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Reduction of Energy Costs

Investigation of Several Company Sites and Derivation of Recommendations for Action

Master Thesis

Production Science and Management

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Statutory Declaration

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Abstract

This master thesis will examine an energy optimization project of Golf Club Fontana in Oberwaltersdorf. A new owner took over the Golf Club in September 2014 and started a project to reduce the energy costs of several company sites. The Golf Club consists of three different buildings, each of which has been investigated separately.

The business was taken over at a time of high energy costs and inefficient energy usage. Additionally, outdated technology for energy transformation and distribution was being used. Therefore it has to be clarified which actions have to be implemented and how much energy can be saved.

The aim of this thesis is to recommend actions that reduce the energy costs of the Golf Club. The energy flow of each building is examined to find potential improvements. The investigation starts with the analysis of energy import process followed by a clarification of the amount of energy used for specific consumption areas. Furthermore, key performance indicators are calculated to compare the energy behaviour to references. These figures assess the existing energy situation. Possible actions and investments are then analysed and estimated.

The investigation shows that a lot potential improvements depend on energy usage and operating behaviour. Moreover investments in energy efficient equipment can save money and energy.

Kurzfassung

Die Masterarbeit beschäftigt sich mit der Energie Optimierung des Golfclubs Fontana in Oberwaltersdorf. Ein neuer Betreiber übernahm den Betrieb im September 2014 und startete ein Projekt zur Reduzierung der Energiekosten. Dabei werden drei getrennte Gebäude des Golfclubs untersucht.

Mit der Betriebsübernahme wurde festgestellt, dass hohe Energiekosten anfallen und die Energie ineffizient genutzt wird. Auch die Energieumwandlungsanlagen und die Energieverteilung sind veraltet. Somit muss festgestellt werden welche Änderungen umsetzbar sind und wieviel Energie eingespart werden kann.

Das Ziel dieser Mastarbeit ist es Realisierungsmaßnahmen zur Reduktion der Energiekosten zu erarbeiten, dabei wird der Energiefluss jedes Gebäudes untersucht um Potentiale zu finden. Der erste Teil der Analyse beschäftigt sich mit dem Energiebezug der verschiedenen Energieträger. Anschließend wird festgestellt wieviel Energie an welchem Ort oder für welche Dienstleistung verbraucht wird und schlussendlich werden Kennzahlen ermittelt um das Energieverhalten mit Referenzwerten zu vergleichen. Daraus können Realisierungsmaßnahmen abgeleitet und analysiert werden.

Die Untersuchung zeigt, dass ein großer Anteil der potentiellen Verbesserungsmöglichkeiten vom Nutzer- und Betriebsverhalten abhängig sind. Jedoch kann durch Investitionen in energieeffiziente Anlagen Geld und Energie gespart.

Table of Contents

1 Introduction

The introduction gives an overview of the investigated building structures. Hence, the different areas of the Golf Club Fontana and what they are used for will be described.

1.1 Objectives

The goal of this thesis is to identify inefficient and unnecessary energy usage to reduce the costs and expenses of energy for the structure sites of the Golf Club in Oberwaltersdorf. The results are compiled into a catalogue that shows the weaknesses that have been defined and evaluated. Furthermore, opportunities for investments that reduce future energy costs are demonstrated.

1.2 About the company

The Fontana was built in 1996 as a part of the European Centre of Magna International. In 2014, a new owner takes over the business of the Fontana Estate and began recognizing the day to day operations. The Golf Club (see Figure 1) is split into three different locations: Clubhouse (1), Tennis Center (2) and Depot (3).

Figure 1: Golfclub Fontana[1]

[1] cf. www.fontana.at (29.08.2015)

The Clubhouse is the center and heart of the Golfclub. It can be divided into four different sections. The Restaurant and Event Area is located on the upper floor (see Figure 2). These areas are not only for club members but also for outside guests. The Event Area is used for various banquets and is suitable for wedding receptions. The lower floor (Figure 3) is a large Wellness area which consists of a swimming pool, sauna, saunarium, steam bath and all associated bath and relaxation rooms. The connection from the outdoor beach area to the Clubhouse is also on the lower floor where changing rooms and toilet facilities can be found.

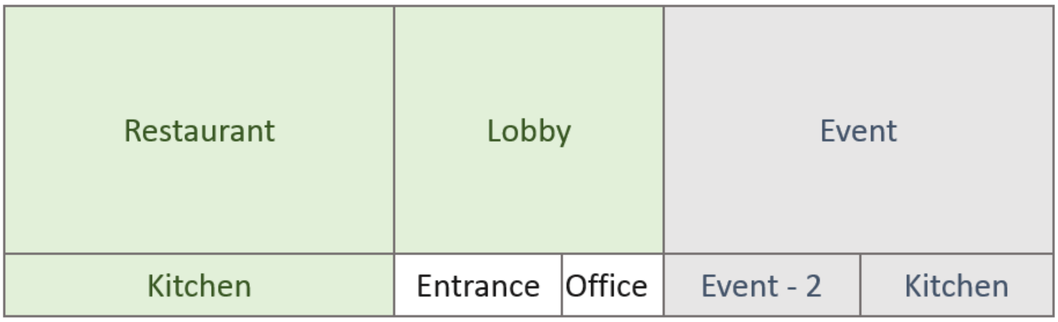

Figure 2: Clubhouse Upper Floor[2]

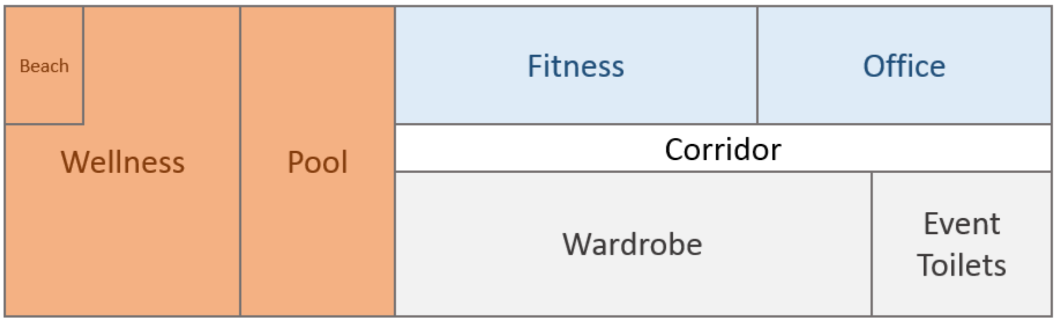

Figure 3: Clubhouse Lower Floor[3]

[2] own illustration, based on construction plan

[3] own illustration, based on construction plan

The second largest building on the golf course grounds is the Tennis Center, containing three indoor courts on the ground floor. One of these courts has also been used as an event hall for ballroom events. There are also wardrobes for guests and a buffet area. On the first floor, above the buffet and entrance area there are five business flats for employees. Other possible uses for the Tennis Center are currently being considered, but have yet to be defined.

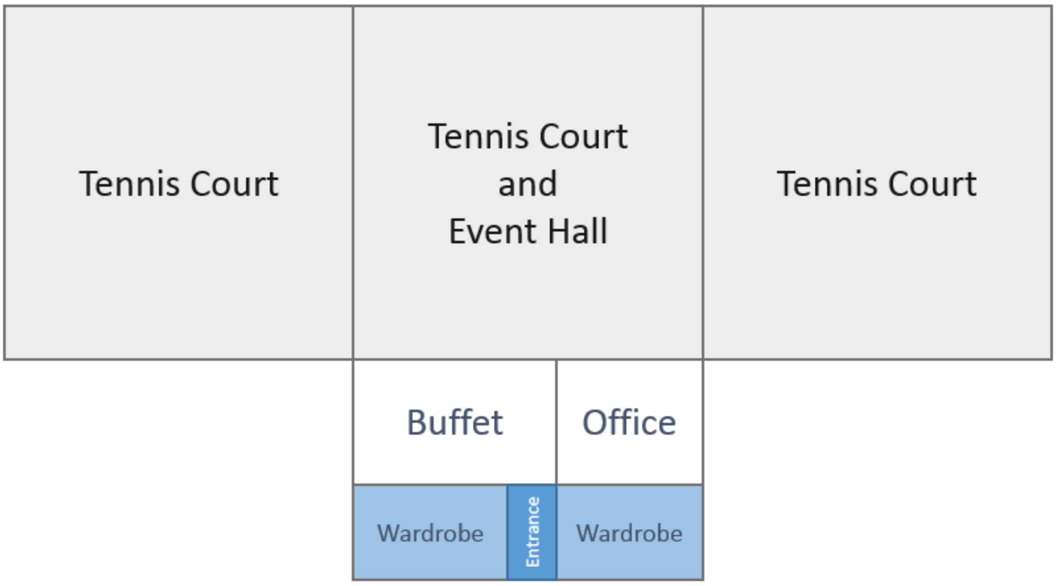

Figure 4: Tennis Center Ground Floor[4]

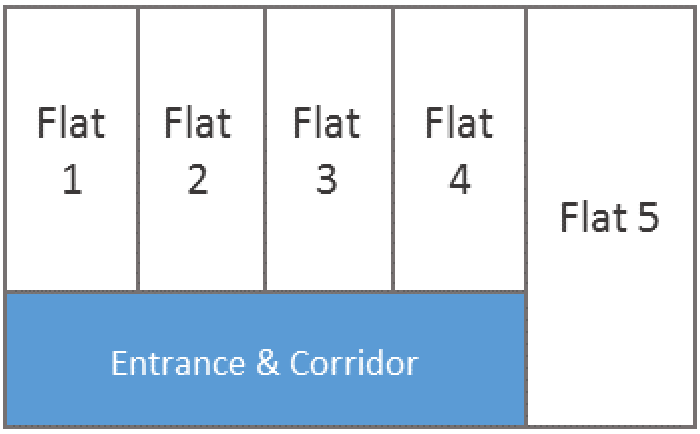

Figure 5: Tennis Center Upper Floor[5]

[4] own illustration, based on construction plan

[5] own illustration, based on construction plan

The last of the three company sites is the Depot. It is the center for all employees who are responsible for outdoor work. It is divided into two different buildings. In one building there is the office space and day rooms for employees including changing rooms and bathrooms. In the other building are workshops and storage facilities, including a separate workshop area with heating.

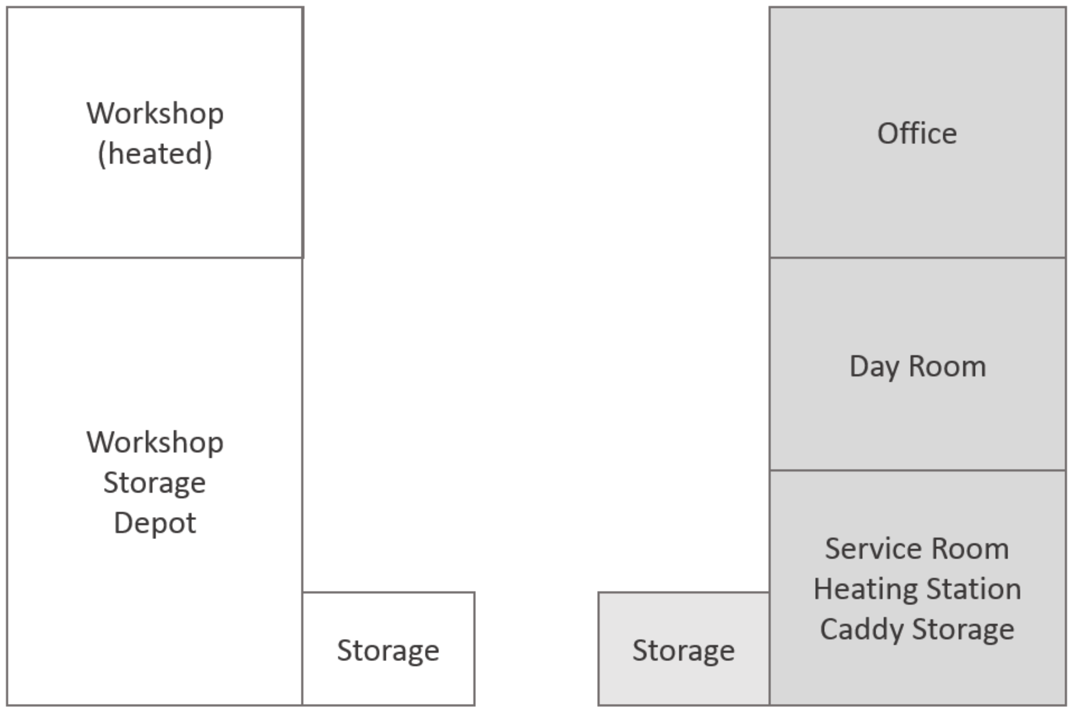

Figure 6: Depot[6]

[6] own illustration, based on construction plan

2 Basics of Corporate Energy Management

"When we consume anything, we consume energy. It takes energy to manufacture, deliver and sell all types of goods and services"[7]

In the late 70's, Bullard, Penner and Pilati pointed out the importance of energy in their paper. Energy is needed everywhere and if people do not realize where, why and how much energy they use, costs will explode. The literature review contains the topics energetic operation analysis, energy import and costs, energy management and controlling and energy efficiency. At the end, two different calculation methods of profitability analysis are described to make sure that investments in energy optimization are profitable.

2.1 Basics of an Energetic Operations Analysis

An important basis for all activities of energy management is a detailed, structured and complete energy inventory. This energetic operations analysis forms and creates preconditions for:[8]

- a strategically oriented energy plan
- an operationally oriented energy demand and management plan
- steering and controlling the energy flow
- the foundation of an rationalization approach

2.1.1 Priorities of the Analysis

The investigation considers the temporal development and all dependents of energy demand for the whole area and some subsections. Lists and measurements of the energy usage provide a foundation for assessing energy requirements. These are for example, the daily, monthly and yearly energy consumption report. Power demand records of grid bound energy sources are also important. For the operational analysis, clarification of the following questions is an essential step:[9]

[7] Bullard, Penner , & Pilati (1978), p.267

[8] cf. Wohinz & Moore (1989), p 61

[9] cf. Wohinz & Moore (1989), p.61

- Which energy sources are supplied and how big is their demand over a specific period of time?
- How have the energy sources developed throughout the past?
- Which factors influenced trends and developments in the past?
- What is the daily, weekly, monthly and annual demand of power consumption of grid-bound energy carriers? What causes the transition?
- What are the peak loads? Do peaks occur incidentally or do typical peaks depend on load and timing?
- Which energy transformation systems are used? What are the technical conditions, energy performance figures and user behavior of those systems?
- In which structure and in what state is the internal power distribution network and what kind of transmission losses occur?
- How are individual energy sources proportionally distributed among the various functional areas? Which energy sources are supplied to which areas? How big is the amount and for what purpose are they supplied?
- Which energy-consumption systems are used in operation? What are their technical conditions, energy performance figures and user behavioral patterns of those systems? Which systems are crucial for the overall energy consumption and the power transmission?
- What is the form and quantity of supplied energy when it leaves the operating area? What is the timing and amount of heat waste flow? What is the location and the temperature of those streams?
- How big is the amount of recovered energy?
- What kind of environmental impacts occur?

2.1.2 Procedure of the Analysis

Thomas Stüger recognized the demand for a standardized but also flexible procedure to analyze the internal flow of energy. Consequently he developed an approach, consisting of six steps to overcome some of the difficulties.

The Six-Step-Approach according to Stüger includes the following parts:[10]

[10] cf. Stüger (1988), p.185

- Setting goals
- Delimitation of the task
- Rough analysis of the actual state
- Detailed analysis of the actual state
- Data synthesis
- Energy flow analysis

The focus of each step is described, as follows.

An exact definition of objectives is important to set appropriate boundaries for the investigation. False or inaccurately formulated goals lead to an incorrect selection of research objects. As a result, unnecessary data material is collected and the efficiency of the investigation degrades.[11]
In addition, it is important to set SMART goals. This method allows for the step-by-step breakdown of goals, making them easier to achieve. In the long-run this process is both helpful and practical. Each letter of SMART is linked with a characteristic of the goal. The method requires setting specific goals that are both manageable and attainable. After that, the goal needs to be relevant, reachable and time-oriented.[12]

- Setting goals:[13]
    - Business goals
    - Technical and organizational goals
    - Economic goals
    - Socio-ecological goals
    - Schedule targets

A single aggregate, a group of aggregates, a sub-area or the whole factory can be a part of the investigation. The investigation area contains energy sources, energy transformation, energy transportation, energy use and energy output. Criteria to delimitate the tasks are: belonging to an investigation specific goal,

[11] cf. Wohinz & Moore (1989), p.64

[12] cf. Green (2014), p.90

[13] cf. Stüger (1988), p.185

intensity of energy, level of energy costs or the economic expectations of the investigation. [14]

- Definition of the Task:[15]
    - Define the investigation area
    - Determine the minimal requirements
    - Form project teams
    - Schedule appointments

The first part of the actual state assessment is the rough analysis of energy sources and energy output. Therefore the entire operation is considered as a black box. The aim of this study is to get an overview and a first idea of the energy usage. It should also create a foundation for further analysis. [16]
During the rough analysis, potentials for improvement are identified and areas for further examination are defined. Mostly, these are areas which demand major part of the energy.[17]

- Rough Analysis of the actual state:[18]
    - Rough analysis of the energy supply and energy output
    - Qualitative determination of the energy flow
    - Selection, delimitation and description of the aggregates
    - Collection of measurements and company specific data
    - Time analysis

The detailed analysis is the second part of the actual state assessment. Here, the data of the rough analysis will be completed with missing measurement data. As support, a measuring program can be used. [19]
In this stage of the analysis specific areas, systems, plants and devices are under examination. It is a “Bottom-Up-Analysis” where improvement measures

[14] cf. Wohinz & Moore (1989), p.66

[15] cf. Stüger (1988), p.185

[16] cf. Wohinz & Moore (1989), p.66

[17] cf. Meyer, Schubert, Nowak, Meyer & Herbergs (2008), p.115

[18] cf. Stüger (1988), p.185

[19] cf. Wohinz & Moore (1989), p.66

and their implementations are developed. There are not only short-term but also mid- and long-term measures.[20]

- Detailed analysis of the actual state:[21]
    - Prepare measuring programs
    - Perform measurements
    - Analyze the measured data

Data synthesis is the next step, in which the data of the core areas (rough- and detailed analysis) will be handled. The steps and processes are presented below.[22]

- Data Synthesis:[23]
    - Execution of pre-calculations
    - Quantification of single energy streams
    - Determination of single energy streams and balances
    - Determination of total energy streams and balances

The last step of the operations analysis is the energy flow analysis. During this phase, the obtained data material will be evaluated and interpreted. It is recommended to identify key performance indicators and to create an energy flow diagram in the form of a Sankey-Diagram. As a result, the energy flow of the investigation area is clarified and graphically illustrated. [24]

- Energy flow analysis:[25]
    - Calculation of key performance indicators (KPI's)
    - Creation of other evaluations

[20] cf. Meyer, Schubert, Nowak, Meyer & Herbergs (2008), p.115

[21] cf. Stüger (1988), p.185

[22] cf. Wohinz & Moore (1989), p.71

[23] cf. Stüger (1988), p.185

[24] cf. Wohinz & Moore (1989), p.73

[25] cf. Stüger (1988), p.185

2.1.3 Internal Energy Flow

Energy efficiency is not only a feature of the whole technical system but also of each single production machine, aggregate and application area. Thereby the system is highly complex and has the following characteristics:[26]

- **Variety of Elements**
  Every single illuminate or electric drive needs energy.
- **Diversity of Elements**
  All boiler, air compressors and buildings use and need energy but have nearly nothing else in common.
- **Variety and Diversity of Connections**
  Convection, conduction or radiation transport energy and radiation losses effect e.g. heating demand which, through integration, heat recovery can take place
- **Seasonal Variations** visible in daily, weekly or annual demand through operating times and – intensity of all application areas
  Examples are the utilization of a single machine or the seasonality of heating demand

According to the conversion chain it is possible to divide the internal energy flow into following sections (see Figure 7).

Energy Import

Energy is received as a primary or secondary source from energy producers or energy trading companies. Energy sources such as natural gas, district heating or electricity are grid-bound and therefore, appropriate pipe connections, transfer stations and measuring equipment for the energy import must be present. Also, residual and waste materials have to be considered as energy source.[27]
A uniform energy import enables suppliers to build distribution and generation facilities cost effectively. This is appreciated by divided prices (power and work) and daytime-dependent rates. Seasonally dependent prices and discounts due to utilization hours may also occur.[28]

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[26] cf. Schmid (2004), p.103f

[27] cf. Schmid (2004), p.104

[28] cf. Hennicke (1991), p.255

Energy Transformation and Distribution

A central transformation or level conversion followed by a redistribution system to the place of energy use is usually required. Essentially it is related to heat converters, generating stations and transformers. Electricity-only plants are rare in the industry. Cogeneration or CHP (combined heat and power) plants where by-products are reused as an energy source are more common.[29]

Energy Use

After the internal distribution, energy sources are supplied to the production process or auxiliary units and transformed to useful energy. This useful energy is used to supply the requested energy service. Mostly, used aggregates are integrated into the production equipment and the transformation and use of energy takes place simultaneously.[30]

There is also a differentiation in the consumption of energy. On the one hand, consumers demand energy directly and on the other hand, indirectly. Directly means that energy is used in the form of gasoline, electricity, natural gas or fuel oil. In contrast, indirect energy is used elsewhere in the economy to produce goods and services purchased by consumer. Because the average consumer demands more energy indirectly than directly, it is a large and significant part.[31]

Energy Output or Recycling

Energy conversion that produces excess energy which is not used during operations, becomes relevant for the energy output. These include electricity from power generators and CHP plants as well as the temperatures of transformation and production. Substations and transmission capacities have to be present for the submission.[32]

[29] cf. Posch (2011), p.141f

[30] cf. Posch (2011), p.143

[31] cf. Bullard, Penner & Pilati (1978), p.268f

[32] cf. Schmid (2004), p.110

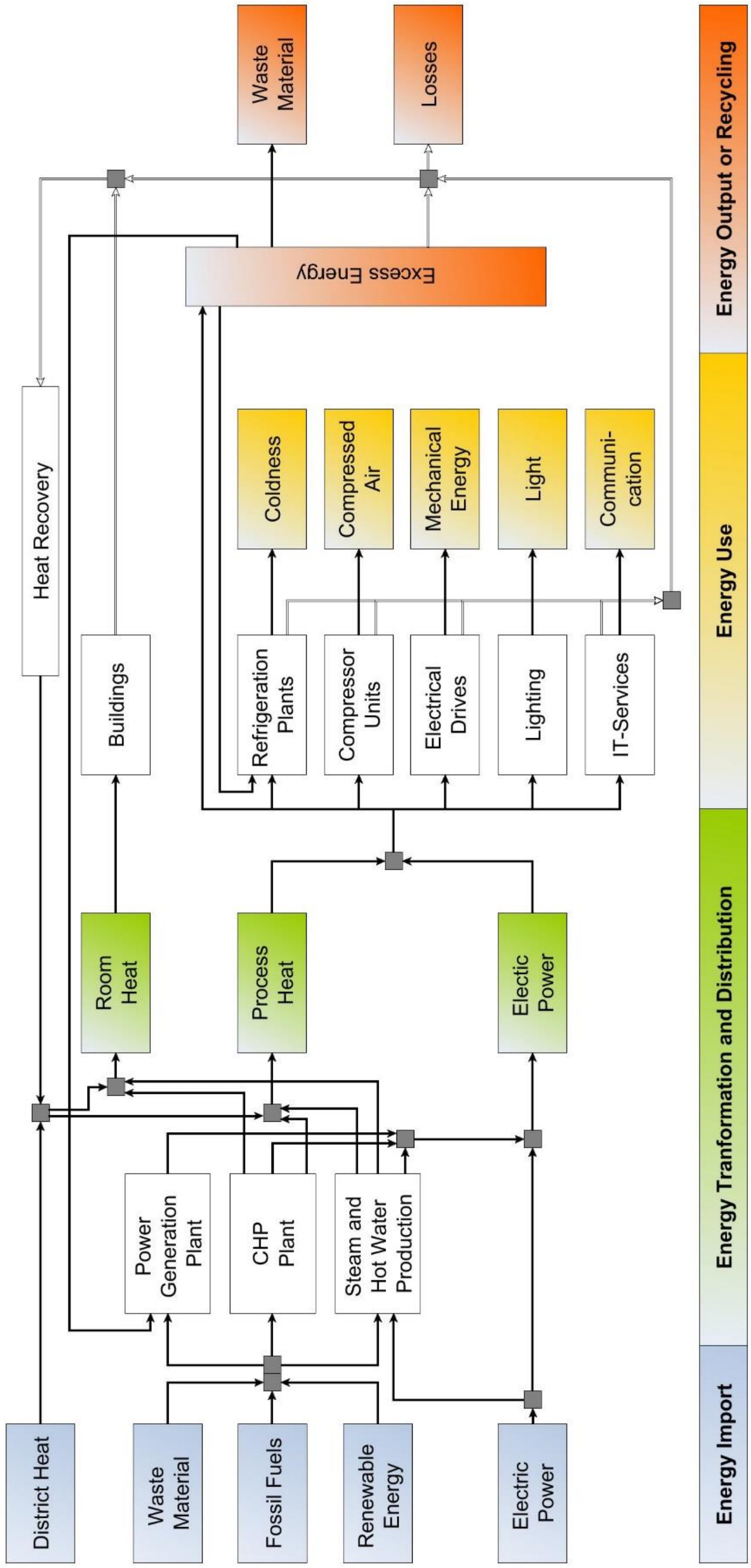

Figure 7: Internal Energy Flow[33]

[33] cf. Schmid (2004), p.105, own illustration

2.2 Energy Import and Associated Costs

The energy import differentiates the different types of energy that are described in this chapter. After that, energy sources of natural gas and electrical energy are considered more in detail. Thereby, also the associated costs are discussed.

2.2.1 Types of Energy

Depending on degree of conversion, there are several types of energy. The energy utilization chain in Figure 8 shows the changes at each conversion point. After each conversion, losses occur which are also mentioned below.

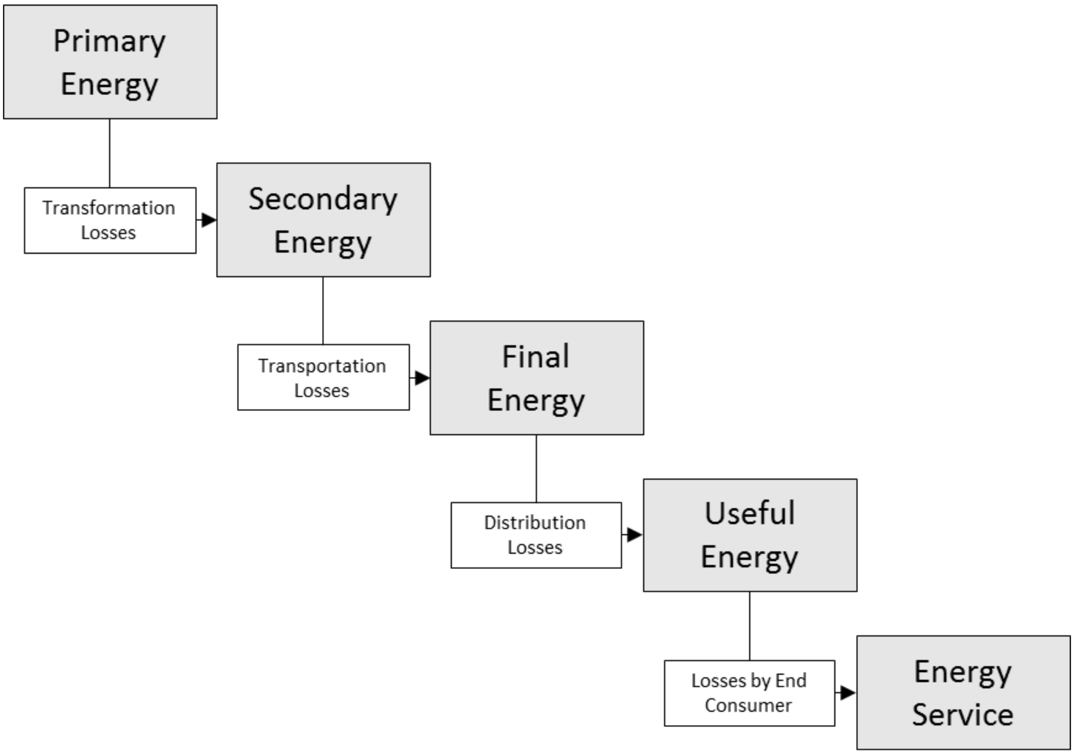

Figure 8: Types of Energy[34]

The different definitions of energy that are used in Figure 8 are explained as follows:[35]

[34] cf. Offner (2001), p.14, own illustration

[35] cf. Kaltschmitt, Streicher & Wiese (2007), p.2

- **Primary Energy** carriers are substances which have not gone through any technical conversion. Some examples of primary energy are wind power or solar insulation. For primary energy carriers this can be hard coal, crude oil or biomass. Secondary energy or secondary energy carriers can be produced directly from primary energy or by one or several conversion steps.

- **Secondary Energy** carriers are produced out of primary energy. Examples are gasoline, heating oil, rapeseed oil or electrical energy. The processing from primary energy is subjected to transformation losses. Secondary energy can be converted into other secondary or final energy carriers.

- **Final Energy** are energy streams that are directly used by the final user. Examples are light fuel oil inside the oil tank or wood chips in front of a combustion oven. The result of final energy minus distribution losses is available for the conversion into useful energy

- **Useful Energy** is energy that is available to the consumer after the last conversion step. It satisfies the requirements or energy demands of the end consumer. Some examples are space heating or cooling.

- **Energy Services** describes the service that the end consumer get out of the useful energy (e.g. transportation, information)

2.2.2 Natural Gas

Industrial plants use natural gas for two different purposes, for production processes and for heating purposes. In contrast to heating operations, natural gas in production is difficult to replace due to technological reasons. [36]

[36] cf. Wohinz & Moore (1989), p.85

In the billing of deliveries for natural gas, suppliers distinguish between three different types of costs (see Figure 9):[37]

- **Energy Costs**
  Utilities settle these costs as an energy supplier depending on the tariff, which includes consumer demand and basic price.

- **Network Costs**
  This type includes the costs of construction, expansion, maintenance and operation of the power system as well as the establishment, operation, calibration and reading of measurement and counting devices. The amount is determined by legislation and the consumer price is divided into zones. Energy companies charge network costs on behalf of the network operator to the consumer.

- **Taxes and Duties**
  National natural gas tax is transferred by the network operator to the tax office.

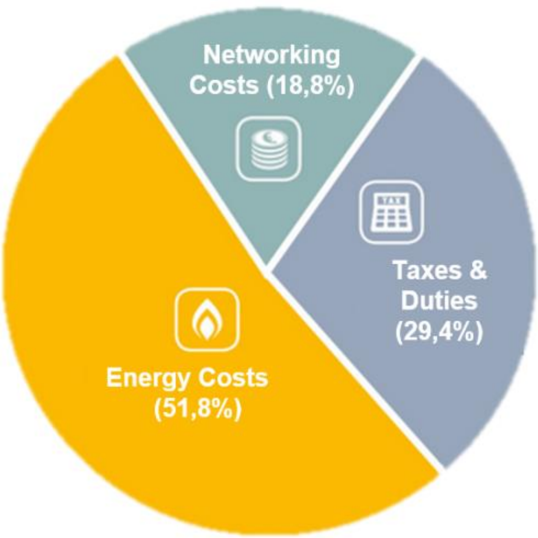

Figure 9: Composition of Gas Prices Industry Vienna[38]

[37] cf. EVN Energievertrieb GmbH (2012), p.3

[38] cf. www.e-control.at (04.08.2015),own illustration

Table 1 shows the bandwidth of natural gas prices in Austria in 2014. The prices are only energy costs without networking costs, taxes and duties.

Type of Survey	Min.	Max.	Average
Production Gas (Industry)	2,75 c/kWh	4,62 c/kWh	3,91 c/kWh
Heating Gas (Industry)	2,20 c/kWh	3,82 c/kWh	3,42 c/kWh
Heating Gas (Household)	3,03 c/kWh	4,34 c/kWh	3,42 c/kWh

Table 1: Bandwidth of Natural Gas Prices Austria 2014[39]

2.2.3 Electrical Energy

Electrical energy is a universally applicable energy source. The demand can be covered by self-generation (CHP Plants or hydro power) or external procurement (utility).[40]

As by natural gas (2.2.2 Natural Gas p. 14) the billing of electricity distinguishes between energy costs, network costs, taxes and duties. The only difference is that network costs not only include network utilization and metering charges but also remuneration for network losses and reactive current.[41]

Compared to natural gas the composition of electricity price is different. Only 40% of the overall electricity price are energy costs. That is nearly 12% less than by natural gas and therefore the networking costs, taxes and duties are 6% higher.

[39] cf. www.e-control.at (04.08.2015), own illustration

[40] cf. Wohinz & Moore (1989), p.85

[41] cf. www.e-control.at (04.08.2015)

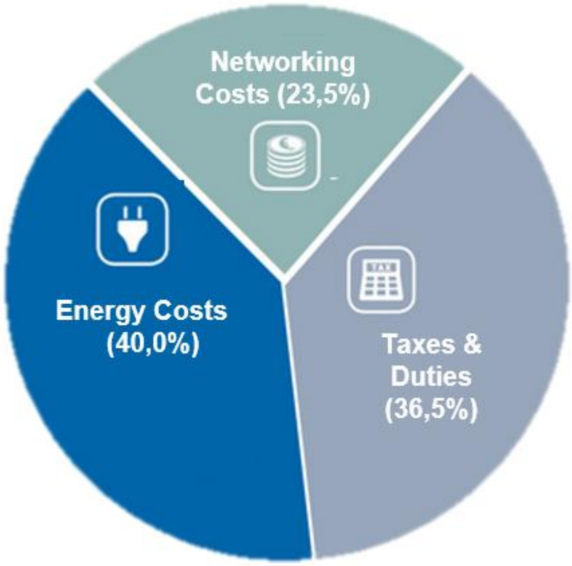

Figure 10: Composition of Electricity Prices Industry Vienna[42]

The following Table 2 shows the bandwidth of electricity prices in Austria in 2014. The prices are only energy costs without networking costs, taxes and duties.

Type of Survey	Min.	Max.	Average
Industry (all classes)	4,02 c/kWh	8,92 c/kWh	6,53 c/kWh
Industry (< 2 GWh)	3,21 c/kWh	7,28 c/kWh	5,14 c/kWh
Household (> 15.000 kWh)	5,62 c/kWh	8,22 c/kWh	6,35 c/kWh

Table 2: Bandwidth of Electricity Prices Austria 2014[43]

2.2.4 Biomass

In contrast to natural gas and electricity, is the energy import of biomass non grid-bound. There is no monopoly for biomass and thus no state regulation. Contracts and energy purchase prices are set individually between energy suppliers and consumers. [44]

[42] cf. www.e-control.at (04.08.2015), own illustration

[43] cf. www.e-control.at (04.08.2015), own illustration

[44] cf. Wohinz & Moore (1989), p.88

Basically, biomass plants require higher investment and maintenance costs, which could be amortized by more favorable procurement costs of fuels. Furthermore, pellets and wood chips have a much better CO_2-balance than gas and oil. That means, from an environmental perspective, by usage of 100% heating energy the effective consumptions of oil and gas is 110% and of biomass 20%.[45]

The quality and composition of wood chips can vary greatly. This affects the different prices and the large bandwidth. Nevertheless, the average price is 1,53 c/kWh for wood chips and 3,7 c/kWh for pellets.[46]

[45] cf. Heidel (2012), p.54

[46] cf. Straiß (2003), p.45

2.3 Corporate Energy Management and Controlling

The term “Energy Management” is perceived differently by different energy market participants. Depending on whether you buy or sell, companies act on the procurement or sales market. “Corporate Energy Management” deals with energy-related issues from the perspective of energy customers. From this point of view, the energy market is consequently the procurement market.[47]

2.3.1 Purpose, Objectives and Tasks

Corporate energy management is seen as a company specific energy management in the industry. Here, a functional portion with focus on energy resource, which is the input of the operational value chain is considered. Therefore, the characterization requires an understanding of purpose, objectives and tasks.[48]

The purpose of corporate energy management is the economic optimum provision, introducing economic exploitation of energy resources for the fulfilment of the company’s respective aim. Therefore the appropriate form of energy resources has to be provided at right quantity, quality and time for the required place of use. Furthermore, all of those requirements should be met under the lowest possible costs.[49]

[47] cf. Offner (2001), p.16

[48] cf. Posch (2011), p.147

[49] cf. Posch (2011), p.148

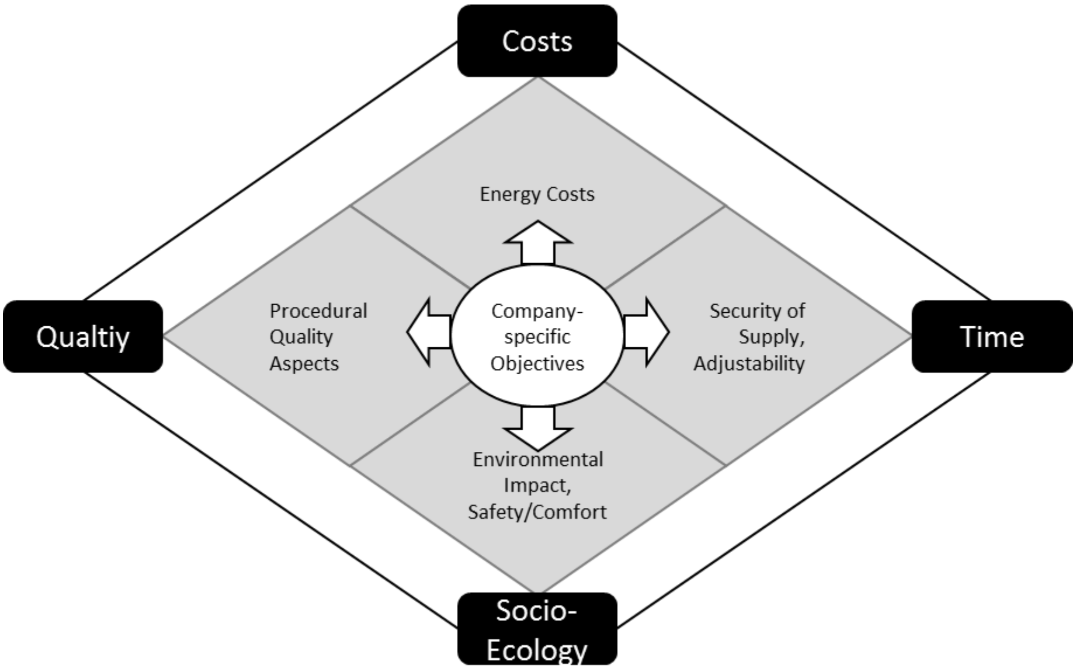

Figure 11: Objectives Depending on Company Goals[50]

As shown in Figure 11, optimizations of energy management are recognized as sub goals and serve to corporate objectives. Although objectives are different from company to company, sub goals can usually be attributed to the factors of quality, costs, time and socio-ecological aspects. While goals can compete each other, an appropriate choice of objectives can result in a balanced polygon.[51]

In setting sub-objectives, a distinction is made between the following options:[52]

- **Quality**
  In a quality-oriented strategy, the most suitable form of energy is supported for applications. In this case, exergetic optimization is less important than procedural characteristics. The qualitative aspect of energy supply must be paramount.

[50] cf. Posch (2011), p.148; own illustration

[51] cf. Posch (2011), p.148f

[52] cf. Posch (2011), p.149f

- **Costs**
  It is aimed at price reductions in the energy procurement and the utilization of efficient generation. In contrast to the quality strategy, the optimization of energy use primarily focuses on exergy.
- **Time**
  In addition to strategically-related mitigation of energy-related shutdowns, also the adaptability of the company's energy infrastructure to changing production conditions, to take advantage of short term market trends plays a role.
- **Socio-Ecology**
  Socio-ecological objectives are supported by the reduction of energy-related pollution and the use of renewable energy forms. These topics are included in the energy targets.

The tasks of energy management can be divided into two categories:[53]

- **Implementation tasks along the internal energy value chain**
  These tasks range from procurement and usage to the purchase and maintenance of energy-related equipment.
- **Management tasks within the corporate energy management**
  The tasks are broken down to normative, strategic and operational levels. Features are planning, organization, personnel management, information and controlling in connection with the corporate energy management.

Specific tasks of corporate energy management are listed below:[54]

- Formulation and setting of objectives
- Analysis and planning of energy demand
- Provision and use of energy
- Control of energy use and energy costs
- Implementation of energy saving projects
- Energy accounting

[53] cf. Posch (2011), p.150

[54] cf. Offner (2001), p.20

Lastly, Figure 12 outlines the corporate energy concept, giving a short summary, overview and description of corporate energy management.

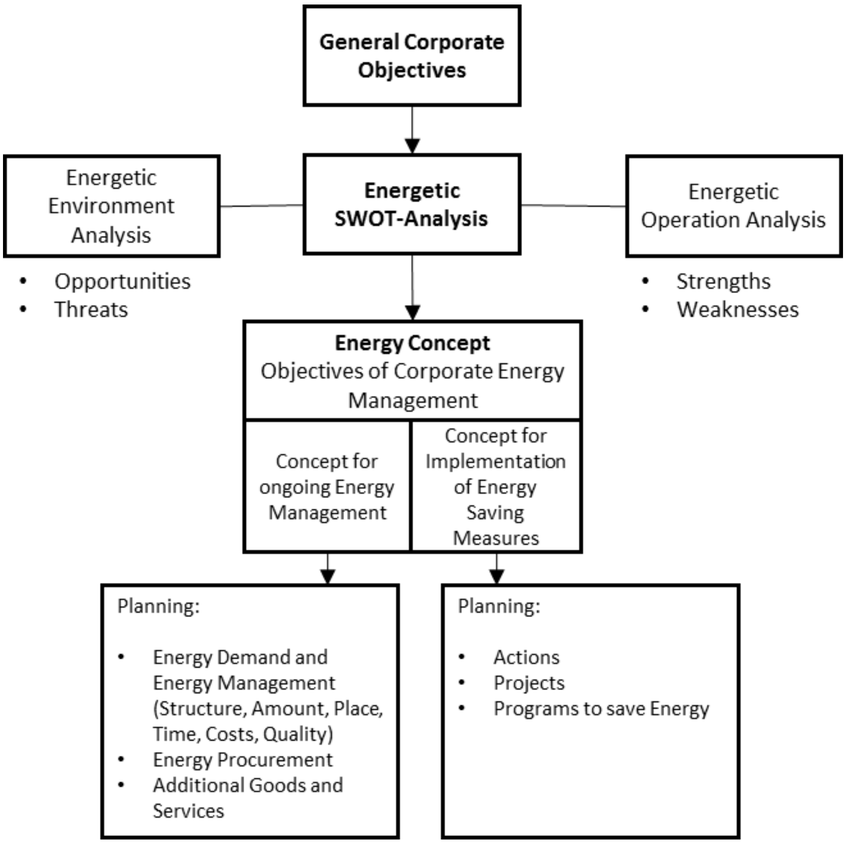

Figure 12: Corporate Energy Concept[55]

[55] cf. Offner (2001), p.21, own illustration

2.3.2 Basics of Energy Control Functions/Systems

Mostly, the last step in energy management is energy control. Tasks in this stage are to compare the achieved results with the planned results. Following by identifying deviations and setting corrective activities. Only in theory is control the last strategic step. In practice it marks a starting point for making the necessary corrections to the whole energy management process. Hence, planning starts again and corrections are implemented simultaneously and without interruption. Also a constant improvement process is integrated, making control a systematic effort.[56]

Energy Control

First of all, the control process starts with defining feedback and comparing results with previously defined standards. Next the size and importance of deviations are identified. The last step is taking appropriate action to reach goals in an efficient and effective way. Therefore the process consists of four stages, as shown in Figure 13.[57]

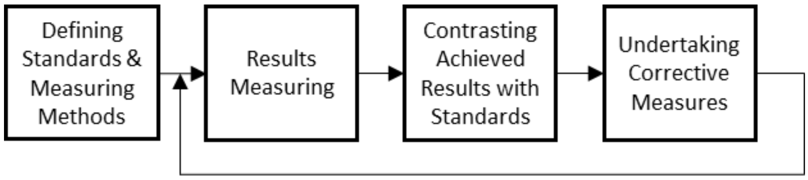

Figure 13: Control Process[58]

[56] cf. Golusin, Dodic & Stevan (2012), p.211

[57] cf. Golusin, Dodic & Stevan (2012), p.211

[58] cf. Golusin, Dodic & Stevan (2012), p.212, own illustration

Energy Systems Maintenance

Also maintenance is a continuous process of energy management. It is a critical part of facility operation and should be an integral part of energy management, therefore it is mentioned with relation to energy control. Maintenance keeps equipment from failing and helps to keep energy costs within limits. Furthermore, it helps to prevent excess capital expenditures, contributes to the quality of a product and is necessary for safety aspects. So the approach of energy systems maintenance shown in Figure 14 is similar to the control process.[59]

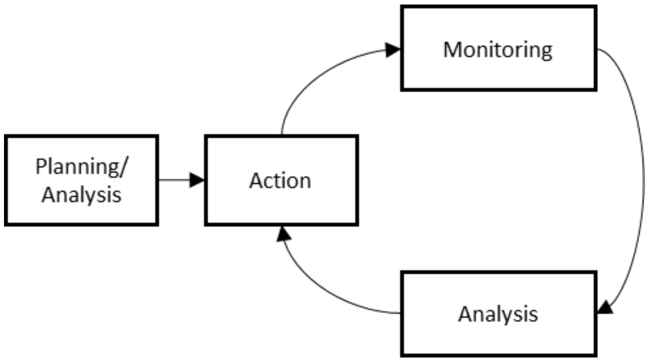

Figure 14: Energy Systems Maintenance[60]

The goal of energy control can be to reduce costs and maximize profits. There are a wide range of possibilities as to how this can be realized. On the one hand control can be as simple as manually turning a switch. On the other hand it can be complex with automated controls that require sophisticated computers. One thing that every piece of energy-consuming equipment has in common is that each has an associated control system. Controls are necessary for the safety and the operation of the equipment and systems. The interest of energy control as a part of energy management is in the energy consumption and efficiency of energy-consuming equipment. Furthermore, control can turn off unneeded equipment and allow them to operate in a manner that reduces energy costs.[61]

[59] cf. Capehart, Turner & Kennedy (2008), p.363

[60] cf. Capehart, Turner & Kennedy (2008), p.363, own illustration

[61] cf. Capehart, Turner & Kennedy (2008), p.341

Energy Management System

There are different Energy Management Systems (EMS) on the market to control energy-consuming equipment and make the energy flow more efficient and effective. An EMS is a system of computer-aided tools which uses electrical operators to monitor, control and optimize the performance of the system. Nowadays automated energy control has become state of the art. Nearly all non-residential buildings have automatic controllers with a central processor (computer). Most systems are called EMS, EMCS (Energy Management Control System) or BAS (Building Automation System). On average these systems save about 10% of overall annual energy consumption by ensuring that:[62]

- equipment is only running when necessary
- equipment is working at the minimum required capacity
- peak electric demand is minimized

Energy Accounting

Energy accounting is used to evaluate information for documentation, planning and the controlling of operational energy flow. It is also a basic instrument of energy management. The primary task is to record quantities of energy. Mostly these measurements are related to energy import and production. The structure is shown in Figure 15.[63]

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[62] cf. Papdopoulou (2012), p.2f

[63] cf. Wohinz & Moore (1989), p.137

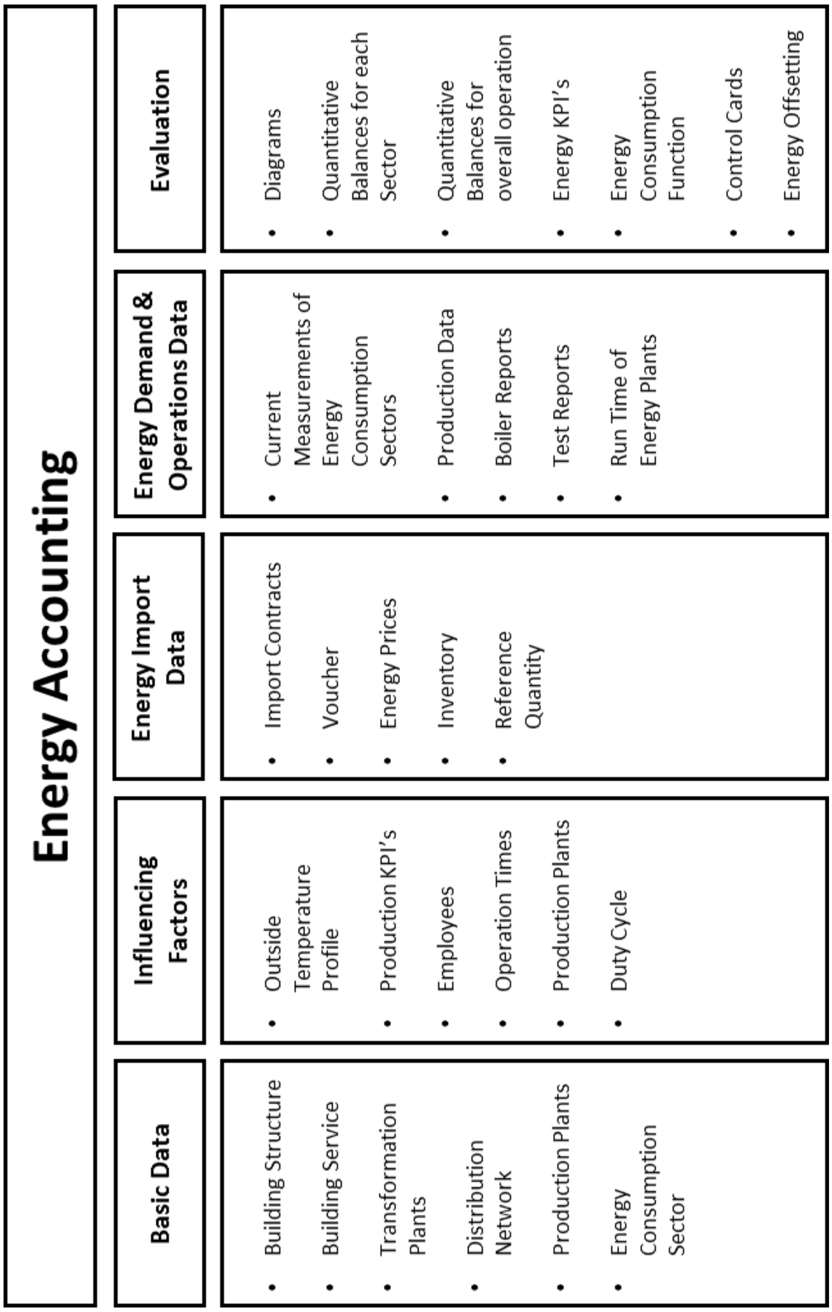

Figure 15: Energy Accounting Structure [64]

[64] cf. Wohinz & Moore (1989), p.138, own illustration

2.4 Energy Efficiency in companies and private households

At the beginning of this chapter the definition of some terms are clarified. Afterwards the actual state and future opportunities will be discussed.

Energy efficiency vs. energy saving

Often, energy efficiency and energy savings are used similar. But, to be strictly accurate, energy efficiency is a partial quantity of energy savings. Energy savings include, in addition, either partial or complete abandonment of energy.[65]

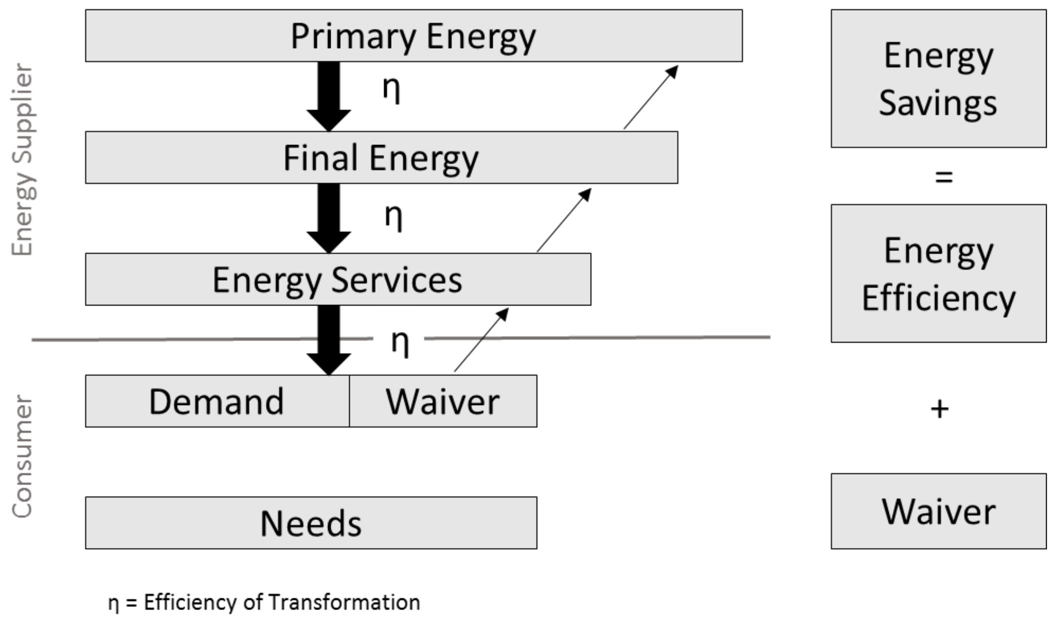

Figure 16: Energy Efficiency vs. Energy Savings[66]

[65] cf. Pehnt (2010), p.4

[66] cf. Pehnt (2010), p.4, own illustration

Efficiency vs. Effectiveness

Effectivity is the relationship between an achieved goal and a defined goal by using resources. This describes the operative effect of an activity. In contrast, it is relevant for efficiency to use a small amount of funds that describes the performance of an activity. Consequently, efficiency is a measure for the ideal use of resources that require effectivity, which beyond that, is a measure of target achievement.[67]

Effectiveness is “Doing the right thing” [68]
Efficiency is “Doing the thing right”[69]

Thus, energy efficiency is the reduction of energy import in a system to provide a service. A system can be transducer like a vehicle or boiler but also a building, company or the overall economy.[70]

[67] cf. Pehnt (2010), p.2

[68] www.smartinsights.com (21.07.2015)

[69] www.smartinsights.com (21.07.2015)

[70] cf. Pehnt (2010), p.2

2.4.1 Past Developments and State of the Art

Although energy management exists in industrial companies it does not achieve maximum savings potential. Several reasons explain that:[71]

- Absence of qualifications
- Unclear of market overview
- Overload of energy management
- Lack of trust in external energy consultants
- Higher priorities in other investment projects

The following facts mark the actual state of energy management of an overall economic view.[72]

- Regulations and pseudo-competition are not currently incentives for energy efficiency because energy savings don’t lead to a gain in prestige of consumers.
- In contrast to energy saving actions, primary energy sources like oil, natural gas and coal are cheaper.
- The EU’s energy management is not geared towards energy saving measures but rather to over generation by increased demand.

In 1992, energy consumption parameters for household appliances were introduced in Europe. So, the energy consumption of electrical devices become transparent. In Germany those characteristic values were implemented in 1998. Since then, improvements of energy efficiency in the range of 35% to 70%, depending on the type of appliance can be seen. Therefore, it is profitable to replace devices that are older than 10 years in many cases.[73]

[71] cf. Britschke (2010), p.182

[72] cf. Wosnitza & Hilgers (2012), p.26

[73] cf. Britschke (2010), p.183

2.4.2 Future Developments and Outlook

In industrial sectors possible solutions become apparent by developing local learning networks to overcome current problems. Thereby, groups of 12-15 corporate energy managers, supervised by a consultant, are assembled and meet regularly. These meetings should take advantage of experience exchange to achieve a reduction in energy costs.[74]

Utilities are important when discussing energy efficiency. They invest in energy efficiency for multiple reason. Some of the main reasons are summarized below:[75]

- Energy efficiency is the lowest cost resource and less expensive than new power plants. Furthermore, in contrast to energy efficiency costs, the cost of new power plants has increased in recent years.
- Energy efficiency is popular with many customers and leads to improved customer satisfaction.
- Necessary approvals for new power plants can be difficult and take many years. It is much easier to get approvals for energy efficiency.
- Energy efficiency programs can be ramped up more quickly than a new baseload power plant.
- There is a lot of uncertainty regarding future environmental regulations. Some utilities are postponing investment in new power plants until those uncertainties are resolved. In the meantime, energy efficiency can help to balance demand and supply.

In the US, programs for energy efficiency are installed and address positive trends. Program administrators need to modify existing programs and add new programs in some cases. Some strategies are summarized, below.[76]

- **Adding new construction programs** that promote higher savings than required. Actual revision of national codes that will reduce energy use in new buildings by 30% relative to prior codes. Energy needs to promote higher levels of savings, such as 50%, compared to current codes. In addition to that, programs should begin to focus on “zero net

[74] cf. Britschke (2010), p.182

[75] cf. Sioshansi (2013), p.55f

[76] cf. Sioshansi (2013), p.74

energy" as a long-term target. A "zero net energy" building is a highly energy efficient and grid-tied structure that produces as much energy as it consumes. Moreover the consumed energy produced, measured over a calendar year, is as clean and renewable as possible. Such buildings typically reduce energy use by 75% relative to current codes and generate the remaining power internally.

- **Improving industrial process and combining heat and power**. Large savings can be realized by modernizing industrial processes. Energy efficiency programs can encourage efficient operations and maintenance and the incorporation of energy management into the overall corporate management structure. In addition to that, programs should help to identify the efficient application of combined heat and power (CHP) and waste energy recovery systems. Such systems work together to generate thermal energy and power for processes.
- **Programs targeted at the largest customer**. Potential savings can be realized by building long-term relationships with customers. By doing so, the customer and utility make multi-year commitments and work together on energy efficiency projects.
- **Deep retrofits** can reduce energy usage in existing buildings. A majority of building floor areas that are used today will exist in future. Therefore their energy use needs to be reduced substantially during major renovations.
- **Advanced technologies, including "intelligent efficiency**". Programs can promote many emerging technologies in the future. Examples can be: LED lightning, heat pump water heater and/or variable speed air conditioners. "Intelligent Efficiency" strategies are also part of these technologies. Thereby, sensors, controls, software and information and communication technology are used to monitor waste and identify opportunities to improve efficiency in building, manufacturing and transportation systems.

2.5 Profitability Analysis of Energy Saving Projects

Energy saving projects are not always self-financing. Thus, the realization of projects require costly investments. To make sure that the investment is profitable and doesn't jeopardize the liquidity of your company, this chapter explains methods to analyze projects.

Mathematical procedures are the basis of the analysis of potential investments. The aim is to calculate the economic benefit of an investment project in comparison to the actual state. Alternative investments which promise greater economic benefits than planned are also tested. The results are economic and/or financial terms that can be compared. Investment analysis allows an objective assessment of entrepreneurial decisions and is used by private companies and public business entities. The evaluation methods can be classified into either static and dynamic procedures or research approaches. Figure 17 shows different types of those methods below. [77]

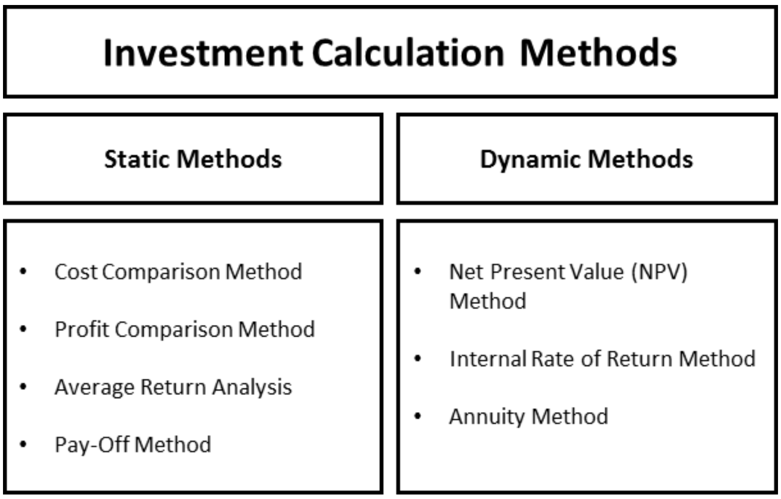

Figure 17: Investment Calculation Methods[78]

[77] cf. Perridon, Steiner & Rathgeber (2004), p.34f

[78] cf. Perridon, Steiner & Rathgeber (2004), p.34, own illustration

2.5.1 Static Methods

The following static methods, listed in Figure 17, are described by means of equations, approaches and figures.

Cost Comparison Method (CCM)

The basis comparison of total costs are period expenses or unit costs. There are two different types for the acquisition:

- total costs are put together according to fixed and variable costs without any further specification concerning cost types
- costs are structured regarding specific types

In practice, the second method is mostly used and therefore explained below.

This approach distinguishes differences between capital charges and operating costs. Hence, the sum of those are the total costs. Operating costs consist of expenses regardless of the operating rate and the variable costs. In contrast, the capital charges are composed of imputed interests and depreciation. As a result, formulas are shown below (Equation 1).[79]

$$C_{total} = C_f + C_v * x + C_D + C_I$$
$$C_D = \frac{P - L}{T}$$
$$C_I = \frac{P + L}{2} * i$$

C_{total} – Total Costs
C_f – Fixed Costs
C_v – Variable Costs
P – Cost Price
x – Amount of Sales
C_D – Imputed Depreciation Allowance
C_I – Imputed Interests
L – Liquidity Revenue
i – Imputed Rate of Interest
T – Imputed Period of Use

Equation 1: Cost Comparison Method[80]

[79] cf. Schaefer (2005), p.31f

[80] cf. Schaefer (2005), p.31

Profit Comparison Method

The profit comparison method is similar to the cost comparison method. Thereby the decision criteria is the average profit of an investment per period. This method can be applied if the investment projects differ in proceeds. However, period of use and capital investment have to be equal in order to provide a accurate basis of decision making. Finally, profit is the difference between proceeds and costs.[81]

$$Profit = Proceeds - Costs$$

Equation 2: Profit Comparison Method[82]

Average Return Analysis

In contrast to the cost and profit comparison methods, the average return analysis also considers different capital investments. It is seen as an improvement of the profit comparison method.[83]

Return on investment (ROI) is an important performance indicator and shows the financial health and how effectively the firm is being managed. It points out the degree of profit that is achieved on the investment. Two key ratios of ROI are:[84]

- Return on Total Assets (ROA)
- Return on Owner's Equity (ROE)

In Equation 3 the calculation of the return on total assets can be seen, This indicator shows the efficiency of employed resources in obtaining income.

[81] cf. Schaefer (2005), p.49f

[82] cf. Schaefer (2005), p.49f

[83] cf. Schaefer (2005), p.49f

[84] cf. Siegel & Shim (2000), p.245f

$$ROA = \frac{Net\ Income}{Average\ Total\ Assets}$$

Equation 3: Return on Total Assets[85]

The Du Pont Formula (Equation 4) shows an essential linkage between the profit margin and the return on total assets which is known as return on investment.[86]

$$Return\ on\ Investment = \ Profit\ Margin * Total\ Asset\ Turnover$$

$$ROI = \frac{Net\ Income}{Net\ Sales} * \frac{Net\ Sales}{Average\ Total\ Assets}$$

Equation 4: Return on Investment[87]

In contrast to the return on total assets, return on common equity measures the rate of return on the investment as shown below (Equation 5).

$$ROE = \frac{Earinings\ available\ to\ common\ Stockholders}{Average\ Stockholder's\ Equity}$$

Equation 5: Return on Owner's Equity[88]

Static Payback Period Method

In contrast to the cost and profit comparison methods, the analysis period of the pay-off method considers more than one period. The aim of this method is to calculate when the investment is amortized through returns of deposit surplus. The basis is not revenue and expenditure but deposit and withdrawal.

[85] Siegel & Shim (2000), p.245

[86] cf. Siegel & Shim (2000), p.245f

[87] cf. Hutzschenreuter (2009), p.98

[88] Siegel & Shim (2000), p.246

Decision criterion is the amortisation period which can be calculated by the formula below (Equation 6).[89]

$$\text{Payback Period} = \frac{\text{Acquisition Cost}}{\text{Deposit Surplus per Period}}$$

Equation 6: Payback Period[90]

2.5.2 Dynamic Methods

When the cash flow of different periods is compared, the time value of money has to be considered. The value of each cash flow depends on the time at which it takes place. Therefore, the value must be transformed by discounting or compounding, allowing at specific points in time. Discounting means that all future cash flows are converted to their value at the beginning of an investment project. In contrast, compounding means the conversion of cash flows to their equivalent value at the end of the investment project (see Figure 18). Values are multiplied by different factors to make comparison possible. The factors (see Equation 7) depend on the rate of interest (i) and the time period (t).[91]

Figure 18: Present and Future Values[92]

[89] cf. Hutzschenreuter (2009), p.125f

[90] Hutzschenreuter (2009), p.126

[91] cf. Götz, Northcott & Schuster (2015), p.47f

[92] cf. Rolfs (2003), p.10, own illustration

$$Discounting\ Factor = (1+i)^{-t}$$

$$Compounding\ Factor = (1+i)^{t}$$

Equation 7: Discounting and Compounding Factors[93]

Net Present Value (NPV) Method

In practice, the net present value method is a common approach. Thereby future net cash flows are estimated initially and then discounted to the present. As a result, the capital value is the difference between the sum of all cash flow (at time step 0) and the investment pay-out. The common formula for calculation is shown in Equation 8. When different projects are compared, the best variant has the highest capital value.[94]

$$C_0 = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} - I_0$$

C_0 – Capital Value *i – Rate of Interest*
C_t – Cash Flow *t –Period of Time*
I_0 – Investment Pay-Out

Equation 8: Capital Value Calculation[95]

The procedure of the net present value method can be described by the example below.

[93] Götz, Northcott & Schuster (2015), p.48

[94] cf. Kolaksazov (2015), p.9f

[95] Perridon, Steiner & Rathgeber (2004), p.72

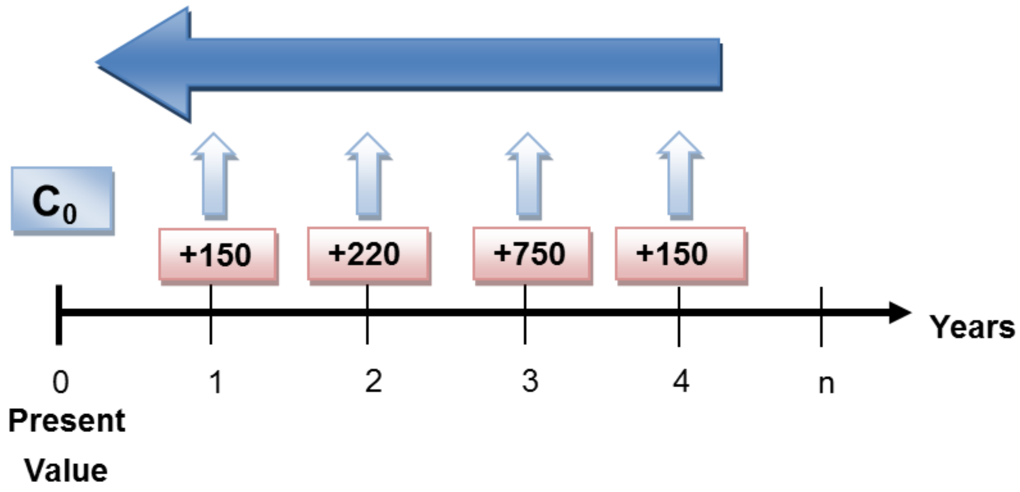

Figure 19: NPV-Method Example[96]

Figure 19, shows the cash flow of an investment project. The first step is to calculate present values. Therefore all cash flows are discounted (see Equation 9). After that, the investment pay-out is subtracted resulting in the capital value (see Equation 10). The assumption for this example is an investment amount of 1000€ and an interest rate of 8%.[97]

$$PV = 150 * 1{,}08^{-1} + 220 * 1{,}08^{-2} + 750 * 1{,}08^{-3} + 150 * 1{,}08^{-4} = 1033{,}13$$

Equation 9: Sum of Cash Flows – Present Value[98]

$$C_0 = PV - Investment\ Pay\ Out = 1033{,}13 - 1000 = 33{,}13$$

Equation 10: Capital Value[99]

[96] cf. Rolfes (2003), p.10

[97] cf. Rolfes (2003), p.10

[98] cf. Rolfes (2003), p.10

[99] cf. Rolfes (2003), p.10ff

Internal Rate of Return Method

This method calculates the rate of interest at which the capital is null (see Figure 20). At this point of time the invested capital is regained and the investment yields interest. In practice, the calculation is done with interpolation (see Equation 11). Therefore two specific points, which are as close as possible to the internal rate of return, are used.[100]

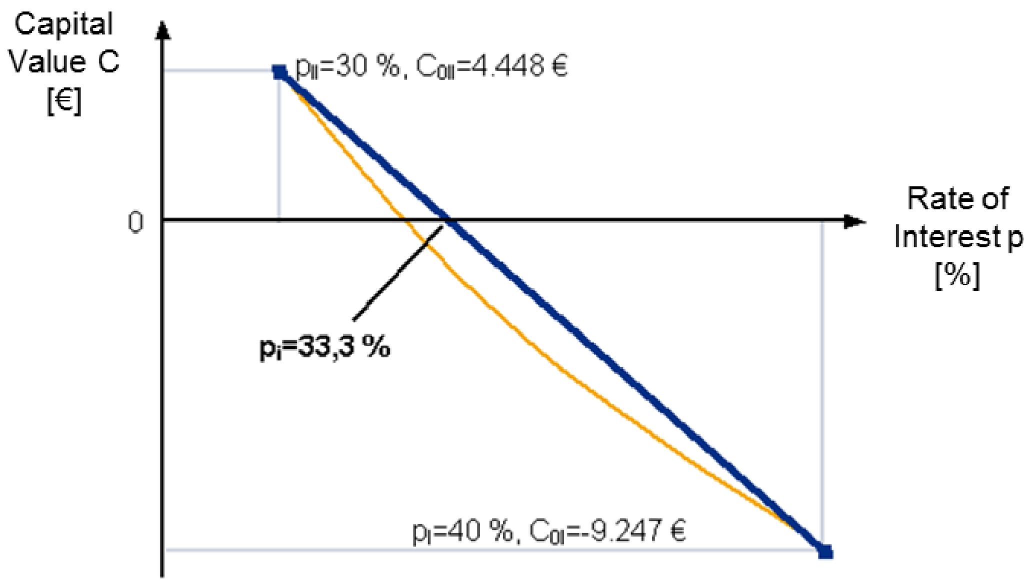

Figure 20: Internal Rate of Return - Method[101]

$$p_i = p_I - ((p_{II} - p_I) * \frac{C_{0I}}{C_{0II} - C_{0I}})$$

Equation 11: Internal Rate of Interest - Calculation[102]

[100] cf. www.betriebswirtschaft.info (20.08.2015)

[101] cf. Warnecke, Bullinger Hichert & Voegele (1996), p.101, own illustration

[102] cf. www.betriebswirtschaft.info (20.08.2015)

Annuity Method

Annuities are series of fixed payments required or paid out at a specific frequency over a fixed time period. Two different types of annuities can be distinguished:[103]

- **Ordinary Annuity**
  Payments which are required at the end of a period (Figure 21).

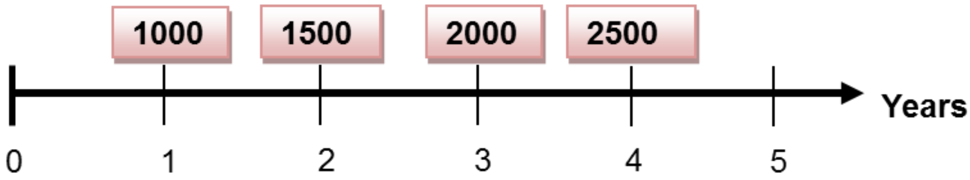

Figure 21: Ordinary Annuity

- **Annuity Due**
  Payments which are required at the beginning of a period (Figure 22).

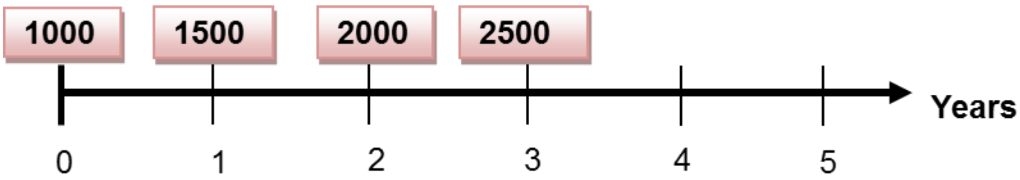

Figure 22: Annuity Due

The Annuity Method might be used in addition to the net present value method. Both methods are based on the same evaluation. But the annuity method re-expresses the net present value as streams of equivalent annual benefits. Consequently, an annuity is the investment's equal average annual benefit.[104]

Often, literature explains the annuity method only by using discounting and compounding formulas for the calculation of present and future values. Nevertheless, the calculation returned from those values to the installment payment should be explained. Thus, the annuity factor is described below.

[103] cf. www.investopedia.com (20.08.2015)

[104] cf. Röhrich (2014), p.76

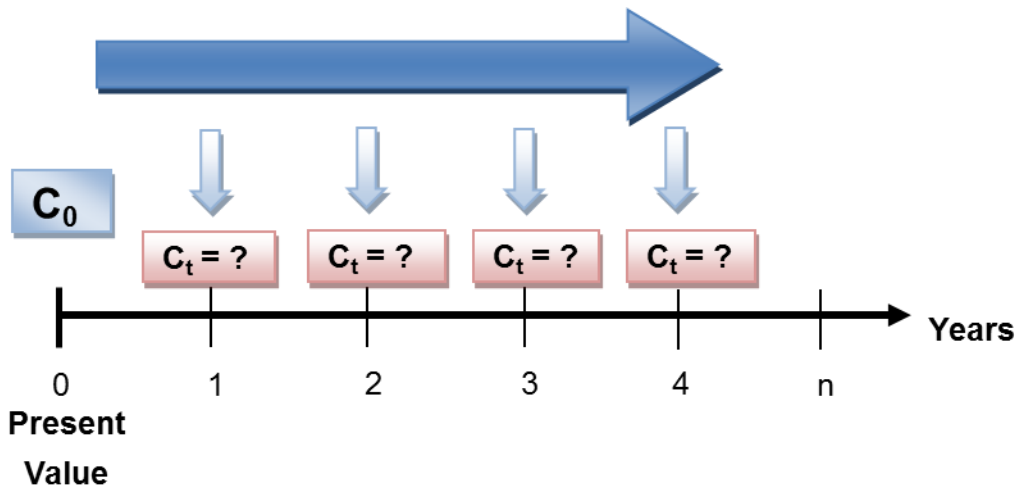

Figure 23: Annuity Factor[105]

As shown in Figure 23, the present value of the capital value (C_0) is compounded. Fixed payments (C_t), depending on the interest rate and period of time are received (Equation 12).

$$C_t = C_0 * a = C_0 * \left(\frac{i * (1+i)^n}{(1+i)^n - 1}\right)$$

C_0 – Capital Value | *i – Rate of Interest*
C_t – Cash Flow | *n –Period of Time*
a - Annuity Factor

Equation 12: Fixed Payments - Annuity Factor[106]

[105] cf. www.rechnungswesen-verstehen.de (18.08.2015)

[106] cf. www.rechnungswesen-verstehen.de (18.08.2015)

3 Energy Analysis Golf Club Fontana

This master thesis deals with the reduction of energy costs at the Golf Club Fontana in Oberwaltersdorf. After a short introduction, the operational energy analysis, including energy import and energy use (in this case) is described. At the end of this chapter, recommendations for actions are derived from weaknesses.

3.1 Introduction and Approach

The Golf Club consists of three buildings analyzed separately. The different buildings are:

- Clubhouse
- Tennis Center
- Depot

The center of the whole Golf Club is the Clubhouse. It comprises the office, a restaurant, an event area and a wellness area for all members and guests. The Tennis Center consists of three indoor tennis courts with a buffet area on the ground floor and five apartments for employees upstairs. The depot is headquarters and head office for all employees that are responsible for outdoor work.

As can be seen in Figure 24, the approach is split up into four different stages, which are described below.

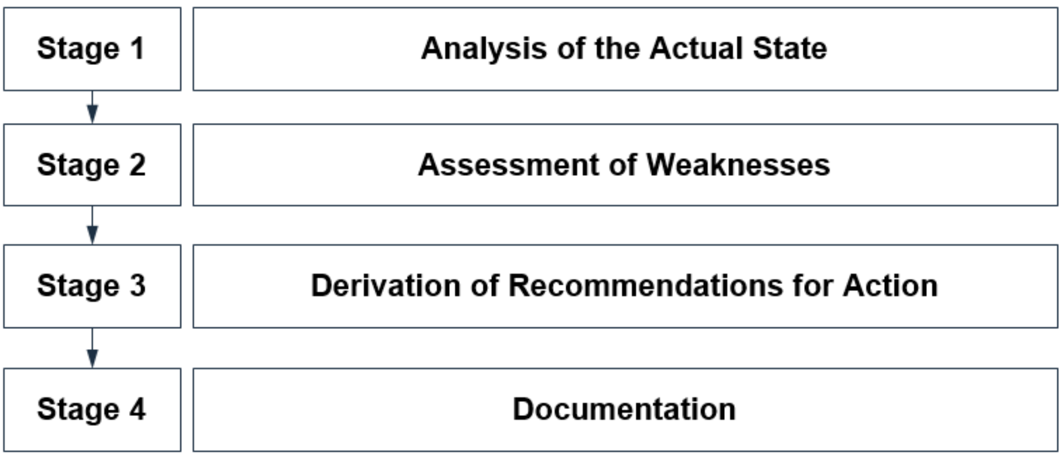

Figure 24: Approach and Stages of the Project

Analysis of the Actual State

All important questions that should be answered during an energetic operation analysis are listed in chapter 2.1.1 (page 5). Not all of them are useful for the investigation of the Golfclub. Therefore, relevant questions are summarized below:

- Which types of energy and energy carriers are used?
  - Fossil Fuels?
  - Electrical Energy?
  - Thermal Energy?
  - Water?
  - Other Energy Sources?
- How big is the demand of each energy carrier?
- How does demand occur over time?
  - Daily?
  - Weekly?
- Which energy transformation units are used?
- How and where are energy carriers obtained?

Assessment of Weaknesses

In the second stage, weaknesses are identified. Three different types are distinguished:

- Short-term remediable weaknesses
- Mid-term remediable weaknesses
- Long-term remediable weaknesses

As a result, a catalogue of weaknesses can be created and assignments to actions executed.

Derivation of Recommendations for Action

In the third phase, derivation of recommendations for action takes place. Following options are considered:

- Prevention of energy demand
- Reduction of energy consumption
- Optimization of the transformation of energy
- Opportunities energy recovery
- Utilization of synergies

Documentation

The fourth and last stage of the approach is used for documentation. A final report that contains the actual state, a catalogue of weaknesses and a description of actions to reduce energy costs is created.

The processes of the project and the milestones are seen in Figure 25. The whole procedure starts with a “Kickoff Meeting” and is divided by “Steering Meetings”. At the end of the project there is a “Final Meeting”.

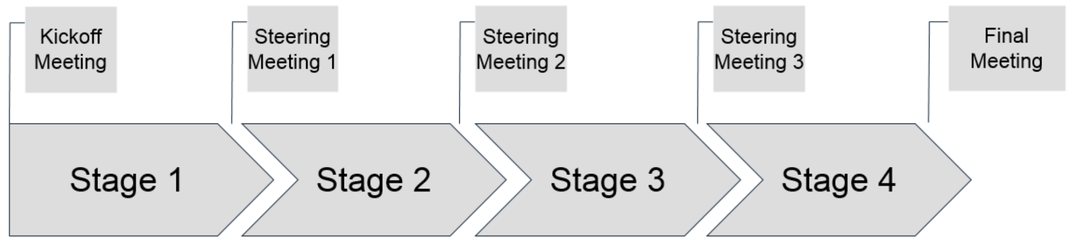

Figure 25: Processes and Milestones

3.2 Analysis of the actual State - Energy Import

In this section, all question related to energy import are answered as accurately as possible. However, it must be mentioned that the investigation is based on provided data of past years. The correctness of this information is assumed.

As part of the actual state analysis, system boundaries are created. Determining these, ensures that the temporal evolution and seasonal variations are considered. The following definitions are established for the examination.

Time Selection

At the Golf Club, industrial metering points are installed. Thus, utility companies record daily (natural gas) and quarter-hourly (electrical energy). For these reasons, an accurate examination is possible. The full calendar years 2013 and 2014 are defined as an observation period in order to identify possible trends.

Geographical Definition

As described in the introduction, the three buildings of the Fontana are considered. These are Clubhouse, Tennis Center, and Depot. At the time of this project, the future use of the Tennis Center was not clarified. Therefore only the actual state and weaknesses are analyzed but no recommendations for action are elaborated for this location.

Structure

The energy import of the various locations is separated into the following subsections:

- Natural Gas
- Electrical Energy

The Fontana obtains natural gas from “EVN - Energie Versorung Niederösterreich” and electrical energy from “Wien Energie”. The report, which considers all buildings separately shows an overview of the total energy import at the beginning of each section. After that, more detailed notes of natural gas and electrical energy are pointed out.

3.2.1 Total Energy Import

The average annual import and energy costs are shown in Table 3. The total consumption of energy is [redacted] kWh costing about [redacted] € per year. The major part of import is natural gas with 59%, but 62% of total costs are caused by electrical energy.

Energy Type	Ø Annual Import		Ø Annual Energy Costs	
Natural Gas	[redacted]	(59%)	[redacted]	(38%)
Electr. Energy	[redacted]	(41%)	[redacted]	(62%)
Total	[redacted]	**(100%)**	[redacted]	**(100%)**

Table 3: Total Energy Import[107]

There was a reduction of 19% in total energy import in 2014 compared to 2013 (see Figure 26). The difference was mostly driven by natural gas (21%) but also by the electrical energy import that was decreased by 15%.

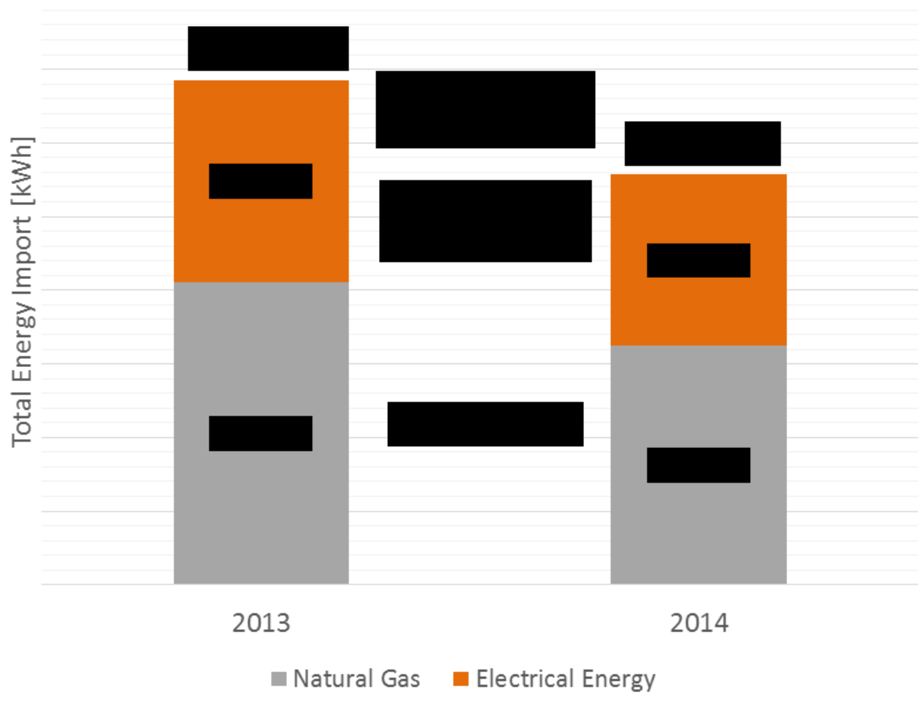

Figure 26: Total Yearly Energy Import[108]

[107] own illustration, based on data from EVN Energievertrieb GmbH (2014) & Wien Energie Vertrieb GmbH (2014)

[108] own illustration, based on data from EVN Energievertrieb GmbH (2014) & Wien Energie Vertrieb GmbH (2014)

Figure 27 shows the Fontana's monthly import of energy. An overall reduction of 19% can be explained by big differences in consumption from September to December, 2014 (as compared to a year before). The reason, therefore, is the business takeover that happened in September, 2014 and with that a changed operating and usage behaviour entered.

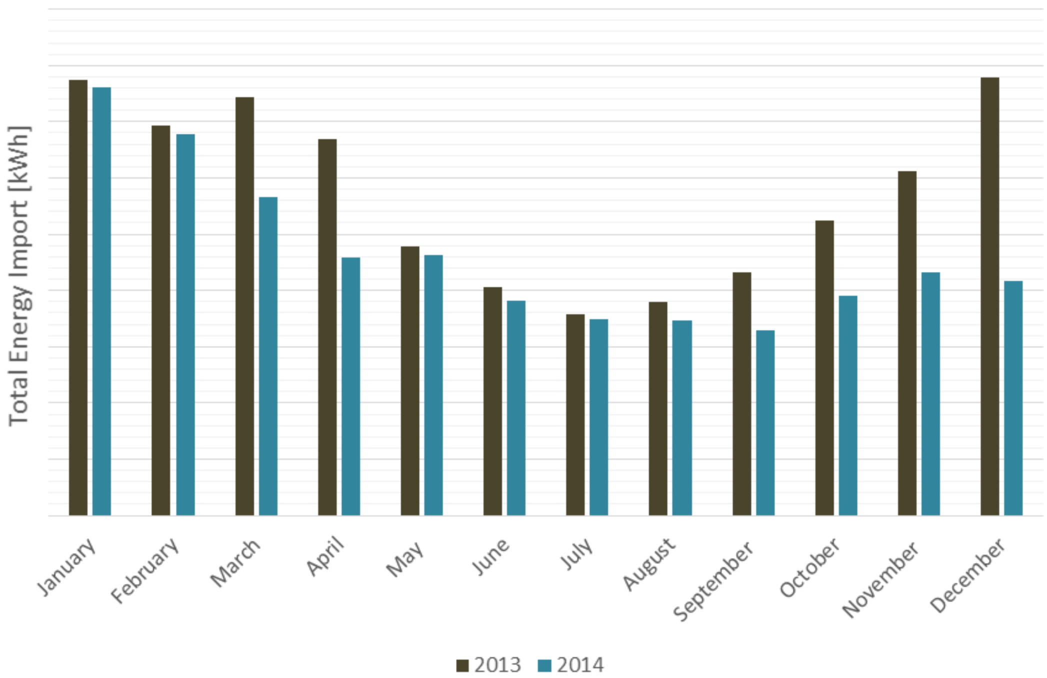

Figure 27: Total Monthly Energy Import[109]

[109] own illustration, based on data from EVN Energievertrieb GmbH (2014) & Wien Energie Vertrieb GmbH (2014)

3.2.2 Natural Gas Import

There are three different metering points for natural gas import (see Table 4). The utility and finance department of the Golfclub distinguishes between the Clubhouse, Depot and Tennis Center. Each station has its own records and bills.

Nr.	Address	Cost Center	Metering Point
1	[redacted]	Clubhouse	[redacted]
2	[redacted]	Depot	[redacted]
3	[redacted]	Tennis Center	[redacted]

Table 4: Metering Points of Natural Gas[110]

The following chart (Figure 28) shows the different amounts of supplied energy for the years 2013 and 2014.

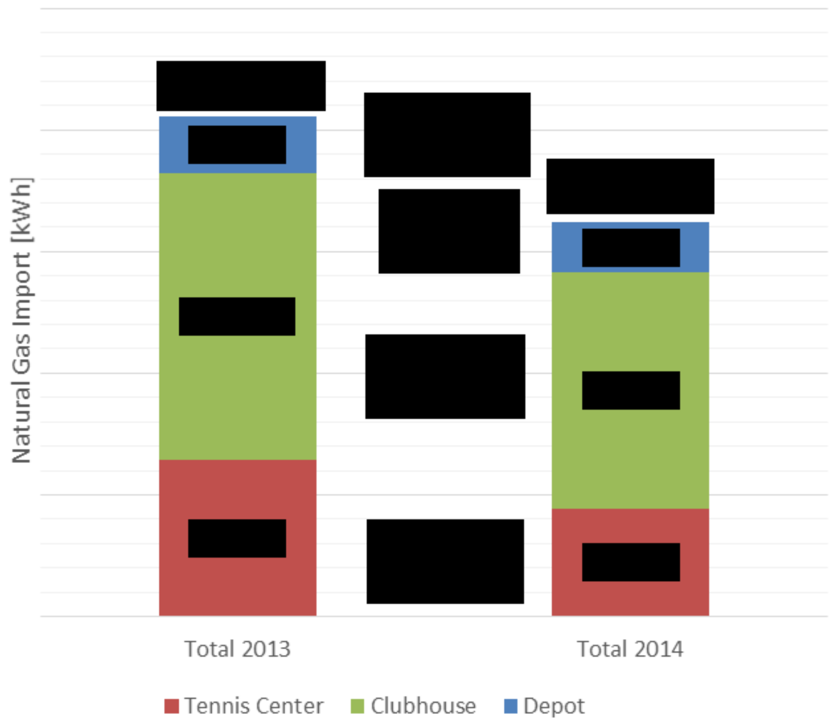

Figure 28: Yearly Natural Gas Import[111]

[110] own illustration, based on data from EVN Energievertrieb GmbH (2014)

[111] own illustration, based on data from EVN Energievertrieb GmbH (2014)

In Figure 28, a reduction of 21% in supplied natural gas in 2014 can be seen. Mostly, it is effected by the Tennis Center which drives the decrease with a 31% reduction. As shown in Figure 30, there has been hardly any natural gas supplied for the Tennis Center since September 2014. This can be explained by changed user behaviour and the temporary closure. Due to a modified operation behaviour, also a reduction of 18% for the Clubhouse was achieved. The consumption behaviour of the Depot was nearly constant.

Table 5 lists annual import and annual energy costs for each building. Nearly 60% of total natural gas costs are caused by the Clubhouse. The total costs for [redacted] kWh of natural gas are [redacted] € per year.

Natural Gas	**Ø Annual Import**	**Ø Annual Energy Costs**	
Clubhouse	[redacted]	[redacted]	(58%)
Tennis Center	[redacted]	[redacted]	(30%)
Depot	[redacted]	[redacted]	(12%)
Total	[redacted]	[redacted]	**(100%)**

Table 5: Natural Gas Import[112]

The monthly demand of natural gas for 2013 and 2014 is shown in Figure 29 and Figure 30. Clear seasonal variations for the Clubhouse and Tennis Center buildings can be seen because natural gas is used only for heating activities. Due to the minimal import for the Depot in comparison with other locations the trend is not as visible.

[112] own illustration, based on data from EVN Energievertrieb GmbH (2014)

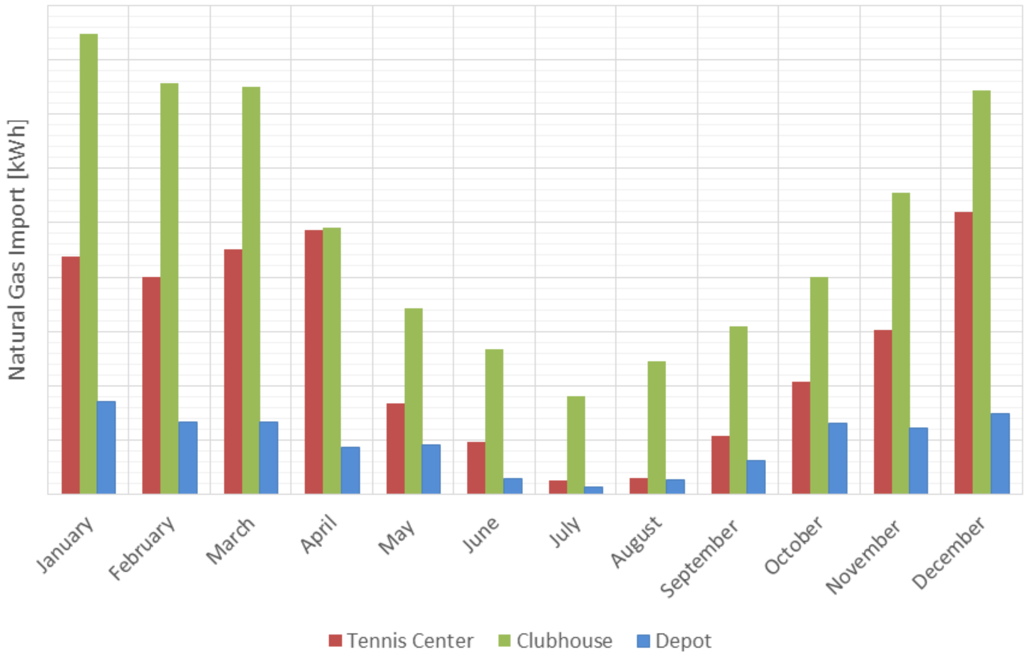

Figure 29: Monthly Natural Gas Import 2013[113]

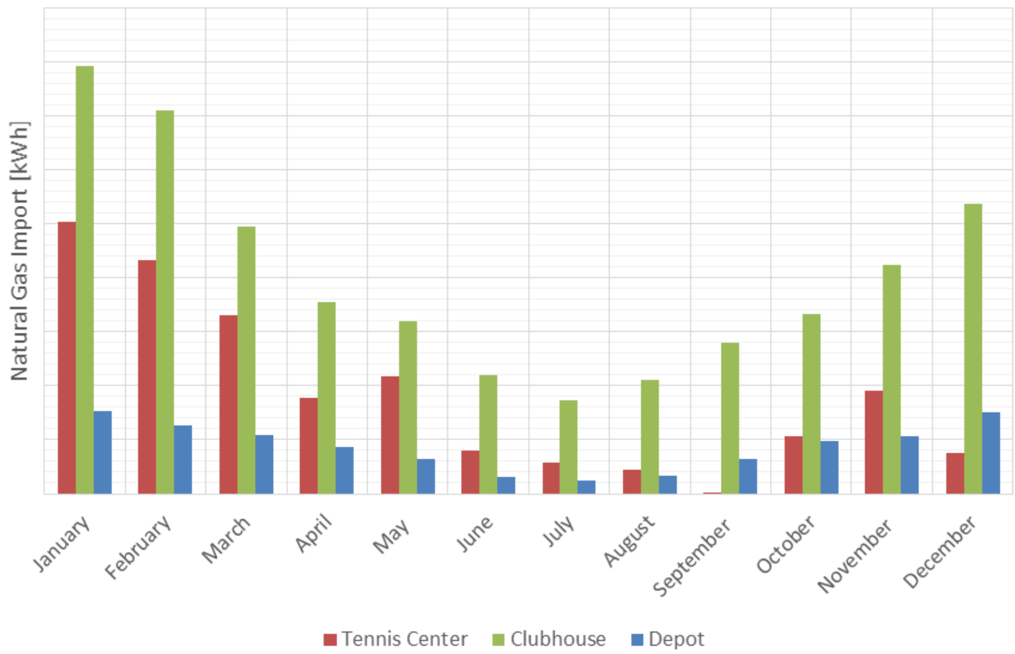

Figure 30: Monthly Natural Gas Import 2014[114]

[113] own illustration, based on data from EVN Energievertrieb GmbH (2014)

[114] own illustration, based on data from EVN Energievertrieb GmbH (2014)

3.2.3 Electrical Energy Import

The import of electricity is divided into three metering points. In contrast to the import of natural gas, there are no separated stations for Tennis Center and Depot. However, electrical devices from the main kitchen (metering point E-Kitchen) are considered separately. Hence, the metering points for the import of electrical energy are: the Clubhouse, E-Kitchen and Tennis Center/Depot (see Table 6).

Nr.	Address	Cost Center	Metering Point
1	[redacted]	Clubhouse	[redacted]
2	[redacted]	E-Kitchen	[redacted]
3	[redacted]	Tennis Center/ Depot	[redacted]

Table 6: Metering Points for Electrical Energy[115]

Figure 31 shows an overall reduction of 15% in supplied energy for 2014 in comparison to 2013. The decrease was mostly driven by the E-Kitchen and Tennis Center/Depot. Nevertheless, the energy demand of the Clubhouse was also reduced by 11%. The differences are explained through the temporary closure of the Tennis Center and by a changed user and operating behavior. Looking at the import, in terms of time, shows that big reductions have occurred since September, 2014 (see Figure 33).

The monthly demand of electrical energy for all the different locations in 2013 and 2014 is shown in Figure 32 and Figure 33.

[115] own illustration, based on data from Wien Energie Vertrieb GmbH (2014)

Figure 31: Yearly Electrical Energy Import[116]

In Table 7, the yearly average import and energy costs are listed. The Clubhouse (including E-Kitchen) causes nearly 75% of total electrical energy costs. The total import of [redacted] kWh electricity costs [redacted] € per year.

Electrical Energy	Ø Annual Import	Ø Annual Energy Costs	
Clubhouse	[redacted]	[redacted]	(67%)
E-Kitchen	[redacted]	[redacted]	(7%)
Tennis Center & Depot	[redacted]	[redacted]	(26%)
Total	[redacted]	[redacted]	**100%**

Table 7: Electrical Energy Import[117]

[116] own illustration, based on data from Wien Energie Vertrieb GmbH (2014)

[117] own illustration, based on data from Wien Energie Vertrieb GmbH (2014)

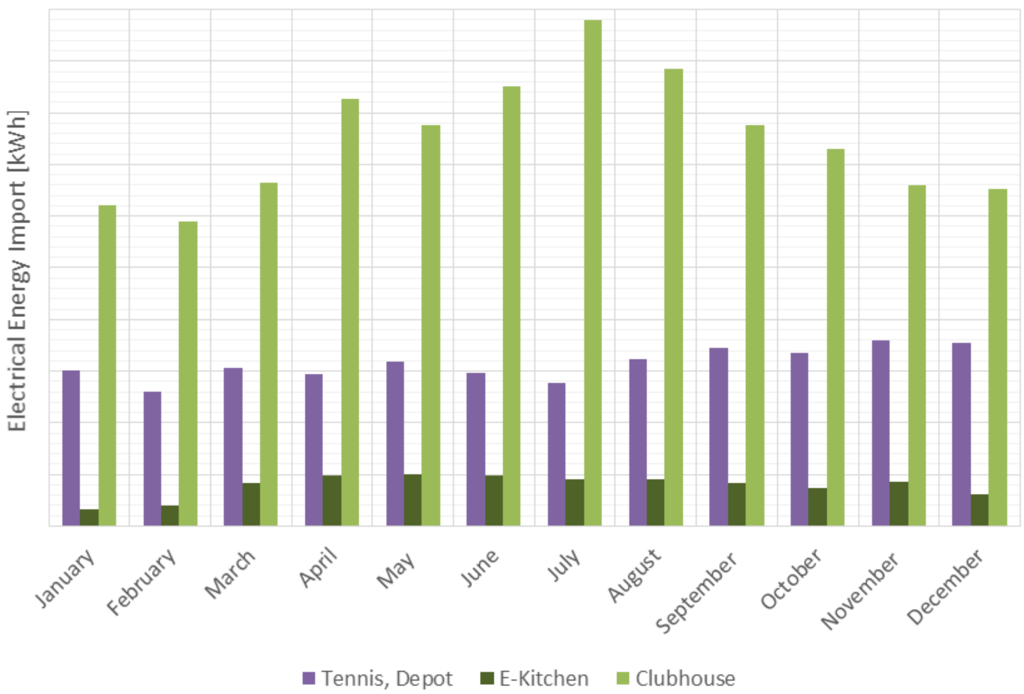

Figure 32: Monthly Electrical Energy Import 2013[118]

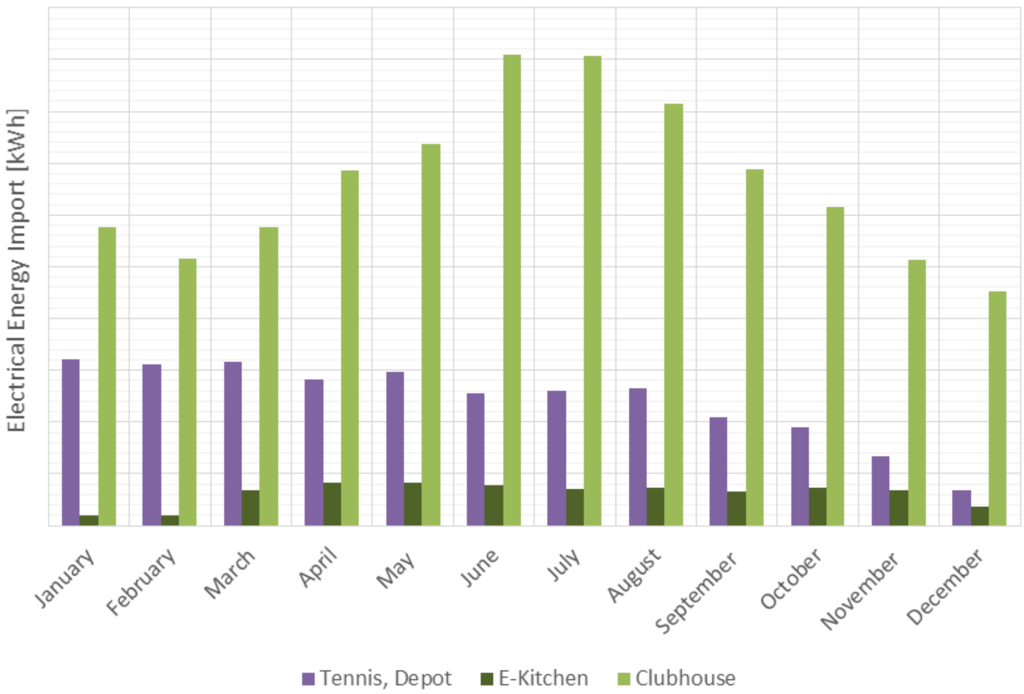

Figure 33: Monthly Electrical Energy Import 2014[119]

118 own illustration, based on data from Wien Energie Vertrieb GmbH (2014)

119 own illustration, based on data from Wien Energie Vertrieb GmbH (2014)

3.3 Assessment of Weaknesses – Use of Energy

After analyzing the energy import, the consumption of energy is categorized to application areas. Therefore the use of energy is reproduced with energy structures. Those structures consist of measurements, records and assumptions. Due to missing and incomplete recordings of past energy behavior, some consumption has to be assumed. The assumptions are checked with employees who are familiar with the operating behavior in the last few years. The output of those tree structures are the amounts of used energy in a specific field.
Before structures and application areas of energy use are shown, some of the data used for calculations is summarized.

3.3.1 Calculation Data

Specific data of water (see Table 8 and Table 9) and air (see Table 10) is applied to calculations for energy demand in following chapters. Evaluated values are listed below.

Characteristics of Water

Water Density (20°C)	ρ_W	998,2	kg/m³
Specific Heat Capacity	c_W	4,187	kJ/kgK

Table 8: Specific Data Water[120]

Temperature Cold Water	t_{cold}	12	°C
Temperature Hot Water	t_{hot}	60	°C

Table 9: Temperature Water[121]

Characteristics of Air

Air Density	ρ_{air}	1,204	kg/m³
Specific Heat Capacity	c_{air}	1,005	kJ/kgK

Table 10: Specific Data Air[122]

[120] cf. Dobrinski , Krakau, & Vogel (2010)

[121] own illustration, based on measurements

[122] cf. Dobrinski , Krakau, & Vogel (2010)

3.3.2 Natural Gas Clubhouse

The supplied natural gas is transformed, by two boilers, to heat energy. After transformation, the energy is used in four different sectors. Type of and data about transformation and distribution equipment of the Clubhouse can be found in the appendix (Appendix 5: Inventory).

In Figure 34 the structure of energy use is illustrated. All assumptions and measurements are marked to understand the different demands of energy. The calculation procedure and required formulas are described below.

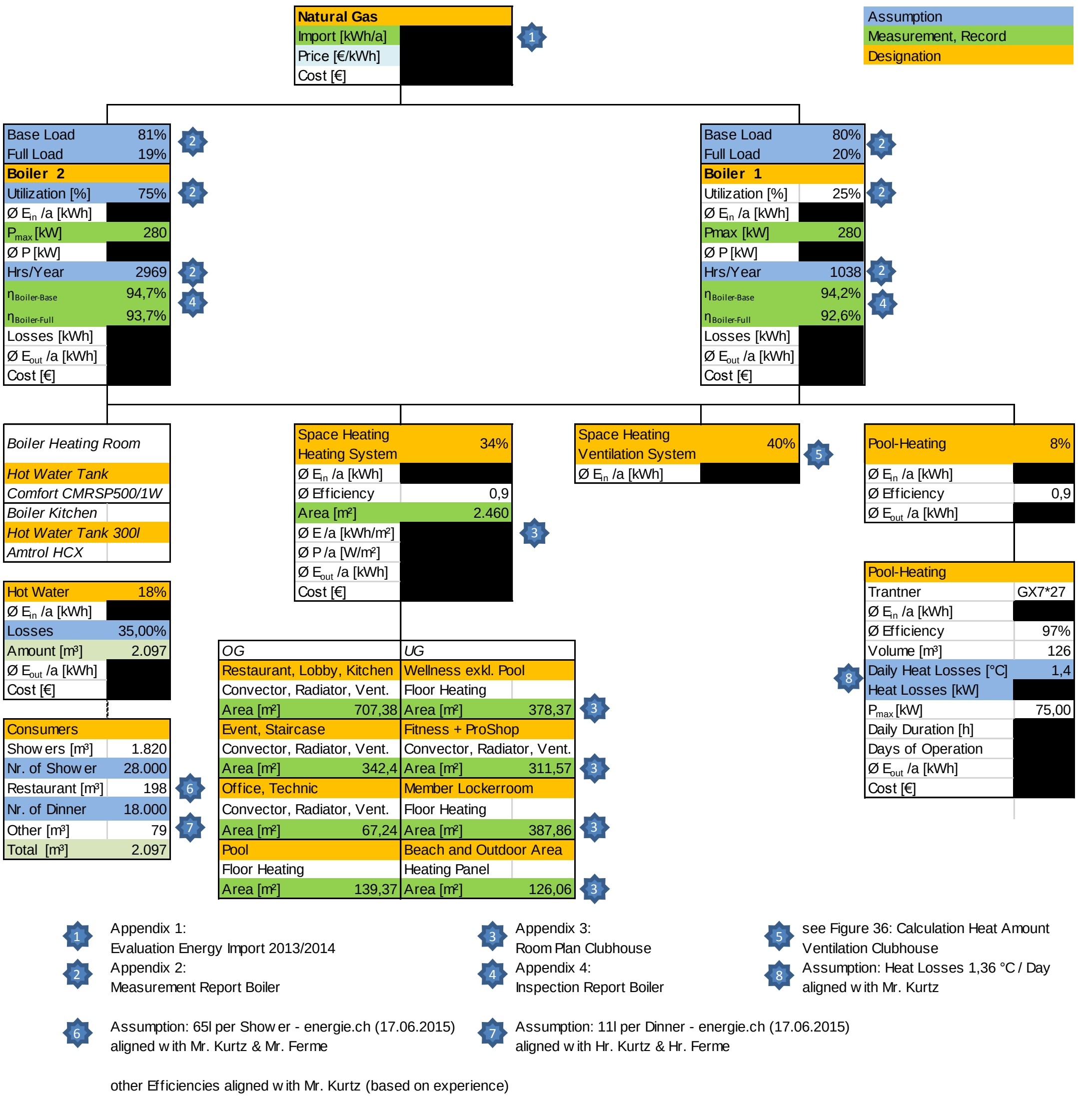

Figure 34: Energy Structure Natural Gas for the Clubhouse[123]

[123] own illustration

The use of natural gas in the Clubhouse is divided into four different application areas.

- **Hot Water**
  The energy demand for provision of hot water is needed in washrooms for showers and in the restaurant for food preparation activities.
- **Space Heating - Heating System**
  Thermal energy that is used for heating rooms with convectors, radiators, heating panels and floor heating.
- **Space Heating - Ventilation System**
  The amount of heat energy for increasing the temperature of air in the ventilation system before it enters the rooms.
- **Pool Heating**
  The energy which is used to hold the water temperature of the pool at a constant level.

The amount energy used for each application area is displayed in Figure 35.

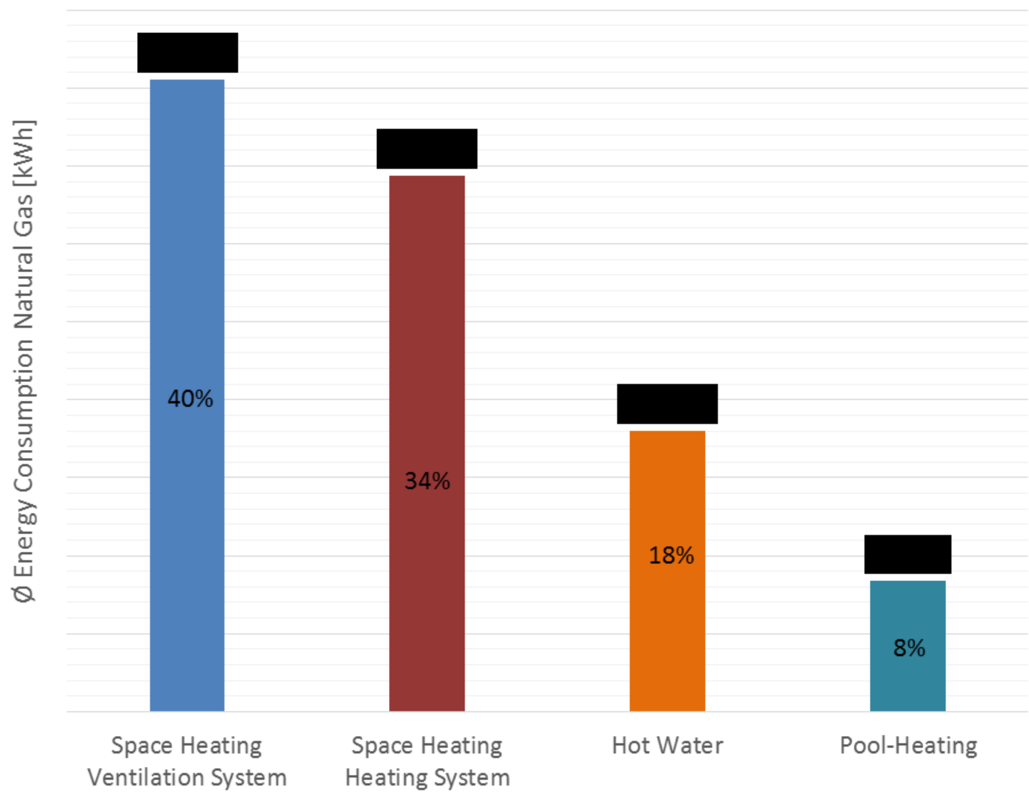

Figure 35: Energy Use Natural Gas for the Clubhouse[124]

[124] own illustration, based on own calculations

For the calculation of energy amounts, different data and equations that were used which are described below.

Pool-Heating

In Equation 13, the heat quantity for the pool is calculated. Specific data of water is shown in Table 8 and characteristics of the pool are listed in Table 11. The Volume is according to the construction plan and daily losses are assumed by benchmarking and empirical values.

$$Q_{Pool} = V * \rho_W * c_w * \Delta T$$

Equation 13: Heat Quantity Pool[125]

Volume	V	126	m³
Daily Heat Losses	ΔT	[redacted]	°C

Table 11: Specific Data Water Pool[126]

Hot Water

The amount of hot water (Table 12) is assumed for the calculation of required heat energy in Equation 14. Therefore, consumption is estimated with average values (see Figure 34). For example, the number of showers are expected to be approximately 28.000 showers a year with an average of 65 litre per shower. So the consumption of 1.820 m³ for the showers can be calculated. The same procedure is applied for the calculation of necessary heat quantities for the restaurant. All relevant values can be seen in Figure 34 and specific data for water is shown in Table 8 and Table 9.

$$Q_{Hot\,Water} = V_{HW} * \rho_W * c_w * (t_{hot} - t_{cold})$$

Equation 14: Heat Quantity of Hot Water[127]

[125] Windisch (2014), p.32f

[126] own illustration, based on construction plan and assumptions from Mr. Kurtz

[127] Windisch (2014), p.32f

Amount of Hot Water	V_{HW}	2097	m³/a

Table 12: Amount of Hot Water for the Clubhouse[128]

Space Heating - Ventilation System

The ventilation system needs a specific heat quantity to increase the level from outside temperature to room temperature before air in the ventilation duct enters the room. Further heating operations through this system are not considered. The outside temperature that is used for calculation in Table 14 was measured by the weather station in Wiener Neustadt[129]. As a base for the average outside temperature values for the years 2013 and 2014 are considered. In Table 13, assumptions for the operation time are shown. An average air exchange of [redacted] m³/h and an operation time of [redacted] hours per day are estimated. Also a factor (x) of 80% full load run time is applied for the calculation for the duration of the month. The formula for the calculation of the heat quantity for the ventilation system is shown below (see Equation 15).

$$Q_{Ventilation} = \dot{V} * \rho_{air} * c_{air} * \Delta T * \frac{1}{3600} \frac{kWh}{kJ}$$

Equation 15: Heat Quantity Ventilation[130]

Air Exchange	$\dot{V}$	[redacted]	m³/h
Duration per Day	t	[redacted]	h
Full Load	x	80	%

Table 13: Specific Data Ventilation Clubhouse[131]

[128] own illustration, based on data from www.energie.ch (17.06.2015)

[129] cf. www.zamg.ac.at (23.06.2015)

[130] Windisch (2014), p.32f

[131] own illustration, based on assumptions from Mr. Kurtz

Days	Month	Average Outside Temperature 2013/2014	Room Temperature	Temperature Difference (ΔT)	Heat Quantity per Hour (Q_H)	Duration per Month (D = t*x*days)	Space Heating Ventilation System ($Q_{Vent}=Q_H*D$)
		°C	°C	°C	kW	h	kWh
31	Jan.	0,6	21,0	20,4	[redacted]	[redacted]	[redacted]
28	Feb.	1,6	21,0	19,4	[redacted]	[redacted]	[redacted]
31	March	4,9	21,0	16,1	[redacted]	[redacted]	[redacted]
30	April	11,1	21,0	10,0	[redacted]	[redacted]	[redacted]
31	May	14,6	21,0	6,4	[redacted]	[redacted]	[redacted]
30	June	18,5	21,0	2,5	[redacted]	[redacted]	[redacted]
31	July	21,8	21,0	-0,8	[redacted]	[redacted]	[redacted]
31	Aug.	19,9	21,0	1,1	[redacted]	[redacted]	[redacted]
30	Sept.	15,0	21,0	6,1	[redacted]	[redacted]	[redacted]
31	Oct.	10,8	21,0	10,2	[redacted]	[redacted]	[redacted]
30	Nov.	6,9	21,0	14,1	[redacted]	[redacted]	[redacted]
31	Dec.	2,7	21,0	18,4	[redacted]	[redacted]	[redacted]
	Total						[redacted]

Table 14: Calculation Heat Amount Ventilation for the Clubhouse[132]

Space Heating - Heating System

The last application area of the use of natural gas in the Clubhouse is the space heating through heating system. For this computation, an energy balance is appropriate. Thus, the heat quantity for the heating system is the difference of generated heat from boiler stations and the used energy from other consumption fields. Equation 16 shows the calculation approach.

$$Q_{Heating\ System} = Q_{Boiler1} + Q_{Boiler2} - Q_{Hot\ Water} - Q_{Ventilation} - Q_{Pool}$$

Equation 16: Heat Quantity Heating System for the Clubhouse[133]

[132] own illustration, based on data from www.zamg.ac.at (23.06.2015)

[133] cf. Recknagel, Sprenger, & Schramek (2007), p.1081

Weaknesses

At the end of the Clubhouse's investigation of energy use, weaknesses can be identified. Therefore, key performance indicators are calculated and compared with reference values. Furthermore, Table 15 gives an overview of the energy behaviour of the Clubhouse. There is a thermal energy demand of [redacted] kWh and energy is transformed by an average efficiency of 94,4%. Thus, the energy import of natural gas is [redacted] kWh (see also Appendix 10.1) which result in energy costs of [redacted] € a year.

Natural Gas	Thermal Energy Demand	Effici-ency	Ø Energy Import	Ø Energy Costs
Clubhouse	[redacted]	94,4%	[redacted]	[redacted]

Table 15: Yearly Thermal Energy Demand for the Clubhouse[134]

In Table 16, indicators for the Clubhouse are computed with an energy reference area of 2.544 m². The specific energy demand total is applied for all energy consumption. In contrast, the indicated specific energy demand, for the room, considers only the heat amount used for space heating. This is the base for calculating the specific power demand, for the room, with an average operation time of 1800 hours per year for heating procedures taken into account. The reference values are calculated by taking into consideration average four to five star hotels in Austria.

KPI's	Energy Reference Area	Specific Energy Demand Total	Specific Energy Demand Room	specific Power Demand Room
Clubhouse	2.544 m²	[redacted]	[redacted]	[redacted]
Reference[135]		280 kWh/m²a	180 kWh/m²a	100 W/m²

Table 16: KPI's Clubhouse[136]

[134] own illustration, based on data from EVN Energievertrieb GmbH (2014)

[135] cf. OEGUT-Österreichische Gesellschaft für Umwelt und Technik (2011)

[136] own illustration, based on data from EVN Energievertrieb GmbH (2014) & construction plan

There are several reasons for the high deviations of indicators. Firstly, the reference values consider a smaller wellness area that is why they are not directly comparable to the Clubhouse. Secondly, the specific energy demand for the room is driven by the energy consumption of the ventilation system. Therefore it is clear that this system runs in a very inefficient way. If only the demand of the heating system is considered, the specific energy demand will be below average at [redacted] kWh/m²a.

Another important fact is illustrated in Figure 36. Normally, in summer, heat energy is used for hot water treatment only. Figure 36 shows the energy import of natural gas depending on the average outside temperature for each month. If the heating operations were only used for hot water provision in July and August, the energy consumption would be about [redacted] kWh per month. But according to the consumption in Figure 34 the demand for hot water is [redacted] kWh per year. Thus, heat energy is used unnecessarily in the summer season.

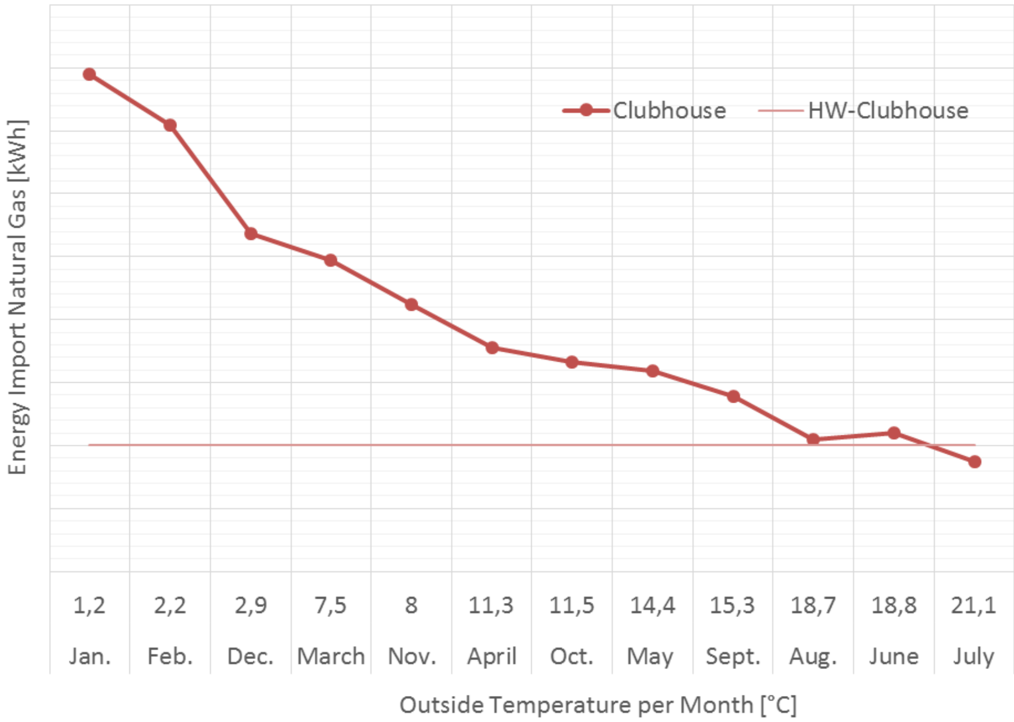

Figure 36: Energy Import of Natural Gas vs. Outside Temperature[137]

[137] own illustration, based on data from EVN Energievertrieb GmbH (2014) & www.zamg.ac.at (23.06.2015)

Further weaknesses are that no energy recovery system is installed and that no measurement and recordings were performed over the previous years. Last but not least, high heat losses in the restaurant area due to open doors and a large window facade are pointed out.

Lastly, all weaknesses are structured and summarized below:

- **Short-term remediable weaknesses**
    - High amount of heat loss due to open windows and a large window facade
    - Missing measurement data and recordings
- **Mid-term remediable weaknesses**
    - High energy consumption through the ventilation system
- **Long-term remediable weaknesses**
    - No recovery systems are installed
    - High amount of heat for heating operations in July and August.

3.3.3 Electrical Energy Clubhouse

The second type of energy used in the Clubhouse is electricity. For the investigation of the operational behaviour, the energy structure in Figure 37 splits the consumption of electrical energy into eight different areas. Because of minimal consumption of the “Fitness”, “Energy Distribution” and “Others” areas, in Figure 37, they are combined into the area “Others” in the energy use diagram in Figure 38. Due to missing data, assumptions for operation times and average energy consumption of some electrical devices have to be made. The procedure is explained as follows.

For the areas “Ventilation”, “Wellness”, and “Air Conditioner” data sheets and name plates are mostly available. Therefore, power of each consumption area can be clarified and recorded in the energy structure. Because of missing operating hour’s data, run times are estimated and discussed with employees afterwards.

The supplied energy which is measured at the metering station E-Kitchen can be seen in the sub-sector “E-Devices and Others” in the “Kitchen and Restaurant” area. An assumed value of 5 kWh/dinner and [redacted] dinners a year fits the consumption measurement of the metering point. Due to missing data for the cold and frozen stores, average values of energy consumption per year are assumed. Often, average values are based on previous investigations and are published at energie.ch.

The determination of energy demand for lightning is premised on figures from the company Eko-Lichtkonzepte for July 2013. The offer is split into single energy consumption devices and so suitable data can be derived.

A minimalized illustration of the energy structure can be seen in Figure 37. In the Appendix 10.6, a clear presentation is given.

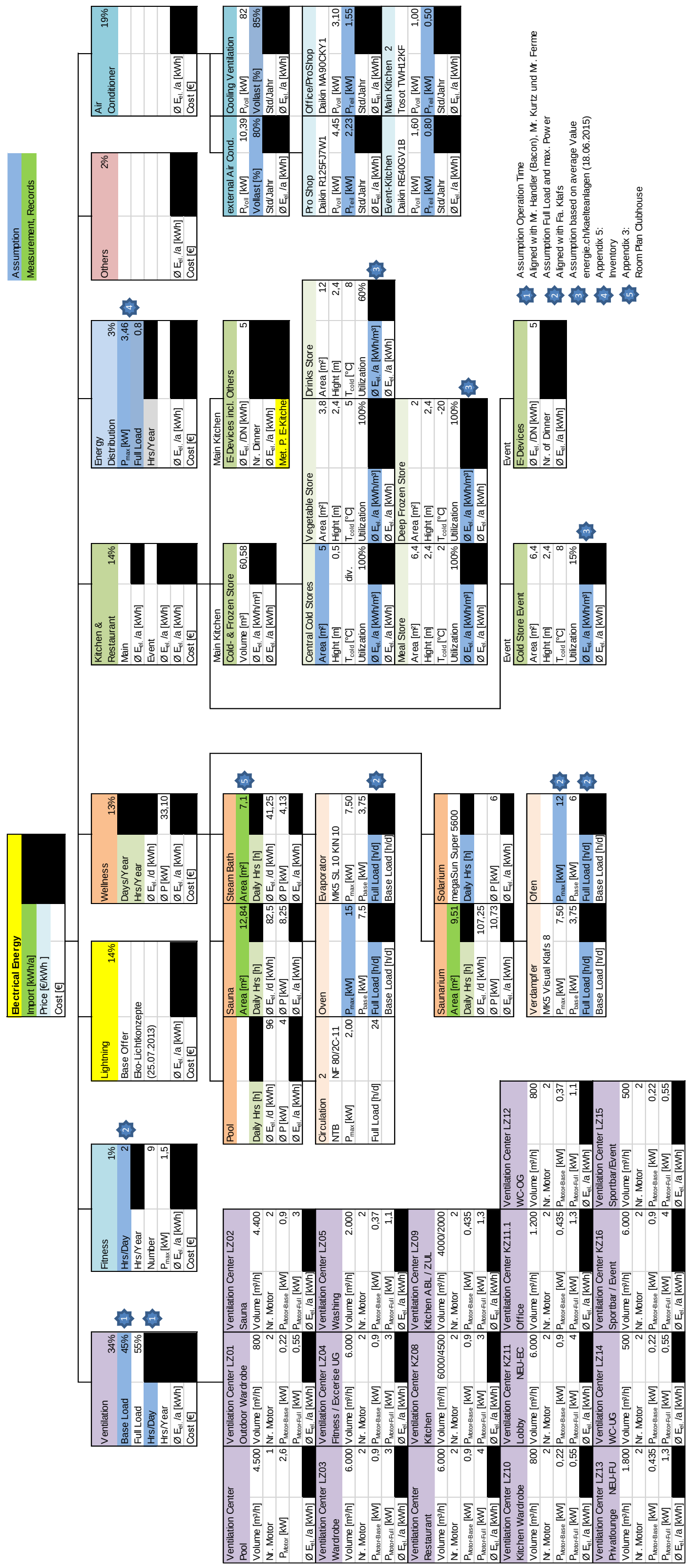

Figure 37: Energy Structure Electrical Energy for Clubhouse[138]

[138] own illustration

Figure 38 shows the amount of consumed energy in each area. It is remarkable that ventilation and air conditioners uses more than 50% of the total supplied electrical energy. Furthermore, “Wellness”, “Lightning” and “Kitchen and Restaurant” produce nearly at the same levels of energy consumption.

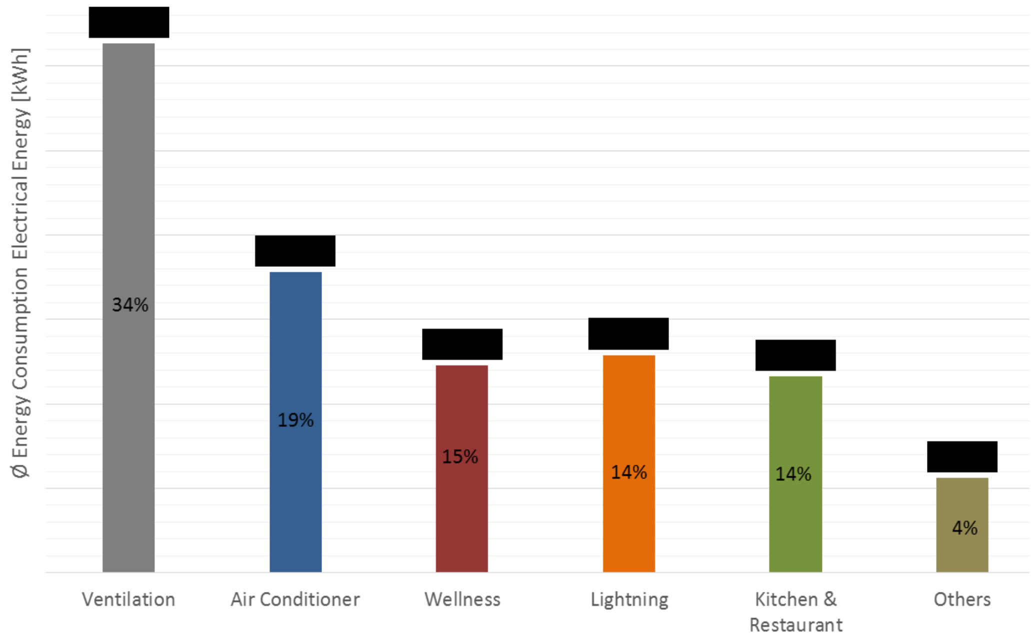

Figure 38: Energy Use Electrical Energy for the Clubhouse[139]

Weaknesses

After the allocation of different consumption areas weaknesses can be identified. Therefore a specific energy demand is calculated and compared to a reference value. The identification of weaknesses from natural gas and the reference figures are based on the benchmarking of four and five star hotels in Austria.

Electricity	Energy Import	Energy Reference Area	Specific Energy Demand
Clubhouse	[redacted]	2.544 m²	[redacted]
Reference[140]			180 kWh/m²a

Table 17: Specific Electrical Energy Demand for the Clubhouse[141]

[139] own illustration, based on own calculations

[140] cf. OEGUT-Österreichische Gesellschaft für Umwelt und Technik (2011)

[141] own illustration, based on data from Wien Energie Vertrieb GmbH (2014) & construction plan

There are many reasons that can explain the wide differences between the specific energy demands of the Clubhouse and the reference value. The reference doesn't consider such a large wellness area yet it does point out that the electrical energy being used inefficient.

In the past, electricity usage was completely uncontrolled, explaining the high amount of energy needed. Furthermore, sub-counters, which are installed in the control cabinet, were never recorded and reported. Also, definite assignments to those sub-counters were not given. That points out, that there was no awareness of energy consumption.

The second large part is the wellness area. A lot of energy is needed for continuous provision to all areas. Sauna, Saunarium and Steam Bath have to maintain the suitable temperatures the entire day because there are no specific times for using the wellness sector. This requires an enormous energy demand.

Below, all identified weaknesses are listed.

- **Short-term remediable weaknesses**
    - Missing responsibility of controlling the heating, ventilation and air-conditioning technology
    - Missing measurement data and recordings
    - Uncertainties of the control unit
- **Mid-term remediable weaknesses**
    - High energy consumption through ventilation
    - High energy consumption through lightning
- **Long-term remediable weaknesses**
    - No recovery systems are installed
    - Continuous energy provision to the wellness area

3.3.4 Natural Gas Tennis Center

For the investigation of the Tennis Center, consumption and use of natural gas is considered. Therefore, the energy structure differs between three application areas: Hot Water, Space Heating – Heating System and Space Heating – Ventilation System (see Figure 39).

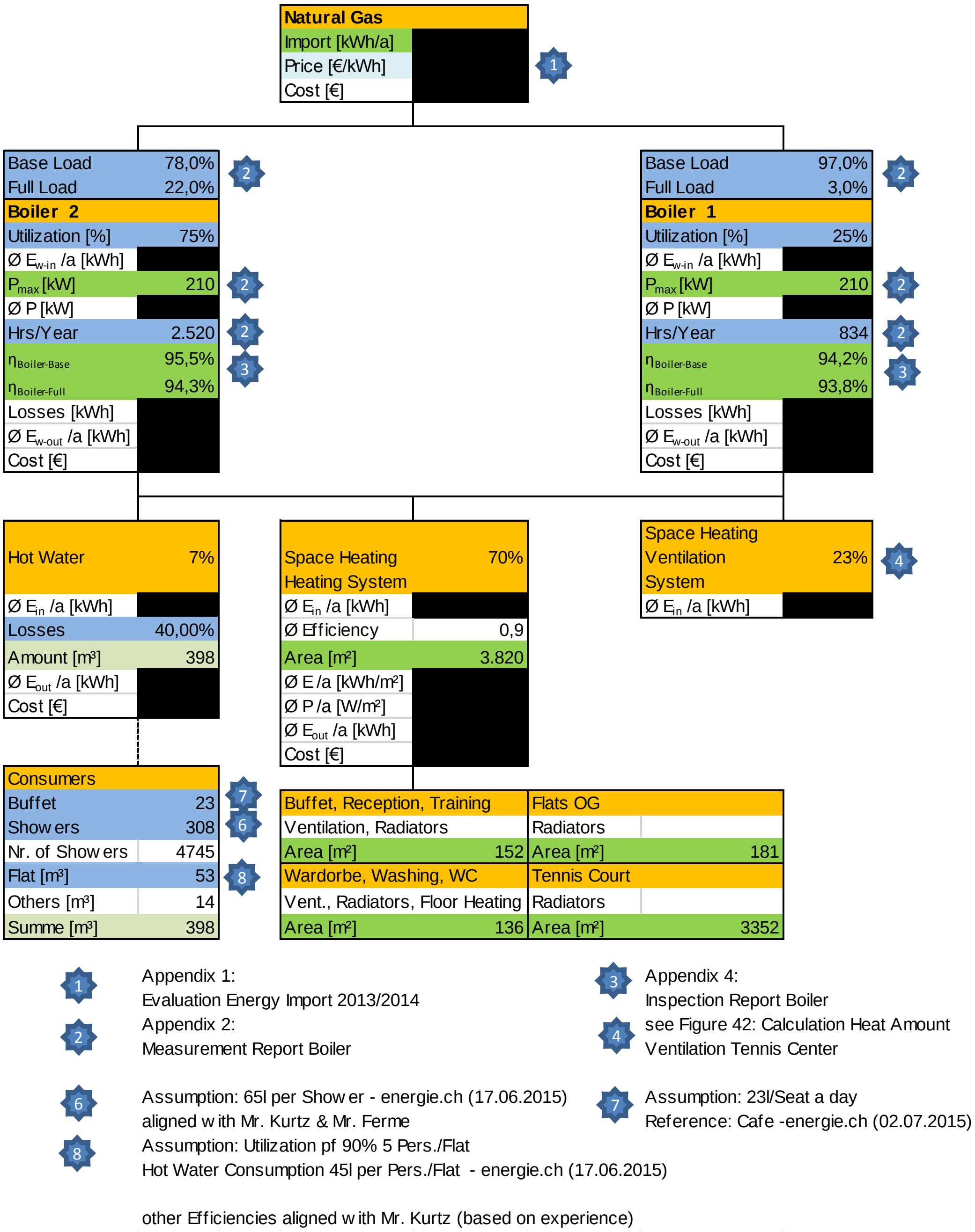

Figure 39: Energy Structure Natural Gas for the Tennis Center[142]

[142] own illustration

In the Tennis Center, heat energy is generated by the transformation of natural gas by two similar boilers. Then energy is distributed by different circulation pumps as are listed in Appendix 10.5

As a result of the energy structure, the consumption of each area is shown in Figure 40. Most of the energy is used for space heating through the heating system. Thereby, a large part is needed for the room heating operations of the Tennis Court where radiators and heating panels are installed.

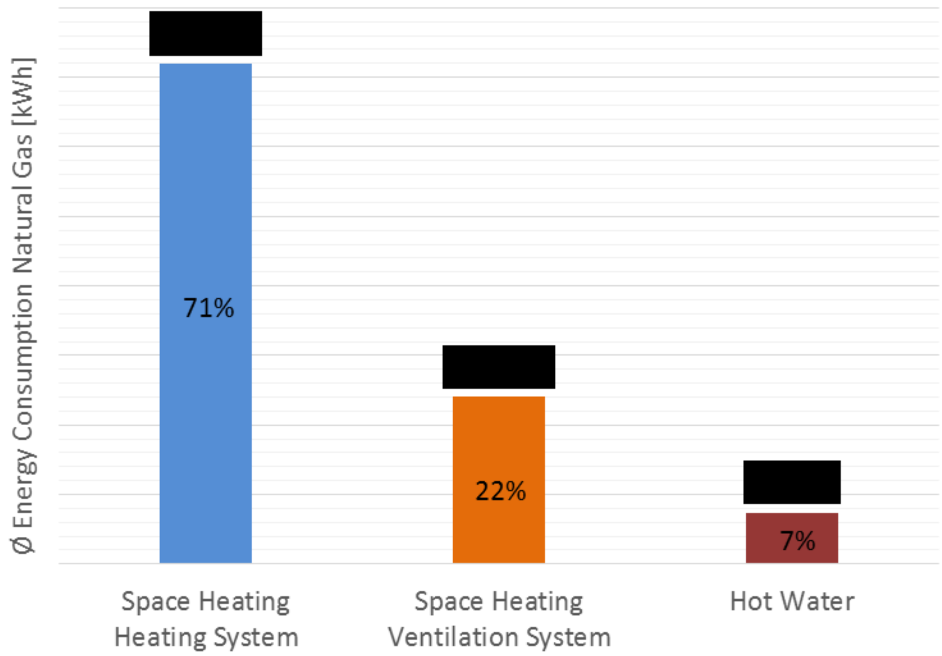

Figure 40: Energy Use Natural Gas for the Tennis Center[143]

The calculation procedure and assumptions illustrated in Figure 39 are described in detail below.

Hot Water

For calculation of the quantity of heat for hot water provision, consumption is assumed and aligned with employees. Consequently the required amount of hot water at the Tennis Center is 398 m³ per year (see Table 18 and Figure 39). Furthermore, Equation 14 is applied with the specific data of water shown in Table 8 and Table 9.

[143] own illustration, based on own calculations

Amount of Hot Water	V_{HW}	398	m³/a

Table 18: Amount of Hot Water for the Tennis Center[144]

Space Heating – Ventilation System

Similar to the Clubhouse, heat energy for the ventilation system of the Tennis Center is needed to increase the level from outside temperature to room temperature. Further heating operations through the ventilation system are not taken into consideration. The outside temperature that is used for the calculation in Table 20 was measured at the weather station in Wiener Neustadt[145]. As a basis for the average outside temperature, values for the years 2013 and 2014 are premised.

In Table 19, assumptions for operational behaviour are shown. Therefore, an average air exchange of [redacted] m³/h and a run time of [redacted] hours a day are estimated. Also a factor (x) of 80% full load run time is applied for the calculation of the duration per month. Equation 15 is used for the calculation of the heat quantity of the ventilation system and in Table 19 specific data is summarized.

Air Exchange	$\dot{V}$	[redacted]	m³/h
Duration per Day	t	[redacted]	h
Full Load	x	70	%

Table 19: Specific Data of the Ventilation for the Tennis Center[146]

[144]own illustration, based on data from www.energie.ch (17.06.2015)

[145] cf. www.zamg.ac.at (23.06.2015)

[146] own illustration, based on assumptions from Mr. Kurtz

Days	Month	Average Outside Temperature 2013/2014	Room Temperature	Temperature Difference (ΔT)	Heat Quantitiy per Hour (Q_H)	Duration per Month (D = t*x*days)	Space Heating Ventilation System ($Q_{Vent}=Q_H*D$)
		°C	°C	°C	kW	h	kWh
31	Jan.	0,6	18,0	17,4	[redacted]	[redacted]	[redacted]
28	Feb.	1,6	18,0	16,4	[redacted]	[redacted]	[redacted]
31	March	4,9	18,0	13,1	[redacted]	[redacted]	[redacted]
30	April	11,1	18,0	7,0	[redacted]	[redacted]	[redacted]
31	May	14,6	18,0	3,4	[redacted]	[redacted]	[redacted]
30	June	18,5	18,0	-0,5	[redacted]	[redacted]	[redacted]
31	July	21,8	18,0	-3,8	[redacted]	[redacted]	[redacted]
31	Aug.	19,9	18,0	-1,9	[redacted]	[redacted]	[redacted]
30	Sept.	15,0	18,0	3,1	[redacted]	[redacted]	[redacted]
31	Oct.	10,8	18,0	7,2	[redacted]	[redacted]	[redacted]
30	Nov.	6,9	18,0	11,1	[redacted]	[redacted]	[redacted]
31	Dec.	2,7	18,0	15,4	[redacted]	[redacted]	[redacted]
	Total						[redacted]

Table 20: Calculation of Heat Amount for Ventilation of the Tennis Center[147]

Space Heating – Heating System

The last application area for the use of natural gas in the Tennis Center is the space heating-heating system. Energy balance is appropriate for this calculation. The heat quantity for the heating system is the difference of heat generated by boiler stations and the energy used from other application areas. Equation 16 shows the resulting calculation approach.

$$Q_{Heating\ System} = Q_{Boiler1} + Q_{Boiler2} - Q_{Hot\ Water} - Q_{Ventilation}$$

Equation 17: Heat Quantity of Heating System for the Tennis Center[148]

[147] own illustration, based on data from www.zamg.ac.at (23.06.2015)

[148] cf. Recknagel, Sprenger, & Schramek (2007), p.1081

Weaknesses

Similar to the approach taken for the Clubhouse, key performance indicators are calculated and compared with reference values. First, Table 21 gives an overview of the energy behaviour of the Tennis Center. A thermal energy demand of [redacted] kWh is required for operation. Therefore [redacted] kWh of natural gas (see also Appendix 10.1) is transformed at an average efficiency of 95%. The energy costs are [redacted] € a year.

Natural Gas	Thermal Energy Demand	Efficiency	Ø Energy Import	Ø Energy Costs
Tennis Center	[redacted]	95,0 %	[redacted]	[redacted]

Table 21: Yearly Thermal Energy Demand of the Tennis Center[149]

In Table 22, indicators for the Tennis Center are computed with an energy reference area of 3.820 m². The specific energy demand total is applied to the total energy consumption. In contrast to that, the indicator specific energy demand room considers only the amount of heat that is used for space heating. This is also the basis for calculating the specific power demand for a room that takes an average operation time of 1800 hours a year for heating procedures. The reference values are based on figures from a Tennis Center in Germany with an area of 2.500 m² and an average heat energy consumption of 170.000 kWh a year.

KPI's	Energy Reference Area	Specific Energy Demand Total	Specific Energy Demand Room	Specific Power Demand Room
Tennis Center	3.820 m²	[redacted]	[redacted]	[redacted]
Reference[150]		90 kWh/m²a	68 kWh/m²a	38 W/m²

Table 22: KPI's Tennis Center[151]

[149] own illustration, based on data from EVN Energievertrieb GmbH (2014)

[150] cf. www.energiekontor-hannover.de (23.07.2015)

[151] own illustration, based on data from EVN Energievertrieb GmbH (2014) & construction plan

There are two reasons for the differences. Firstly, that the reference value doesn't account for the energy consumption of flats at the second floor of the Tennis Center. Second, the difference shows the excessive heating operation of the Tennis Courts through heating panels.

Below, all weaknesses are summarized.

- **Short-term remediable weaknesses**
  - Missing measurement data and recordings
- **Mid-term remediable weaknesses**
  - Excessive heating operation of Tennis Courts
- **Long-term remediable weaknesses**
  - No recovery systems are installed

3.3.5 Electrical Energy Tennis Center

The second energy source of the Tennis Center is electrical energy. The use of energy and the different application areas are described below.

Figure 41 exhibits a simulation energy behaviour at this location. In this analysis, consumption of energy is split into four different areas: “Ventilation”, “Flats”, “Lightning” and “Buffet”. The underlying assumptions, specific values and the calculation approach are explained below.

For the “Ventilation” area data sheets and name plates are available. Mostly of the power figures for each ventilation system can be defined. Because of missing operating hours counter, run times are estimated and cross-referenced with employees afterwards.

The section “Flats” contains the energy consumption of the five separated business apartments that are used by employees. For the calculation of the energy demand, average values are used. As mentioned before, these average values are based on benchmarking data and are published on www.energie.ch. For consumption values for the buffet, mean values are also applied.

Due to missing information and recordings the power of lights for the Tennis Courts are assumed.

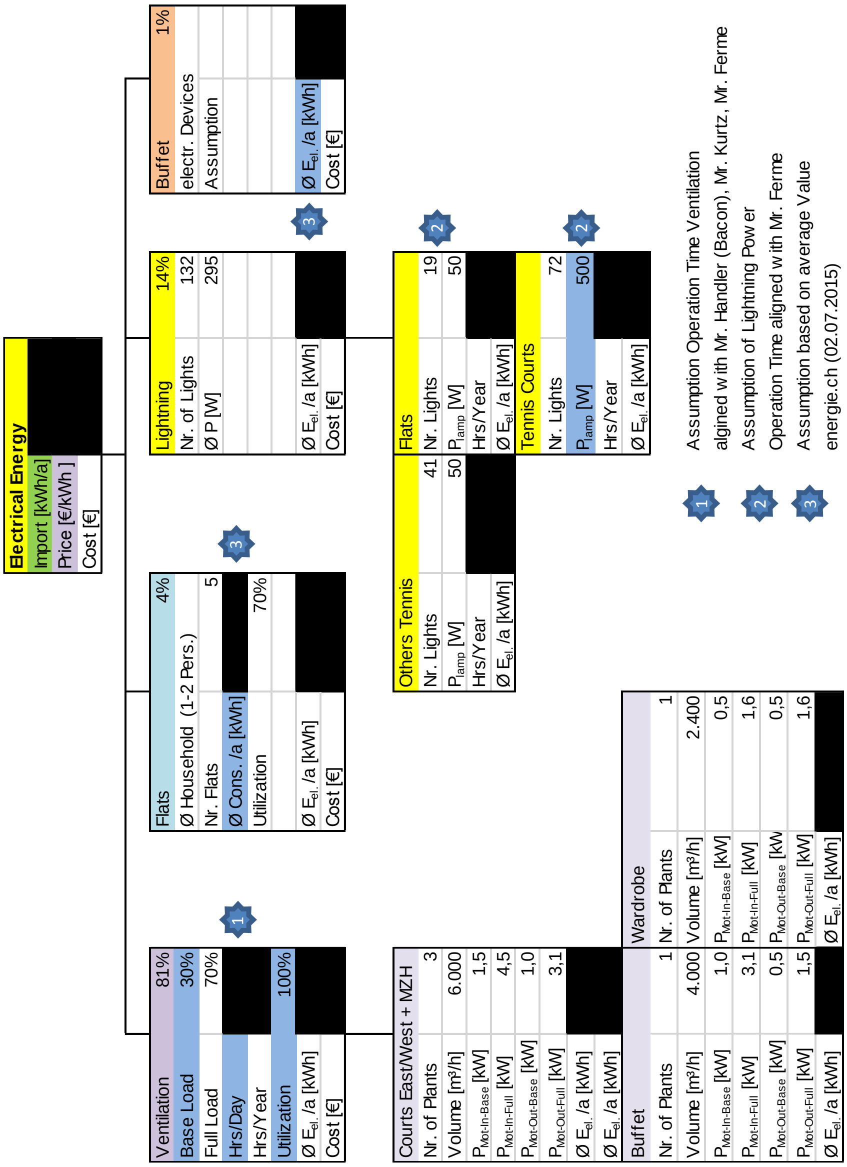

Figure 41: Energy Structure for Electrical Energy of the Tennis Center[152]

[152] own illustration

By referencing the results of the energy structure, energy consumption for each area can be shown in Figure 42. The diagram clearly shows that a large part (81%) of energy is used by the ventilation system. In contrast, the areas “Flats” and “Buffet” combine for only 5% of the total energy.

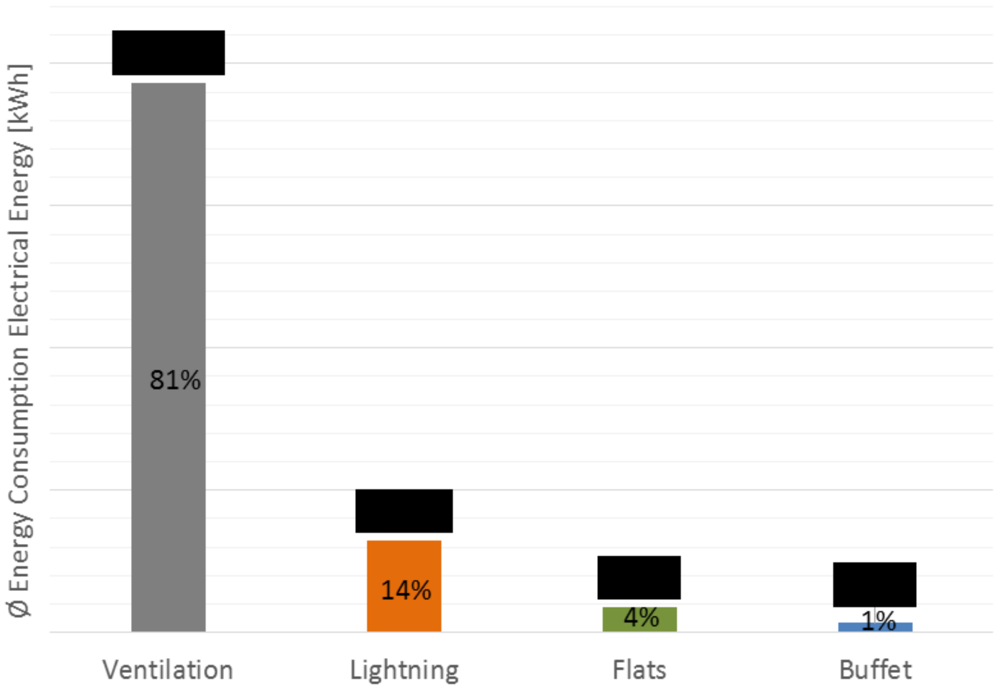

Figure 42: Energy Use of Electrical Energy of the Tennis Center[153]

Weaknesses

After the allocation of different consumption areas, weaknesses can be identified. Therefore a specific energy demand is calculated and compared with a reference value. In this case, the reference value is based on benchmarking data for sports halls and gyms in Germany. With an energy import of [redacted] kWh and a reference area of 3.820 m², the specific demand of electrical energy of the Tennis Center is [redacted] kWh/m²a.

[153] own illustration, based on own calculations

Electricity	**Energy Import**	**Energy Reference Area**	**Specific Energy Demand**
Tennis Center	[redacted]	3.820 m²	[redacted]
Reference[154]			23 kWh/m²a

Table 23: Specific Electrical Energy Demand of the Tennis Center[155]

Table 23 reveals that the energy consumption is above average. There are additional reasons that explain the difference.

First of all, there is no strict separation of the energy import for the Depot and Tennis Center. Hence, the exact energy import of each location is difficult to assign. Furthermore, data based on accurate recordings and measurements isn't available.

As Figure 42 states, most of the energy is used for ventilation. This leads to the assumption that the high energy usage is due to unchecked usage and inefficient operating behaviour. Another disadvantage is that no recovery systems are installed to use the radiated heat of ventilation systems.

Below, a summary of all weaknesses is listed.

- **Short-term remediable weaknesses**
  - Missing measurement data and recordings
- **Mid-term remediable weaknesses**
  - High energy consumption through ventilation
  - High energy consumption through lightning
- **Long-term remediable weaknesses**
  - No recovery system are installed

[154] cf. www.ages-gmbh.de (12.07.2015)

[155] own illustration, based on data from Wien Energie Vertrieb GmbH (2014) & construction plan

3.3.6 Natural Gas Depot

As the last location, the Depot is investigated. The same procedure is used as before. The energy structure differs between two main areas, hot water and space heating through the heating system (see Figure 43). Space heating combines the heating operations for the office and the workshop. Before the heat energy is consumed at these stations, natural gas is transformed by a boiler.

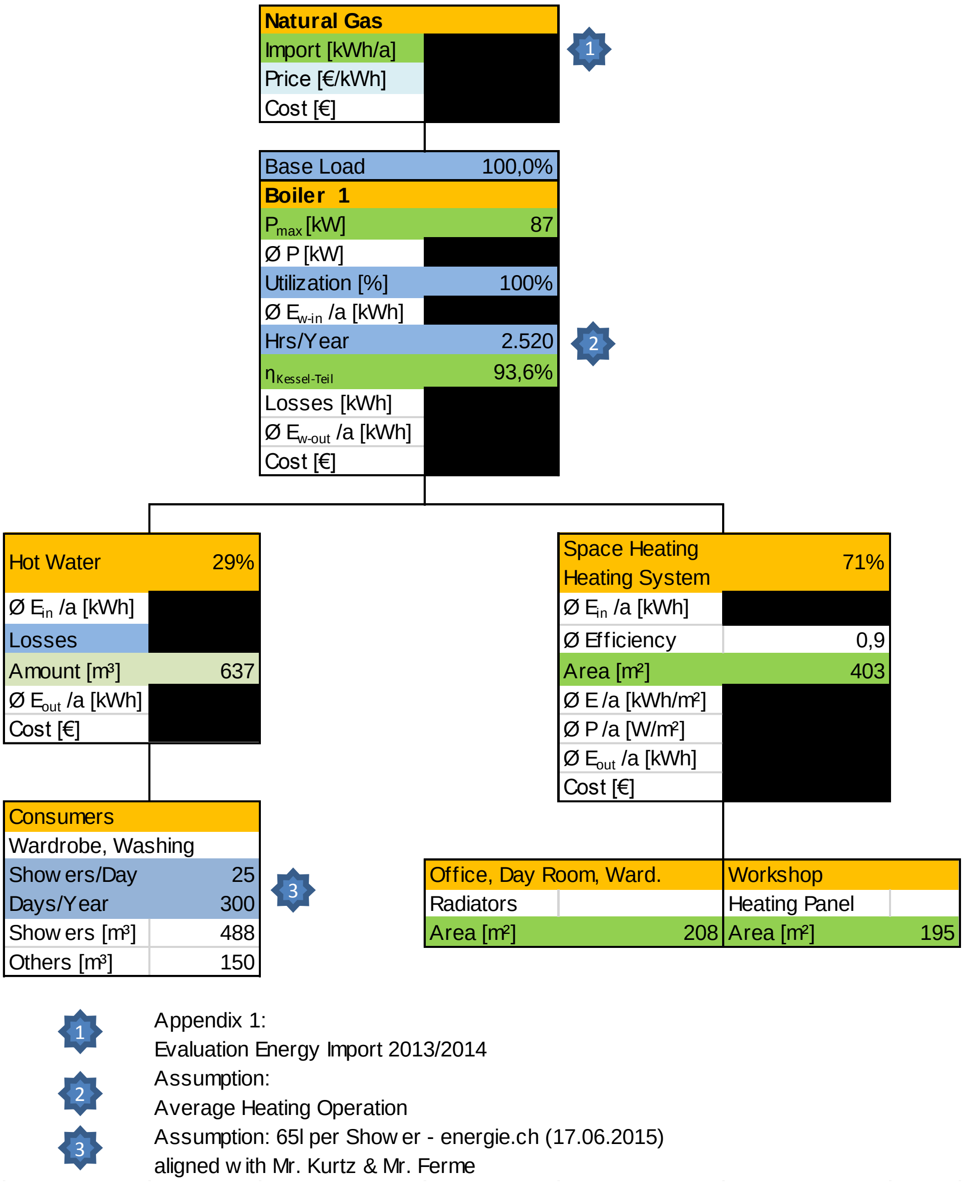

Figure 43: Energy Structure Natural Gas Depot[156]

[156] own illustration

The energy consumption results shown in Figure 44 are based on the energy structure. The calculation procedure is described below.

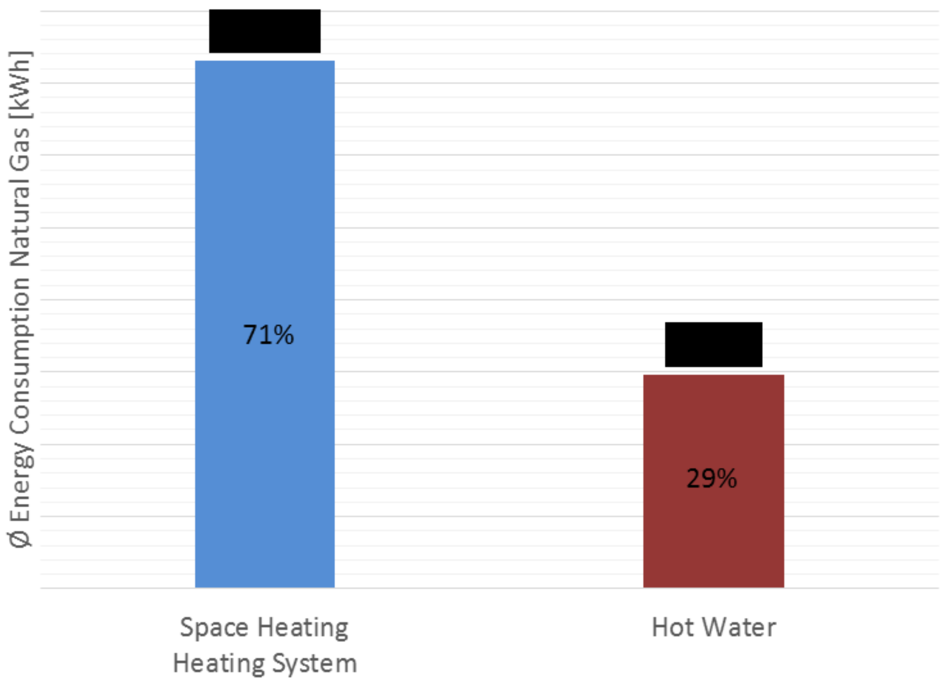

Figure 44: Energy Use Natural Gas Depot[157]

Hot Water

For the calculation of the heat quantity required for hot water provision, consumption figures are derived by cross-referencing usage according to employees. Consequently the required amount of hot water for the Depot is 637 m^3 a year (see Table 24 and Figure 43). Furthermore, Equation 14 is applied to the specific data of water shown in Table 8 and Table 9.

Amount of Hot Water	V_{HW}	637	m^3/a

Table 24: Amount of Hot Water for the Depot[158]

[157] own illustration, based on own calculations

[158]own illustration, based on data from www.energie.ch (17.06.2015)

Space Heating – Heating System

The second and last application area for the use of natural gas at the Depot is space heating through the heating system. The energy balance is appropriately used for this calculation. The heat quantity for the heating system arises from the difference of the heat generated by boiler stations and the energy used for hot water provision. Equation 18 states the calculation approach.

$$Q_{Heating\ System} = Q_{Boiler} - Q_{Hot\ Water}$$

Equation 18: Heat Quantity Heating System Depot[159]

Weaknesses

Afterwards, key performance indicators are calculated and compared with reference values. However, first, Table 25 gives an overview of the Depot's energy behaviour. A thermal energy demand of [redacted] kWh is required for operation. Therefore [redacted]kWh of natural gas (see also Appendix 10.1) is transformed at an average efficiency of 95%. The energy costs are [redacted]€ a year.

Natural Gas	Thermal Energy Demand	Efficiency	Ø Energy Import	Ø Energy Costs
Depot	[redacted]	95,0 %	[redacted]	[redacted]

Table 25: Yearly Thermal Energy Demand of the Depot[160]

In Table 26, indicators for the Depot are computed with an energy reference area of 403 m². The specific energy demand total is applied to the total energy consumption. In contrast, the indicator specific energy demand room considers only the heat amount used for space heating not including hot water provision. This is the basis for calculating the specific power demand room taken into account an average operation time of 1.800 hours per year for the heating

[159] cf. Recknagel, Sprenger, & Schramek (2007), p.1081

[160] own illustration, based on data from EVN Energievertrieb GmbH (2014)

procedure. The reference values are based on the average energy consumption of the garages and offices.

KPI's	Energy Reference Area	Specific Energy Demand Total	Specific Energy Demand Room	Specific Power Demand Room
Depot	403 m²	[redacted]	[redacted]	[redacted]
Reference[161]		125 kWh/m²a	70 kWh/m²a	38 W/m²

Table 26: KPI's Depot[162]

Table 26 shows that the heating operations in the Depot are completely unchecked. The specific energy demand is four times higher than the references value and points out that there an enormous saving potential. Due to unregulated heating controls, overheating of all rooms takes place the year round. The weaknesses are listed below.

- **Short-term remediable weaknesses**
  - Missing measurement data and recordings
- **Mid-term remediable weaknesses**
  - Enormous energy consumption through overheating
- **Long-term remediable weaknesses**
  - No recovery system are installed

[161] cf. www.energie.ch (09.07.2015)

[162] own illustration, based on data from EVN Energievertrieb GmbH (2014) & construction plan

3.3.7 Electrical Energy Depot

The last chapter deals with the consumption of electrical energy usage of the depot. The energy structure in Figure 45 splits the supplied energy into four different application areas. These are “Caddy Load”, “Lightning”, “Office” and “Workshop”.

The depot is where the Fontana’s golf carts are recharged. Charging of the batteries normally takes eight hours and consumes 1 kW per hour. According to Mr. Wagner ten golf carts are recharged [redacted] days a year. So the total amount of nearly [redacted] kWh can be calculated.

For the second area “Lightning” three sections are distinguished: office, workshop and outdoor lightning including the lamps for the office and workshop. In contrast, outdoor lightning figures are assumed due to unclear assignment of the car park lightning.

For the last two areas, “Office” and “Workshop” specific average values are used for the calculation. This values are based on the benchmarking published on www.energie.ch.

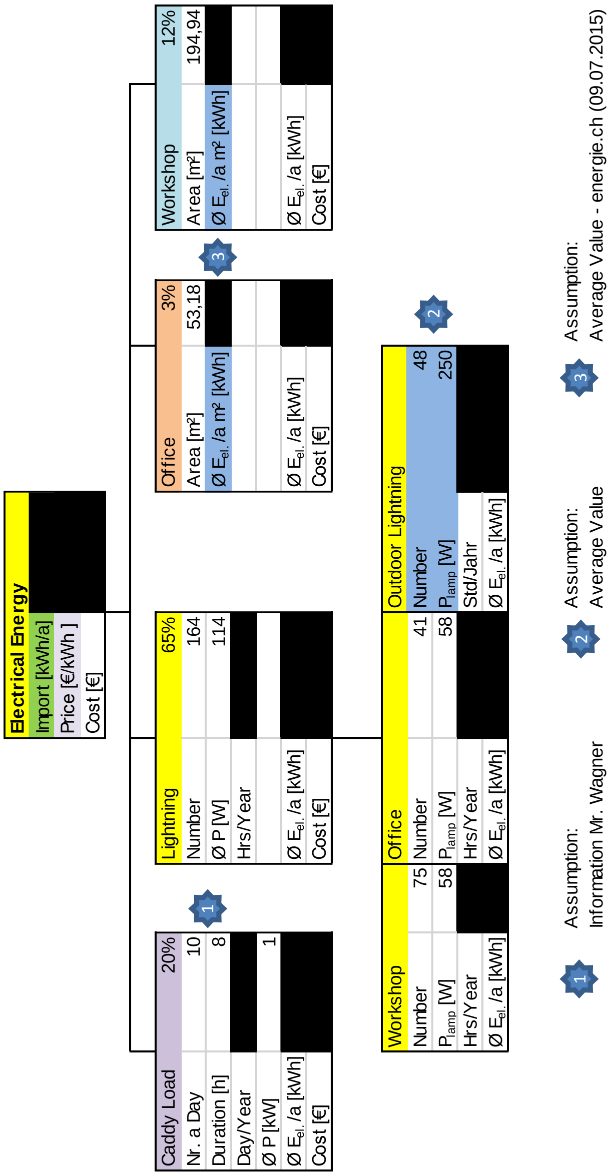

Figure 45: Energy Structure of Electrical Energy for the Depot[163]

[163] own illustration

Figure 46 shows the amount of consumed energy for each specific area based on the energy structure. It is interesting that “Lightning” and “Caddy Load” use 85% of the total energy. Considering that most of the work is done during the day when the sun is shining this result is unexpected. Mostly, this energy is used for lightning the car parking area. Conversly, the consumption of “Workshop” and “Office” with about 15% is minimal.

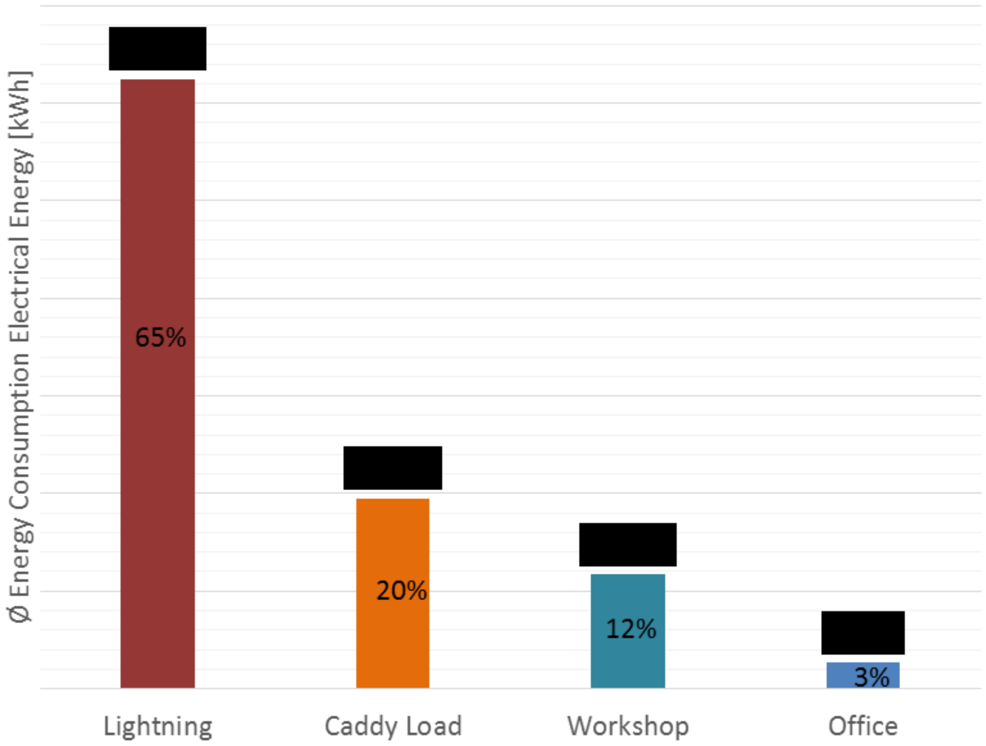

Figure 46: Energy Use of Electrical Energy for the Depot[164]

Weaknesses

At the end of this chapter, specific indicators are calculated as in the previous chapter. An energy import figure of [redacted] kWh and a reference area of 403 m² results in a specific energy demand of [redacted] kWh/m² a year (see Table 26). The reference value is based benchmarking data for the energy consumption of garages and offices.

[164] own illustration, based on own calculations

Electricity	Energy Import	Energy Reference Area	Specific Energy Demand
Depot	[redacted]	403 m²	[redacted]
Reference[165]			64 kWh/m²a

Table 27: Specific Electrical Energy Demand for the Depot[166]

The high demand of energy for lightning is also seen by comparing its value to the reference value. If the outdoor lightning and caddy loads are not considered in the calculation, the energy demand is below the reference value ([redacted] kWh/m²a). Nevertheless, improved energy awareness of employees can save energy. This can be simple things like turning off the lights when they are not needed or using natural sunlight.

Furthermore, it is pointed out that no clear separation of the consumption of electrical energy is possible due to the common metering point of the Tennis Center and Depot. Below all weaknesses are summarized.

- **Short-term remediable weaknesses**
    - Missing measurement data and recordings
- **Mid-term remediable weaknesses**
    - Enormous energy consumption through lightning
    - Lack of energy awareness of employees

[165] cf. www.energie.ch (09.07.2015)

[166] own illustration, based on data from Wien Energie Vertrieb GmbH (2014) & construction plan

3.4 Catalogue of Weaknesses

Golfclub

- Short-term remediable weaknesses
    - Missing measurement data and recordings
    - Missing responsibility of controlling the heating, ventilation and air-conditioning technology
    - Uncertainties of the control unit
- Mid-term remediable weaknesses
    - Lack of energy awareness of employees
- Long-term remediable weaknesses
    - No recovery systems are installed

Clubhouse

- Short-term remediable weaknesses
    - High amount of heat loss due to open windows and large window facade
- Mid-term remediable weaknesses
    - High consumption of heat energy through ventilation
    - High consumption of electrical energy through ventilation
    - High consumption of electrical energy through lightning
- Long-term remediable weaknesses
    - High amount of heat for heating operation in July and August
    - Continuous energy provision to the wellness area

Tennis Center

- Mid-term remediable weaknesses
    - Excessive heating operation of tennis courts
    - High consumption of electrical energy through ventilation
    - High consumption of electrical energy through lightning

Depot

- Mid-term remediable weaknesses
    - High consumption of heat energy through heating system
    - High consumption of electrical energy through lightning

3.5 Savings Potential – Recommendations for Action

The basis for deviation of recommendations for actions is the catalogue of weaknesses. Below, actions are described in the same sequence and assignment.

Before the calculation of investments starts, Table 28 shows imputed values which are needed for the resulting dynamic investment calculation. Those values are assumed based on the economic development from 2013 onward.

Imputed Interest Rate	3,0 %
Imputed Inflation Rate	2,0 %

Table 28: Imputed Values[167]

[167] own illustration, based on assumptions

3.5.1 Recommendations for the Golfclub Fontana

Regular Energy Control and Reporting

There is almost no investment needed to avoid short and mid-term remediable weaknesses. Mostly, those weaknesses can be remedied by introducing organizational actions by the management. Therefore, the regular inspection of plants, counter recordings and measurement comparison values (plausibility check) have to be done. Such regular activities help to avoid energy losses due to faulty equipment, control units and/or lines. Also costs due to the damage caused can be minimized.

The following actions for savings realization are suggested:

- Installation of measurement equipment for hot water consumption
- Installation of separated metering points for the Tennis Center and Depot
- Clarification of sub-counters in the low-voltage center in Clubhouse
- Regular, weekly inspection walk-throughs and recordings of counters and measurement equipment for:
    - boiler and air conditioners (operational hours counter)
    - electrical energy (metering points)
    - natural gas (metering points)
    - cold and hot water
- Improved energy awareness of employees (meetings, training)
- Regular inspection of settings (boiler, ventilation, air conditioner)

Resulting, after implementation 10% of total energy costs can be saved. The assumption of this defined value is based in possible cost saving by implementing an energy management system (explained in chapter 2.3.2).

Heat Recovery Systems

Missing recovery systems are a weakness of the whole golf course, but are also a part of each individual location and therefore discussed in the following points.

3.5.2 Recommendations for the Clubhouse

Reduced Use of Ventilation Systems

An optimized use of the ventilation systems in the Clubhouse shows that minimal changes of the usage behavior can have a big impact on energy costs. Figure 47 shows the comparison of the actual state and an optimized state. The actual state has daily operation time of 18,5 hours a day for the whole ventilation system. In contrast, the optimized state considers a daily operation time of 15 hours and the usage of ventilation for the event area only when required. As a result, cost savings of [redacted] € per year are possible.

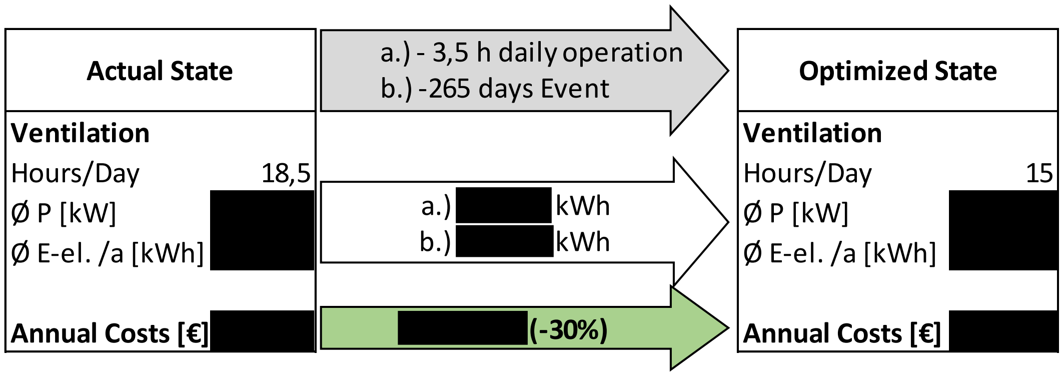

Figure 47: Savings of Electrical Energy by Reduced Ventilation[168]

[168] own illustration, based on own calculations

Reduced Operation Time Wellness Area

The actual operation time of the Sauna, Saunarium and Steam Bath areas is 12 hours a day. During this time the temperature of the whole wellness area is maintained whether it is used or not. While not efficient, maintaining a constant temperature uses less energy than a complete heat up operation.

Figure 48 shows possible yearly cost savings for electrical energy when the daily operation time is reduced by one hour a day. Also the savings due to closing of the swimming pool at the end of the year is considered.

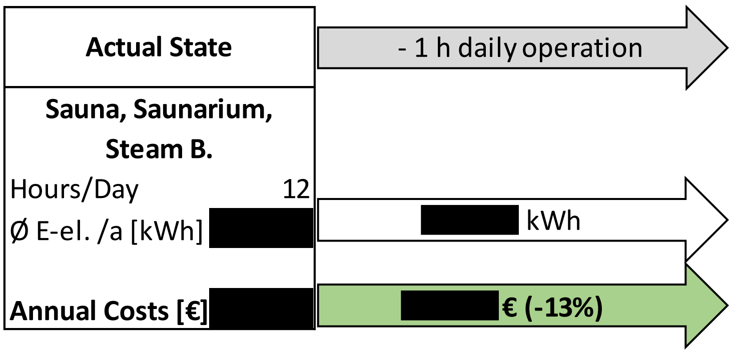

Figure 48: Savings of Electrical Energy by Reduced Operation Wellness[169]

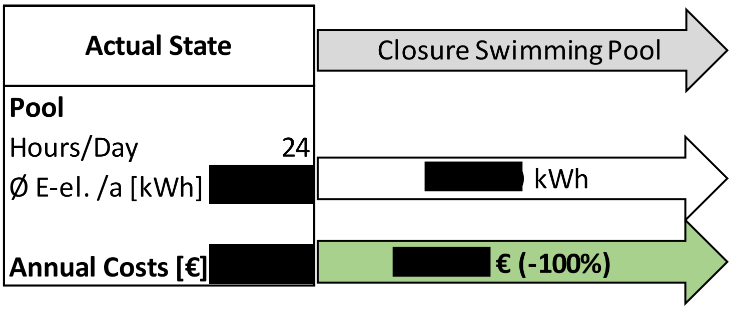

Figure 49: Savings of Electrical Energy by Closed Pool[170]

[169] own illustration, based on own calculations

[170] own illustration, based on own calculations

Implementation of LED-Lightning

Through a change of existing light bulbs, costs for lightning can be reduced by 85%. The calculation is based on figures by EKO-Lichtkonzepte. Potential savings and the investment calculation are illustrated below (Figure 50 and Table 29)

Figure 50: Optimized Lightning[171]

Actual State	
Annual Operating Costs Electrical Energy	[redacted] *€/a*
Action	
Investment Costs	25.000 €
Period of Use	10 Years
Optimized State	
Annual Operating Costs Electrical Energy	[redacted] *€/a*
Annual Operating Cost Savings	[redacted] €/a
KPI's – Dynamic Investment Calculation	
Average Annual Cost Savings over the Period of Use	[redacted] €/a
Payback Period	[redacted] Years
Capital Value	[redacted] €

Table 29: Investment Calculation LED-Lightning[172]

[171] own illustration, based on own calculations

[172] own illustration, based on own calculations

Optimized Operating Behaviour and New Heating System

By the installing a new heating system more than one weakness can be remedied. Heat recovery systems can be integrated and space heating can be separated from hot water provision to reduce heating operation in July and August. Additionally, surplus energy from recovery systems can be used for low temperature heating systems (like floor heating).

It is suggested to implement a new heating system which consists of natural gas condensing boilers and air-heating pumps. In this case, the advantages of both units can be used. Important facts for this recommendation are listed below.

- Installation of new boilers with integrated heat recovery
  (Condensing boilers also use condensation and evaporation heat)
- Separated hot water provision through air-heating pumps
- Heat recovery of ventilation systems and air conditioner through air-heating pumps
- Optimized control and regulation of ventilation
  - Air exchange [redacted] m³/h → [redacted] m³/h
  - Operating Time [redacted] h/day → [redacted] h/day
- Optimized control and regulation of heating system
  - Saving of 10% due to controlling and reporting (see page 25)

After implementation annual cost savings of [redacted] € are possible as illustrated in Figure 51. In contrast to the electrical energy, the import of natural gas can be reduced [redacted] kWh. For air heating pumps [redacted] kWh additional electrical energy is needed. Details are explained below.

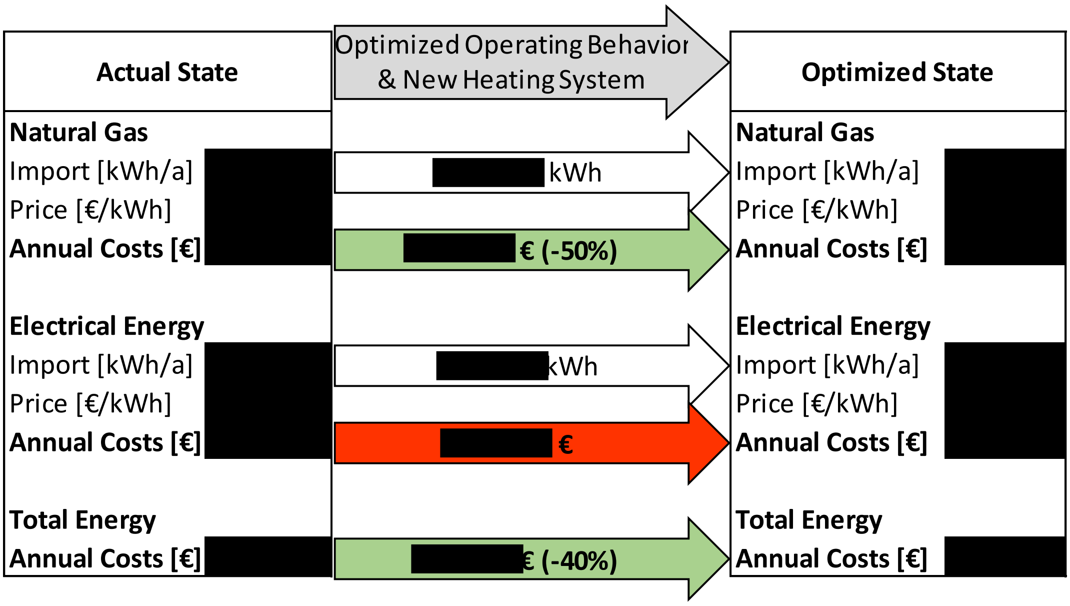

Figure 51: New Heating System for the Clubhouse[173]

In Figure 52, the possible savings in every specific field are shown. The shutdown of the pool-heating (-[redacted] kWh) is also considered in the following calculations. Through an optimized operating behaviour, energy consumption for space heating through the ventilation (-[redacted] kWh) and heating systems (-[redacted] kWh) can also be reduced. Furthermore, a separated hot water provision saves [redacted] € per year. Consequently, this is a reduction of [redacted] kWh natural gas per year. When the installation of new condensing boilers is also considered, a total decrease of [redacted] kWh of natural gas can be achieved. Regarding electrical energy [redacted] kWh is needed for air-heating pumps.

[173] own illustration, based on own calculations

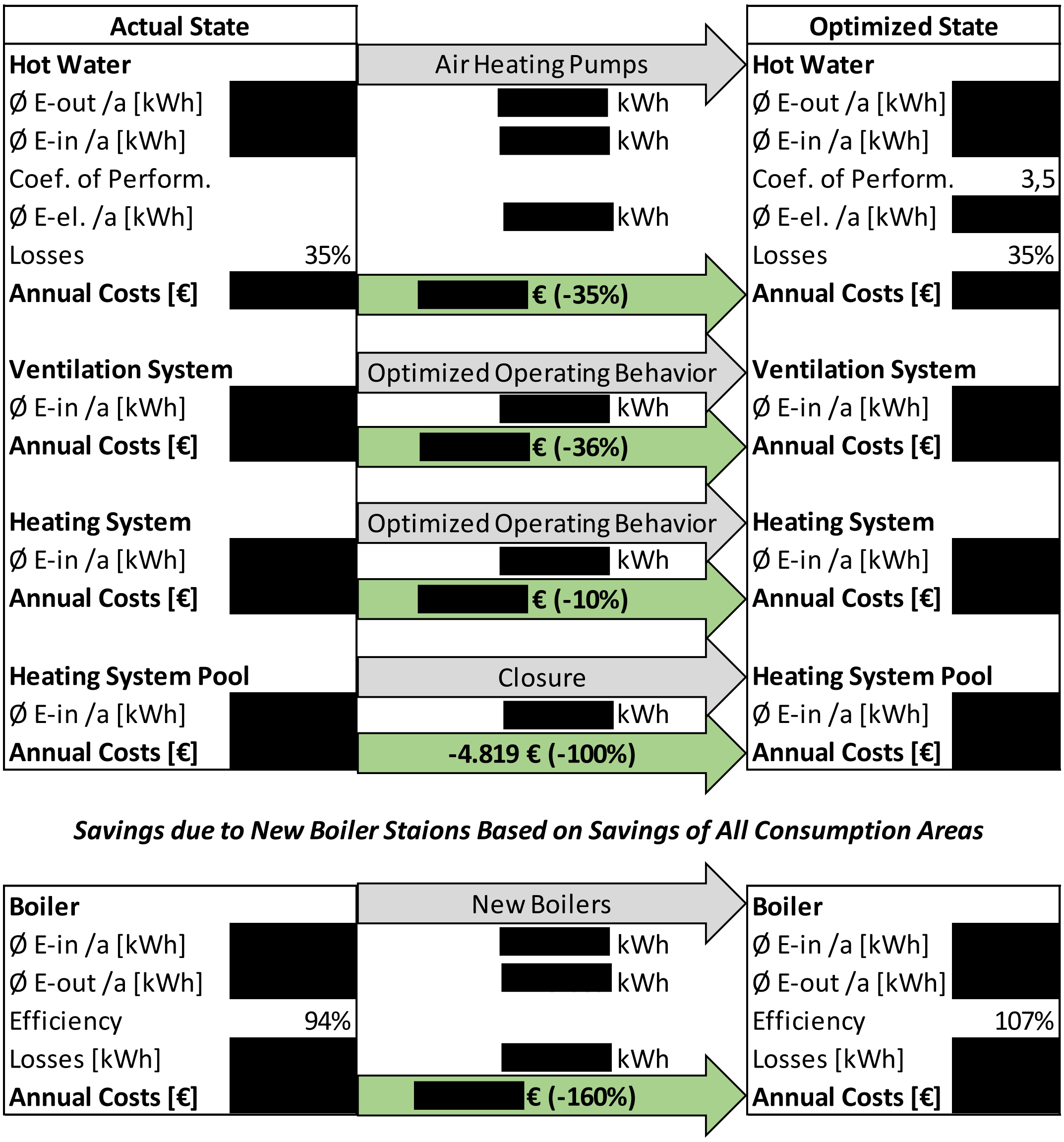

Figure 52: Details New Heating System for the Clubhouse[174]

Table 30 shows the dynamic investment calculation of the recommended heating system. The potential cost savings in Figure 51 are based on not only technical improvements but also on changed user and operating behaviour. It should be pointed out, that changed behaviour is necessary for the achievement of profitable investments.

[174] own illustration, based on own calculations

The investment costs for a new heating system are about 150.000 €. These costs are assumed by Mr. Kurtz of "Reisenhofer Haustechnik".[175]

There are three different indicators that are calculated for the profitability analysis. The average annual cost savings over the period of use also considers also the imputed rate of interest and inflation. Therefore it differs from the annual operating cost savings. The payback period shows when the investment is amortized and at the end the capital value (NPV-Method) is calculated. Different indicators of different calculation methods are used to form a clear statement.

Actual State	
Annual Operating Costs Natural Gas	[redacted] *€/a*
Annual Operating Costs Electrical Energy	[redacted] *€/a*
Annual Operating Costs Total	[redacted] *€/a*

Action	
Investment Costs	150.000 €
Period of Use	15 Years

Optimized State	
Annual Operating Costs Natural Gas	[redacted] €/a
Annual Operating Costs Electrical Energy	[redacted] €/a
Annual Operating Costs Total	[redacted] €/a
Annual Operating Cost Savings	[redacted] €/a

KPI's – Dynamic Investment Calculation	
Average Annual Cost Savings over the Period of Use	[redacted] €/a
Payback Period	[redacted] Years
Capital Value	[redacted] €

Table 30: Investment Calculation New Heating System of the Clubhouse[176]

[175] Meeting Mr. Kurtz (30.07.2015)

[176] own illustration, based on own calculations

Overall Potential Cost Savings

Figure 53 shows a potential optimized state of the operating costs after the implementation of all recommended actions. It's is assumed that the daily operation time of the wellness area is reduced by four hours. The function of cost savings is linear, resulting the potential savings of [redacted] € per year, as described above, are multiplied by four as described above.

Total potential savings are about [redacted] € a year, which is almost equally distributed to the import of natural gas and electrical energy.

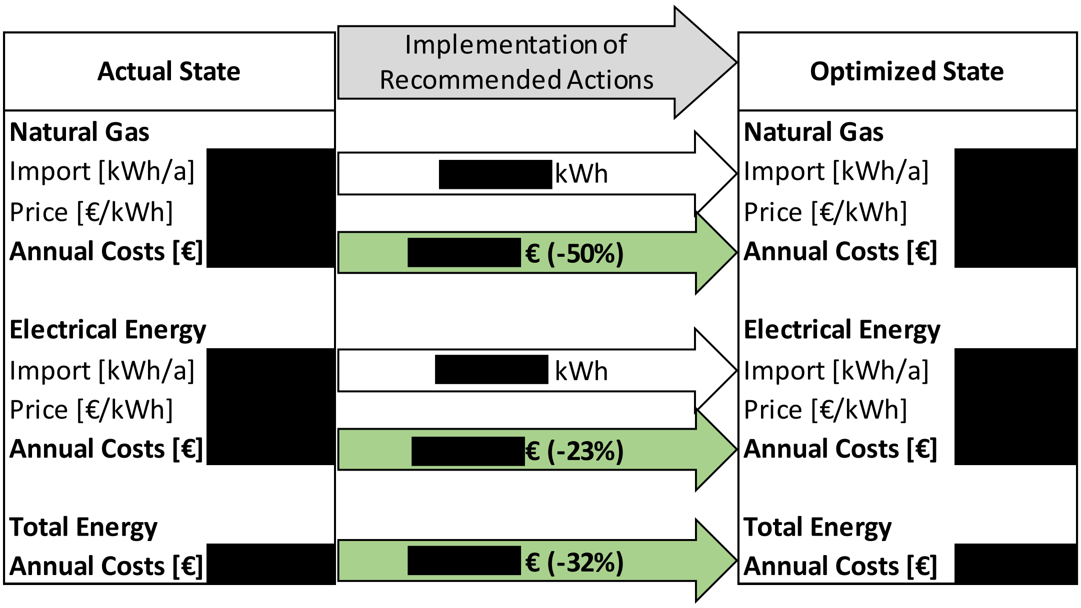

Figure 53: Operating Costs after Implementation[177]

[177] own illustration, based on own calculations

3.5.3 Recommendations for the Tennis Center

At the moment of this project, future use of the Tennis Center is not clarified. Savings potential highly depends greatly on the form of use and associated influencing factors. Therefore Mr. Pongratz agreed in Steering Meeting 2 that no recommendations for action should be formed for this location.

3.5.4 Recommendations for the Depot

Optimized Operating Behaviour and New Heating System

The catalogue of weaknesses and the indicators of the Depot show excessive heating operation for the space heating of the office and workshop. One reason is inadequate function of the control unit. Following, actions are recommend to reduce costs:

- Installation of new boilers with integrated heat recovery (Condensing boilers also use condensation and evaporation heat)
- Separated hot water provision through air-heating pumps
- Installation of a simple usable and clear structured control unit
- Optimized control and regulation of the heating operation

Hot water provision should be separated from the room heating unit to avoid unnecessary heating operation during the r months of July and August. Therefore the boiler can be deactivated and an air –heating pump can be used to supply the consumers with hot water.

Figure 54 illustrates the overall view of the cost reduction by implementing a new heating system and an optimized operating behaviour. Annual cost savings of [redacted] € for natural gas results in [redacted] € by consideration the electrical energy.

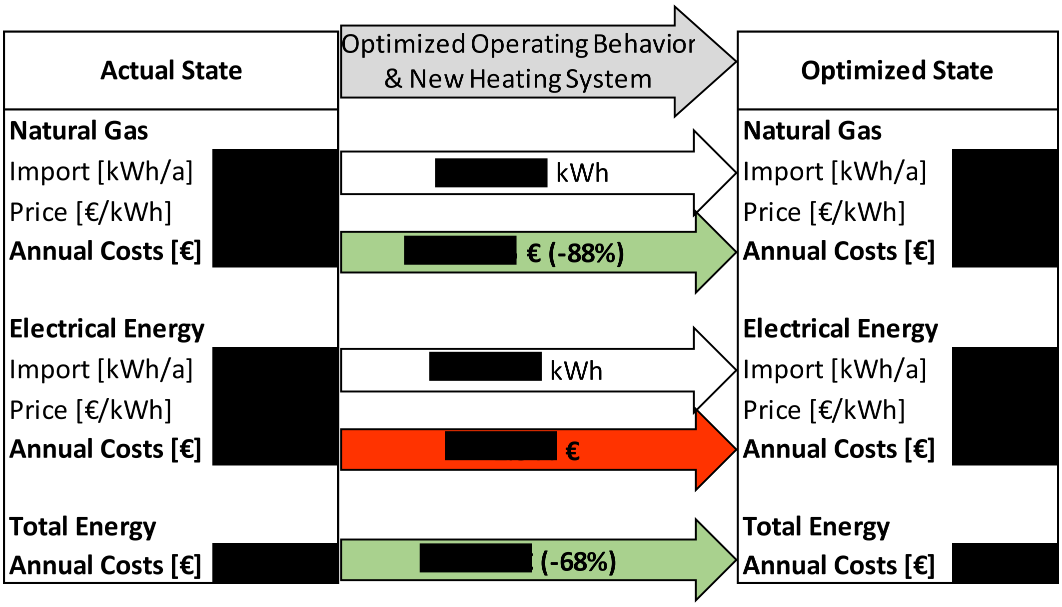

Figure 54: New Heating System for the Depot[178]

In Figure 55, potential cost savings and optimized state of energy consumption is shown in detail. In total, the natural gas consumption can be reduced by [redacted] kWh. If a better efficiency of the boiler is also considered a resulting energy reduction of [redacted] kWh of natural gas can be achieved. With regard to electrical energy, [redacted] kWh is needed for hot water provision.

For the reduction of the consumption of the heating system depends on an optimized operating behaviour. It is assumed that the reference value in Table 26 can be achieved in future. Resulting, cost savings of by optimized operating behaviour are [redacted] €.

[178] own illustration, based on own calculations

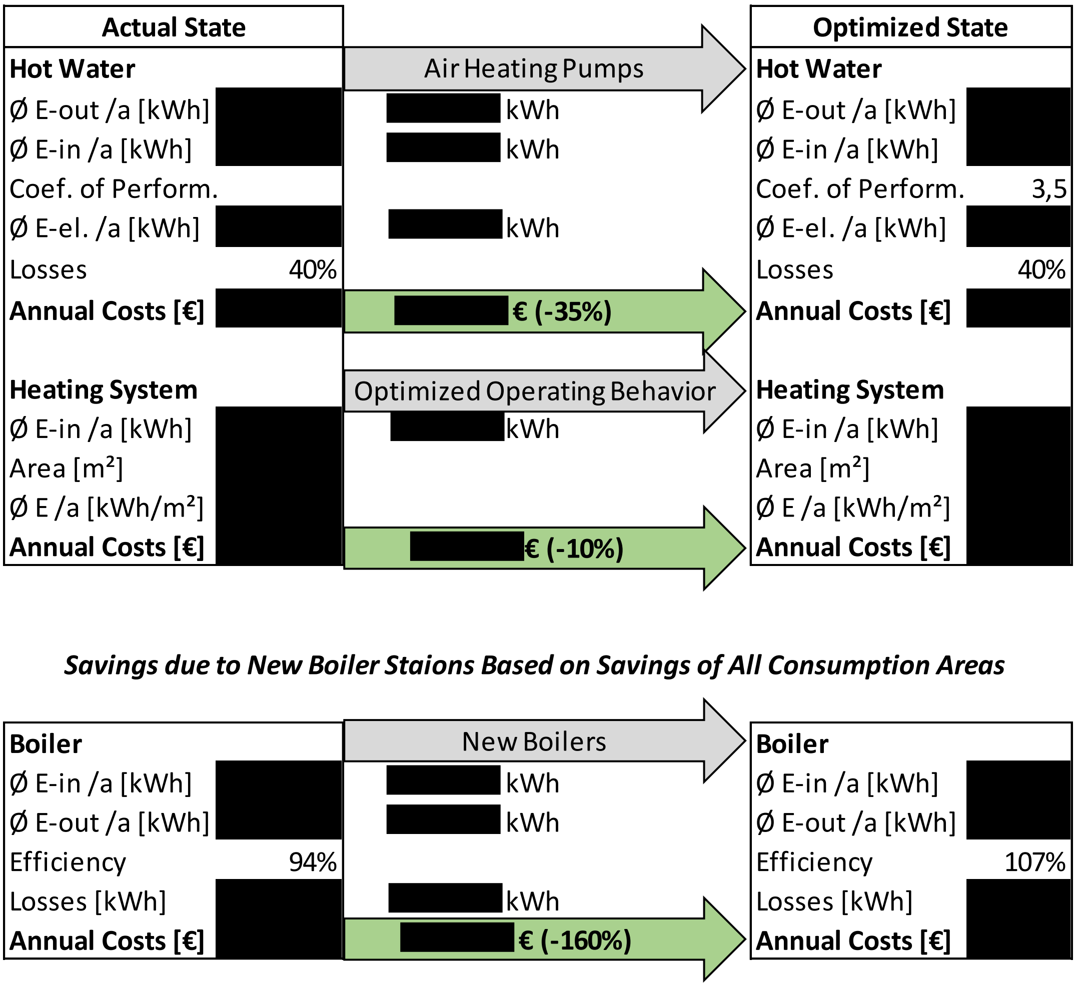

Figure 55: Details New Heating System for the Depot[179]

Table 31 shows the dynamic investment calculation of the new heating system. The potential cost savings in Figure 54 are based not only on technical improvements but also on changed user and operating behaviour. It should be pointed out, that changed behaviour is necessary to achieve profitable investments.

The investment costs for a new heating system are about 40.000 €. This costs are assumed by Mr. Kurtz of "Reisenhofer Haustechnik". [180]

[179] own illustration, based on own calculations

[180] Meeting Mr. Kurtz (30.07.2015)

The three different key performance indicators of the dynamic investment calculation were explained on page 94 for the heating system calculation of the Clubhouse.

Actual State	
Annual Operating Costs Natural Gas	[redacted] *€/a*
Annual Operating Costs Electrical Energy	[redacted] *€/a*
Annual Operating Costs Total	[redacted] €/a

Action	
Investment Costs	40.000 €
Period of Use	15 Years

Optimized State	
Annual Operating Costs Natural Gas	[redacted] *€/a*
Annual Operating Costs Electrical Energy	[redacted] *€/a*
Annual Operating Costs Total	[redacted] €/a
Annual Operating Cost Savings	[redacted] €/a

KPI's – Dynamic Investment Calculation	
Average Annual Cost Savings over the Period of Use	[redacted] €/a
Payback Period	[redacted] Years
Capital Value	[redacted] €

Table 31: Investment Calculation of a New Heating System for the Depot[181]

[181] own illustration, based on own calculations

4 Summary and Conclusion

The investigation shows that energy was used often unnecessary and inefficient in the past. This happened because of a lack of energy awareness of employees and the missing responsibility for monitoring and controlling the energy consumption.

It is demonstrated that large savings can be achieved by reducing operating times. Therefore only a changed operating and usage behaviour is needed to achieve those reductions without any investment. For this change the most important point is to clarify, monitor and control the energy demand of single areas. So, failures due to faulty equipment, broken control devices or incorrect use of heating, ventilation or cooling systems can be pointed out at an early stage and future costs can be avoided. Furthermore regularly maintaining the systems shall ensure that the operations are running efficient.

However, the prevention of energy demand and the reduction of energy consumption are not the only possibilities to decrease energy costs. Mostly, technologies of electrical devices, heating, ventilation and cooling systems are outdated after 10 years. After that time new technologies for energy transformation are on the market and it is advisable to think about changing some devices or equipment. Often, only small investments have to be realized to reduce yearly energy costs.

Another important point is to check the energy costs with the utility regular and to compare energy prices with average market prices. For negotiations with energy companies it is important to be informed about actual average prices on the energy market.

Finally, on the economical view, a company has to make sure that their income is bigger than their expenditures otherwise the company will not run business over a long time. Resulting, it is not always necessary to increase income to make profit, sometimes it is easier to reduce expenditures. For companies, the energy costs can be a big part of their total costs, therefore it pays off to direct attention on the energy management.

Be aware of how much energy is used and how much energy is really needed, the environment and the financials will be grateful.

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6 List of Figures

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9 Formula Directory

a	Annuity Factor
c_{air}	Specific Heat Capacity of Air
c_W	Specific Heat Capacity of Water
C_D	Imputed Depreciation Allowance
C_f	Fixed Costs
C_I	Imputed Interests
C_t	Cash Flow
C_{total}	Total Costs
C_v	Varibale Costs
C_0	Capital Value
D	Duration per Month
i	(Imputed) Interest Rate
I_0	Investment Pay Out
L	Liquity Revenue
n	Periode of Use
P	Cost Price
P_i	Internal Rate of Interest
P_V	Present Value
Q	Heat Quantity
Q_H	Heat Quantity per Hour
$Q_{Hot\ Water}$	Heat Quantity for Hot Water
Q_{Pool}	Heat Quantity for the Pool
Q_{Vent}	Heat Quantity for Ventilation
ROA	Return on Total Assets
ROE	Return on Owner's Equity
ROI	Return on Investment
T	(Imputed) Period of Use
t	Period of Use
t	Duration per Day
t_{cold}	Temperature of Cold Water
t_{hot}	Temperature of Hot Water
V	Volume
V_{HW}	Amount of Hot Water
$\dot{V}$	Air Exchange
x	Rate of Full Load

ΔT	Daily Heat Losses
ρ_{air}	Density Air
ρ_w	Density Water

10 Appendix

10.1 Appendix 1: Evaluation Energy Import 2013/2014

Energy Import Natural Gas 2013/2014 - Golfclub Fontana[3]

Nr.	Description	Address	Cost Center	Metering Point
1	Fontana Sportveranstaltungs	[redacted]	Clubhouse	[redacted]
2	Fontana Sportveranstaltungs	[redacted]	Depot	[redacted]
3	Fontana Sportveranstaltungs	[redacted]	Tennis Center	[redacted]

Monthly Energy Import (rising outside temperature)

	Month	Year	Temp.	Tennis Center	Club-house	Depot
			[°C]	[kWh]	[kWh]	[kWh]
1	Jan.	2013	0	[redacted]	[redacted]	[redacted]
2	Feb.	2013	0,4	[redacted]	[redacted]	[redacted]
12	Dec.	2013	2	[redacted]	[redacted]	[redacted]
3	March	2013	2,3	[redacted]	[redacted]	[redacted]
11	Nov.	2013	5,3	[redacted]	[redacted]	[redacted]
10	Oct.	2013	10,1	[redacted]	[redacted]	[redacted]
4	April	2013	10,8	[redacted]	[redacted]	[redacted]
9	Sept.	2013	14,6	[redacted]	[redacted]	[redacted]
5	May	2013	14,8	[redacted]	[redacted]	[redacted]
6	June	2013	18,2	[redacted]	[redacted]	[redacted]
8	Aug.	2013	21,1	[redacted]	[redacted]	[redacted]
7	July	2013	22,4	[redacted]	[redacted]	[redacted]

	Month	Year	Temp.	Tennis Center	Clubhouse	Depot
			[°C]	[kWh]	[kWh]	[kWh]
1	Jan.	2014	1,2	[redacted]	[redacted]	[redacted]
2	Feb.	2014	2,2	[redacted]	[redacted]	[redacted]
12	Dec.	2014	2,9	[redacted]	[redacted]	[redacted]
3	March	2014	7,5	[redacted]	[redacted]	[redacted]
11	Nov.	2014	8	[redacted]	[redacted]	[redacted]
4	April	2014	11,3	[redacted]	[redacted]	[redacted]
10	Oct.	2014	11,5	[redacted]	[redacted]	[redacted]
5	May	2014	14,4	[redacted]	[redacted]	[redacted]
9	Sept.	2014	15,3	[redacted]	[redacted]	[redacted]
8	Aug.	2014	18,7	[redacted]	[redacted]	[redacted]
6	June	2014	18,8	[redacted]	[redacted]	[redacted]
7	July	2014	21,1	[redacted]	[redacted]	[redacted]

Total Energy Import

	Month	Year	Temp.	Tennis Center	Club-house	Depot	Total
			[°C]	[kWh]	[kWh]	[kWh]	[kWh]
1	Jan.	2013	0	[redacted]	[redacted]	[redacted]	[redacted]
2	Feb.	2013	0,4	[redacted]	[redacted]	[redacted]	[redacted]
3	March	2013	2,3	[redacted]	[redacted]	[redacted]	[redacted]
4	April	2013	10,8	[redacted]	[redacted]	[redacted]	[redacted]
5	May	2013	14,8	[redacted]	[redacted]	[redacted]	[redacted]
6	June	2013	18,2	[redacted]	[redacted]	[redacted]	[redacted]
7	July	2013	22,4	[redacted]	[redacted]	[redacted]	[redacted]
8	Aug.	2013	21,1	[redacted]	[redacted]	[redacted]	[redacted]
9	Sept.	2013	14,6	[redacted]	[redacted]	[redacted]	[redacted]
10	Oct.	2013	10,1	[redacted]	[redacted]	[redacted]	[redacted]
11	Nov.	2013	5,3	[redacted]	[redacted]	[redacted]	[redacted]
12	Dec.	2013	2	[redacted]	[redacted]	[redacted]	[redacted]

	Month	Year	Temp.	Tennis Center	Club-house	Depot	Total
			[°C]	[kWh]	[kWh]	[kWh]	[kWh]
1	Jan.	2014	1,2	[redacted]	[redacted]	[redacted]	[redacted]
2	Feb.	2014	2,2	[redacted]	[redacted]	[redacted]	[redacted]
3	March	2014	7,5	[redacted]	[redacted]	[redacted]	[redacted]
4	April	2014	11,3	[redacted]	[redacted]	[redacted]	[redacted]
5	May	2014	14,4	[redacted]	[redacted]	[redacted]	[redacted]
6	June	2014	18,8	[redacted]	[redacted]	[redacted]	[redacted]
7	July	2014	21,1	[redacted]	[redacted]	[redacted]	[redacted]
8	Aug.	2014	18,7	[redacted]	[redacted]	[redacted]	[redacted]
9	Sept.	2014	15,3	[redacted]	[redacted]	[redacted]	[redacted]
10	Oct.	2014	11,5	[redacted]	[redacted]	[redacted]	[redacted]
11	Nov.	2014	8	[redacted]	[redacted]	[redacted]	[redacted]
12	Dec.	2014	2,9	[redacted]	[redacted]	[redacted]	[redacted]

Yearly Hot Water Consumption [kWh][2]
(Calculation based on 2-Year Mean Value)

	Tennis Center	Club-house	Depot
	[kWh]	[kWh]	[kWh]
Average 2013	[redacted]	[redacted]	[redacted]
Average 2014	[redacted]	[redacted]	[redacted]
2Y-Average	[redacted]		

Energy Import [kWh]
(Calculation based on 2-Year Mean Value)

	Tennis Center	Club-house	Depot	**Total**
	[kWh]	[kWh]	[kWh]	**[kWh]**
Average 2013	[redacted]	[redacted]	[redacted]	[redacted]
Average 2014	[redacted]	[redacted]	[redacted]	[redacted]
2Y-Average	[redacted]			

1 Temp - average monthly outside temperature- w w w .zamg.ac.at (23.06.2015)
2 Approach for the Determination of Heat Water - Jagnow /Wolff - w w w .delta-q.de (16.06.2015)
3 Mail from Guido Ferme on 11.05.2015 - EVN Energievertrieb GmbH (2014)

Figure 56: Evaluation Energy Import 2013/2014[182]

182 own illustration, based on EVN Energievertrieb GmbH (2014)

10.2 Appendix 2: Measurement Report Boiler

Boiler 1				
Date	Time	Operating Hours		Source
		Base Load [h]	Full Load [h]	
20.04.2015	19:45	15593,75	4128,43	Image Documentation
22.04.2015	10:40	15593,75	4128,45	Image Documentation
23.04.2015	11:20	15593,75	4128,45	Image Documentation
28.04.2015	15:20	15593,75	4128,45	Image Documentation
29.04.2015	11:20	15593,75	4128,45	Image Documentation
21.05.2015	11:00	15594,46	4128,47	Image Documentation

Full Load	**20,93%**	**Term [Years]**	**19**
Base Load	**79,07%**	**Hrs/Year**	**1038**

Boiler 2				
Date	Time	Operating Hours		Source
		Base Load [h]	Full Load [h]	
20.04.2015	19:45	21867,69	4850,72	Image Documentation
22.04.2015	10:40	21867,56	4850,75	Image Documentation
23.04.2015	11:20	21867,56	4850,75	Image Documentation
28.04.2015	15:20	21867,56	4850,75	Image Documentation
29.04.2015	11:20	21867,56	4850,75	Image Documentation
21.05.2015	11:00	21867,56	4850,94	Image Documentation

Full Load	**18,15%**	**Term [Years]**	**9**
Base Load	**81,85%**	**Hrs/Year**	**2969**

Figure 57: Measurement Report Boiler Clubhouse[183]

Boiler 1				
Date	Time	Operating Hours		Source
		Base Load [h]	Full Load [h]	
23.04.2015	14:00	15495,7	354,8	Image Documentation

Full Load	**2,24%**	**Laufzeit [Jahr**	**19**
Base Load	**97,76%**	**Std/Jahr**	**834**

Boiler 2				
Date	Time	Operating Hours		Source
		Base Load [h]	Full Load [h]	
23.04.2015	14:00	37779,1	10091,4	Image Documentation

Full Load	**21,08%**	**Term [Years]**	**19**
Base Load	**78,92%**	**Hrs/Year**	**2520**

Figure 58: Measurement Report Boiler Tennis Center[184]

183 own illustration, based on own measurements

184 own illustration, based on own measurements

10.3 Appendix 3: Room Plan Clubhouse

Floor Plan Clubhouse										
Nr.	Floor	Main Point	Desription	Area	Unit	Heating	Heating System	Ventilation	Ventilation System	LZ Nr.
1	**EG**	**Restaurant**	**Restaurant**	**233,27**	**m²**					
		Restaurant	Dining Room 50P	168,39	m²	Y	Convector	Y	Restaurant	7
		Restaurant	Restaurant/Bistro	64,88	m²	Y	Convector	Y	Restaurant	7
2	**EG**	**Pers., Depot, Cold Stor.**	**Pers., Depot, Cold Stor.**	**74,32**	**m²**					
		Pers., Depot, Cold Stor.	Depot	6,09	m²					
		Pers., Depot, Cold Stor.	Cold Stores	14,8	m²					
		Pers., Depot, Cold Stor.	Wind Collector	7,36	m²	Y	Convector			
		Pers., Depot, Cold Stor.	Corridor	14,13	m²	Y				
		Pers., Depot, Cold Stor.	Washroom L	11,41	m²	Y	Convector	Y	Kitchen Gardrobe	10
		Pers., Depot, Cold Stor.	Antroom L	2,62	m²	Y	Convector			
		Pers., Depot, Cold Stor.	WC L	1,25	m²	Y	Convector			
		Pers., Depot, Cold Stor.	Washroom G	11,44	m²	Y	Convector	Y	Kitchen Gardrobe	10
		Pers., Depot, Cold Stor.	Antroom G	2,62	m²	Y	Convector			
		Pers., Depot, Cold Stor.	WC Guest	2,6	m²	Y	Convector			
3	**EG**	**Kitchen, AR, Office, Sink**	**Kitchen, AR, Office, Sink**	**95,6**	**m²**					
		Kitchen, AR, Office, Sink	Antroom	6,1	m²	Y				
		Kitchen, AR, Office, Sink	Kitchen	63,75	m²	Y		Y	Kitchen	8
		Kitchen, AR, Office, Sink	Office	5,18	m²	Y	Convector			
		Kitchen, AR, Office, Sink	Sink	20,57	m²	Y	Convector			
4	**EG**	**Bistro, Lounge**	**Bistro, Lounge**	**199,46**	**m²**					
		Bistro, Lounge	Bistro/Lounge	99,73	m²	Y	Convector	Y	Lobby	11
		Bistro, Lounge	Lounge	99,73	m²	Y	Convector	Y	Lobby	11
5	**EG**	**WC Guest**	**WC Guest**	**54,55**	**m²**					
		WC Guest	Antroom	17,22	m²	Y	Convector			
		WC Guest	WC-Handicap.	4,87	m²	Y	Convector	Y	WC-OG	12
		WC Guest	Washroom L	17,65	m²	Y	Convector	Y	WC-OG	12
		WC Guest	WC L	1,43	m²	Y	Convector	Y	WC-OG	12
		WC Guest	Washroom G	11,95	m²	Y	Convector	Y	WC-OG	12
		WC Guest	WC G	1,43	m²	Y	Convector	Y	WC-OG	12
6	**EG**	**Lobby, Reception**	**Lobby, Reception**	**53,47**	**m²**		Convector			
		Lobby, Reception	Lobby	39,18	m²	Y	Convector			
		Lobby, Reception	Reception	14,29	m²	Y				
7	**EG**	**Wind Collector**	**Wind Collector**	**17,6**	**m²**	**Y**	**Convector**			
8	**EG**	**Office**	**Office**	**55,36**	**m²**					
		Office	Office	38,91	m²	Y	Convector	Y	Office	11.1
		Office	Manager Office	16,45	m²	Y	Convector	Y	Office	11.1
9	**EG**	**Technik, Gard, Cor.**	**Technik, Gard, Cor.**	**11,88**	**m²**					
		Technik, Gard, Cor.	Technik	4,86	m²	Y				
		Technik, Gard, Cor.	Gardrobe	2,75	m²	Y				
		Technik, Gard, Cor.	Corridor	4,27	m²	Y				
10	**EG**	**Event**	**Event**	**287,31**	**m²**					
		Event	Event	64,88	m²	Y	Convector	Y	Sportbar/Event	16
		Event	Event	94,82	m²	Y	Convector	Y	Sportbar/Event	16
		Event	Event/Seminar	74,18	m²	Y	Convector	Y	Lounge	13
		Event	Event Manipulation	50,23	m²	Y	Convector	Y	Sportbar/Event	15
		Event	Cold Stores	3,2	m²					
11	**EG**	**Staircase**	**Staircase**	**22,44**	**m²**	**Y**	**Convector**			
12	**UG**	**Beach, Depot, DR**	**Beach, Depot, DR**	**79,33**	m²					
		Beach, Depot, DR	Buffet	15,29	m²	Y	Heating Panel			
		Beach, Depot, DR	Depot	13	m²					
		Beach, Depot, DR	Depot Beach	15,54	m²	Y	Heating Panel			
		Beach, Depot, DR	Dressing Room D	7,56	m²	Y	Heating Panel	Y	Dressing Room	1
		Beach, Depot, DR	Washing Room D	7,59	m²	Y	Heating Panel	Y	Dressing Room	1
		Beach, Depot, DR	WC D	2,6	m²	Y	Heating Panel	Y	Dressing Room	1
		Beach, Depot, DR	Dressing Room H	7,56	m²	Y	Heating Panel	Y	Dressing Room	1
		Beach, Depot, DR	Washing Room H	7,59	m²	Y	Heating Panel	Y	Dressing Room	1
		Beach, Depot, DR	WC H	2,6	m²	Y	Heating Panel	Y	Dressing Room	1

Continuation:

13	**UG**	**Wellness**	**Wellness**	**238,22**	m²					
		Wellness	Massage	14,24	m²	Y	Floor Heating			
		Wellness	Relaxing Room	52,13	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Antroom	14,9	m²	Y	Floor Heating			
		Wellness	Service	11,41	m²	Y	Floor Heating			
		Wellness	Washing Room	11,56	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Gardrobe	7,94	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Sauna	12,84	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Corridor	20,02	m²	Y				
		Wellness	Steam Bath	7,1	m²	Y	Floor Heating			
		Wellness	Sauna - L	9,51	m²	Y	Floor Heating			
		Wellness	Revisions-R.	2,1	m²					
		Wellness	Gardrobe L	5,35	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Washing Room L	4,77	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Corridor	15,61	m²	Y				
		Wellness	Solarium	11,77	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Massage	12,56	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	WC L	8,22	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	WC G	6,47	m²	Y	Floor Heating	Y	Sauna	2
		Wellness	Engineering Room Pool	9,72	m²	Y				
14	**UG**	**Pool**	**Pool**	**223,37**	m²	**Y**	**Floor Heating**	**Y**	**Pool**	
15	**UG**	**Corridor**	**Corridor**	**142,25**	m²					
		Corridor	Corridor Wellness	15,04	m²	Y				
		Corridor	Corridor Mid	45	m²	Y				
		Corridor	Corridor Fitness	82,21	m²	Y				
16	**UG**	**Fitness + Pro Shop**	**Fitness + Pro Shop**	**311,57**	m²					
		Fitness + Pro Shop	Fitness 1	188,44	m²	Y	Conv. Heating P.	Y	Fitness Excerise	4
		Fitness + Pro Shop	Fitness/Office	54,58	m²	Y	Conv. Heating P.	Y	Fitness Excerise	4
		Fitness + Pro Shop	Pro-Shop	53,33	m²	Y	Conv. Heating P.	Y	Fitness Excerise	4
		Fitness + Pro Shop	OfficePro-Shop	15,22	m²	Y	Conv. Heating P.	Y	Fitness Excerise	4
17	**UG**	**Gardrobe, Washing**	**Gardrobe, Washing**	**387,86**	m²					
		Gardrobe, Washing	Gardrobe L	122,91	m²	Y	Floor Heating	Y	Gardrobe	3
		Gardrobe, Washing	Washing Room L	40,15	m²	Y	Floor Heating	Y	Gardrobe	3
		Gardrobe, Washing	Depot	11,68	m²	Y	Floor Heating			
		Gardrobe, Washing	Washing Room G	37,32	m²	Y	Floor Heating	Y	Gardrobe	3
		Gardrobe, Washing	Gardrobe G	175,8	m²	Y	Floor Heating	Y	Gardrobe	3
18	**UG**	**Event WC**	**Event WC**	**27,06**	m²					
		Event WC	WC G	6,88	m²	Y	Ventilation	Y	WC-UG	14
		Event WC	WC L	9,5	m²	Y	Ventilation	Y	WC-UG	14
		Event WC	Depot	5,44	m²	Y	Ventilation			
		Event WC	Antroom	5,24	m²	Y	Ventilation			
19	**UG**	**Washing**	**Washing**	**34,92**	m²			**Y**	**Washing**	5
20	**UG**	**Staircase**	**Staircase**	**8,79**	m²	**Y**	**Convector**			
21	**UG**	**Outdoor Gard/Wash**	**Outdoor Gard/Wash**	**59,73**	m²					
		Outdoor Gard/Wash	Gardrobe G	22,05	m²	Y	Ventilation			
		Outdoor Gard/Wash	Washing Room G	6,8	m²	Y	Ventilation			
		Outdoor Gard/Wash	Washing Room L	7,04	m²	Y	Ventilation			
		Outdoor Gard/Wash	Gardrobe L	23,84	m²	Y	Ventilation			
22	**UG**	**Bag + Caddy Depot**	**Bag + Caddy Depot**	**41,21**	m²					
		Bag + Caddy Depot	Depot	37,09	m²					
		Bag + Caddy Depot	Batterie laden	4,12	m²					

Total UG + OG	2659,57	m²
Total UG	1554,31	m²
Total OG	1105,26	m²
Heating Area	**2544,25**	**m²**

Groups		
Restaurant, WC, Lobby, Kitchen	707,38	m²
Event, WC, Staircase	342,4	m²
Wellness	517,74	m²
Fitness + ProShop	311,57	m²
Gardrobe	387,86	m²
Beach and Outdoor	126,06	m²
Office and Engineering	67,24	m²
Pool	84	m²

Table 32: Room Plan Clubhouse[185]

185 own illustration, based on construction plan

10.4 Appendix 4: Inspection Report Boiler

Boiler 1 **Boiler 2**

Figure 59: Inspection Report Boiler Clubhouse[186]

[186] image from the author (14.05.2015)

Boiler 1 **Boiler 2**

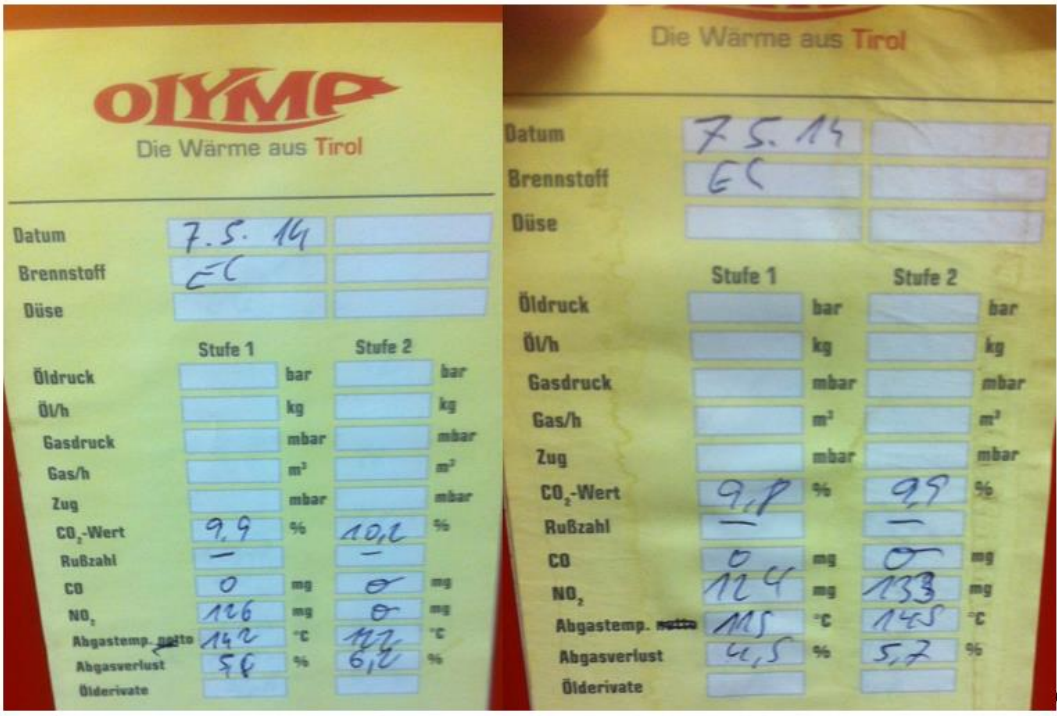


Figure 60: Inspection Report Boiler Tennis Center[187]

[187] image from the author (14.05.2015)

10.5 Appendix 5: Inventory

Nr.	Building	Category	Classification	Application	Description	Producer	Type	Constr. Year	Nominal Power [kW]	Power P1 [kW]	Power P2 [kW]	Power P3 [kW]	Capacity (Water) [l]	Medium Refrigerant	Air Volume Flow[m³/h]
1	Clubhouse	Heating	Energy Conversion	Heating Clubhouse	Boiler 1	Hoval	UNO-3 280/600 T	1996	280,00	-	-	-	487,00	-	-
2	Clubhouse	Heating	Energy Conversion	Heating Clubhouse	Boiler 2	Hoval	UNO-3 (280)	2006	280,00	-	-	-	480,00	-	-
3	Clubhouse	Heating	Energy Conversion	Hot Water Heating Center	Hot Water Tank	Comfort	CMRSP500/1W	-	150,00	-	-	-	500,00	-	-
4	Clubhouse	Heating	Energy Distribution	Circulation	Cirulation Pump 1	Grundfos	UPS 32-60 180	-	0,09	0,09	0,07	0,05	-	-	-
5	Clubhouse	Heating	Energy Distribution	Circulation	Circulation Pump 2	Grundfos	UPS 32-60 180	-	0,09	0,09	0,07	0,05	-	-	-
6	Clubhouse	Heating	Energy Distribution	Space Heating	Cirulation Pump	Biral	Redline LX 653	-	0,49	0,49	-	0,18	-	-	-
7	Clubhouse	Heating	Energy Distribution	Space Heating	Cirulation Pump	Biral	Redline LX 653	-	0,49	0,49	-	0,18	-	-	-
8	Clubhouse	Heating	Energy Distribution	Ventilation	Cirulation Pump	Biral	Redline LX 653	-	0,49	0,49	-	0,18	-	-	-
9	Clubhouse	Heating	Energy Distribution	Radiatore, Convecotr	Cirulation Pump	Grundfos	UPS 50-120/F	-	0,72	0,72	0,53	0,45	-	-	-
10	Clubhouse	Heating	Energy Distribution	Kitchen, Pool	Cirulation Pump	Biral	NRB 15T-2	-	0,29	0,29	0,19	0,13	-	-	-
11	Clubhouse	Heating	Energy Distribution	Floor Heating	Cirulation Pump	Biral	Redline L 322-1	-	0,08	0,08	-	0,06	-	-	-
12	Clubhouse	Heating	Energy Distribution	Floor Heating	Cirulation Pump	Biral	Redline LX 654	-	0,72	0,72	-	0,33	-	-	-
13	Clubhouse	Coldness	Energy Use	Ventilation	Air Condition 1	GEA	Hydro Kit GLHM 32 GEA	2008	-	-	-	-	-	-	-
14	Clubhouse	Coldness	Energy Use	Ventilation	Air Condition 2	GEA	Hydro Kit GLHM 32 GEA	2008	-	-	-	-	-	-	-
15	Clubhouse	Coldness	Energy Use	ProShop	Air Condition	Daikin	MA90CKY1	2000	3,00	-	-	-	-	R22	-
16	Clubhouse	Coldness	Energy Use	Event	Cold Store	--	--	-	-	-	-	-	-	-	-
17	Clubhouse	Coldness	Energy Use	--	--	--	--	-	-	-	-	-	-	-	-
18	Clubhouse	Coldness	Energy Use	--	--	Mitsubishi E	PU-P3YGAA	2004	-	-	-	-	-	R407C	-
19	Clubhouse	Coldness	Energy Use	Kitchen	Air Condition	Daikin	RE40GV1B	1999	1,60	-	-	-	-	R22	-
20	Clubhouse	Coldness	Energy Use	ProShop	Air Condition	Daikin	R125FJ7W1	2000	4,50	-	-	-	-	R22	-
21	Clubhouse	Coldness	Energy Use	--	--	Haier	HSU-12HD03/R2	2004	1,09	-	-	-	-	R410A	-
22	Clubhouse	Coldness	Energy Use	Kitchen	Air Condition	Tosot	TWH12KF-K3DNA5J/O	2013	1,20	-	-	-	-	R410A	-
23	Clubhouse	Coldness	Energy Use	Kitchen	Air Condition	Tosot	TWH09KF-K3DNA5J/0	2013	0,90	-	-	-	-	R410A	-
24	Clubhouse	Coldness	Energy Use	Kitchen	Central Cooling	Tecumsek	380184-C May	2013	-	-	-	-	-	R134a	-
25	Clubhouse	Coldness	Energy Use	Cold Store	Cold Store	Tecumsek	380184 March	2012	-	-	-	-	-	R134a	-
26	Clubhouse	Coldness	Energy Use	Vegeteables	Cold Store	Tecumsek	380184 March	2012	-	-	-	-	-	R134a	-
27	Clubhouse	Coldness	Energy Use	Cold Store	Cold Store	Tecumsek	380184 June	2012	-	-	-	-	-	?	-
28	Clubhouse	Ventilation	Energy Use	GL 10682-6	Ventilation Center Pool	Bösch	--	-	-	-	-	-	-	-	-
29	Clubhouse	Ventilation	Energy Use	GL 10682-7	Outdoor Wardrobe LZ01	Bösch	Modul 0,5	1996	-	-	-	-	-	-	800
30	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Outdoor Wardrobe LZ01		80L	1996	0,55	0,55	0,22	-	-	-	-
31	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Outdoor Wardrobe LZ01		80L	1996	0,55	0,55	0,22	-	-	-	-
32	Clubhouse	Ventilation	Energy Use	GL 10682-8	Sauna - LZ02	Bösch	Modul1,5	1996	-	-	-	-	-	-	4 400
33	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Sauna - LZ02		112M	1996	3,00	3,00	0,90	-	-	-	-
34	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Sauna - LZ02		112M	1996	3,00	3,00	0,90	-	-	-	-
35	Clubhouse	Ventilation	Energy Use	GL 10682-9	Warderoben - LZ03	Bösch	Modul1,5	1996	-	-	-	-	-	-	6 000
36	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Warderoben - LZ03		112M	1996	3,00	3,00	0,90	-	-	-	-
37	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Warderoben - LZ03		112M	1996	3,00	3,00	0,90	-	-	-	-
38	Clubhouse	Ventilation	Energy Use	GL 10682-10	Fitness / Excerise UG - LZ04	Bösch	Modul1,5	1996	-	-	-	-	-	-	6 000
39	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Fitness / Excerise UG - LZ04		112M	1996	3,00	3,00	0,90	-	-	-	-
40	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Fitness / Excerise UG - LZ04		112M	1996	3,00	3,00	0,90	-	-	-	-
41	Clubhouse	Ventilation	Energy Use	GL 10682-11	Washing - LZ05	Bösch	Modul 0,5	1996	-	-	-	-	-	-	2 000
42	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Washing - LZ05		90S	1996	1,10	1,10	0,37	-	-	-	-
43	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Washing - LZ05		90S	1996	1,10	1,10	0,37	-	-	-	-
44	Clubhouse	Ventilation	Energy Use	GL 10682-12	Restaurant - LZ07	Bösch	--	1996	-	-	-	-	-	-	-
45	Clubhouse	Ventilation	Energy Use	GL 10682-13	Kitchen - KZ08	Bösch	Modul 1,5	1996	-	-	-	-	-	-	6 000
46	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Kitchen - KZ08		112M	1996	3,00	3,00	0,90	-	-	-	-
47	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Kitchen - KZ08		112M	1996	3,00	3,00	0,90	-	-	-	-
48	Clubhouse	Ventilation	Energy Use	GL 10682-14	Kitchen ABL - LZ09	Bösch	Modul 1	1996	-	-	-	-	-	-	4 000
49	Clubhouse	Ventilation	Energy Use	Motor	Kitchen ABL - LZ09		90L	1996	1,50	1,50	0,50	-	-	-	-
50	Clubhouse	Ventilation	Energy Use	GL 10682-15	Kitchen Wardrobe - LZ10	Bösch	Modul 0,5	1996	-	-	-	-	-	-	800

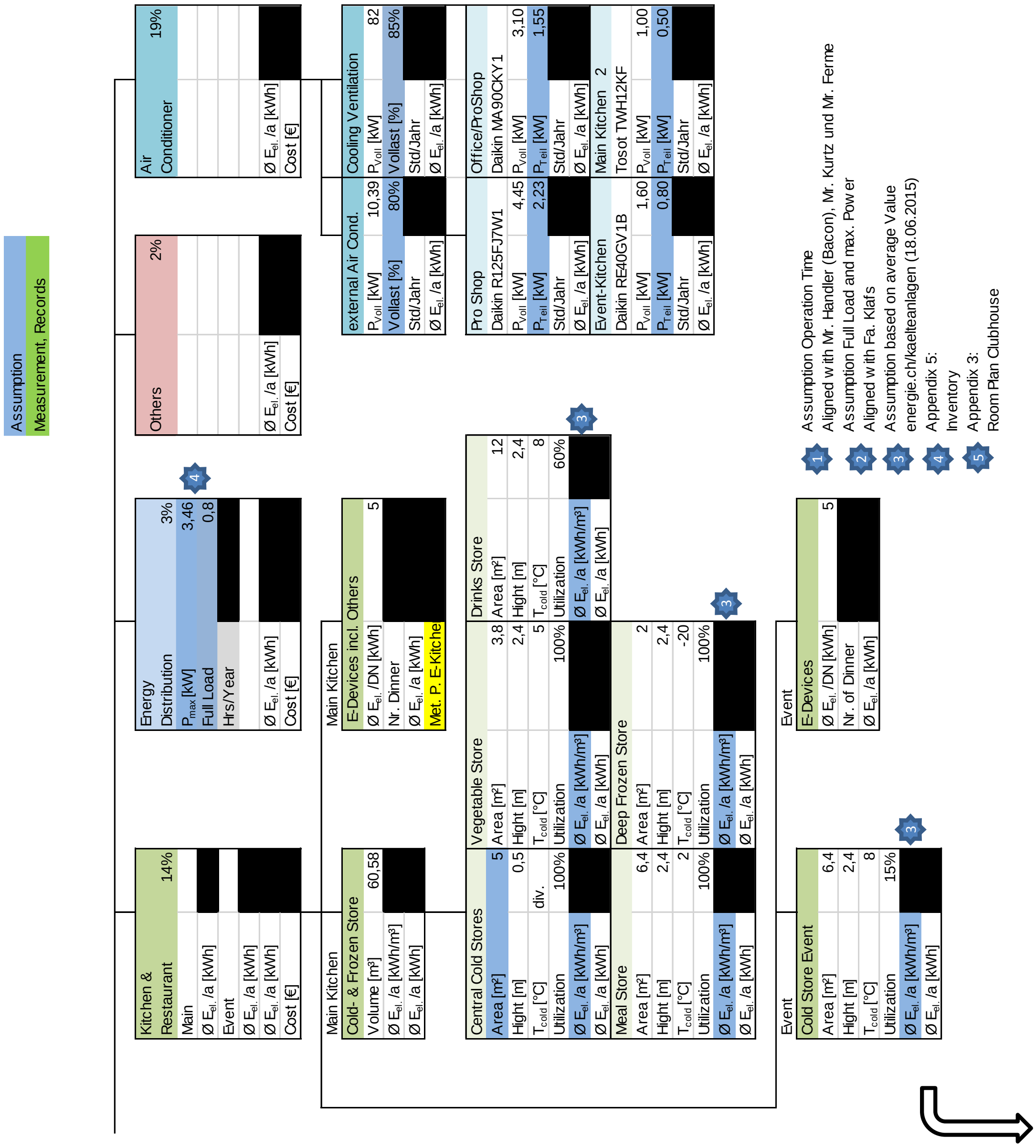
Continuation:

Nr.	Building	Category	Classification	Application	Description	Producer	Type	Constr. Year	Nominal Power [kW]	Power P1 [kW]	Power P2 [kW]	Power P3 [kW]	Capacity (Water) [l]	Medium Refrigerant	Air Volume Flow[m³/h]
51	Clubhouse	Ventilation	Energy Use	Motor AUL/ZUL	Kitchen Wardrobe - LZ10		80L	1996	0,55	0,55	0,22	-	-	-	-
52	Clubhouse	Ventilation	Energy Use	Motor ABL/FOL	Kitchen Wardrobe - LZ10		80L	1996	0,55	0,55	0,22	-	-	-	-
53	Clubhouse	Ventilation	Energy Use	GL 10682-16	Lobby - KZ11	Bösch	--	1996	-	-	-	-	-	-	-
54	Clubhouse	Ventilation	Energy Use	GL 10682-17	Office KZ11.1	Bösch	Modul 0,5	1996	-	-	-	-	-	-	1200
55	Clubhouse	Ventilation	Energy Use	Motor	Office KZ11.1		90L	1996	1,50	1,50	0,50	-	-	-	-
56	Clubhouse	Ventilation	Energy Use	Motor	Office KZ11.1		90L	1996	1,50	1,50	0,50	-	-	-	-
57	Clubhouse	Ventilation	Energy Use	GL 10682-18	WC-OG - LZ12	Bösch	Modul 0,5	1996	-	-	-	-	-	-	800
58	Clubhouse	Ventilation	Energy Use	Motor	WC-OG - LZ12		90S	1996	1,10	1,10	0,37	-	-	-	-
59	Clubhouse	Ventilation	Energy Use	Motor	WC-OG - LZ12		90S	1996	1,10	1,10	0,37	-	-	-	-
60	Clubhouse	Ventilation	Energy Use	GL 10682-19	Privatlounge - LZ13	Bösch	--	1996	-	-	-	-	-	-	-
61	Clubhouse	Ventilation	Energy Use	GL 10682-20	WC-UG - LZ14	Bösch	Modul 0,5	1996	-	-	-	-	-	-	500
62	Clubhouse	Ventilation	Energy Use	Motor	WC-UG - LZ14		80L	1996	0,55	0,55	0,22	-	-	-	-
63	Clubhouse	Ventilation	Energy Use	Motor	WC-UG - LZ14		80L	1996	0,55	0,55	0,22	-	-	-	-
64	Clubhouse	Ventilation	Energy Use	GL 10682-21	Sportbar/Event - LZ15	Bösch	Modul 0,5	1996	-	-	-	-	-	-	500
65	Clubhouse	Ventilation	Energy Use	Motor	Sportbar/Event - LZ15		80L	1996	0,55	0,55	0,22	-	-	-	-
66	Clubhouse	Ventilation	Energy Use	GL 10682-22	Sportbar / Event - KZ16	Bösch	--	1996	-	-	-	-	-	-	-
67	Clubhouse	Ventilation	Energy Use	GL 10682-23	Kitchen ZUL - LZ09	Bösch	Modul 0,75	1996	-	-	-	-	-	-	2000
68	Clubhouse	Ventilation	Energy Use	Motor	Kitchen ZUL - LZ09		90S	1996	1,10	1,10	0,37	-	-	-	-
69	Clubhouse	Wellness	Energy Use	Heating Pool	Heat Exchanger	Trantner	GX7*27	2004	75,00	-	-	-	-	-	-
70	Clubhouse	Heating	Energy Use	Boiler Kitchen	Hot Water Tank	Amtrol Nov	HCX	2003	47,00	-	-	-	300,00	-	-
71	Clubhouse	Wellness	Energy Use	Pool	Circulation Pump 1	NTB	NF 80/2C-11	2005	2,00	-	-	-	-	-	-
72	Clubhouse	Wellness	Energy Use	Pool	Circulation Pump 2	NTB	NF 80/2C-11	2005	2,00	-	-	-	-	-	-
73	Clubhouse	Wellness	Energy Use	Sauna	Oven	--	--	-	-	-	-	-	-	-	-
74	Clubhouse	Wellness	Energy Use	Saunarium	Oven	--	--	-	-	-	-	-	-	-	-
75	Clubhouse	Wellness	Energy Use	Saunarium	Evaporator	Klafs / Con	MK5 Visual Klafs 8	-	6,00	-	-	-	-	-	-
76	Clubhouse	Wellness	Energy Use	Steam Bath	Evaporator	Klafs / Con	MK5 SL 10 KIN 10	-	7,50	-	-	-	-	-	-
77	Clubhouse	Wellness	Energy Use	Solarium	Solarium	megaSun	Super 5600	-	-	-	-	-	-	-	-
78	Depot	Heating	Energy Conversion	Heating Depot	Boiler Depot	Hoval	UNOLYT S87/300	1996	87,00	-	-	-	136,00	-	-
79	Depot	Heating	Energy Distribution	Circulation	Circulation Pump HK	Wilo	Smart 30/6	-	-	-	-	-	-	-	-
80	Depot	Heating	Energy Distribution	Office	Circulation Pump	Wilo	Smart 30/4	-	-	-	-	-	-	-	-
81	Depot	Heating	Energy Distribution	Workshop	Circulation Pump	Grundfos	UPS 25-60 180	-	0,09	0,09	0,07	0,05	-	-	-
82	Tennis Center	Heating	Energy Conversion	Heating Tennis Center	Boiler Tennis 1	Hoval	UNO-3 210	1996	210,00	-	-	-	480,00	-	-
83	Tennis Center	Heating	Energy Conversion	Heating Tennis Center	Boiler Tennis 2	Hoval	UNO-3 210	1996	210,00	-	-	-	480,00	-	-
84	Tennis Center	Heating	Energy Distribution	Central Heating	Circulation Pump	Wilo	TOP-S50/10	-	0,88	0,88	0,68	0,50	-	-	-
85	Tennis Center	Heating	Energy Distribution	Central Heating	Circulation Pump	Wilo	TOP-S50/10	-	0,88	0,88	0,68	0,50	-	-	-
86	Tennis Center	Heating	Energy Distribution	Floor Heating	Circulation Pump	Grundfos	UPS 32-60 180	-	0,10	0,10	0,07	0,04	-	-	-
87	Tennis Center	Heating	Energy Distribution	Radiators	Circulation Pump	Grundfos	UPS 25-60 180	-	0,10	0,10	0,07	0,04	-	-	-
88	Tennis Center	Heating	Energy Distribution	Heating Panel	Circulation Pump	Biral	Redline HX 502	-	1,02	1,02	-	0,49	-	-	-
89	Tennis Center	Heating	Energy Distribution	Hot Water	Circulation Pump	Grundfos	UPS 32-60 180	-	0,09	0,09	0,07	0,05	-	-	-
90	Tennis Center	Heating	Energy Distribution	Hot Water	Hot Water Tank	--	--	-	-	-	-	-	1 000,00	-	-
91	Tennis Center	Ventilation	Energy Use	Anlage 5 - Zuluft	Buffet and Kitchen	Weger	ZL/66	1996	3,10	3,10	1,00	-	-	-	4 000
92	Tennis Center	Ventilation	Energy Use	Anlage 5 - Abluft	Buffet and Kitchen	Weger	AL/66	1996	1,60	1,60	0,50	-	-	-	3 400
93	Tennis Center	Ventilation	Energy Use	Anlage 4 - Zuluft	Warderobe	Weger	ZL/64	1996	1,60	1,60	0,50	-	-	-	2 400
94	Tennis Center	Ventilation	Energy Use	Anlage 4 - Abluft	Warderobe	Weger	AL/64	1996	1,60	1,60	0,50	-	-	-	2 200
95	Tennis Center	Ventilation	Energy Use	Anlage 3 - Zuluft	Tennis East	Weger	ZL/96	1996	4,50	4,50	1,50	-	-	-	6 000
96	Tennis Center	Ventilation	Energy Use	Anlage 3 - Abluft	Tennis East	Weger	AL/96	1996	3,10	3,10	1,00	-	-	-	6 000
97	Tennis Center	Ventilation	Energy Use	Anlage 1 - Zuluft	Tennis West	Weger	ZL/96	1996	4,50	4,50	1,50	-	-	-	6 000
98	Tennis Center	Ventilation	Energy Use	Anlage 1 - Abluft	Tennis West	Weger	AL/96	1996	3,10	3,10	1,00	-	-	-	6 000
99	Tennis Center	Ventilation	Energy Use	Anlage 2 - Zuluft	Multifunctional Hall	Weger	ZL/96	1996	4,50	4,50	1,50	-	-	-	6 000
100	Tennis Center	Ventilation	Energy Use	Anlage 2 - Abluft	Multifunctional Hall	Weger	AL/96	1996	3,10	3,10	1,00	-	-	-	6 000

Table 33: Inventory[188]

[188] based on data from data plates

10.6 Appendix 6: Energy Structure Electrical Energy for Clubhouse



Continuation:

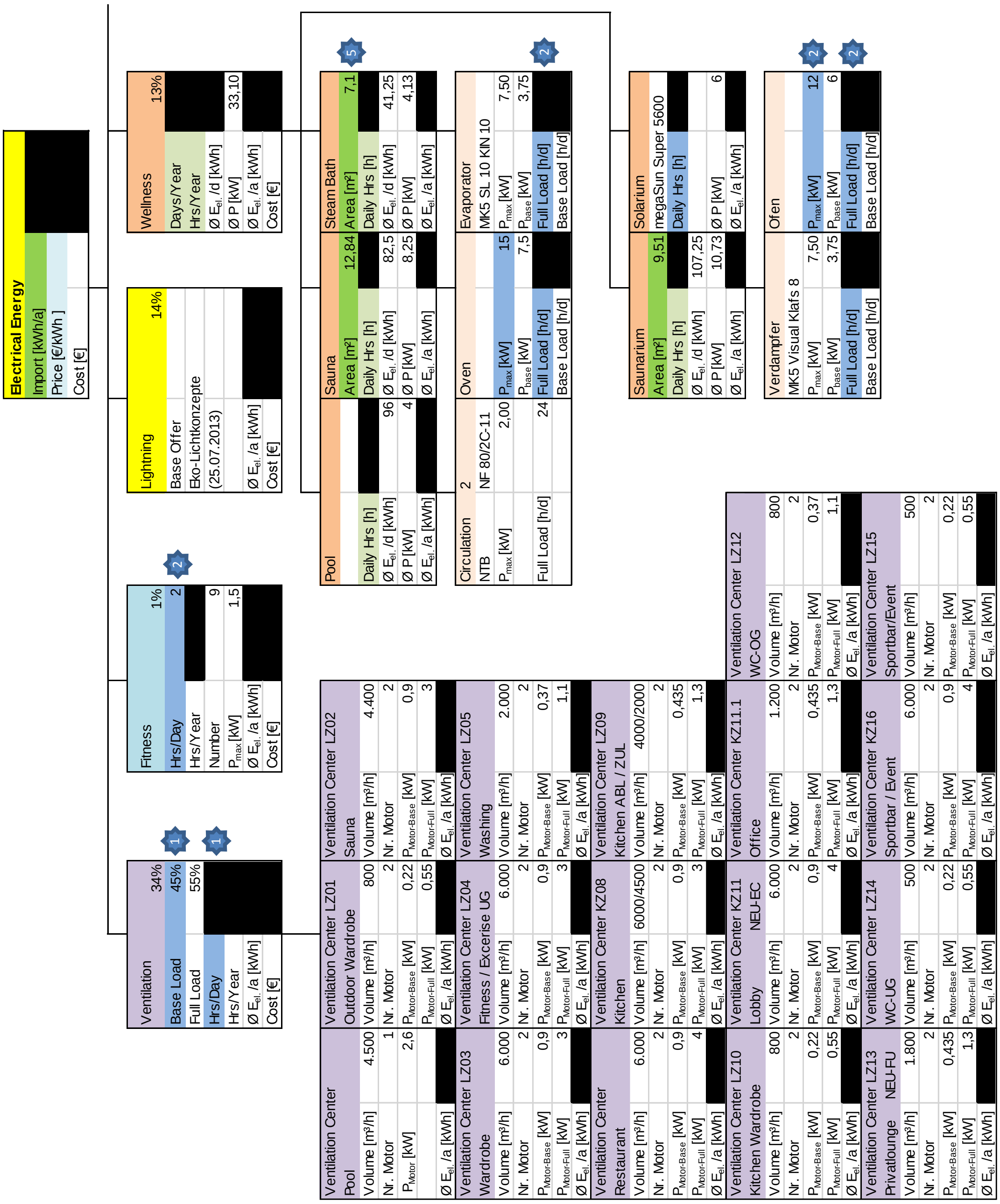


Figure 61: Energy Structure Electrical Energy for Clubhouse[189]

[189] own illustration