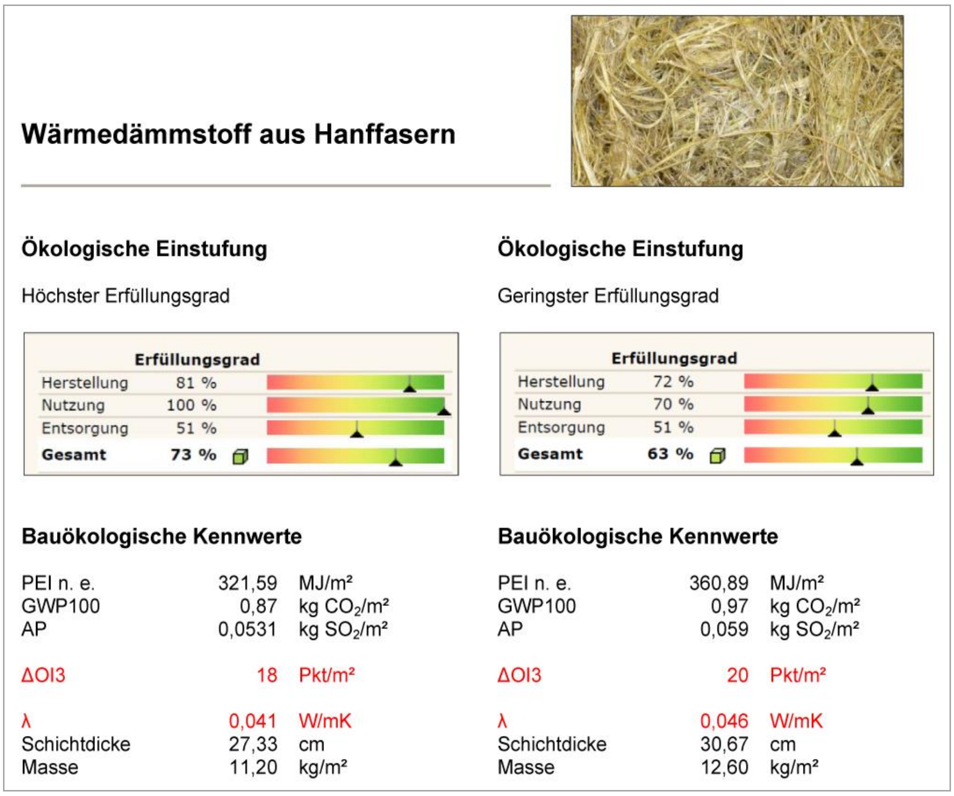

Fig. 1: Example product description of hemp insulation

Two **conferences focusing renewable raw materials construction materials** and best practice experiences are planned for 2013:
- " Regional renewable building materials in the context of healthy and ecological hotels", in Vienna on 17 October 2013 ,and
- "Implementation of RRMs in refurbishment strategies" in the framework of the conference “Sustainable buildings” in collaboration with the project partner Vorarlberg Energy Institute, in Bregenz, 28–30 November (in addition one half day excursion)

More information on the programs is available under: http://www.klimaaktiv.at/erneuerbare/nawaro_markt/Aktuelles.html

HOMETAINER

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Short Summary

The Hometainer project set itself the aim to make sustainability, ecological thinking and resource-efficient construction to the basic module on the subject of living. In order to highlight this focus the draft has been specifically designed for developing and emerging countries. The Hometainer units should also feature the topic of a sustainable environment on a low expenditure and budget. The goal is the implementation of a prototype.

Keywords: sustainable development; lifecycle; developing countries; urban poor; ecological thinking, common property.

1. Introduction

„According to estimates of the United Nations Human Settlements Programme (UN-Habitat) in 2030, nearly two billion people worldwide must live under intolerable conditions in poor and overcrowded homes, often under the threat of expulsion, flood or crime.“

This quote and a comprehensive research were the starting point for the development of the Hometainer project.

The generated living space will be planned, built, maintained and exploited by the residents themselves. The support of the planning team should be lowered to a minimum.
The entire project is not only designed to educate people about ecology and sustainability. Instead they should live it. The building and the cycle of land use will contribute to a sustainable environment. Working together towards a sustainable future can open new perspectives to the residents.

2. Project development

The Hometainer project was developed in front of a realistic background and can be realized location-independent. The basic unit of the project are used 20' and 40' feet shipping container units. Therefore the entire system is extremely flexible and can be adapted to almost any size and condition.

2.1 Implementation – and the promotion of the natural cycle

As possible building sites unappealing properties in slums or in its vicinity should be selected. During the operating life expectancy of the units, the improvement of the natural environment is desirable and should be seen as a sustainable upgrading of living space.

2.2 Structure and Zoning - The variety of simplicity

A few basic rules and the standardized dimensions and couplings of the container allow a simple implementation. A Hometainer unit consists out of three up to six levels; a level is composed out of five times two 20 foot containers. This results in a square floor plan with 40 * 40 feet. Through the vertical access and infrastructure in the middle the building is divided into two halves, each with two flats per level.

All units consist out of a 40-foot and two 20 foot containers. One half of the infrastructure module is assigned to an apartment. Depending on the size of the family and its needs a floor space of 47-60 m² is available.
The ground floor is used as a business, and community area. The roof areas are freely available to the residents. The usage should be referred to the Community, e.g.: for urban gardening, Rainwater harvesting or power generation.

The decision to entrust the layout of the rooms and the choice of the façade to the resident is based on the fact that a high percentage of the poor population has good technical skills. The freedom of an autonomous decision and the opportunity to contribute their part will be encouraged.

2.3 Building materials

The structure of the Hometainer consists 100% out of used containers and represents the first major contribution to a sustainable cycle of use. In order to make the container habitable most of the steel walls will be removed. These parts can be reused on the building or sold as a recyclable commodity.

Instead of expensive high-tech – façade solutions it will be set to local and freely available or repurposed materials that are joined to an inexpensive but effective solution. The variants range from single facade such as mud to multilayer components made of wood, reeds, textiles and scrap. This diversity of outward appearance should reflect the freedom, self-determination and the participatory planning process, of the Hometainer user and should show how to use resources sustainable and meaningful.

For furniture and interior design a reference is made to structural panels (chipboards), which are made from recycled scrap from the agricultural industry. A process for the preparation of these kind of boards was developed by the Bern FH and is freely available (no patents).

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ELAS – Assessing the energy aspects of settlements

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Short Summary

ELAS is the abbreviation of the research project “Energetic Long-term Analysis of Settlement structures” [1], in which the interrelations between spatial aspects as well as technical aspects of residential settlements and energy aspects were modelled. The results were transferred in a freely available online calculator for settlements, the ELAS-calculator: www.elas-calculator.eu.

Keywords: Energy calculator; sustainable urban planning; energy efficiency, renewable energy supply; sustainability assessment.

Energy consumption linked to settlements is a major factor within the energy balance of society. In the European case much of the 27 % share of the energy consumption of households is defined by the infra-structure of settlements. This also holds true for a considerable part of the 33 % share of the energy consumed by transport, given that the location of settlements determines the mobility of their inhabitants to a large part; on top of the mobility of individuals, building houses and infra-structure such as roads, sewage systems and energy distribution grids also cause transport of goods, thus adding to the transport impact of settlements. Finally production of all these goods again requires energy in the industrial sector, appropriating a substantial part of the 24 % share of the industrial sector within Europe’s energy balance [2].
Following this line of argument it becomes clear that (1) decisions taken regarding site, structure and operation of buildings and settlements have a strong impact on energy consumption of society and all related environmental impacts, (2) these decisions affect all sectors of life and may not be reduced to just the impact of household energy consumption and (3) as these decisions tend to define energy consumption patterns of society in the long term they must be based on solid strategic evaluation of all available alternatives if sustainable development shall be achieved.
Any sustainability oriented energy strategy from the supranational to the local level rests on three pillows: energy saving, energy efficiency and renewable energy supply. This is also true for the European Energy Strategy as laid down in the Energy Roadmap 2050 [3]. The environmental overshoot of the current energy systems are caused by high energy intensity of society as well as the predominant reliance on fossil and/or nuclear based energy provision [4]. Housing and settlement infra-structure as well as the operation of buildings and the mobility of citizens living in them constitute a pivot for turning the energy system towards sustainability.
This pivot function can however only be realized when all actors in the field take informed decisions. Therefore tools are required that offer evaluation of impacts incurred by those decisions from all aspects of sustainability. If decision takers have a holistic view on the consequences of their actions, including all ecological impacts along the life cycle of buildings and settlements, the life cycle costs and social implications the chance that they may opt for sustainable development pathways increases considerably.
There is no shortage on evaluation tools regarding buildings and their impacts on the economy and

environment.
All these tools are useful and may help decision takers in their task to cut through the intricacies of finding the optimal solution for housing development. They offer however only partial information that has to be put together to obtain a comprehensive sustainability evaluation of decisions related to housing. This paper introduces a holistic decision making tool (The ELAS Calculator, www.elas-calculator.eu) that models complex systems of energy demand and supply of residential settlement structures and provides a basic sustainability appraisal considering (1) energy demand and supply for the construction of buildings, (2) energy demand and supply for the construction of public infrastructure, (3) energy demand and supply for the operation of buildings including room heating, warm water and electricity, (4) energy demand and supply for the operation of public infrastructures as well as (5) energy demand and supply for the mobility of residents depending of the demographic structure of the inhabitants as well as the location of the settlement and (6) the impact regional economic turn over, revenue and (7) labor market.

The model can be applied to existing settlements as well as to planned projects spanning from (1) new settlements as greenfield developments, (2) renewal and renovation of existing settlements with/without expanding them (3) the tearing down and reconstructing settlements on the same site or on a different site.

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GUGLE – A smart urban quarter model for the building stock in Vienna

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Short Summary

Cities like Vienna are obliged to achieving energy policy targets. The GUGLE – master plan originates from the need of collective actions at regional, national and EU levels, while considering user needs in an urban area and incorporating sustainable technologies and actions. Although a transition to a more sustainable path is commonly acknowledged, it has been proven to be rather difficult to change the incumbent system. In order to implement appropriate concepts and strategies for achieving sustainability and for assessing the potential impact of novel clean technologies and measures, GUGLE serves as a gate towards advanced regional, national and EU demonstrations, by building upon Bottom-Up-Approaches.

The comprehensive integration approach used in GUGLE aims at drawing a technical feasibilty study (TFS) for two Viennese districts, Penzing and Alsergrund, considering within their borders every aspect of a smart city life and energy services. The TFS serves as a gate towards advanced regional, national & EU demonstrations by designing, implementing and validating a plausible scientific framework for proper actions and co-operation towards future sustainable energy policies in end-use sectors for the EU-targets 2020 / 2050.

The objective of this scientific study relies on developing a comprehensive interdisciplinary urban quarter concept as a trendsetting business model in close co-operation with related envisaged investors and industrial partners. Based on selected lighthouse projects and on related promotion activities of empirical results the wishful market extension will be pushed on mid-term. Proposed future scenarios and measures of the GUGLE Master plan are not new, but have been intensively discussed with all relevant stakeholders within project meetings and workshops and are specified for extended deployment at district level.

Keywords: urban quarter concept, smart city development, sustainable energy policies, future scenarios

1. Introduction Smart Cities

In one decade about two thirds of the world’s population will live in urban areas. Only cities with a functional ecology can offer the prospects of saving natural landscapes from urbanization in order to secure high quality of life for its inhabitants [1].
This is the background of many so called „smart city“ initiatives - they pursue the goal of creating more attractive and livable cities, which have the highest potential for energy-efficient way of live, because of their density.

In Austria the national programme „Smart Energy Demo - FIT for SET“ was issued by the Austrian Climate and Energy Fund, which emphasizes on the establishments of Austrian smart city initiatives. Among this programme was the research project “GUGLE” (Green Urban Gate towards Leadership in sustainable Energy), which focuses on the energy-efficient refurbishment of two Viennese districts, Alsergrund (9^{th} district) representing the inner city and Penzing (14^{th} district) representing suburban settlements, which contains very opposite types of existing building developments.

2. GUGLE

GUGLE builds on the objectives of the previous „Smart City Wien“ project, which was striving for solutions for an overall smarter Vienna. In its course a roadmap addressing several areas of activity was developed in order to ensure ambitious targets related to energy and climate protection. Those goals should be achieved at city level by 2020 and 2050.

The comprehensive approach used in GUGLE is in line with these smart city actions and aims at drawing an energetic master plan for the two Viennese districts Penzing and Alsergrund. This master plan addresses every necessary aspect for a smart district life and also covers the topic of energy services and supply. The aim of the project is to find intelligent and innovative ways at district level which eventually can be applied to full city scale, based on a bottom up approach.
The objective of this scientific study based on the thematic fields presented in fig.1 relies on developing a comprehensive interdisciplinary city quarter concept as a trendsetting business model in close co-operation with related envisaged investors and industrial partners. The goal was to use and integrate existing Viennese strategies like the climate protection program (KLIP Klimaschutzprogramm der Stadt Wien) and the city development plan (Stadtentwicklungsplan) as well as other programs.

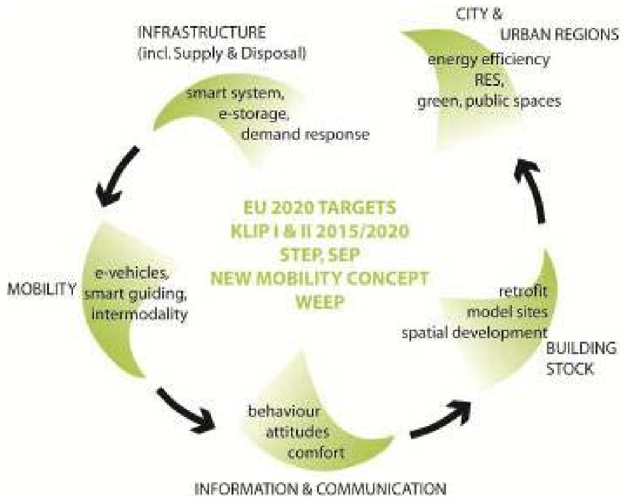

Fig. 1: Relationship between the thematic fields of GUGLE and the energy-political frame of Vienna [Source: BOKU Vienna].

3. Outlook

For the GUGLE-master plan the interdisciplinary consortium identified the most important measures for the upgrading of urban sites towards sustainability and in particular for the two Viennese districts Penzing and Alsergrund. These consist of:

- The renovation of existing buildings,
- the integration of renewable energies and
- a sustainable design of urban mobility.

These actions will help to tackle national and European CO_2 reduction targets at district level. Based on selected lighthouse projects and on related promotion activities of empirical results, the market extension will be pushed on mid-term.

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Review of LCA for concrete and its applicability to Austria

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Short Summary

The construction sector has a large share on the global warming potential. Concrete generates a substantial part of the environmental impact especially due to its content of Portland cement clinker. To quantify the ecological effects, concrete has to be assessed over his whole life cycle.

The method of Life Cycle Assessment (LCA) [1,3] helps to identify opportunities to improve the environmental performance and provides informations for a strategic business planning.
The literature review in the presented paper provides a survey of the state of the art in the D-A-CH (Germany – Austria – Switzerland) countries. An analysis of the regional concrete constituents is the background for the comparison with typical types of Austrian concrete.

Based on these results the optimization potential for concrete is addressed.

Keywords: Life Cycle Assessment (LCA); global warming potential (GWP); concrete

1. Introduction

The majority of their time (90%) people spend in buildings or use infrastructure. This fact points to the importance of the construction sector. It generates about 10% of the global warming potential in the European Union [2]. Buildings and infrastructure have the highest product lifetimes (decades, often centuries).
On the other hand, the construction sector also causes huge mass flows. Concerning the large amount of concrete which is used for those constructions, the environmental effects have to be investigated in detail.
To provide a basis for research, an evaluation of the current situation is necessary.

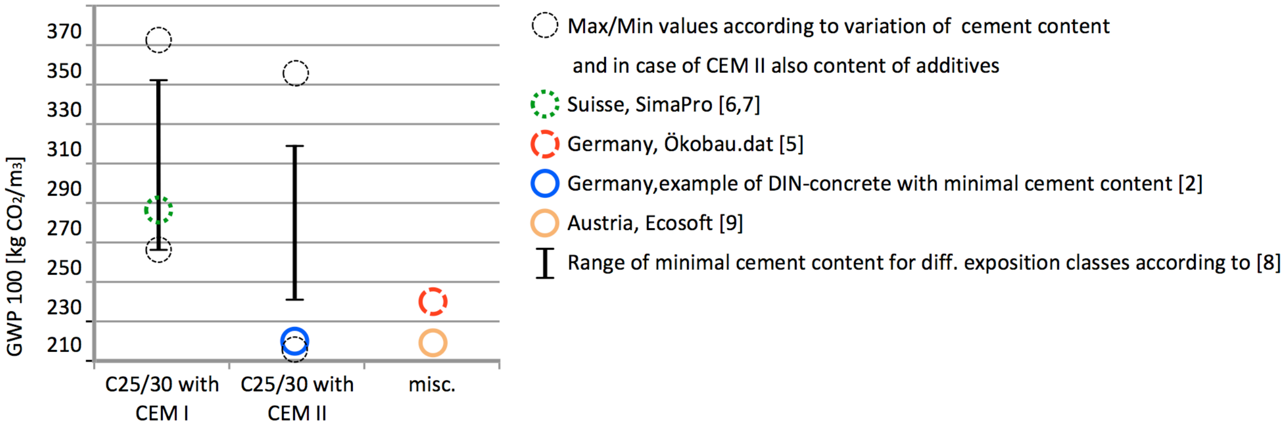
2. Methodology

Requirements for the preparation of an LCA are shown in ÖNORM EN ISO 14040 [1] and ÖNORM EN ISO 14044 [3].
The LCA refers to the environmental aspects and impacts during the life cycle of a product from raw material acquisition through production, use, waste treatment, recycling and final disposal (i.e. "cradle to gate"). The framework of an LCA study includes the goal and scope definition, inventory analysis, life cycle impact assessment and interpretation.
The method of LCA can help with the development and improvement of products, strategic planning, public decision-making and marketing.

In the first step a literature survey was undertaken and compared with an LCA calculation regarding Austrian conditions. To allow the comparability of the different data, the comparison was limited to concrete class C25/30 with CEM I and CEM II. Other types of concrete (national average concrete without specific informations) are listed seperately.

3. Results and discussion

GWP (global warming potential) is the most frequently used indicator and significant for concrete. For this indicator the LCA calculation for the above mentioned concrete class is done.
In the full paper the following literature is being compared and results explained with background information in detail.
Germany: Result, according to Proske [2, 4]. Result by ökobau.dat [5], typical recipe for average transport concrete.
Switzerland: Result by Ecoinvent [6] / SimaPro [7], Suisse average concrete.
Austria: Result of own calculation according to ÖN B 4710-1:2007 [8] with SimaPro by the use of Ecoinvent data, adaption to the Austrian electricity mix. A variation of different amounts of cement was made. Result by Ecosoft [9], Austrian average concrete.



The result shows different findings depending on the amount of cement and country-specific conditions. Another point is the share if cement on the GWP of concrete, which is up to 90%. In actual literature different concrete mixtures are investigated without taking into account the same functional requirements (class of strength resistance, cement ratio, exposition class etc.).
Due to this reasons, it is indispensable to take into account national requirements, specifications and standards as a basis for a LCA of concrete and to differentiate between concrete types according to their performance requirements.
In an on-going research project carried out at the Institute concrete for precast application is optimized technologically with the aim to reduce its environmental impact while ensuring identical technical performance.

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Legal and economic prerequisites for sustainable refurbishment of housing companies in Finland

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Summary

The Finnish building stock is young, and fast built. Now we are encountering the need of comprehensive refurbishments on large scale, but the refurbishment of residential buildings in Finland faces particular legal and economic challenges. Case Virkakatu 8, the second energy retrofit in Finland realized with the TES Energy Facade method, pinpoints economic advantages, shortcomings in building regulations and difficulties in decision making processes with regard to deep retrofits. The case revealed the interests of an institutional owner and a lack of competition with regard to retrofits. The question is: How to foster cost efficient deep retrofits in cold climates?

Keywords: refurbishment, housing company, energy efficiency regulations, TES Energy Façade, E2ReBuild

1. Introduction

The Finnish building stock is young in a European perspective, and was rapidly built due to the needs of urbanization. Suburbs consisting of mainly concrete apartment buildings were built with a foreseen life-span of approximately 40 years. Now we are encountering the need of renewal. [1]

2. The Finnish context

The Finnish building stock derives mainly from the Post War Era, with 75% built after 1960 [2]. The buildings are in the need of improved indoor air quality, renewed facades and building services, improved energy efficiency, and in the need of elevators for improved accessibility. [3]

The majority of Finnish homes are owner-occupied, single family homes. [4] The majority of multi-residential buildings in Finland are Limited Liability Housing Companies, occupied by company shareholders. Shares confer the right of possession to apartments, and all shares carry equal rights in the company. Modernization is decided by majority vote. [5] A majority may prevent renovations, or a minority may be obliged to pay for renovations not in their personal interest. Owners faced with the prospect of an energy retrofit, may opt to neglect or postpone the renovation. Institutional owners of residential buildings seem more likely to make investments in refurbishments.

In Finland the development of the national building code towards targets set by the recast Directive 2010/31/EU [6] started in 2010 by developing the Energy-Smart Built Environment 2017 action plan with the target to position Finland as the leader in energy-efficient building [7]. As a result the first Finnish statutory regulation regarding renovations and alteration works on existing buildings was published on 27.02.2013. The regulation is applicable to buildings in which is done renovation or alteration works requiring a building permit. The emphasis is on measures to improve the energy efficiency of existing buildings. [8]

3. Deep retrofit, case Virkakatu 8

Case Virkakatu 8 in Oulu, Finland is an example of a deep retrofit of an institutionally owned rental apartment housing block. [9] The building was built in 1985 and has now been refurbished. Construction works on site started in August 2012 and finished by the end of February 2013. [10]. The Oulu pilot is the second retrofit in Finland realized with the TES Energy Facade - method [11]. The energy efficiency target was set to the Finnish VTT passive house recommendation [12] and went above current new building regulations. The building works in Oulu took place before the publication of the new regulation on the improvement of energy efficiency of existing buildings. Hence, regulations for new building were applied due to the extent of the retrofit including a complete reskinning of the building envelope, a new floor slab, new building services and new interiors. The project revealed that current Finnish building regulations do not anticipate the real risks of deep retrofits. The case proved that contractors are prepared to take on deep retrofits, and that ambitious energy efficiency targets for the retrofit of buildings in cold climates demand major investments.

4. Discussion, conclusions and acknowledgements

In Finland, there is a growing need for refurbishment and deep retrofits. Until recently, the National Building Code of Finland only recognized new building, but starting June 2013 the first regulations with regard to the upgrading of existing buildings came into force. Currently there exists no financial support to refurbish buildings, and hence the decrease of energy consumption of the built environment is, due to the Finnish ownership structure of residential buildings, dependent of individual investment interests. Such interests seem to occur more likely among institutional owners. The question remains: How to foster cost efficient retrofits on cold climates?

4.1 Acknowledgements

The paper is based on work in project E2ReBuild *Industrialised energy efficient retrofitting of resident buildings in cold climates*. The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 260058.

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Monitoring of Land Use Development and Building Stocks in Germany – Methodology and Results

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Extended Abstract

Creating smart built environments entails making the best of new technologies available in order to optimise municipal services. The optimisation of built environment resources supports a sustainable development which is crucial for the well-being of current and future generations. Spatial data on land use, buildings and their development is of importance for sustainable planning approaches on all planning levels and the development of smart concepts. Despite their significance for both researchers and planners, area-wide statistical data with high resolution is sparse. In Germany official statistical data are currently only available on municipality or on districts level. For research and planning issues spatial data with higher resolution are therefore necessarily needed. Information and communication technologies considerably contribute to the planning and management of the built environment. Against this background the article gives insights into the research unit "Monitoring of settlement and open space development" of the Leibniz Institute of Ecological Urban and Regional Development (IOER).

The concept and results of the "Monitor of settlement and open space development" (www.ioer-monitor.de) are presented. The monitoring system describes the state and the development of land use for the entire Federal Republic of Germany. It sets up on homogeneous, nationwide spatial base data, the Digital Landscape Model (DLM) which is an object-based geo-topographical information system covering the whole country. On its basis different indicators with focus on settlement, open space, nature reserves, population and traffic can be derived automatically. In addition, official building footprint data were integrated. For the first time it has become possible to quantify the amount of buildings in Germany on a very detailed level. The calculated indicators are stored in a database and can be visualised in thematic maps via a WebGIS-based internet platform. In addition to administrative spatial units (federal state, region, district, municipality), indicators are also visualised in regular raster maps with different cell sizes. This allows spatial and temporal comparisons based on constant reference areas.

After that, we give an insight into tools and developments which are useful for the data acquisition. Firstly, the technology of the tool SEMENTA® is presented, which is based on an automated analysis of analogue topographic maps at scale 1: 25.000 (TK25 and DTK25(-V)) and which has recently been further developed. By means of digital image analysis building footprints are extracted, vectorised and classified according to a pre-defined building typology. On the basis of the building footprints, various indicators on urban block-level are derived to describe the

settlement structure on a very detailed level. These are e.g. building density, floor space ratio, building volume or the number of housing units, households and inhabitants. Secondly, a module entitled SEMENTA®-CHANGE has been developed, which allows the analysis of the settlement development on building level. Finally a tool for the automatic georeferencing of scanned topographic maps is presented, which makes the data preparation more efficient.

The high-resolution, Germany-wide monitoring requires an enormous volume of data. Therefore, it is a great challenge to ensure a robust and efficient geodata management and processing. Small-scale geo-information will be indispensable to understand spatial structures and processes within the next decades.

Keywords: Monitoring Technology, Spatial Analysis, Land Use Development, Building Stock Analysis, Building Footprints, Geographic Information System (GIS)

Orona IDeO – innovation city

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Creating an Ecosystem of Innovation

Orona IDeO – innovation city is the flagship design of the new extension of San Sebastian's Technology Park that frames in public-private collaboration between ORONA and the Technology Park. ORONA's activity centres on the design, manufacturing, installation, maintenance and modernisation of mobility solutions, such as lifts, escalators and moving walkways.

The purpose of this project is to house ORONA's Innovation Ecosystem, which stands out as it brings together different synergetic activities –business, technology canters and university- and it will be a laboratory where leading-edge technologies in sustainability and energy management in buildings will be applied.

Orona IDeO is overtaking the future with the cutting edge bioclimatic design of its buildings and urban spaces, a district heating cooling system using 100% renewable energy sources and a perfectly integrated photovoltaic roof aimed at its own consumption as well as for research on electricity storage linked to elevator systems. The construction started in mid 2011 and is under way at this moment. Its opening in 2014 will coincide with the company´s 50th anniversary.

Keywords: bioclimatic architecture, solar roofing, District Heating-Cooling, sustainability certification, Urban Cell, Leed & Breeam, biomass, geothermal, cantilever

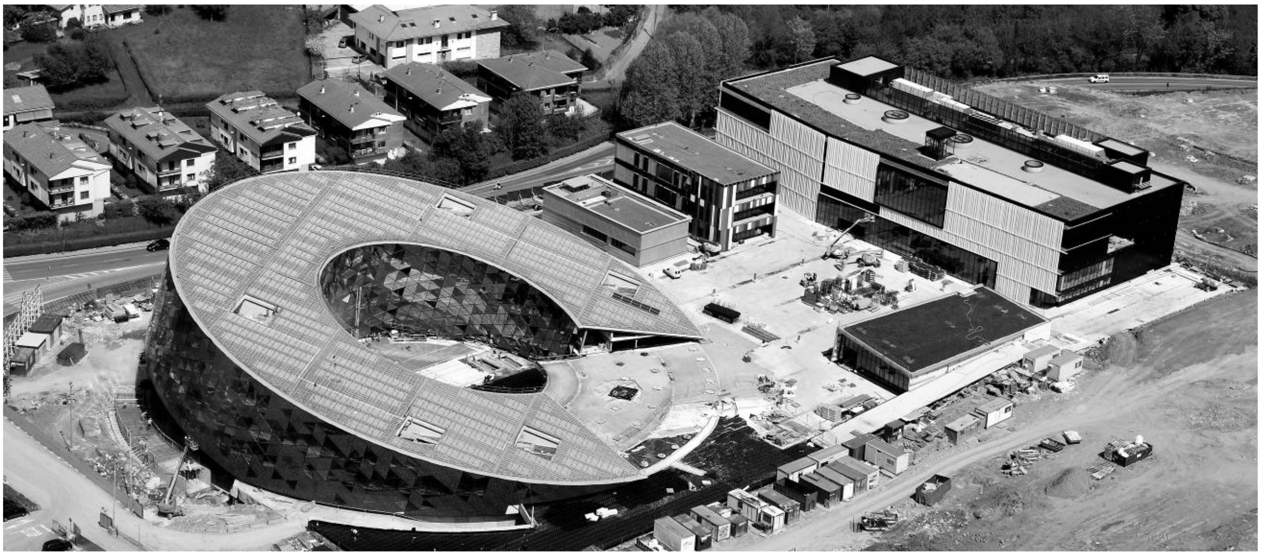

Figure 1. Aerial view showing the cladding works of the buildings.

1. A project for innovation must be innovative in itself

The company and the architects stated that a Project for Innovation had to be Innovative in itself, which includes a range of aspects where the project incorporates cutting edge solutions that will help evolve a new common corporate culture for Orona IDeO - innovation city, i.e.:

-Urban design: integrative, environmentally friendly and open to citizens.
-Architecture: mixed-use, innovative, and highly innovative design.
-Mobility and accessibility showroom of ORONA's cutting edge technology.
-Sustainability: to be certified simultaneously both in LEED Gold and BREEAM excellent.
-Energy Lab: onsite 100% green thermal energy production and integrated PV design managed by an ESCO.
- Orona Foundation's activities will strengthen the local knowledge network.

2. Net Zero Energy Buildings for a Carbon Neutral Campus.

Every building has integrated bioclimatic measures from the early design phase, but the conception, orientation and diversity of users of each one of the building has led to radically different solutions.

The Orona Zero building stands out for its singular design and its rich architectural composition. It is mainly devoted to office space that has large internal loads due to its occupants and to the density of the electronic equipment which dissipates heat and, at the same time, requires diffused light to avoid glare. The ground plan places the workplace near the outer façade which is mainly north facing, whereas the south-facing ring-shaped gallery distributes the flow of people and overlooks the building's central void.

The cylinder façade is made up of a curtain wall with a skin composed of triangular pixels which change from: opaque, translucent and transparent, depending on their position and the different circumstances regarding exposition to solar radiation, access to views, the relation with the use of internal space, etc.

The energy use in the buildings is based on the premise of making the most of the District Heating-Cooling system of the whole. This system is powered on 100% renewable energy sources: biomass, thermal solar and geothermal and is managed by an ESCO.

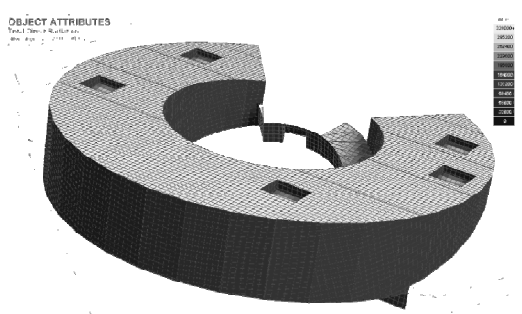

Figure 2. Simulation of accumulated radiation on the different façades of the Orona Zero building and graph showing the energy distribution both for electrical and thermal energy.

More than one thousand polycrystalline photovoltaic modules are integrated on the inclined rooftop of the Orona Zero building that will have an annual electricity output similar to the consumption of 100 average flats. This energy will be both used for self consumption as well as to investigate on new Net Zero Energy Lifts and new battery technologies at real time balance.

2012 Austrian State Prize for Architecture and Sustainability

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Short Summary

The Austrian State Award for Architecture and Sustainability is conferred under the auspices of klima:aktiv, the Austrian Ministry for Agriculture, Forestry, Environment and Water Management's climate change initiative. The prize is significant because it provides definitive proof that architectural and aesthetic needs can be combined seamlessly with ecological, social and economic responsibility. The special feature of this award is that a building is eligible only if it can show both excellent architecture and outstanding sustainable construction

Keywords: architecture, energy efficiency, ecology, sustainability, award, lighthouse projects

1. Background, purpose, and goal

When traveling through cities, villages, and rural areas with our eyes wide open, we immediately evaluate what we see. We spontaneously judge the buildings we cast our eyes over as beautiful, ugly, fascinating, boring, bizarre or pretentious regardless of their energy credentials.

Energy-efficient construction, Passive House, Solar House and Plus Energy House buildings often do not stand up well to architectural critique. The print media loves to publish attention-grabbing quotes by architects in keeping with the premise that bad news is good news, such as: "Thermal insulation - the burka for the home" (Frankfurter Allgemeine Zeitung, November 14, 2010).

2. Method, evaluation, and judging

Jury decisions had to be unanimous to ensure assessment of equivalence. A building cannot receive the prize if it is a real treat architecturally speaking, but its sustainability, its ability to benefit future generations, is anything short of excellent. The opposite is also true: a building with all of the energy-efficiency and environmental credentials in the world cannot receive a state award if the jury deems its architectural features to be average. This is the first special element of the prize. The process has three stages: an invitation for submissions, an initial round and judging. While the preliminary review of architectural features can focus solely on whether formal criteria have been met, buildings undergo rigorous scrutiny of their sustainability credentials at this stage. A web portal set up for the State Award for Architecture and Sustainability documented the entries. The content of this web portal leans heavily on klima:aktiv's evaluation structure:

- Building data and general information
- A Planning and implementation (max. 130 points)
- B Energy and supply (max. 600 points)
- C Building materials and construction (max. 150 points)
- D Comfort and indoor air quality (max. 120 points)

Buildings can achieve up to a maximum of 1,000 points from all four categories. Each category or sector is subdivided into up to three levels, for example:

D Komfort und Raumluftqualität

D.1 Thermischer Komfort

D.1.1 Thermischer Komfort im Sommer

Standardnachweisverfahren gem. ON B1800-3

- Sommertauglichkeit gemäß ÖN B 8110-3 nicht gegeben; Klimatisierung mit/ohne Kälteaggregat
- Sommertauglichkeit gemäß ÖN B 8110-3 ist gegeben.

Nachweisweg PHPP

- Übertemperaturhäufigkeit <10% (Nachweis PHPP Blatt Sommer, Übertemperaturgrenze 25°C)

Nachweisweg Dynamische Gebäudesimulation

- Nachweis mit dynamischer Gebäudesimulation, dass Überschreitungen der Behaglichkeitstemperatur von 25°C an maximal 10% der Jahresstunden für sämtliche kritischen Wohn- und Schlafräume gegeben sind.

Nachweis ohne Berechnung

- Nachweis eines außen liegenden, beweglichen Sonnenschutzes mit einem z-Wert von ≤ 0,27 für Fenster in Süd-, Ost- und Westorientierung (sowie Zwischenorientierungen).
[mehr Informationen]

Nachweis
[neue Datei hochladen]

A total of 99 buildings were put forward for the prize. At its first meeting, the jury narrowed the field down from 99 entries to 14 buildings that members visited in person during a three-day trip. Another meeting at the end of the trip selected the five award recipients from the nine buildings nominated for the prize.
In his summary, Roland Gnaiger writes: "*This group's contributions are so important because they provide definitive proof that architectural and aesthetic needs can be integrated seamlessly with ecological, social and economic responsibility. Paul Valéry got to the heart of the matter in his wonderful dialog "Eupalinos or the Architect". His Socrates says, "This type of artist has no need for modesty. They have discovered the means to mix necessity and artifice inextricably.*""
While few and no famous prize-winning architects had designed buildings put forward for the award just a few years ago, a surprisingly large number were in the running for the 2012 State Award for Architecture and Sustainability. This a good sign that excellent architecture does not fly in the face of sustainability, ecology and solar power. In this vein, Otto Kapfinger, one of Austria's most well-known and acclaimed architecture critics, remarked that "*the three school projects in the final round by themselves are far superior to what we normally see in branding architecture in terms of their functionality, room quality and detail while meeting the highest ecological and energy standards.*"

3. Outlook

The 2012 Austrian State Award for Architecture and Sustainability demonstrates that architecture can go hand in hand with sustainability. . These architectural lighthouses can no longer be ignored; they serve as benchmarks for other projects. As a result, they will also influence everyday architecture, which shapes our perception of building culture.

4. More information

There are all projects presented with detailed explanations on the website:
www.staatspreis.klimaaktiv.at >> http://www.klimaaktiv.at/bauen-sanieren/staatspreis

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klima:aktiv

Die Klimaschutzinitiative des Lebensministeriums

klima:aktiv Bauen und Sanieren

behaglich, gesund und energiebewusst!

klima:aktiv Bauen und Sanieren steht für
Energieeffizienz, ökologische Qualität, Komfort und Ausführungsqualität. Egal ob Neubau oder Gebäudesanierung, klima:aktiv Bauen und Sanieren hilft Ihnen, die richtigen Entscheidungen zu treffen. Welche Maßnahmen lohnen sich? Welcher Energieträger ist in welcher Situation sinnvoll? Welche Förderungen gibt es?

Gebäude in klima:aktiv Qualität garantieren Ihnen
- niedrigen Energieverbrauch und niedrigste CO_2-Emissionen
- beste Raumluftqualität
- optimalen Nutzungskomfort und eine ökologische Bauweise
- hohe Planungs- und Ausführungsqualität
- Wirtschaftlichkeit und hohen Wiederverkaufswert der Immobilie

„klima:aktiv Bauen und Sanieren" ist Teil der Klimaschutzinitiative klima:aktiv des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft.

Bilder: iStockphoto/StockLib, Lukas Schaller, Paul Ott

Weitere Infos auf:
www.bauen-sanieren.klimaaktiv.at

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klima:aktiv

Building and Refurbishment

Comfortable, healthy and energy-conscious

klima:aktiv Building and Refurbishment stands for energy efficiency, ecological quality, comfort and high quality of execution. No matter, whether we are talking about a newly constructed building or the renovation of a building, **klima:**aktiv Building and Refurbishment helps you to take the right decisions. Which measures are worthwhile? Which energy source is useful in which situation? Which funding schemes are available?

klima:aktiv Building and Refurbishment is part of the climate protection initiative of the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

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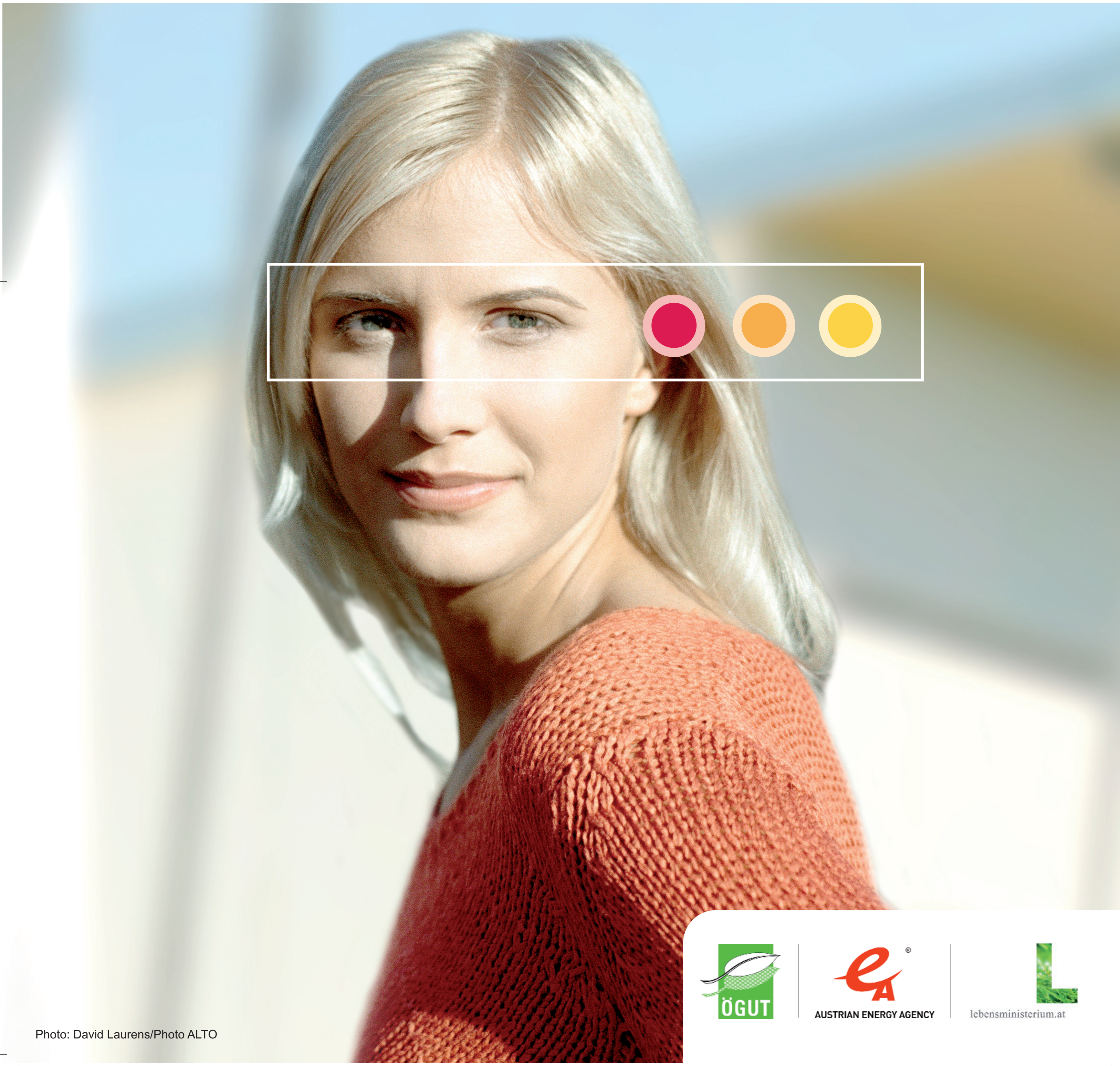

Photo: David Laurens/Photo ALTO