International Benchmarking in Facility Management – Comparison of Different National Benchmarking Pools

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Abstract

Various facility management benchmarking reports have been released in the past few years. These reports have different focuses such as facility management cost, space utilization, energy consumption, etc. Most benchmarks provided by these reports are national or regional ones. However, the demand of international facility management benchmarking reports is increasing. This study sets out to explore whether it is possible to establish an international facility management benchmarking pool through integrating existing national/regional facility management benchmarking pools (Indirect Method). The greatest challenge lies in the in-comparability of national benchmarks. The in-comparability is discussed in the following three aspects. First, facility management cost benchmarks are developed according to different facility management cost classification systems. Second, space is measured based on different area measurement rules, which has great effect on the values of benchmarks. Third, currencies and price level situations are different between one country and another, which also has a great influence on the values of benchmarks. Since the indirect method does not allow for generating new indicators, a set of common cost components of national benchmarking pools are defined as key performance indicators of the international facility management benchmarking program established in this work. For the in-comparability caused by area measurement rules, the critical discrepancies between area measurement standards are identified. The *Code of Measuring Practice: A Guide for Property Professionals* published by the *Royal Institution of Chartered Survey* is chosen as the *standard code*. The adjustment solutions of area values are obtained, by mapping the differences between the *standard code* and other codes, Based on the purchasing power parity theory, a uniform currency and price level platform is established. National facility management benchmarks can be compared in one currency without the influence of price level. Based on the method system established in this study, national facility management benchmarks can be compared directly with a few easy adjustments. Hence, an international facility management benchmarking pool can be generated automatically by integrating these comparable national benchmarks.

Zusammenfassung

In den letzten Jahren sind zahlreiche Facility-Management Benchmarking-Berichte veröffentlicht worden. Diese Berichte haben unterschiedliche Schwerpunkte, wie Facility-Management Kosten, Raumnutzung, Energieverbrauch etc. Die Benchmarks, die von diesen Berichten zur Verfügung gestellt werden, sind meist national oder regional. Allerdings steigt die Nachfrage nach einen vereinheitlichten internationalen Facility-Management Benchmarking-Bericht.

Das Ziel dieser Arbeit war es, mit Hilfe der Integrations-Methode einen internationalen Facility Management Benchmarking Pool zu erstellen. Die größten Probleme beim Ver-

gleich und der Vereinheitlichung der verschiedenen Benchmarks ergaben sich in drei Bereichen.

Im ersten Bereich ging es um Facility-Management Kosten-Benchmarks, die nach verschiedenen Facility-Management Kosten-Klassifikationssystemen gebildet wurden. In einen zweiten Bereich wurde der Einfluss verschiedener Messregeln zur Flächenermittlung auf die Aussagekraft von Flächen-Benchmarks untersucht. Der dritte untersuchte Problemkreis ergab sich aus den unterschiedlichen Währungs- und Preisniveaus in den untersuchten Ländern.

Für den internationalen Facility-Management Benchmarking Pool wurden die geeignetsten Kennzahlen aus den nationalen Benchmarking Pools ausgewählt. Nach der Analyse der einzelnen Flächenmessungsregeln wurde die Norm *Code of Measuring Practice: A Guide for Property Professionals* als Standard Code gewählt. In der Arbeit wurde eine Lösung entwickelt, mit der zwischen dem Standard Code und den anderen Normen die Flächen angepasst werden können.

Um nationale Facility-Management Benchmarks ohne den Einfluss von Preisniveaus vergleichen zu können, wurde auf der Basis der Kaufkraftparitätstheorie eine einheitliche Plattform entwickelt. Mit den in der Arbeit entwickelten Verfahren können die nationalen Facility-Management Benchmarks mit wenigen und einfachen Anpassungen direkt verglichen werden.

CONTENTS

Abbreviations (alphabetic order)

1. Organizations
    - ARESG: Association des Directeurs et Responsables de Services Généraux (in French);
    - ANSI : American National Standards Institute;
    - BCIS : Building Cost Information Service;
    - BCO : British Council for Offices;
    - BIFM : British Institut of Facilities Managment;
    - BOMA : Building Owners and Managers Association;
    - CEEC : The European Council of Construction Economists;
    - CEN : European Committee for standardization;
    - DFM : Danish Facility Management Network;
    - DTZ : DTZ Holdings Public Limited Company;
    - EIA : U.S. Energy Information Administration;
    - EPA : U.S.Environmental Protection Agency;
    - GBCA: Green Building Council of Australia;
    - GEFMA : German Facility Management Association;
    - IAMFA : International Association of Museum Facility Administrators;
    - IBI : Institute for Building Informatics;
    - IFMA : International Facility Management Association;
    - IPFMA: Irish Property & Facility Management Association;
    - IPD : Investment Property Databank Limited Company;
    - IPD Occupiers: Investment Property Databank Limited Company - Occupiers;
    - ISA : International Sustainability Alliance;
    - ISO : International Standard Organization;

- KTI : parasta kiinteistötietoa (in Finnish, and in English is KTI Property Information Limited Company);
- NBEF : Norweigian Facility Management Association;
- NFC Index: The Netherlands Facility Costs Index;
- NFCIC : Netherlands Facility Costs Index Cooperative;
- OECD : Organisation for Economic Co-operation and Development;
- RealFM : Association for Real Estate and Facility Managers;
- pom+ : pom+ consulting public limited company;
- RICE : Royal Institution of Chartered Survey;
- TU Graz : Graz University of Technology;
- SAPOA : South African Property Owners Association;

2. Parameters
    - IFA : Internal Floor Area;
    - IPLR: Integrate Price Level Ratio;
    - GDP : Gross Domestic Products;
    - GEA : Gross External Area;
    - GFA : Gross Floor Area;
    - GIA : Gross Internal Area;
    - NFA : Net Floor Area;
    - NIA : Net Internal Area;
    - NRA : Net Room Area;
    - RFA : Rentable Floor Area;
    - UFA : Usable Floor Area;
3. Countries Currencies
    - CNY : Chinese Yuan;
    - EUR : Euro;
    - GBP : British Pound;
    - UK : United Kingdom;

- US : United States;
- USD : US dollar;

4. Others
    - BAS : Building Automation System;
    - BEX : Online benchmarking system "Benchmarking Exchange";
    - BOQ : Bill of Quantities;
    - BRA : Buzzy ®Arseg Ratios;
    - CAD : Computer Aided Design;
    - CAFM : Computer Aided Facility Management;
    - CBECS : The Commercial Buildings Energy Consumption Survey;
    - CCTV : Closed Ciruit Television;
    - CMMS : Computerized Maintenance Management System;
    - CREM : Corporate Real Estate Management;
    - EER : Experience Exchange Report;
    - FM : Facility Management;
    - GB : Gigabyte;
    - ICP : International Comparison Program;
    - KPIs : Key Performance Indicators;
    - LEED-EBOM : Leadership in Energy & Environmental Design for Existing Buildings: Operations & Design;
    - Ltd : Limited Company;
    - MERs : Market Exchange Rates;
    - PPP : Purchasing Power Parity;
    - PPPs: Purchasing Power Parity exchange rates;
    - PLC : Public Limited Company;
    - REM : Real Estate Management;
    - RICS code: Code of measuring practice (published by RICS);
    - TEOM : Taxe d'enlèvement des ordures méngagères (Garbage Collection Tax);

- VAT : Value Added Tax.

1 INTRODUCTION

1.1 Motivation

Until now, many national/regional facility management (FM) benchmarking pools exist, while international ones are still rare. However, the demand of international FM benchmarking pools is gradually growing.

1.1.1 Benefits of facility management benchmarking

Every organization needs facilities and infrastructures to accommodate and support its activities. The running cost of a facility, however, may account for a significant part of the annual expenditure, e.g., the annual utility cost of a 684,000 square feet research facility A is US $ 2195,640 and the annual maintenance cost of an aerospace corporation B (facility size is 920,000 square feet) is US $ 1628,400. It is necessary to find a solution for reducing costs in these areas.

Benchmarking is one of the most suitable tools to reduce cost. It involves the process of comparing current own practice with a perceived higher level of performance and provides a comparable outcome, from which improving measures can be obtained. Take the above mentioned facility A as an example. It takes part in a FM benchmarking program [1] and realizes that a significant improvement is possible. It focuses on building management control, lighting, reheat options, etc. It reduces its utility costs from US $ 3.21 per square foot to US $ 2.46 per square foot with no impact on the quality of the research programs. This yields a saving of up to US $ 513,000 in the first year. For corporation B, its total maintenance costs drop from US $1.77 per square foot to US $1.51 per square foot in the first year attributed to the benchmarking activities, while the total saving is US $ 239,000.

Cost reduction may be the first concern of organizations, and most benchmarking indicators are cost-centered. Besides, there are some other benchmarking facets such as sustainability. With the help of "green rating systems" such as *Leadership in Energy & Environmental Design for Existing Buildings: Operations & Maintenance* (LE ED-EB OM), *Energy Star*, etc., an organization can achieve more than just cost reduction, but also social approval and sense of belonging for its employees.

[1] Data source comes from FM benchmarking which is organized by FM Link & FM Issues.

1.1.2 Worldwide facility management benchmarking pools

One of the most important prerequisites for benchmarking is to find a suitable benchmarking partner which can be its own company (Internal Benchmarking), competitors, industry-dependent companies or industry-independent companies (External Benchmarking). Benchmarking pools established by a third party institution are the best sources of industry-dependent benchmarks. There are already many of FM benchmarking pools, such as the Benchmarks of *International Facility Management Association* (IFMA) in North America, the FM Monitor of *pom+ Consultancy Corporation* (pom+) in Switzerland, the FM Benchmarking pool of *parasta kiinteistötietoa* (KTI) in Finland, etc.

However, most benchmarks provided by the above mentioned benchmarking pools are national. Most of the international benchmarking pools produce energy consumption benchmarks only such as the benchmarking report from the *International Sustainability Alliance* (ISA). The *FM Monitor International* Report [34] is not restricted by national boundaries but limited to German-speaking regions. The benchmarking program of the *Investment Property Databank Limited Company - Occupiers* (IPD Occupiers), which is called *IPD occupiers Benchmark*, is one of the rare international FM benchmarking pools.

1.1.3 Demand of international facility management benchmarking pools

The demand of international FM benchmarking pools is steadily increasing. One of the most important reasons is that more and more companies purchase or rent properties globally. The number of international companies has increased dramatically. Some of them purchase or rent factories in other countries where the price of labor is cheaper; some purchase or rent offices abroad for core-business. These companies operate a large number of properties in different countries. They need to know which facilities are run efficiently and how to run other properties equally profitable. In this context, there is an increasing demand for FM international benchmarks.

Second, a suitable benchmarking partner is critical to the success of benchmarking. Compared to external benchmarking, information is easier to be obtained when an internal benchmarking is applied. However, systematical problems inside a company cannot be avoided. Likewise, it is easier to obtain information and to process data in nationwide benchmarking than in an international one. Nevertheless, more "Best Practices" can be found worldwide. In order to establish world-class FM, the future of benchmarking must be international.

Furthermore, when countries whose FM industries are still immature want to improve their facility management levels but not have national benchmarks at hand, international benchmarks can be adopted with some adjustments.

1.2 State of the problems

There are many challenges regarding international FM benchmarking such as information collection, communication in different languages, legal issues, etc. However, the most intractable obstacle may be the comparability of data. The aspects most concerned are area measurement regulation, FM cost classification, and currency & price level.

1.2.1 Area measurement regulation

The in-comparability of data may be caused by many reasons. Area measurement regulation is a key factor because a lot of benchmarking parameters are referenced to space parameters. It is necessary to have a common area measure platform in order to calibrate the comparison. However, different countries prefer different measurement regulations.

As long as all facilities within a benchmarking program are measured in a consistent way, it is to some extent irrelevant how many measurements there are and which ones are used. One good example is the *IPD occupiers benchmarks*. It collects properties data all over the world. All data are processed on the basis of *IPD space codes*. Unfortunately, this case is not easy to duplicate. It is required that the organizer of benchmarking has good control in many fields such as research, data source, power of influence, etc.

Since there are many national FM benchmarking studies, it is more cost-effective to establish an international benchmarking pool with the corporation of different national benchmarking organizations. Following this method, the international benchmarks are a kind of data re-treatment of the benchmarks of partner benchmarking organizations. The question is: how to deal with the different area measurement regulations?

1.2.2 Facility management cost classification

Similar to the area measurement regulation, there are various FM cost classification systems in the world. It is true that the FM cost data from different countries are comparable as long as all FM costs are collected following the same system within the benchmarking program. However, if we want to make use of the achievements of national benchmarking programs, who have already applied different cost classification systems, the inconsistency of FM cost classifications of different benchmarking programs constitutes a significant problem.

1.2.3 Currencies and price levels

Different countries have their own currencies while a comparison is possible when FM costs are displayed in the same currency. One might think that displaying costs in the same currency is not difficult since there are market exchange rates (MERs) among different currencies. Actually, most international/regional FM benchmarking studies such as *FM Monitor International* and *DTZ Occupier Perspective- Occupancy Cost- Logistics* apply this conversion method. Nevertheless, this method has its disadvantages. One is that MERs change every day even every second while data processing is time consuming. Which MERs can be adopted requires great consideration especially when MERs suddenly change because of some event. Another disadvantage is that it cannot reflect the discrepancies of price levels among countries.

Even in a same currency region like the Euro region, different countries use the same currency but have different price levels. One Euro may buy one cup of coffee in Slovenia but only half or even one third in Austria. The goods will be sold at the same price if all goods circulate internationally, all countries have the same tax and there are no transaction fees. However, this assumption exists only in economics books but not in the real societies. Many goods and services cannot be provided internationally and are influenced by many location factors, e.g., when the price of labor is cheaper in a country, labor-intensive services are certainly cheaper than in many other countries. On the other hand, when a country is poor of natural resources, the price of resources such as water or electricity will be higher. Therefore, we cannot simply compare two numerical values of FM costs even if they are displayed in the same currency. A conclusion which national FM industry is better developed is also not possible.

1.2.4 Other problems

It is well known that FM costs vary in correspondence with the service levels (quality) as shown in Figure 1.1. However, the quality measurement is under-developed and varies from one country to another.

Tax, climate, service time, etc. are other factors that differ from one country to another. The value added tax is 8.0% in Switzerland while it reaches up to 20% in Austria. The heating energy demand of existing buildings accounts for more than 50% of the primary energy demand of residential and service buildings in the European region in average according to [3]. The consumption of heating energy in Nordic countries is obviously higher than that in Italy or Spain. This result may be influenced by different facility management ability of different countries, but the climate discrepancy across countries is also a key factor. A full-time employee in Austria works about 38 hours per week while in China it may be 50 or even 60 hours. The consumption of energy for electricity will certainly be influenced by these factors.

Model	Level of Service	Description	Cost per GSFT	Cost per Occupant
Aircraft Hangar	High	Clean floors 5 times per week and remove trash 7 times per week. Complete restroom service 5 times per week.	$.80	$427
	Medium	Clean floors and remove trash 3 times per week. Complete restroom service 3 times per week.	$.49	$261
	Low	Clean floors 2 times per week. remove trash 3 times per week. Complete restroom service 2 times per week.	$.30	$160
Apartments, 1-3 Story	High	Clean floors in living areas 2 times per week, clean and vacuum upholstered furniture 2 times per week. Bedrooms: Empty trash, dust, make bed, replace linen & supplies daily. Clean kitchen area appliances, surfaces, floors 2 times per week. Complete restroom service 2 times per week.	$1.50	$338
	Medium	Clean floors in living areas once per week, clean and vacuum upholstered furniture once per week. Bedrooms: Empty trash, dust, make bed, replace linen & supplies once per week. Clean kitchen area appliances, surfaces, floors once per week. Complete restroom service once per week.	$.75	$169
	Low	Clean floors in living areas every 2 weeks, clean and vacuum upholstered furniture every 2 weeks. Bedrooms: Empty trash, dust, make bed, replace linen & supplies every 2 weeks. Clean kitchen area appliances, surfaces, floors every 2 weeks. Complete restroom service every 2 weeks.	$.38	$86

Figure 1.1: Cost of different service levels [35]

1.3 State of the art

There are many national FM benchmarking pools but only very few international ones. Table 1.1 shows an incomplete but representative list of them.

Among these 13 international FM benchmarking programs, almost all use the direct method, which means that data are collected directly from different countries and processed based on one uniform measurement platform. To use this method, it is required that the organizers have extensive data resources. Both IFMA, *Building Owners and Managers Association* (BOMA), *Investment Property Databank Limited Company* (IPD) and *DTZ Holdings Public Limited Company* (DTZ) are leading international organizations of the property industry with branches and members all over the world. The FM benchmarking program organized by *FM Link* and *Facility Issues* receives great support from the *Association of Facilities Engineering*, *British Institute of Facilities Management* (BIFM) and *CoreNet Global*. Some have established recognizable measurement standards such as ASTME 1836 [23], ANSI/BOMA z.65, IPD codes, etc. Some like ISA do not conclude one standard, but define every indicator in detail. The measurements of some energy consumption benchmarking programs are accepted worldwide, which means that they have a uniform measurement platform.

Only the report *FM Monitor International* uses the indirect way. It is a corporation of *FM Monitor*, *FM Austria*, and *fm.benchmarking report*. The cost and area indicators are generated at a national level, adjusted and subsequently compared internationally.

Table 1.1: List of international / multinational FM benchmarking programs

No.	Benchmarking Program	Data Source	Methodology
1	Benchmarks: Annual Facility Cost (IFMA)	North America	Direct
2	European Benchmarks (IFMA)	Europe	Direct
3	Space & Project Management (IFMA)	North America	Direct
4	Operation & Maintenance Benchmarks (IFMA)	North America	Direct
5	The Experience Exchange Report (BOMA)	North America	Direct
6	FM Benchmarking (FM Link & Facility Issues)	International	Direct
7	Museum and Cultural Institutions Benchmarking (Facility Issues etc.)	International	Direct
8	IPD Occupiers Benchmark (IPD Occupiers)	International	Direct
9	Facilities Operations Cost Reference, International Version (Whitestone)	International	Direct
10	Facility Maintenance & Repair Cost Reference (Whitestone)	North America	Direct
11	ISA Benchmarking Report (ISA)	International	Direct
12	FM Monitor International (pom+)	German-speaking countries	Indirect
13	DTZ Occupier Perspective-Occupancy Cost (DTZ)	International	Direct

In order to establish an international FM benchmarking pool, the report *FM Benchmarking in Nordic Countries* [42] must be mentioned. It identifies similarities and differences of important cost components in the Nordic countries and finds a limited number of trustworthy common Nordic cost components. IFMA benchmarking program shows that national climate zone maps can be used to remove the climate influence and adjust the energy consumption data.

FM Monitor International uses MERs to change all FM costs of Switzerland from Swiss francs into Euros, but it does not point out which MER is applied. In the report *DTZ Occupier Perspective - Occupancy Cost* the Euro is also used as the basic currency and all other currencies are exchanged into Euro according to the MERs. The report states which MERs were used and refers to the price level problem, but it does not reflect the influence of the price level in its final result. The *International Comparison Program* (ICP)[1] implemented by the World Bank uses Purchasing Power Parity (PPP) to solve the currency and price level problem. PPP is an economic theory and a technique used to determine the relative value of currencies.

There are also several studies identifying the appropriate indicators for facilities performance. One was conducted in the United Kingdom (UK) [26] and is based on a survey of 25 of the top 100 UK organizations involving a series aspects such as business, building, portfolio, acquisition, disposal, etc. The indicators range from simple operating costs to space use comparisons, costs of disposal and vacancy rates. The study reveals which indicators are the most popular for implementation. Another study investigates FM benchmarks in the Asia Pacific region [15] and provides a ranking of one hundred indicators applied within the region. The research shows that the top ten indicators are, not surprisingly, those with a financial implication.

1.4 Aims of the dissertation

There are two primary methods to establish an international benchmarking pool. **One** is the **direct way** by which data are collected from different countries directly and processed according to one uniform criterion. **The other** is the **indirect way** by which indicators are generated at the national level and then adjusted and compared internationally. These two methods have their own advantages and disadvantages which are listed in Table 1.2.

Table 1.2: Comparison of the direct way and indirect way

		Direct way	**Indirect way**
Comparability problem	Area measurement	Not exist	Exist
	FM cost classification	Not exist	Exist
	Currency	Exist	Exist
	Price level	Exist	Exist
	Service level	Exist	Exist
	Climate	Exist	Exist
	Hours of use	Exist	Exist
Data source requirement		High	Middle
Cost		High	Low

The direct method has no in-comparability problem caused by area measurement regulations and cost classifications, but other problems such as climate, tax, currency and price level still exist. Huge data resources are needed and it costs more compared to the indirect way.

These international benchmarking pools established by the direct way provide a uniform area measurement platform. However, it may be not identified with area measurement

rules those benchmarking participants used before. Participants may not be willing to recalculate the area of their properties since area calculation is always a troublesome, time consuming task. They prefer to use the data they already have and state which measurements they use. The benchmarking results displayed on the basis of the area data which they are familiar with will be more useful for them.

It is much more likely that, in the future, standards will use a common language and describe the area measurement process more consistently, i.e., EN 15221-6 is published as the official national standard among 30 member countries of the *European Committees for standardization* (CEN). There is still a long way to go before one area measurement standard is accepted worldwide. *Unified Approach for Measuring Floor Area in Office Space* is published jointly by IFMA and BOMA to provide consistency between area standards of two organizations. The international benchmarking pool should try to provide this kind of conversion solutions instead of just providing different measurement methods.

This study aims to find out whether it is possible to set up an international FM benchmarking pool by integrating existing national FM benchmarking pools and explore integrating methods.

1.5 Outline

In *Chapter 2*, two concepts about FM and benchmarking are introduced, which should help readers to build a concept framework of FM benchmarking.

In *Chapter 3*, some popular FM benchmarking practices are listed. Furthermore, some representative area measurement standards and FM cost classifications are introduced.

In *Chapter 4*, a solution to the in-comparability problem caused by discrepancies of FM cost classifications applied by different national FM benchmarking pools is proposed. The similarities and differences of current FM cost Key Performance Indicators (KPIs) of national/regional FM benchmarking pools are compared. A set of common cost components is defined as the KPIs of the integrating international FM benchmarking program of this work.

In *Chapter 5*, the in-comparability problem caused by different area measurement standards used by various FM benchmarking pools is discussed. Based on the comparison analysis, the uniformity and differences of examined area measurement codes are presented. Ignorable and important differences of those standards are determined. Subsequently, one code is chosen as the standard code of the proposed international benchmarking pool. The adjustments of area data of other national benchmarking pools are suggested by mapping.

In *Chapter 6*, the in-comparability problem caused by currency and price level is worked out using the PPP methodology. With the application of the method *Pricing A Basket of FM Service Inputs*, PPP exchange rates for the FM industry (and four sub-industries) are calculated. Furthermore, three examples are presented to illustrate how FM cost values are adjusted to remove the influence factor of the price level.

In *Chapter 7*, a short summary is given. A discussion of the possible extensions of the study is also presented.

In *Appendix A*, major FM services are introduced and workers, equipment/tools and materials/resources involved are presented.

In *Appendix B*, the discussion about the product selection of the FM non-labor inputs is illustrated.

In *Appendix C*, the price information of tools, equipment and materials for building cleaning industry is demonstrated in the form of an example, since price collection for the FM industry is one fundamental part of this study,

In *Appendix D*, the calculation of the PPP exchange rates for the utility services is presented.

2 FACILITY MANAGEMENT AND BENCHMARKING

2.1 Background of facility management

2.1.1 Origin and why facility management

The term 'Facility Management' (FM) originated in the late 1960s in the United States (US) and was used to describe the growing practice of banks outsourcing responsibility for processing of credit card transactions to specialist providers.

In 1978, furniture manufacturer Herman Miller convened a meeting in Arbor Michigan to discuss the developing trends in office design likewise naming them "Facility Management". Participants in the workshop founded the American and subsequently the *Association of Facility Management* established in 1985 in the UK. The *German Facility Management Association* (GEFMA) followed in 1989. In 1993, the *European Facility Management Association* was founded in the Netherlands. By the end of the 1980s, FM was also introduced in Australia[1] and Japan[2].

Running costs of facilities are a big part of the annual expenditure. Certainly there is a great pressure to reduce costs in these non-core business areas. However, no matter how well an organization might focus on its core business, it cannot loose sight of the non-core business. Budget cutting can be financially expedient but may not be beneficial to the long-term development of the organization. An appropriate environment must be created to support the core business. The fundamental function of FM is to provide an environment with a holistic view of the dynamics of the workplace: people, process and environment.

2.1.2 Definitions and interpretations of facility management

Facility. In general, facilities may be defined as public utilities. They describe the physical properties and services provided to a location. In the Oxford Dictionary (2005), a facility is defined as something that is "established, created, designed and installed to provide service". As a result, facility refers to not only *physical buildings* and *equipments* but also *soft services*.

[1]Facility management Association of Australia established in 1989. Its website is `http://www.fma.com.au/cms/index.php`.

[2]Japan Facility Management Association (JFMA) established in 1987.

Facility management. FM of facilities has traditionally been regarded as providing care taking, cleaning, repairs and maintenance. Nowadays, it covers real estate management, health and safety and contract management, in addition to building maintenance, domestic services and utilities supply. It can be concluded that all non-core business can be managed in the framework of FM. There are various definitions of FM provided by different organizations like *International Facility Management Association* (IFMA), *European Council of Construction Economists* (CEN), etc. In this work, we apply the definition by GEFMA: *It is a management discipline, which plans and controls the coordinated activities during the facility processes.* [11]

Process-oriented facility management. The goal of FM is to meet a large number of customer requirements with a minimum use of financial, human and material resources. This involves many FM activities and processes. To achieve this goal, each process must be carefully analyzed. FM is described in the form of process model as shown in Figure 2.1. Firstly, various process levels must be defined. It means to define who is responsible for the planning, management, implementation and control and in which steps the process is executed. The planning of an individual process should be based on the existing process landscape. All parties involved should be included:

- Customers to define the requirements and service levels (quality);
- Employees to optimize the FM processes (by using their experience and ideas)
- Executive managers to generate strategic plans
- Suppliers and external representatives to achieve an optimal reconciliation.

Any sub-processes can be developed from the above basic process model. These sub-processes can be analyzed separately, but many such sub-processes are parallel to each other during the daily operation. To organize such a great number of different processes, an effective computer program is required to assist management (computer aided facility management (CAFM)).

In order to make proper decisions in the planning phase, it is not sufficient to only understand FM as a process model for a civil engineer, architect or building technician. A detailed knowledge of the core processes, individual services and products is also required. [41]

Facility management and architecture. According to the philosophy of traditional design, which requires minimizing construction costs, FM is restricted to the service phase of the building. Compared with facility manager, architecture takes responsibilities mainly in the planning and construction phase. They often do not have many intersections.

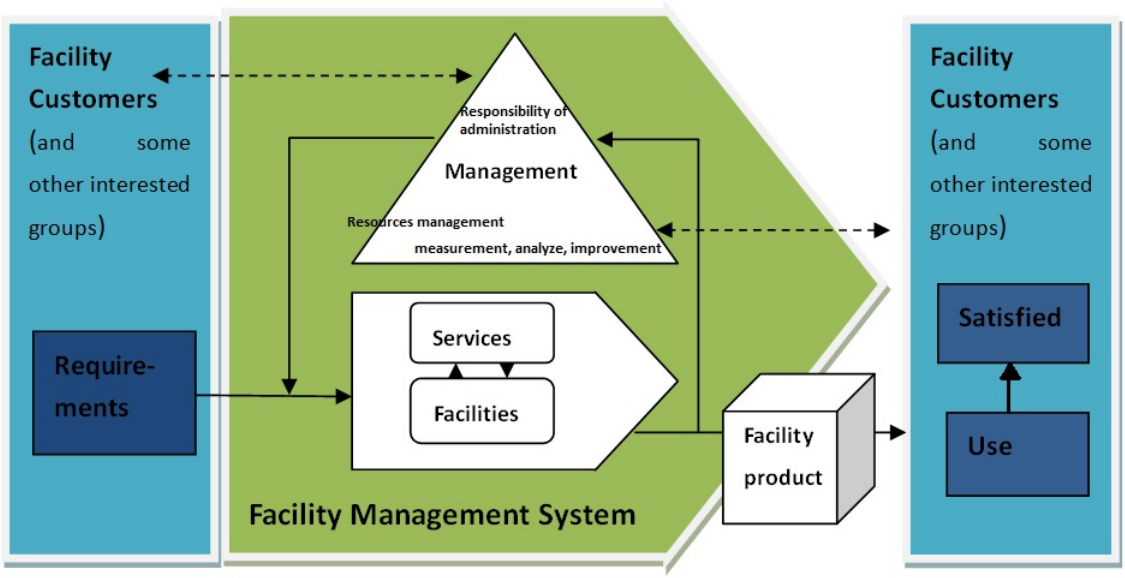

Figure 2.1: Process model of FM (source: [11])

FM-oriented design tries to minimize the costs of the whole life-cycle of a building instead of only the costs occurring during the construction stage. It means that running costs such as cleaning costs, maintenance costs and energy consumptions should be considered from the very beginning. As a result, facility managers should also be involved at the planning stage.

In fact, the planning phase can be sub-divided into three stages, which are planning, organizing, and designing. Planning means to determine the functions that a building has to fulfill. Organizing is to plan and organize the quantitative physical requirements of resources needed to accomplish established goals. Designing refers to the realization of what was organized by applying accurate drawing. Facility managers' work takes place at the planning sub-stage while architects are mainly involved at the design sub-stage. Facility managers propose specific goals and methods which can lead to lower operating costs, suitable work places, reasonable space arrangement, etc. while architects achieve those goals with drawing.

Facility management and building management. Building management encompasses all coordination tasks, which are necessary to guarantee the effective use of buildings. Building management can be divided into three fields, which are technical building management, infrastructural building management and commercial building management.

The division into technical, infrastructural, and commercial is also used in FM. As a result, building management often seems to be the same as FM. Actually, there are two basic distinctions between these two concepts. Firstly, all facilities (physical facilities and services)

outside of buildings are automatically excluded from building management. Secondly, building management only takes place during the service phase. Building management is only a part of FM.

Facility management and corporate real estate management. Other than Real Estate Management (REM), Corporate Real Estate Management (CREM) is used in "non-property-companies" such as industrial, commercial and service companies. They hold large numbers of properties, but their core business is not real estate. The goal of CREM is to obtain as much profit from the properties of their own companies as possible in order to enhance the entire profitability of the companies. CREM has developed from the traditional REM. Thus, the functions of CREM also include analysis, planning, organization and control.[28]

According to CREM, properties are seen as a whole and treated as an investment. It is a management conception mainly applied at the decision-making level of an organization. On the other hand, FM is more "operational". Even strategy FM follows the decision of the executive level of an organization as well.

2.1.3 Levels and functions of facility management

As FM masters numerous resources over a long period, it is necessary to divide it into strategic FM and operative FM. Operative FM focuses on tactical day-to-day issues. It solves problems related to specifics such as where individuals sit or the type of equipment required accommodating a specific situation. Strategic FM is to answer the question: What buildings and space are needed to support the strategic goals? The first important thing is to carry out an in-depth analysis of the existing building including location, capability, utilization and condition. Once the organization's business plan has been established and a clear understanding of assets and capabilities has been gathered, it is possible to identify the required facility requirements by the method of gap analysis.[17]

2.1.4 Approaches to facility management and facility management cost

There are common approaches to FM, regardless of the size and location of buildings, although these may not necessarily result in common solutions to problems. In some cases, estates-related and facilities services are contracted out (outsourcing) while others are retained in-house for good reasons. Many organizations also operate what might be described as a mixed economy, where some services, even the same services, are partially outsourced and partially retained in-house.

It is not a simple choice between retention in-house or outsourcing. The organization has to determine its requirements precisely. The first step is to consider which attributes of each service are important. The cost is bound to be a prominent factor for many organizations. However there are many others, which include but are not limited to customer service, uniqueness of service, priority, flexibility and speed of response, management implications and indirect cost, direct cost and control, security, etc. It should also be pointed out that the choice is not limited to either in-house provision or outsourcing. Table 2.1 shows seven of many further options.

Table 2.1: Definitions of options [2]

No.	Option	Definition
1	In-house	The assignment of the organization's employees for the delivery of estates-related and facilities service.
2	Special company/business unit	The reorganization of the in-house team into an independent company, with the objective of expanding its business by gaining contracts from other clients.
3	Managing agent	The appointment of a specialist to act as client representative. This person (or organization) is then responsible for arranging the appointment of service providers.
4	Managing contractor	The appointment of an organization to manage all service providers. The contractor is paid a fee for providing this service, usually as a percentage of the value of the expenditure managed.
5	Managed budget	A variation on the managing contractor, where a contractor takes responsibility for the payment of all suppliers and provides a consolidated invoice at the end of each month. The fee is related to the contractor's own resources as deployed.
6	Total facility management	The responsibility for providing services and for generally managing the facilities is placed in the hands of a single organization.
7	Off-the-shelf/ agency	The contractual employment of personnel through a specialist or general recruitment agency. Agencies provide variable standards of selection expertise, personnel support and training, and customer support.

FM costs exist throughout the whole life-cycle but the most part only occurs at the service phase. Many countries established standards of FM cost structure such as DIN 18960, ÖNORM B 1801-1. Many associations or consultancies also published FM cost classification systems like IFMA and *Investment Property Databank Limited Company* (IPD). Table 2.2 shows an example of FM cost structure during the service phase.

Table 2.2: FM cost structure of DIN 18960 [10]

1. Capital cost	1.1 External capital 1.2 Internal capital
2. Management cost	2.1 Staff 2.2 Material 2.3 Management, others
3. Operation cost	3.1 Supply and disposal 3.2 Cleaning 3.3 Operating of technical equipments 3.4 Inspection & maintenance of building structures 3.5 Inspection & maintenance of technical equipments 3.6 Supervisory service 3.7 Tax and fee 3.8 Operation, others
4. Maintenance cost	4.1 Building structures repair 4.2 Technical equipments repair 4.3 Outdoor installation repair 4.4 Furniture repair

Different standards may use different names for the same kind of cost. The same sub-components can be arranged in different main components. All of these increase the difficulty of the international FM cost comparison.

2.1.5 Facility management market

FM services provided and purchased on the market can be separated into four hierarchical levels. The first level comprises suppliers of single services who specialize in specific trades within technical, infrastructural or commercial FM. The second level encompasses suppliers of bundled services who operate in one or two FM service areas (commercial, technical or infrastructure). The third level includes suppliers of system services who cover all three service areas (integrated service). The last level contains suppliers of integrated FM [40].

According to the activation period of the four supplier types, FM market is divided into four types [13]:

- Pre-emerging markets: these markets are just beginning to develop recognizable FM. Countries of this category have seen the emergence of single service provisions since the end of the 1990s.

- Emerging markets: these markets have existed since the late 1980s. The highest product level attained so far consists of system services.

- Developed markets: these markets have a high level of market maturity as a result of almost 20 years of FM activities. Integrated services are available but have only emerged during recent years.

- Pioneer markets: these markets are the most developed of all and can be seen as leaders in the field of FM. FM has been available in a clearly recognizable form for over 20 years and integrated services including operator / cooperation models such as "Public Private Partnership" and "Build Operate Transfer" models have been offered since the end of the 1990s.

US[3]. There is a mature/pioneer facility services market in the US. Despite the economic downturn, the US external FM market (outsourcing) reached a new height in 2010 with over 271.2 billion US Dollars. Furthermore, the market gets more concentrated. The market share of the top 10 increased from 11.8% in 2008 to 13.2% in 2010.

The service cleaning won first place with an annual turnover of 65.4 billion US Dollars in 2010 and an increase of 3.2% covering 46.8% of the total market of soft services, which is followed by catering (32.2%) and security (5.7%).

The US is a very attractive market for many foreign facility service companies due to its great size. Some European players took a major stake in the market by focusing on one segment such as *ISS A/S Company* on cleaning or *Sodexo corporation* on catering. Furthermore, the market gets more concentrated. The market share of the top 10 increased from 11.8% in 2008 to 13.2% in 2010.

Europe. Based on the above market model, European countries can be categorized according to their level of maturity. (Table 2.3)

The FM market volume of Europe was about 655 billion Euro in 2008, of which 331 billion Euro were in-house services and 324 billion Euro outsourcing services. The top five countries (UK, German, France, Italy, and Spain) took up 422 billion Euros accounting for 64% of the whole market volume. In the developed and pioneer markets, the outsourcing grade is higher than 40%. Revenues of cleaning services took the first place in 2010 occupying 52.8%. Maintenance and catering followed up with 22.5% and 13.1%. [27]

[3]Data source from website `http://www.interconnectionconsulting.com/index.php?lang=en&presse=11`.

Table 2.3: FM-Volume in Europe (Volume unit: Billion, Euro)[39]

Country	Market type	GDP	Total FM service	Place	Outsourcing rate
UK	Pioneer	1859.05	204.39	1	59.2
Germany	Developed	2360.06	73.38	2	47.7
France	Developed	1795.75	58.89	3	45.0
Italy	Developed	1488.29	48.78	4	41.0
Spain	Developed	946,66	37.31	5	40.2
Holland	Pioneer	527.08	25.93	7	59.7
Belgium	Developed	313.13	15.41	8	47.1
Switzerland	Developed	309.92	15.25	9	47.1
Austria	Developed	258.45	12.72	12	47.1
Denmark	Developed	218.46	10.75	15	47.1
Ireland	Developed	170.42	8.38	17	47.1
Luxembourg	Developed	30.79	1.52	26	46.7

Asia-Pacific. In mainland China, the FM concept is prevalent only among international companies e.g. Nokia, Intel, IBM, etc. It is not well accepted by local enterprises. FM is treated as "facility maintenance" by the public. Service is mainly provided by in-house teams. It is still a pre-emerging market.

The FM concept came to Japan in the mid 1980s while early attempts were rudimentary and only consisted of facility maintenance. Now the need to FM tends to increase sharply when to build a new office or move an existing one. Japanese companies often manage space by division or location. Only few companies have an integrated company-wide system.

The Australian FM market earned revenues of $5.14 billion in 2009 and is likely to reach $7.87 billion in 2016 according to the new analysis from Frost & Sullivan[4]. This FM market has the strong support from its government and regulatory agencies. The efforts of bodies such as the *Property Council of Australia* have made the country one of the most sophisticated property sectors in the world.[5]

South Africa. A new analysis from Frost & Sullivan [6] on the South African FM market indicates that the market earned 587.3 million USD in 2008 and estimates that it will reach 1.1 billion US Dollars in 2015. Most end-users are still unaware of the benefits of FM

[4] http://www.buildingtechnologies.frost.com.

[5] http://www.frost.com/prod/servlet/press-release.pag?docid=217071858.

[6] Data source from website http://www.facilitiesshowafrica.com/Uploads/Images/FM\%20Brochure\%2007_04_2011.pdf.

because the FM market is still unrecognized as a formal industry. Only 30% of FM is outsourced at current.

2.2 Background of benchmarking

The concepts of benchmarking are defined differently but the cores are similar. A benchmark is a reference point of a measured best performance. Benchmarking is a process, during which products, services and practices are measured and a comparison between own performance data with benchmarks obtained from identified comparable partners is made.

2.2.1 Origin and development

The company *Rank Xerox* plays an essential role in the development of benchmarking. In 1979 *Xerox* found that the Japanese competitor of a copying machine sold at a price which was even lower than *Xerox*'s production cost. Afterward, *Xerox* started a benchmarking process with the competitors in the manufacturing sector.

In 1981, *Xerox* started a industry-independent benchmarking project with the company *L.L. Bean* whose main business was on logistics and distribution. This project proved that benchmarking can also be done in a non-production process and the benchmarking partner must not be from the same industry.

In 1989, Robert Camp published the first detailed guidelines and process methods about how to practice benchmarking. Before that, there were very few articles about benchmarking. After Camp's publication, the benchmarking method got wide acceptance.

In 1992, the *International Benchmarking Clearinghouse* was established at the *American Productivity Quality Center*. Later, *Strategic Planning Institute Council on Benchmarking* was also founded in the US. Next was England which established its *Benchmarking Center* in 1993. In 1994, the first benchmarking center was opened in Germany and the *Global Benchmarking Network* was set up in 1995. The latter is a network of benchmarking centers worldwide which transfers information among the benchmarking partners and builds agreements between all national organizations.

2.2.2 Advantages and disadvantages of benchmarking

Advantages and applications. Benchmarking makes it possible to analyze and compare products, business processes, services, methods, companies or even company envi-

ronments. A organization can get a top position by applying the following changes to its own services:

- meet the requirements of customers;
- systematically exchange the differences with best practice solutions of the industry;
- define more objective efficiency methods;
- adopt good methods from "Best Practice";
- recognize new technologies;
- encourage workers.

Disadvantages and difficulties. Benchmarking is a new concept. There are only few professionals who have experience in conducting benchmarking projects. Another difficulty is the access to information. Benchmarking cannot exist without information.

Different benchmarking types have their own disadvantages, e.g., the biggest problem for internal benchmarking is that the systematical weakness of an organization may not be revealed. When an external benchmarking is made, the benchmarking partners may be potential competitors. The question is how to control the quality of information exchanged.

2.2.3 Types of benchmarking

Benchmarking is not a unified tool. Based on the benchmarking object and the potential partners, there are different benchmarking types as Figure 2.2 shows.

Internal benchmarking. Internal benchmarking is the comparison of similar activities or functions inside a company or an organization. The advantages and disadvantages of internal benchmarking are concluded as follows:

- Advantages
  - easy to get information;
  - easy to develop benchmark;
  - easy to choose partner;
  - possible to publish all data and no danger of leaking company secrets.

- Disadvantages
  - not possible to rank outside the company;
  - prejudice.

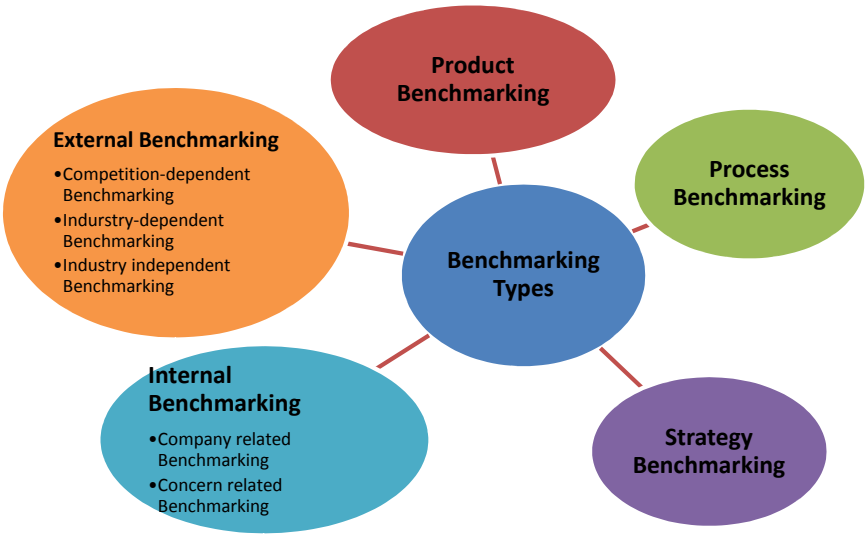

Figure 2.2: Types of benchmarking [37]

Internal benchmarking detects the advantages and disadvantages of the company and provides the possibility to change. However, it is not sufficient to help the organization to reach a first class position globally because it lacks the perspective of an external environment.

External benchmarking. External benchmarking is the implementation of benchmarking outside the own company. It is subdivided into competition-dependent benchmarking, industry-dependent benchmarking and industry-independent benchmarking.

Competition-dependent benchmarking refers to the comparison and analysis of products, services and processes with direct competitors. Industry-dependent benchmarking has the same goals as competition-dependent benchmarking but it broadens the comparison scope to the whole industry. Industry-indenpendent benchmarking is to learn from other companies no matter which industry they belong to. Table 2.4 displays the contractions of different forms of external benchmarking.

Product benchmarking. During the process of the product benchmarking, the own product will be compared with the competitors'. Its goal is to find the differences in function scope and technical solutions. Differences are evaluated and converted into cost

Table 2.4: Comparisons of external benchmarking [37]

	Competition-related benchmarking	Industry-related benchmarking	Industry-irrelevant benchmarking
Access of information	Difficult & expensive	Expensive	Easy
Fields of application	Strongly restricted	Restricted	Extensive
Chances of improvement	Middle	High	High
Choice of partner	Easy	Easy	Difficult
Contracting	Possible to easy	Easy	Difficult
Comparability	Easy	Middle	Difficult
Competition problem	High	Exist	Hardly exist
Transferability	Good	Exist	Exist
Legal issues	Often	Seldom	Seldom

details. Based on the cost estimation, costs and technical solutions of the own company can be detected.

Process benchmarking. Process benchmarking is to compare similar processes with the goal of process-optimation. It can help an organization to better understand its current processes and give a better grasp of its starting point when it considers a potential change.

Strategy benchmarking. Strategy benchmarking is the process of comparing the strategies of own company with other benchmarking partners. The benchmarking elements may include core competencies, process capability, strategic intent, etc. Its goal is to devise ideal strategies for improving organizational performances.

2.2.4 Benchmarking procedures

There are many different definitions of the benchmarking procedure but the differences only exist in the name and the number of the phases. Their basic ideas are generally the same. In this study, the five-stage-concept is introduced as an example (Figure 2.3).

- In the *goal definition* phase, the fundamentals, the frameworks and the goals of the benchmarking project are fixed. A lot of time is spent on this phase to avoid possible mistakes which may influence the further project process.

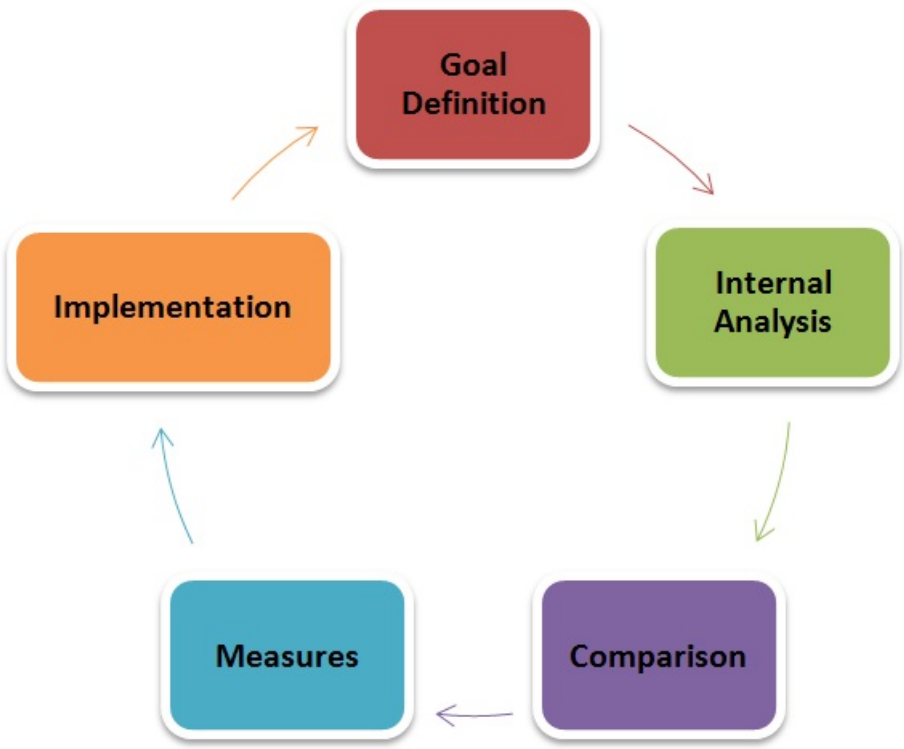

Figure 2.3: Five-phase benchmarking procedure [37]

- In the *internal analysis* phase, the benchmarking objects are analyzed. The measured value and all necessary information will be produced for the further benchmarking process.

- In the *comparison* phase, the features of the benchmarking partners are determined. The most important factor is the comparability between the own company and benchmarking partners.

- In the process of the *measures* development, the measurements will be developed based on the results of the comparison phase. It is a systematical work which includes developing as many measurements as possible, assessing measurements, making a work plan and choosing the optimal measurement plan.

- In the *implementation* process, the developed and chosen measurements are implemented.

2.3 Facility management benchmarking

The definition of FM benchmarking can be described as follows *measure performances and results of FM services including FM costs, sustainability, rents, customer satisfaction, etc., and compare them with the performances of internal or external organizations.*

There are already many benchmarking projects around the world. They are carried out by FM associations, governments, property consulting companies in different countries or regions. Some benchmark databases concentrate on costs; some focus on energy consumption; some pay great attention to space utilization. More detailed information will be introduced in the next chapter.

Compared with the process and strategy benchmarking, the product benchmarking seems to be the easiest and most popular one. Up to now, FM benchmarking focuses on results such as operation cost, operation efficiency which can be seemed as service products. There are no process benchmarking practices that compare the work flow of FM services.

FM benchmarking programs can be executed among different departments within an organization, e.g., *Graz University of Technology* (TU Graz) has several campuses, so that the FM benchmarking can be done among those campuses even among different buildings in one campus. FM benchmarking may also be carried out with other organizations in the same industry. TU Graz has two possibilities. One is the direct comparison, i.e., TU Graz can do FM benchmarking with the University of Graz. Sometimes this direct comparison is impossible because of the competition. As a result, the other solution is to make benchmarking with the industry's average benchmarks. Many FM benchmarking pools supply benchmarks for educational facilities.

Compared with other benchmarking programs, FM benchmarking has its special difficulties. One of the most important factors is that FM is a kind of service. It is invisible and intangible. For the same kind of service, the service level may vary, e.g., both hotels in the same street supply rooms for travelers. One has five-stars while the other is a youth hotel. Their rates are certainly quite different. However, we cannot compare their rates directly because their service levels are different. Similarly, facility management service levels are various, so that their costs cannot be compared directly. Adjustments are required.

3 FACILITY MANAGEMENT BENCHMARKING REPORTS AND MEASUREMENT STANDARDS

Various FM benchmarking reports have been released in the past few years. Some of them will be introduced in this chapter. Some popular area measurement standards and FM cost classification systems will be presented as well.

3.1 Introduction of facility management benchmarking reports

3.1.1 IFMA: "Benchmarks: Annual Facility Costs"

The report *Benchmarks: Annual Facility Costs* is published by *International Facility Management Association* (IFMA)[1]. In 2011, the sixth survey for this benchmarking program was carried out. Earlier versions were published in 1987, 1994, 1997, 2004, and 2008, respectively.

Organizer. IFMA, formed in 1980, is the world's largest and most widely recognized international association for professional facility managers. It certifies facility managers, support research, provides educational programs, recognizes FM certificate programs and organizes the world's largest FM conference and exposition "World Workplace".

Benchmarking indicators. This benchmarking report publishes various FM cost benchmarks which are listed in the following. Furthermore, it provides indicators about space utilization such as facility size and square footage per occupant.

- occupancy costs;
- janitorial costs[2];
- utility costs;
- maintenance costs;
- providing the fixed asset costs;

[1] `http://www.ifma.org/`.

[2] This category of cost is more often called as cleaning costs in other countries.

- expensed project costs;
- life and safety costs; [3]
- environmental costs;
- emergency/disaster planning costs;
- physical security costs;
- employee amenities costs[4];
- space planning costs;
- FM information technology costs.

Remarks. In the earlier versions, the paper questionnaire was the only method for survey. Now, a new on-line survey management system titled *Benchmarking Exchange* (BEX) is applied additionally to the paper questionnaire. The surveys are mainly executed in North America. Because of the great influence of the IFMA, this benchmarking report is supposed to be one of the most important reports in the world.

3.1.2 IFMA: "European Benchmarks"

The report *European Benchmarks* is produced by IFMA as well. Unlike *Benchmarks: Annual Facility Cost* which publishes benchmarks of North America, this report published FM benchmarks of Europe. The report has only one version so far which was released in 2001.

Benchmarking indicators. The benchmarks released by this report are also mainly about facility costs which includes:

- maintenance costs;
- housekeeping costs;
- utility costs;
- security costs;
- facility management costs.

[3] The costs associated with compliance to building regulations required by federal, state/provincial and municipal laws to maintenance and operate the facility.

[4] This category of cost is used to provide or maintain amenities like the cafeteria, food service operations etc. More details will be introduced in the next chapter.

Remarks. It is the first attempt of IFMA to conduct a benchmarking study in Europe. However, it did not continue because of many reasons. It also illustrated that it is a difficult task to organize an international FM benchmarking program.

3.1.3 IFMA: "Space and Project Management Benchmarks"

The report *Space and Project Management Benchmarks* released by IFMA deals mainly with space utilization.

Benchmarking indicators. This benchmarking study provides rounded benchmarks that are related to space utilization and also involves performance indicators about computer aided FM and project management.

Remarks. The survey has been successfully administered in 2001, 2006 and 2010. The data mainly comes from North America. This study analyzed all facility types and the results are presented for each type of facilities.

3.1.4 IFMA: "Operation and Maintenance Benchmarks"

The report *Operation and Maintenance Benchmarks* is another benchmarking study administrated by IFMA. The first survey of this study was carried out in 2008. An updated version is expected presently.

Benchmarking indicators. The benchmarking indicators of this study are about cost. Unlike the report *Benchmarks: Annual Facility Cost* which provides the rounded FM cost, this study focuses on three categories of cost: janitorial, maintenance and utility cost. It also presents staffing and utility consumption data.

Remarks. This benchmarking program was conducted for the first time in 2008 and collected data mainly from North America by paper questionnaire. In the next survey round, the on-line survey channel "BEX" will be used. The costs of cleaning, maintenance, and utility form a great part of the total FM costs. Many benchmarking studies only collect data from this field. From this point of view, this report may have more homogeneity with other FM benchmarking reports.

3.1.5 BOMA: "Experience Exchange Report"

The *Experience Exchange Report* (EER) is one of the great achievements of *Building Owner and Managers Association* (BOMA)[5]. This benchmarking program has already existed for 90 years. It is widely recognized in North America.

Organizer. Founded in 1907, today BOMA international has 93 local associations throughout the US and 13 affiliates worldwide (Australia, Brazil, Canada, China, Finland, Indonesia, Japan, Mexico, New Zealand, Philippines, Republic of South Africa, South Korea, United Kingdom). Besides producing the leading industry publications like EER, it is a standard for measuring buildings. BOMA published the *Standard Method of Floor Measurement for Office Buildings*, an accepted and approved methodology by the *American National Standards Institute* (ANSI).

Benchmarking indicators. This benchmarking study tracks not only the costs of FM, but also rent and taxes which are particularly relevant for property owners. The specific benchmarking indicators are:

- office rents;
- retail and other rental income;
- telecoms and wire access income;
- real estate taxes;
- energy and other utilities costs;
- repairs and maintenance costs;
- cleaning costs;
- administrative costs;
- security costs;
- roads and grounds costs.

[5] http://www.boma.org/Pages/default.aspx.

Remarks. The data is collected annually through the EER on-line survey. The data encompasses more than 275 markets in the US and Canada. This report only collects data of offices, corporate facilities and medical office buildings. It is worth pointing out that there is an agreement published jointly by IFMA and BOMA, which is called *Unified Approach for Measuring floor Area in Office Space for Use in Facility and Property Management*. It discusses the heterogeneity of the two standards which are BOMA Office Standard and IFMA Standard.

3.1.6 FM Link & FM Issues: "FM Benchmarking"

The benchmarking program *FM Benchmarking* [6] is a corporation between *FM Link* [7] and *Facility Issues* [8]. It is an on-line benchmarking system which initiated in January 2009.

Organizer. *FM Link* is a web-based FM publication. It blends information from its own sources as well as those from many others including most leading magazines and associations in the field. *Facility Issues* is an organization which provides a variety of facility benchmarking consulting services for their clients throughout the world.

Benchmarking indicators. The indicators of this benchmarking study include two parts. One is sustainability and the other is operating costs. In terms of the operating costs, this study focuses on four key FM areas which comprise 97% of a building's annual operating costs:

- utilities;
- maintenance;
- janitorial;
- security.

Remarks. This benchmarking study is conducted on-line. It collects and releases data for all kinds of facilities. Because it is global, the system also provides support for customers to generate reports in their preferred unit measurements.

[6] http://www.fmbenchmarking.com
[7] http://www.fmlink.com
[8] http://www.facilityissues.com

3.1.7 IAMFA: "Museum and Cultural Institution Benchmarking"

The report *Museum and Cultural Institution Benchmarking* is carried out by *Facility Issues* and endorsed by the *International Association of Museum Facility Administrators* (IAMFA). It is a benchmarking program for cultural facilities only and has existed for 13 years.

Organizer. The IAMFA is an international, educational organization devoted to meeting the professional needs of museum facility administrators especially setting and attaining standards in the design, construction, operation and maintenance of world-class cultural facilities. In pursuit of these goals, the association sponsors an annual conference and communicates quarterly with its member and friends around the world through the IAMFA journal *Papyrus*. The museum benchmarking report is one of the most important information provided by IAMFA.

Benchmarking indicators. One of most important benchmarking aspects of this report is operation cost which includes the following specific indicators:

- janitorial/ custodial services;
- utilities;
- building maintenance;
- exterior grounds maintenance;
- security.

This study investigates not only the final costs, but also different variants which can affect cost such as

- Space utilization;
- Organization structures;
- Temperature and relative humidity;
- Service level agreement;
- Customer satisfaction;
- Best practice and strategic planning.

Remarks. The study has been executed on-line for 13 years. Over 155 cultural institutions from nine countries have participated in this benchmarking program.

3.1.8 Facility Issues: "Facility Managers Round-Table"

Facility Managers Round-Table is another benchmarking study conducted by *Facility Issues*. It has been conducted for 21 years until 2012.

Benchmarking indicators. The benchmarking indicators of this program are mainly about various FM costs which include:

1. operation and maintenance
    - utilities;
    - custodial;
    - building maintenance;
    - roads and paving;
    - grounds and landscaping;
    - facility security.
2. general services
    - fixed expense;
    - mail services;
    - inventory management.
3. environmental health and safety
    - environmental health and safety.
4. facilities projects
    - moves and relocation;
    - projects construction.

Remarks. Like other benchmarking studies carried by *Facility Issues*, *Facility Managers Round-Table* uses the on-line survey system as well. It uses a standard set of survey definitions which is also used by other *Facility Issues* benchmarking programs. The data are collected from all kinds of facilities throughout the US.

There are two other benchmarking studies conducted by *Facility Issues*, which are *IFMA's Utilities Council Benchmarking* and *Research Facilities Benchmarking*. All three use a standard questionnaire. The only difference is the target benchamrking facility type. Round-Table is for all facilities; *IFMA's Utilities Council Benchmarking* is only for utility facilities and *Research Facilities Benchmarking* is for research buildings.

3.1.9 IPD Occupiers: "IPD Occupiers Benchmark Report"

The report *IPD Occupiers Benchmark* is provided by *Invest Property Data-bank limited Company* (IPD) Occupiers. Based on an on-line service system, the report can be generated at any time and according to the needs of the customer.

Organizer. IPD Occupiers[9] is a leading global expert in independent property performance measurement. Established in 1994, IPD Occupiers hold the largest independent database of corporate real estate information, which is updated annually with data on over 70,000 properties. The most important products and services are the *IPD Occupiers Reporting Tool*, *Global Estate Measurement Standards*, *IPD Rent Review Analysis*, *Facility Management Benchmarking Group*, *Value for Money Service*, etc. The first two products are mostly related to its benchmarking subject. *Global Estate Measurement Standards* created a standard platform which enables users to generate consistent and comparable performance information about their buildings anywhere in the world. *IPD Occupiers Reporting Tool* gives users an instant access to a range of useful reports and benchmarking options through a secure on-line portal.

Benchmarking indicators. IPD Occupiers developed a model (Figure 3.1) to assess a property's performance. For the efficiency part, the benchmark indicators are developed as shown in Figure 3.2.

Remarks. IPD Occupiers has one of the largest databases of properties in the world and collects data from Austria, Belgium, Central and Eastern Europe, Denmark, France, Germany, Ireland, Italy, the Netherlands, Nordic region, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, and UK.

[9] http://www.ipdoccupiers.com

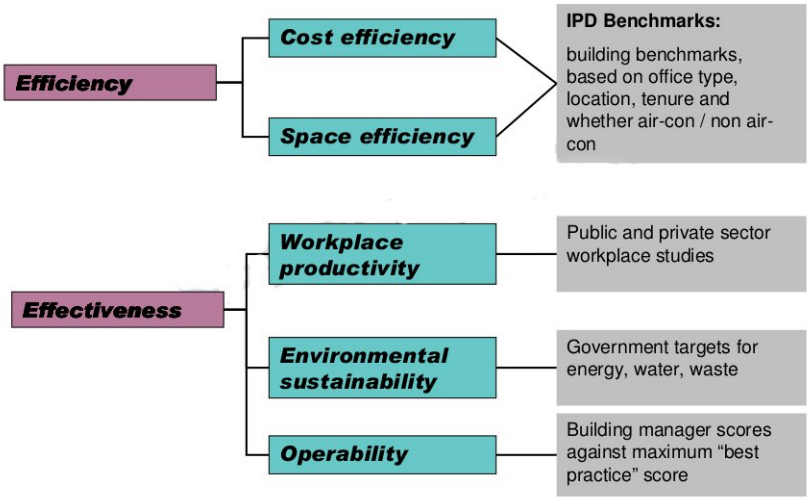

Figure 3.1: IPD property performance measurement model

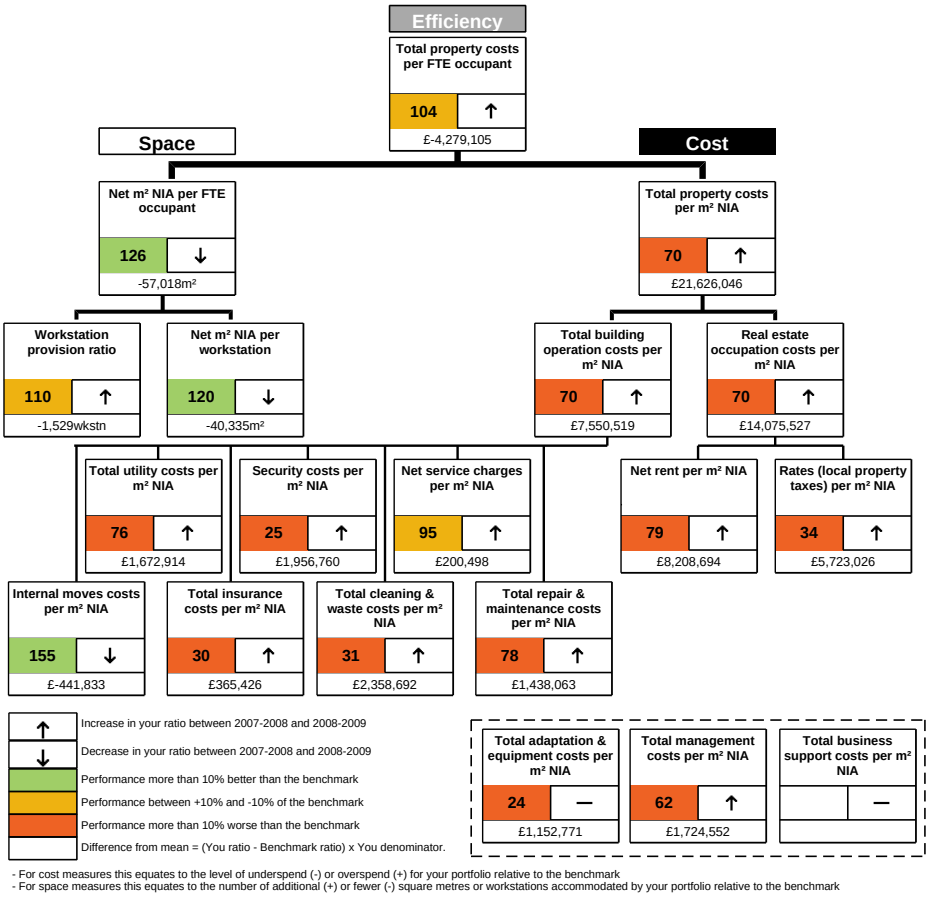

Figure 3.2: IPD benchmarks in terms of efficiency

3.1.10 BCIS: "Building Running Cost"

The report *Building Running Cost* is a benchmarking product provided by *Building Cost Information Service* (BCIS) which is a trading name of the *Royal Institution of Chartered Survey* (RICS) and was established in 1962 to exchange detailed building price information. Currently, this report only offers cost information of the UK.

Organizer. RICS [10] is a leading property professional body in the world, which originates from the UK. It covers all aspects of property, construction and associated environmental issues. It represents, regulates and promotes the work of these property professionals throughout 146 countries. RICS acts in the public interest and is also a professional regulatory body approved by the government (HM Treasury). BICS is the leading provider of cost information for the construction industry. Its services are divided into four areas: construction, maintenance, rebuilding and intelligence.

Benchmarking indicators. This benchmarking program provides the running costs for different building types, which include:

- redecoration cost;
- construction maintenance cost;
- service maintenance cost;
- cleaning cost;
- utilities cost;
- administrative cost.

This study also provides occupancy pricing and general cost movement in different industry sectors, so that customers can monitor their costs against the inflation.

Remarks. This benchmarking study is supposed to be the most representative benchmarking study in the UK. The area and cost measurements provided by RICS are widely accepted in the UK as well as many other countries.

[10] http://www.rics.org

3.1.11 KTI: "KTI Operational Cost Benchmarking"

The report *KTI Operational Cost Benchmarking* is provided by *parasta kiinteistötietoa (in Finnish, and in English is KTI Property Information Limited Company)* (KTI)[11], which is an independent information business offering benchmarking, research and analysis services for the Finnish real estate sector. This benchmarking program collects data from Finland only. So far the study has been conducted 14 times.

Benchmarking indicators. Benchmarking indicators cover mainly two parts: energy consumption and operation costs. The operation costs are divided into 13 categories according to the Finnish book-keeping law (30.12.1997/1339):

- administration;
- operations;
- outdoor maintenance (Roadways, parking and grounds);
- cleaning;
- heating;
- water and waste water;
- electricity;
- waste management;
- insurance;
- rent (ground rent, if applicable);
- property tax;
- other maintenance costs;
- repairs.

Remarks. It is the most representative benchmarking database in Finland. Besides, KTI Finland cooperates with other three FM databases in Nordic countries (Sweden, Denmark, Norway), in order to establish a Nordic FM platform.[42]

[11] http://www.kti.fi

3.1.12 Whitestone Research: "Facility Operations Cost Reference, International"

The report *Facility Operations Cost Reference* is a product of *Whitestone Research*. Its international version was published for the first time in 2011 but the North America version has been published for 5 years.

Organizer. *Whitestone Research* [12], whose offices are located in Washington, D.C., Santa Barbara, and California, specializes in applied policy research and software development. Its services include facility life-cycle cost analysis, policy development and implementation, demand modeling and market analysis, index definition and benchmarking, condition assessment methods as well as data analysis.

Benchmarking indicators. The benchmarking aspect of this report is operation cost. The specific indicators are:

- custodial;
- energy;
- grounds;
- maintenance and repair;
- management;
- pest control [13];
- road clearance;
- security;
- telecoms;
- water/sewer.

Remarks. Unlike other benchmarking studies, this report did not provide the average performance of database as benchmark. It creats 75 building models and provides cost indexes for over 100 areas, so that readers can find cost references in their area for the similar facilities.

[12] http://www.whitestoneresearch.com

[13] It refers to the management of a species defined as a pest, usually because it is perceived to be detrimental to a person's health, the ecology or the economy

3.1.13 ISA: "ISA Benchmarking Report"

The ISA Benchmarking Report was released by *International Sustainability Alliance* (ISA) for the first time in 2011.

Organizer. ISA is a global network of leading corporate occupiers, property investors, developers and owners. ISA is dedicated to achieve a more sustainably built environment through better measurement and understanding of the sustainable performance of buildings.

Benchmarking indicators. Performance of properties in the ISA database addresses energy, greenhouse gas emissions, water consumption and waste. The specific key performance indicators (KPIs) are:

- total indirect energy consumption;
- total direct energy consumption;
- building energy intensity;
- on-site renewable energy generation by volume;
- total direct and indirect greenhouse gas emissions by weight;
- total direct and indirect greenhouse gas intensity from building energy;
- total water withdrawal by source;
- building water intensity;
- total weight of waste by type and disposal method.

Remarks. All KPIs in this report are presented in the form of consumption volume instead of cost. Only office and shopping centers are the target buildings. The data of the report comprise over 40 countries including Austria (2%), Belgium (17%), China (1%), France (10%), Germany (19%), India (1%), the Netherlands (6%), Portugal (9%), Spain (9%), Taiwan (1%), Turkey (3%), UK (2%), and others (20%).

3.1.14 pom+: "FM Monitor"

The report *FM Monitor* is a product of *pom+ consulting public limited company* (pom+). This Swiss database has been in existence for more than 10 years.

Organizer. *Pom+* [14] is a consultant company for all kinds of real estate companies and public building owners. Its service covers corporate development, process design and structure, information and communication management as well as cost and value management.

Benchmarking indicators. The benchmarking indicators of *FM Monitor* include three aspects: space utilization, FM costs and CO^2 emission. The area is measured according to SIA 416 [5] and DIN 277 while FM costs are divided into four parts based on DIN 18960 including:

- supply and disposal costs;
- cleaning costs;
- inspection & maintenance costs;
- control and security costs;
- tax and fee.

Remarks. The *FM Monitor* report is the representative FM benchmarking publication in Switzerland. Based on this report, *FM Monitor* cooperated with *fm.benchmarking* as well as *FM Austria* and released *FM Monitor International* which is an regional FM benchmarking pool established by the integration method.

3.1.15 GEFMA etc.: "fm.benchmarking report"

The *fm.benchmarking report* [15] is a corporation between *German Facility Management Association* (GEFMA), the *Association for Real Estate and Facility Managers* (RealFM) and *rotermund.Ingenieure*. 10 Versions of the report have been released and they are highly recognized.

Organizer. GEFMA, founded in 1989, is the German association of decision makers in FM. It provides education and training in the field of FM and is also involved in the standardization work for FM. RealFM is the professional association for facility and real estate managers. The focus of RealFM activities is the linking of the tasks of real estate and facility management and the design of interfaces between all parties involved in these processes.

[14] http://www.pom.ch
[15] http://www.fm-benchmarking.de

Benchmarking indicators. The indicators of this benchmarking study also focus on FM costs while the cost classification follows DIN 32736. [9]

3.1.16 IBI: "FM Austria"

The report *FM Austria* [6] was published for the first time by the *Institute for Building Informatics (IBI), TU Graz* in 2009.

Benchmarking indicators. The area indicators are generated according to ÖNORM B1800 [20]. According to ÖNORM B1801-1[18], facilities are divided into nine categories. In the first version of 2009, only the data for office, educational and industrial buildings were analyzed due to a lack of sufficient data in other types of facilities. The two benchmarking aspects are space utilization and FM cost. The area definitions in this report are according to DIN 277 and the FM cost taxonomy is based on ÖNORM B 1801-2 [19].

3.1.17 Property Council of Australia: "National Benchmarks"

Every year *the Property Council of Australia* [16] publishes *National Benchmarks* for office and retail buildings.

Organizer. The *Property Council of Australia* is the leading property association in the country. It releases different series of research publications such as office market report, benchmarks, shopping center directories and investment performance indexes.

Benchmarking indicators. The indicators of this study also focus on FM costs which are divided into two parts: statutory charges and operating expenses. Different from many other FM benchmarking studies, the water and sewerage charge in Australia is arranged in statutory charges. The operating expenses are detailed listed in the following:

- insurance;
- air conditioning / ventilation;
- common area cleaning;
- center supervision;
- car parking;

[16] http://www.propertyoz.com.au/

- electricity;
- fire protection/public address;
- gas and oil;
- lifts and escalators;
- pest control;
- repairs and maintenance;
- emergency generators;
- energy automation systems;
- security/ access control;
- sewerage disposal;
- public telephone;
- uniforms;
- salaries and wages;
- signs;
- gardening/landscaping;
- administration/management fee.

3.1.18 NFCIC: "NFC Index"

The *Netherlands Facility Cost Index* [17] (NFC Index) was released by the *Netherlands Facility Cost Index Cooperative (NFCIC)* for the first time in 2004. About 80 companies and organizations participate in the program, which accounts for more than 5% of Dutch offices. NFC Index shows the median market-level facility costs and related services. The target benchmarking facilities include office buildings, educational buildings and healthcare facilities.

Organizer. On 28 November 2002, 20 members of the standards committee for NEN 2748 established NFCIC as an independent institute that would provide the Dutch facility management market with the desired updated objective benchmarks and trend figures.

[17] www.nfcindex.nl

Benchmarking indicators. The indicators of this benchmarking program are FM costs. The classification of FM costs in this program follows NEN 2748 where FM activities processes and services are categorized into five areas:

- housing;
- service and means;
- information and communication technology;
- external services;
- facility management.

However, it is claimed that NFC index will gradually adopt the standard NEN-EN 15221. In the report of the NFC index, the differences and accordance of two standards are pointed out as shown in Figure 3.3.

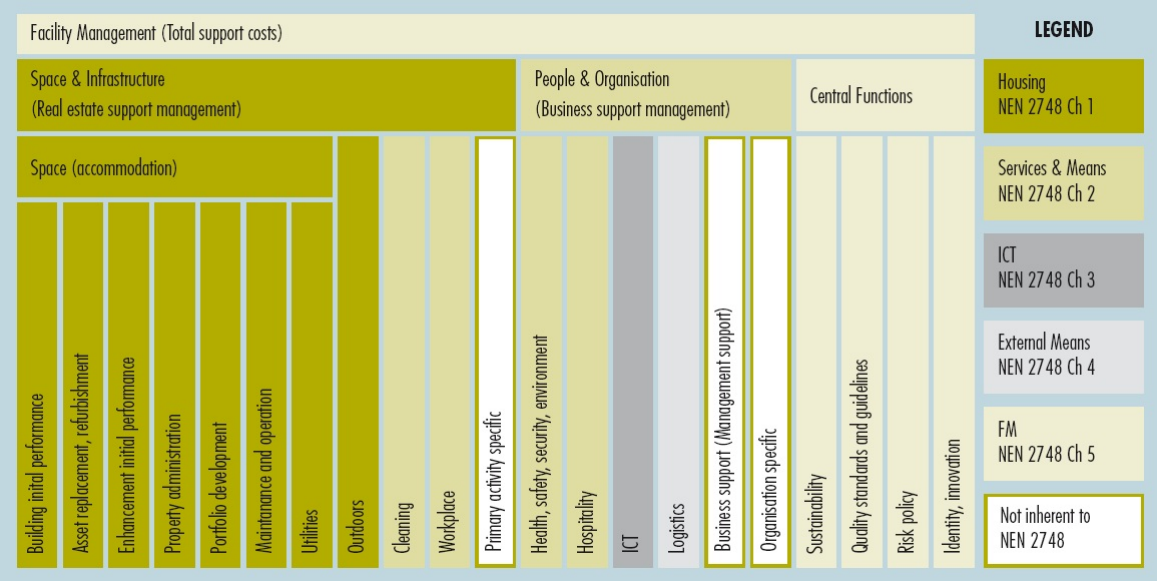

Figure 3.3: FM cost classification of EN 15221 and NEN 2748

Remarks. The Netherlands is one of the world's pioneer FM market. As the most professional and representative index of the Netherlands, the NFC Index is certainly worth to being investigated in detail. It has already taken measures to adopt European standard NEN-EN 15221 which makes convenient to establish a uniform European benchmarking platform.

3.1.19 DTZ: "Occupier Perspective-Occupancy Cost - Logistics"

This benchmarking program has already been carried out for two years until 2011 by *DTZ Holding Public Limited Company* (DTZ). The target benchmarking facility type is logistics buildings.

Organizer. Starting in the 18th century in England, DTZ provides leading property management to investors, developers, corporate and public sector occupiers in 145 cities across 43 countries.

Benchmarking indicators. The benchmarking indicators in this study are occupancy costs. Total occupancy cost is defined as the *total costs of leasing prime usable space on a gross internal basis*. It includes

- rents,
- service charges;
- taxes.

Service charge may typically include *security*, *site maintenance* and *landscaping* and can vary depending on the size of the estate and from site to site.

Remarks. This report presents occupancy costs across 28 markets in 15 European countries as well as some selected Asia Pacific markets. The data is collected by DTZ network of local offices around Europe. In terms of currency exchange, the rate of 30 September 2010 was applied.

3.1.20 NBEF: "Key-Database"

This benchmarking database, started in 1999, is provided by the *Norwegian Facility Management Association (NBEF)* [18]. Now it offers an on-line service [19].

Organizer. NBEF has the vision to be the leading association in the building and property / facilities management in Norway. It provides key figures of the industry and has a special expert group which meets regularly to organize conferences, seminars and other professional services for the benefit of the association's members and the rest of the market.

[18] http://www.nbef.no

[19] http://www.nbef.no/kompetanse/noekkeltall/

Benchmarking indicators. The indicators of this database are facility operation costs and energy consumption volumes. Its cost taxonomy follows NS 3454, which is:

1. Management
    - taxes and fees;
    - insurance;
    - administration;
    - other.
2. Operating
    - continuous operation;
    - cleaning;
    - energy;
    - water and sewer;
    - waste management;
    - security and safety;
    - outdoor;
    - other.
3. Maintenance
    - scheduled maintenance;
    - replacements;
    - outdoor;
    - other.
4. Development
    - ongoing reconstruction;
    - public requirements and orders;
    - upgrades;
    - outdoor;
    - other.
5. Service

- administrative office management;
- switchboard and reception services;
- catering;
- furniture and fixtures;
- moving work place;
- telecoms and IT services;
- postal and courier services;
- supplies and copying services.

3.1.21 DFM: "DFM-ratios"

The benchmarking program *DFM-ratios* [20] was established in 1996 by the *Danish Facilities Management Network* (DFM) [21]. Annual data about services and property management of Denmark are collected and analyzed by a web-based analytical system. The results are documented by a number of reports with both overall and detailed figures.

Organizer. DFM is the leading FM association in Denmark. It was founded in 1991 and has nearly 200 corporate members today. Its members are scattered throughout Denmark and from different business and industrial sectors. It offers conferences, summer events and training courses every year and gathers data from 200 major Danish companies.

Benchmarking indicators. The indicators of this benchmarking program are about FM costs, which are

- Cost of operation;
- Cost of cleaning (indoor);
- Cost of guard, security and postal service;
- Cost of catering;
- Cost of office support;
- Cost of planning of operational activities;
- Cost of management and administration.

[20] http://www.dfm-key.dk/index.asp?page_id=242
[21] http://www.dfm-net.dk

Remarks. The performance and results from the DFM are regarded as the de facto standards in Denmark. It also has a leading position among Nordic countries. Norway, Sweden, Denmark and Finland try to establish a Nordic FM benchmarking platform based on their national databases.

3.1.22 Energy Star: "Portfolio Manager"

Portfolio Manager [22] is an interactive energy management tool provided by *Energy Star*. It allows users to track and assess energy and water consumption in a secured on-line environment. It can help users to set investment priorities, identify under-performing buildings, verify efficiency improvements and receive EPA recognition for superior energy performance.

Organizer. *Energy Star* [23] is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy, which protects the environment through energy efficient products and practices.

In 1992, the EPA introduced *Energy Star* as a voluntary labeling program, which is designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. Now the *Energy Star* label has moved on to major appliances, office equipment, lighting, home electronics, etc. EPA has also extended the label to cover new residential buildings as well as commercial and industrial buildings.

Benchmarking indicators. This benchmarking program focuses on energy and water consumption especially energy consumption of IT. The information of parking space is also collected.

Remarks. Buildings in this benchmarking system will receive an *Energy Star* score which is a benchmark that indicates how efficiently buildings use energy on a 1-100 scale. A score of 50 indicates that energy performance is average compared to similar buildings while a score of 75 or higher indicates top performance and means your building may be eligible to earn the *Energy Star* label.

[22] http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager_benchmarking

[23] http://www.energystar.gov

3.1.23 EIA: Commercial Buildings Energy Consumption Survey

The *Commercial Buildings Energy Consumption Survey (CBECS)* [24] is a national sample survey that collects information from U.S. commercial buildings including energy-related building characteristics, energy consumption and energy expenditures.

Organizer. The CBECS is provided by the *U.S. Energy Information Administration (EIA)*[25] which is the statistical and analytical agency within the U.S. Department of Energy. EIA collects, analysis, and disseminates independent and impartial energy information to promote proper policy making, efficient markets, etc.

Benchmarking indicators. The indicators of this benchmarking program focuses on energy consumption and cost. The report released in 2003 provides rounded key data of different sources of energy: major fuels, electricity, natural gas, fuel oil, and district heat, which are used by the end user for space heating, cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment, computers and others [26].

Remarks. It is a U.S. nation wide survey that was initiated in 1979. The newest version was published in 2003. The survey of 2007 has not yielded valid statistical estimates of building counts, energy characteristics, consumption and expenditures. After a budget delay in 2011, CBECS will be conducted for the reference year 2012.

3.1.24 ARSEG: "Buzzy ®Arseg Ratios"

Buzzy ®Arseg Ratios (BRA) is developed by the *Association des Directeurs et Responsables de Services Généraux (in French)* (ARSEG)[27]. In 2010, it was carried out based on a panel of 2.6 million m^2 of office buildings spread across all sectors in France. It is offered in two ways: one is *Custom Benchmark* which is offered for companies that have joined the ARSEG; the other is *Packs Buzzy Ratios* which is offered for businesses that are not a member of the ARSEG.

Organizer. The ARSEG is the largest French network of professional managers devoted to general services. There are also Belgian and Swiss ARSEG members.

[24] http://www.eia.gov/emeu/cbecs/

[25] http://www.eia.gov/

[26] http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#consumexpen03

[27] http://www.arseg.asso.fr/

Benchmarking indicators. Its benchmarking indicators are about FM costs including

- occupation;
- rents;
- taxes;
- insurance;
- works maintenance & landscaping;
- technical maintenance;
- elevator;
- security;
- water;
- energy (electricity, oil, gas, steam);
- cleanliness and waste removal;
- mail;
- vehicle;
- telephone, mobile, etc.

3.1.25 SAPOA: "Operating Costs Report"

The *Operating Cost Report* releases the facility operation data of South Africa, which is provided by the *South African Property Owners Association (SAPOA)* [28]. The report is based on the IPD database and published every two years.

Organizer. SAPOA was established in 1966 by leading property investment organizations in South Africa to bring together all role players in the commercial property field and create a powerful platform for property investors. Today, its members control about 90% of all commercial and industrial properties in South Africa.

[28] http://www.sapoa.org.za

Benchmarking indicators. The benchmarking indicators of this report are about FM costs:

- building management;
- cleaning;
- security;
- gardens;
- repair and maintenance air-conditioning;
- repair and maintenance of elevators and escalators;
- service and building maintenance;
- rates and taxes;
- other municipal charges;
- electricity;
- tenant installation costs;
- letting fees and commissions;
- management costs;
- insurance;
- bad debts;
- other operating costs.

3.1.26 GBCA: "Green Star"

Green Star [29] is a comprehensive, national, voluntary environmental rating system organized by the *Green Building Council of Australia (GBCA)*. It evaluates the environmental design and construction of buildings and communities.

Organizer. Launched in 2002, the GBCA [30] is a national, none-profit organization that is committed to developing a sustainable property industry for Australia by encouraging the adoption of green building practices. It is supported by both the industry across the country as well as the government.

[29] http://www.gbca.org.au/green-star/rating-tools/green-star-education-v1/1762.htm
[30] http://www.gbca.org.au/

Benchmarking indicators. The indicators of this benchmarking system are related to sustainability of buildings including

- management (weighting: 10%);
- indoor environment quality (Weighting: 20%);
- energy (weighting: 25%);
- transport (weighting: 10%);
- water (weighting: 15%);
- materials (weighting: 10%);
- land use and ecology (Weighting: 5%);
- emissions (weighting: 5%).

3.1.27 Other benchmarking practices

There are also many other benchmarking practices which will not be listed and discussed in detail. In this work, a rough list (Table 3.1) together with the above mentioned benchmarking programs is presented.

Table 3.1: FM benchmarking programs rough list

No.	Benchmarking program	Data source	Indicators	Facility type	Latest version/ Data gathered since	On-line system	Data accessible through	Regulation applied
1.	Benchmarks: Annual Facility Cost (IFMA)	North America	Total Facility Cost	All	6^{st} in 2012/ 1987	Yes	Published reports & online database	Area: ASTME 1836:2009
2.	European Benchmarks (IFMA)	Europe	Facility Cost	All	1^{st} in 2001 / 2001	No	Published report	unknown
3.	Space & Project Management Benchmarks (IFMA)	North America	Space utilization	All	3^{st} in 2011/ 2001	Yes	Published reports & online database	Area: ASTME 1836:2009
4.	Operation & Maintenance Benchmarks (IFMA)	North America	Operation Cost	All	1^{st} in 2008/ 2008	Yes	Published reports & online database	unknown
5.	Experience Exchange Report (BOMA)	North America	Rent & Cost	Office	90^{st} in 2011 / 1920	No	Published reports	ANSI/BOMA Z65.1- 2010
6.	FM Benchmarking (FM Link & Facility Issues)	International	Operation cost & sustainability	All	-/2009	Yes	On-line database	unknown

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7.	Museum and Cultural Institutions Benchmarking (Facility Issues & IAMFA)	International	Space utilization & Cost & some other issues	Museum & Culture	12st in 2011/ 2000	No	Membership	Self Definition
8.	Facility Managers Round Table (Facility Issues)	US	Facility cost	All	20st in 2011/ 1992	No	Membership	Self Definition
9.	IFMA's Utilities Council (Facility Issues)	US	Facility cost	Utilities	23st in 2011/ 1989	No	Membership	Self Definition
10.	Research Facilities Benchmarking (Facility Issues)	US	Facility cost	Research	10st in 2011/ 2002	No	Membership	Self Definition
11.	IPD Occupiers Benchmark (IPD Occupiers)	International	Space utilization & cost & rent	All	-/unknown	Yes	On-line database	Area: IPD space code & Cost: IPD cost code
12.	Building Running Cost On-line (BCIS)	UK	Life-cycle cost	All	-/unknown	Yes	On-line database	Area: RICS code & Cost: Standard Form of Property Occupancy Cost

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13.	KTI Operational Cost Benchmarking (KTI)	Finland	Operation cost	All	13st in 2011/ 1998	No	Published reports	Area: unknown & Cost: Finnish bookkeeping law (20.12.1997/ 1339)
14.	Estates and Facilities Benchmarking Project	Scotland	Facility cost	Health	1st in 2009/ 2009	No	Published reports	Self Definition
15.	Facility Operations Cost Reference, International version (Whitestone)	International	Operation cost	All	1st in 2011/ 2011	No	Published reports	Self Definition
16.	Facility Maintenance & Repair Cost Reference (Whitestone)	North America	M & R cost	All	16st in 2011/1995	No	Published reports	Self Definition
17.	CBSS Benchmarks (Chief Building Surveyors Society)	UK	Maintenance cost	All	2008/-	No	Membership	Area: RICS code & Cost: self Definition

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18.	ISA Benchmarking Report (ISA)	International	Sustainability	All	1st in 2011/ 2011	No	Published reports	Self Definition
19.	FM Monitor (pom+)	Switzerland	Space utilization & cost	All	10st in 2011/ 2002	No	Published reports	Area: SIA 416 and DIN 277 & Cost: DIN 18960
20.	FM Monitor International (pom+)	German-speaking region	Space utilization & Cost	All	1st in 2009/ 2009	No	Published reports	Area: DIN 277 & Cost: DIN 18960
21.	fm.benchmarking report (GEFMA etc.)	Germany	Space utilization & Cost	All	8st in 2011/ 2004	No	Published reports	Area: DIN 277 & Cost: DIN 32736
22.	FM Austria (IBI)	Austria	Space utilization & Cost	All	1st in 2009/ 2009	No	Published reports	Area: DIN 277 and "O-NORM B 1800 & Cost: "O-NORM B 1801-2
23.	National Benchmarks (Property Council of Australia)	Australia	Cost	Office, retail	2011/ At least from 2005	No	Published reports	Area: Method of measurement-commercial 2008 & Cost: The property council's chart of accounts

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24.	Operating Expenses Benchmarks (Property Council of New Zealand)	New Zealand	Cost	Office, retail	2010/unknown	No	Published reports	Area: Guide for the measurement of rentable areas & Cost: Recommended chart of accounts
25.	NFC Index (NFCIC)	the Netherlands	Cost	Office, education, health	2010/2004	No	Membership	Area: NEN 2580 & Cost: NEN 2748
26.	DTZ Occupier perspective-Occupancy Cost -Logistics (DTZ)	International	Rent, Cost	Logistics	2st in 2011/ 2010	No	published reports	Self Definition
27.	Key-database (NBEF)	Norway	Cost	All	-/1999	Yes	On-line database	Area: unknown & Cost: NS 3454
28.	DFM-ratios (DFM)	Denmark	Cost	All	-/1992	Yes	On-line database	Area: Self Definition & Cost: DFM 19.12.2007

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29.	HEFMA Benchmark Report (The Higher Education Facilities Management Association of Southern Africa (HEFMA))	South Africa	Cost	Education	5st in 2011/ 2004	No	Published reports	Area: South Africa Higher Education Management Information System Definitions
30.	Facilities Performance Indicators (APPA, Leadership in Educational Facilities)	US	Cost,financial measures	Education	2011/-	No	Published reports	Unknown
31.	Portfolio Manager (Energy Star)	US	Energy and water consumption & Cost	All	Now/-	Yes	On-line database	Unknown
32.	Green Star (GBCA)	Australia	Sustainability	All	Now/-	Yes	on-line database	unknown
33.	Commercial Buildings Energy Consumption Survey (EIA)	US	Energy consumption & cost	Non-residential	2003/1979	No	Published reports	Unknown

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34.	e-Bench^{TM}(Energy and Technical Ltd)	US & New Zealand	Energy consumption & Cost	All	Now/-	Yes	On-line database	Unknown
35.	The Energy Efficiency Building Benchmarking Program (Energy Sustainability Unit)	Singapore	Energy consumption & Cost	Office, hotel	Now/-	Yes	On-line database	Unknown
36.	Benchmarking (Carbon Trust)	UK	Energy consumption & Cost	All	Now/-	Yes	Published reports & On-line database	Unknown
37.	Contract Cleaning Benchmarking Report	US	Cleaning cost & Measures	All	2009/-	No	Published reports	Unknown
38.	Workspace Utilization and Allocation Benchmark (US General Service Administration)	US	Space utilization	Office	3st in 2010/1997	No	Published report	Unknown

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39.	Space Utilization Rate Analysis (University of Technology, Malaysia)	Malaysia	Space utilization	Education	2009/ 2009	No	Published reports	Unknown
40.	UK Higher Education Space Management Project	UK	Space utilization	Education (Space Management Group)	Now/-	Yes	Published reports & Online database	Unknown

3.2 General analysis

In this section, a general analysis about the benchmarking practices mentioned above will be presented. Firstly, the geographical distribution of the benchmarking programs is illustrated (Table 3.2).

Table 3.2: Geographical distributions of benchmarking practices

Region	Number	Region	Number
International	6	North America	5
Europe	1	German-speaking countries	1
US & New Zealand	1		
US	8	UK	4
Germany	1	Austria	1
Switzerland	1	Australia	2
New Zealand	1	Denmark	1
Finland	1	the Netherlands	1
Norway	1	Malaysia	1
South Africa	1	Scotland	1
Singapore	1		

Fourteen benchmarking programs collect data from more than one country. The other 26 FM xbenchmarking programs are national. Of those nation wide benchmarking programs, almost half are located in European countries and one sixth are located in North America. (see Figure 3.4).

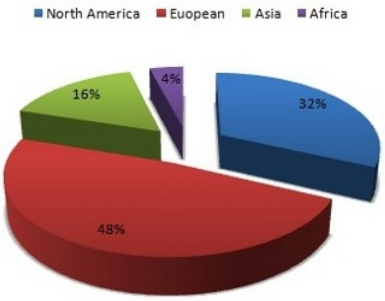

Figure 3.4: Geographical distribution of benchmarking practices

Most benchmarking programs pay great attention to FM costs. As Figure 3.5 shows, more than 30 benchmarking programs include FM cost indicators. The other two popular aspects are space utilization and energy consumption (sustainability). Energy consumption

relates to not only operation costs but also environment protection which attracts much attention of different entities such as governments, associations, facility managers, etc. Many other energy benchmarking programs are not introduced in this study because of the space limitation. It needs to be pointed out that many indexes which only supply facility rent index are not included. In this study, the benchmarking programs studied must not only have the indicator *Rent*, but also involve some other indicators such as FM costs or space utilization.

Figure 3.5: Metrics distribution of benchmarking practices

24 benchmarking programs conduct comparisons for all building types while other benchmarking programs make comparisons only for one or several building types. The commercial facility takes the first place (Figure 3.6). More and more education and health organizations pay great attention to FM, which leads to the increase of the number of benchmarking programs in these fields.

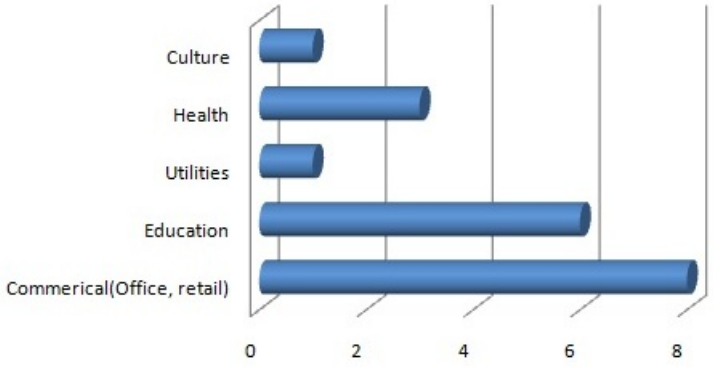

Figure 3.6: Facility types of benchmarking practices

Fifteen benchmarking programs have existed for more than 10 years, among which the *Experience Exchange Report* from BOMA has even existed for 90 years. In recent years,

many new benchmarking programs have been established (Figure 3.7).

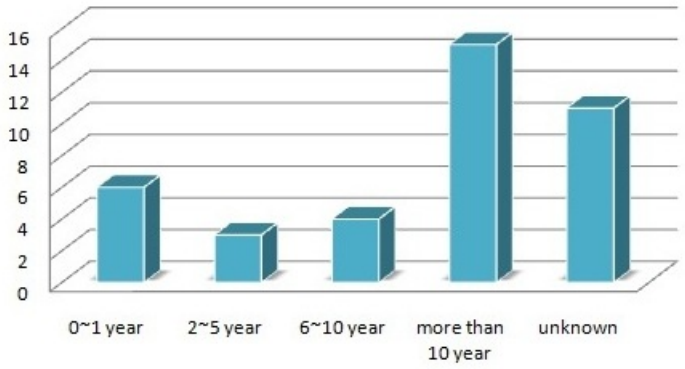

Figure 3.7: Existing years of benchmarking practices

Many benchmarking programs (thirteen) have developed on-line database systems. In order to compare facilities of different sizes, nearly all benchmarking data published by trade and professional associations depend on a presentation by square meter. However, those reports do not apply the same measurement standard even within the same region. In North America, for example, different benchmarking programs use different standards (Table 3.3).

Table 3.3: Area measurement standards used by benchmarking programs in North America

Benchmarking program	**Area measurement standard**
Benchmarks: Annual Facility Cost (IFMA)	ASTME 1836:2009
Space & Project Management Benchmarking (IFMA)	ASTME 1836:2009
The Experience Exchange Report (BOMA)	ANSI/BOMA Z65.1-2010
Facility Managers Round Table (Facility Issues)	Self Definition

The *Unified Approach for Measuring floor Area in Office Space for Use in Facility and Property Management* is published jointly by IFMA and BOMA. This document is not a standard but it establishes a common basis of terminology, concepts and methods, which intends to become the basis for future efforts to harmonize the BOMA Office Standard with the IFMA Standard. Unfortunately, not all standards have such an unified approach especially when the comparison of benchmarks begins to stretch beyond a single country. In Table 3.4, we can see that European benchmarking programs use various area measurement standards. Only DIN 277 is accepted outside of Germany but it works only in German-speaking countries.

Table 3.4: Area measurement standards used by different benchmarking programs in EU countries

Benchmarking program	Country	Area measurement standard
Building Running Cost On-line (BCIS)	UK	RICS Code
Operational Cost Benchmarking (KTI)	Finland	Unknown
FM Monitor (pom+)	Switzerland	SIA 416 & DIN 277
fm.benchmarking (GEFMA etc.)	Germany	DIN 277
FM Austria (IBI)	Germany	ÖNORM 1800
NFC Index (NFCIC)	The Netherlands	NEN 2580
Key-database (NBEF)	Norway	Unknown
DFM-ratios (DFM)	Denmark	Self Definition

3.3 Area and cost measurement standards in the world

In the following a brief introduction of area measurement standards and FM cost classification systems is listed. The systems have been chosen because they are quite commonly used.

3.3.1 Area measurement standards

North America.

1. US

   - *The Building Owners and Managers Association Gross Areas of a Building: Methods of Measurement* is the best documented and most detailed standard for measuring the gross areas of any building.

   - BOMA/ANSI Z65.1 Office Standard *Office Buildings: Standard Methods of Measurement (2010)* is the latest version of the predominant method for measuring and calculating the usable and rent-able areas of office buildings throughout the US.

   - *ASTM E 1836-09* is used in conjunction with facility management, occupant space requirements, space planning and strategic facility planning but not for leasing office space. For lease area measurements, this document explicitly refers to the BOMA Standards, BOMA/ANSI Z 65.1.

- *The Unified Approach for Measuring floor Area in Office Space for Use in Facility and Property Management* is published jointly by IFMA and BOMA. Property managers and facility managers have different objectives when they measure floor area, yet their methods must coexist in commercial properties. This document is not a standard but has established a common basis of terminology, concepts and methods.

- *The Post-secondary Education Facilities Inventory and Classification Manual (2006)* describes standard practice for initiating, conducting, reporting, and maintaining a post-secondary institutional facilities inventory. In its chapter 3, the technical definitions, measurement procedures and coding structures for building area data elements are provided.

2. Canada

   - *CAN/CSA-Z317.11-02(R2007) Area Measurement for Health Care Facilities* is published by the Canadian Standards Association. This Standard establishes a basic, uniform system of area measurements to facilitate meaningful comparisons between health care facilities throughout Canada.

Asia.

1. Australia

   - *Method of Measurement: commercial (2008)* is published by the *Property Council of Australia*. It is a reprint of the 1997 version. This version provides guideline for measuring floor space in leased premises. It is widely accepted in Australia.

2. New Zealand

   - *Guide for the Measurement of Rent-able Areas (2006)* is published by the *Property Council of New Zealand*, aiming to provide a guide to uniform and impartial methods of measuring floor space in commercial and industrial buildings, office accommodation, retail premises, warehouses and factories.

3. Singapore

   - *Handbook on Gross Floor Area* was released by the *Urban Redevelopment Authority of Singapore* [38] in February 2010.

4. China

   - *GT/B 50353* is the national area measurement standard [32].

Europe.

1. Austria
    - *ÖNORM B 1800 (2002): Definition of Building Areas and Volumes* published by the *Austrian Standards Plus Company* is the most popular standard used in Austria in the field of area management.
2. Germany
    - *DIN 277 Teil 1 (1987): Gross Floor Area and Volume of Building Construction; Conceptions, Calculation Bases.*
    - *DIN 277 Teil 2 (1987): Gross Floor Area and Volume of Building Construction; Structure of Usable Area, Functional Area and Transportation Area.*
    - *DIN 277 Teil 3 (1998): Gross Floor Area and Volume of Building Construction; Quantities and Related Units.*

      This series published by the *German Institute of Standard* is widely used in German-speaking region (Germany, Austria, Switzerland).
3. UK
    - *BS 7641(1993)/ISO 9836(1992) Performance Standards in Building: Definition and Calculation of Area and Space Indicators.* It is the current version of national standard about area and volume definitions in the UK. However, it has been partially replaced by *BS EN 15221-6: Area and Space Measurement in Facility Management*.
    - RICS published the *Code of Measuring Practice* [31]. This code has extensive applications in the UK and even in some other English-speaking countries.
    - The *British Council for Offices* (BCO) published a new version of *BCO Guide to Specification*[8] in 2009, which is an area measurement code for the commercial property sector.
4. Switzerland
    - *SN 504 416/SIA 416 (2003): Area and Volume of Buildings* is the national standard for area definitions.
5. Denmark
    - *DS 13000 (2007) Measurement of buildings, concepts of area and volume* is the national standard for area definitions in Denmark.
    - *The Space Measurement Template for Operating Activities* released by the DFM is seen as the de facto standard in Denmark, which is presented in detail in the "Handbook of Facilities Management" by Per Anker Jensen.

6. Finland

    - *SFS 5139* is the latest national standard for building surface including floor space, gross and net floor area in Finland.

7. Sweden

    - *SS 21054 (2009) Area and Volume of Buildings- Terminology and Measurement* is the latest national standard for building area in the Sweden.

8. Norway

    - *NS 3940 Area Calculations* is the national standard for area definitions.

9. The Netherlands

    - One of the most important area measurement standards in the Netherlands is *NEN 2580 Areas and Volumes of Buildings- Terms, Definitions and Determination Methods.* This standard has not been changed since 1997.

Others.

1. International Standard Organization (ISO)

    - *ISO 9836 Performance Standards in Buildings: Definition and Calculation of Areas and Space Indicators* was published in 1992 by the ISO. Some countries like the UK accept it as the national standard but it is not widely used in North America.

    - *ISO 6707-1 Building and Civil Engineering- Vocabulary- Part 1: General Terms* has some definitions for building area.

2. CEN

    - CEN has published *EN 15221-1, 2, 3, 4, 5, 6*, which define the European facility management market. By April 2012 at the latest, all national standardization bodies (About 30 CEN members) had to publish the EN 15221 as their official national standard. EN 15221-6 describes how to measure space and areas in buildings.

3. IPD Occupiers

    - IPD Occupiers creates a standard platform within the real estate management industry. One standard of this platform is *IPD Space Code*. This measurement is endorsed by leading industry bodies such as RICS, British Institut of Facilities Managment, British Council for Offices, IFMA and CoreNet.

3.3.2 Facility management cost classification systems

FM cost taxonomy is closely linked to the definition of FM and the scope of facilities services. Some FM cost classification systems are published as standards, while some are not.

North America.

1. US
    - *IFMA Benchmarks: Annual Facility Cost* is not published as a standard. It is widely used in the US because of the reputation of IFMA.
    - *BOMA Chart of Accounts*.

Asia.

1. Australia
    - *The Property Council's Chart of Accounts for Commercial, Industrial and Retail Properties* is published by the *Australian Property Council of Australia*. It is widely accepted in Australia.
2. New Zealand
    - The *Property Council of New Zealand* published *Recommended Chart of Accounts for Commercial, Industrial and Retail Properties* in 1988.

Europe.

1. UK
    - RICS published *Standard Form: Property Occupancy Cost Analysis*.
2. Norway
    - *NS 3454 Life-cycle costs calculations for construction* defines all the costs occurring in the a building's life-cycle, which includes operational costs in the service phase.
3. Denmark
    - Just like space measurement, the account template for the operating activities of DFM-benchmarking *DFM 19.12.2007* is seen as the de facto standard in Denmark. The detailed information is described in the "Handbook of Facilities Management".

4. Finland

    - There is no typical FM cost standard in Finland. It is often that the *Bookkeeping law (30.12.1997/1339)* is used as basis of the division of operation cost of buildings.

5. The Netherlands

    - The scope and organization of facilities and the method of determining the annual cost are normed in *NEN 2748 (2001) & NEN 2748/A1 (2003)* and explained in *NPR 2744*. *NPR 2744* provides additional indications for the use of NEN 2748 and distinctions among the costs for tenants and landlords.

6. Sweden

    - There is no national standard about facility operational costs. The biggest Swedish benchmarking pool "REPAP" has worked for many years in order to clearly define and delimit the concepts of different FM cost groups.

7. Germany

    - GEFMA and IFMA Switzerland published *GEFMA 220: Life-cycle costs calculation in FM* together, which provides support for the FM cost calculation. [12]

    - *DIN 18960 (1999): Operation Cost in the Building Construction* is widely used in Germany and even in other German-speaking countries.

    - *DIN 32736* is another FM cost classification system widely used in Germany.

8. Austria

    - *ÖNORM B 1801-1(1995): Costs in Buildings and Under-structures; Cost Structure* and *ÖNORM B 1801-2 (1997): Costs in Buildings and Under-structures; Object Data and Object Using* are national standards for the FM cost calculation in Austria.

9. Switzerland

    - As mentioned above, IFMA Switzerland has also joined the development of the *GEFMA/IFMA 220* in order to apply this standard successfully.

    - *SN 506 502 Swiss Standard Element Costs Structure* was published by the Swiss Research Center for Building Rationalization.

    - The Swiss Society of Engineers and Architects published *SIA d 0165 Key Performance Indicators in Real Estate Management* in cooperation with the *Swiss Association of Real Estate Agents and Administrators*.

Others

1. ISO
    - *The ISO 15686-5 (2008): Buildings and Constructed Assets-Service-Life Planning-Part 5: Life-cycle Costing* gives guidelines for the performing life cycle cost analyzes of buildings and constructed assets. The life-cycle cost is structured in construction costs, operational costs, maintenance cost and demolition cost.
2. CEN
    - *EN15221-4: Classification and Structures* provides the classification of FM cost.[21]
3. The European Committee for Standardization (CEEC)
    - CEEC published *CEEC Code of Measurement for Cost Planning* to provide a standard basis for the sub-division of costs for European budgeting, comparison and analysis at management level.
4. IPD Occupiers
    - In the standard platform of real estate industry created by the IPD Occupiers, one of the most important codes is the *IPD Cost Code* [25], which can be mapped against most national standards.

4 KEY PERFORMANCE INDICATORS

Benchmarking is only feasible when key performance indicators (KPIs) are clearly defined. Since the indirect method was chosen for international FM benchmarking in this work, only the KPIs common to all the national FM benchmarking pools can be the indicators of our international FM benchmarking program.

4.1 Definition and classification of facility management key performance indicators

4.1.1 Definition of facility management key performance indicator

A key performance indicator is a type of performance, measurement. An organization may use KPIs to evaluate its success or to evaluate the success of a particular activity in which it engaged. KPIs can vary according to each organization.

- A business may apply "the percentage of its income that comes from returned customers" as one of its KPIs.
- A manufacturing company may use "overall-equipment effectiveness" as one of its KPIs.
- A management may assign "the saving of the costs" as one of its KPIs.

Whichever KPIs are selected, they must reflect the organization's goals, must be the key to its success and measurable. KPIs are usually long-term considerations. The definitions of what they are and how they are measured should not change frequently.

Thus, FM KPIs are quantifiable measurements that reflect the critical success factors to the facility management of an organization.

4.1.2 Classification of facility management key performance indicators

Based on different classification measures, FM KPIs can be divided into several categories.

Calculation method. According to different calculation methods, FM KPIs can be divided into independent and relevant parameters.

1. Independent parameters

   This type of parameters can be subdivided into single numbers, sums or/and gap and mean values. They are characterized by not having any relations to other parameters; instead the observed facts are presented in a condensed way directly. The applicability of independent parameters in facility management is therefore restricted because it constitutes a problem of comparability against the background of the heterogeneity of the real estates. Some independent parameters for facility estate management may be: *gross floor area*, *year of completion of the building*, *quantity of living and/or trade units*.

2. Relevant parameters

   These parameters are formed by quotients of single absolute values and thus show a higher significance and general validity. As a result, it is possible that the coherence is recognized and comparisons between different examination objects are performed. Relevant parameters are always formed by the arithmetical operations. They can be divided into different groups according to the type and content of the referenced and observed numbers which are used.

   - Relational parameters

     This type of parameters is the most important relevant parameter. It tries to present coherence, where two different parameters are set in relationship with each other. What should be paid attention to is that these two parameters have in fact relationship, e.g.,

     $$\text{Relative operation cost} = \frac{\text{Sum of operation costs}}{\text{Using area}} \quad .$$

   - Structural parameters

     Structural parameters present the structure of the data in its entirety by the division. This allows for a more detailed data analysis, i.e.,

     $$\text{Rent quotient} = \frac{\text{Rented area}}{\text{Rentable area}} \quad .$$

   - Measuring parameters

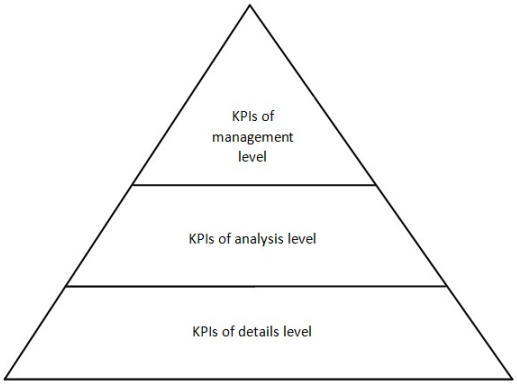

Figure 4.1: Pyramid of KPIs

In order to compare the temporal development of particular influencing variables, measuring parameters are established. They present the temporal development by describing the change of particular parameters. The value of original period 0 is defined as the basic number, e.g.,

$$\text{Development of energy cost} = \frac{\text{Energy cost 2011}}{\text{Energy cost 2010}} \quad .$$

- Index parameters

  The index parameter is very similar to the measuring parameter. The only difference is that index parameters are formed according to the percentile counting method.

Hierarchical aspects. There should be few KPIs for the whole FM benchmarking. Every general KPI should have several supporting KPIs. As a result, KPIs can be divided into three levels according to their grade of detail (Figure 4.1).

1. Management level KPIs

   The management level KPIs make a general assessment of a property possible. They are very important for management and have been widely used. They illustrate the level with the highest compression of information, e.g.,

$$\frac{\text{Using area}}{\text{Gross floor area}}, \quad \frac{\text{Costs of operation}}{\text{Gross floor area}} \quad .$$

2. Analysis level KPIs

   The analysis level KPIs present the middle level of the KPIs pyramid such as,

$$\frac{\text{Costs of cleaning}}{\text{Gross floor area}}, \quad \frac{\text{Costs of heating}}{\text{Gross floor area}} \quad .$$

3. Details level KPIs

   The details level KPIs are the lowest level of the KPI pyramid and show the least information. For the management and analysis levels KPIs, normally only two parameters are needed (e.g. costs of heating per gross floor area) while detail level KPIs may depend on three or more parameters.

$$\frac{\dfrac{\text{Costs of heating}}{\text{Gross floor area}}}{\text{Energy source}} \quad .$$

Aspect. FM KPIs can be divided into three categories according to different benchmarking aspects.

1. Area KPIs

   The initial goal of a facility is to provide an area for people to work, reside, shop, etc. Thus, area management is a fundamental part of facility management and area parameters should be part of KPIs. They may be

$$\textit{Gross floor area}, \textit{Net floor area}, \textit{Using area}.$$

2. Cost KPIs

   Monetary parameters, no matter if income or cost, are always the most important indicators. Normally, FM department is a cost center rather than a profit centre. Different cost parameters thus will be KPIs, e.g.,

$$\textit{Cost of using}, \textit{Cost of cleaning}, \textit{Cost of heating}.$$

3. Service quality KPIs

   Service quality KPIs are often forgotten. The most important reason is that service quality is usually difficult to measure while KPIs are supposed to be quantifiable. However, this kind of KPIs is also very important to FM since the goals of facility management are not only cost reduction but also providing high quality services to promote the satisfaction and efficiency of the clients, e.g.,

$$\textit{Percentage of total work completed at a given time}, \textit{Maintenance reactive time}.$$

4.2 Key performance indicators for the international facility management benchmarking program

The goal of this study is to establish an international FM benchmarking pool by integrating existing national FM benchmarking pools of different countries. Therefore, **only the KPIs common to all the national FM benchmarking programs** can be chosen as the indicators of our international pool.

4.2.1 Choice of member facility management benchmarking pools

Since there are so many national/regional FM benchmarking pools in the world (listed in the second chapter), it is impossible to integrate all of them. The member FM benchmarking pools will be filtered by the following criteria:

1. Benchmarking indicators: FM cost

   Different benchmarking pools have different benchmarking indicators such as rent, energy consumption, space utilization, etc. However, FM cost is their common interest. In the international FM benchmarking pool established in this work, the KPIs are fixed only on FM cost. The FM benchmarking pools for other indicators such as *Space and Project Management Benchmarking* from *International Facility Management Association* IFMA, *ISA Benchmarking Report* will not be examined.

2. Benchmarking facility types: office / commercial, education and health

   Some benchmarking pools collect data of all facility types, while some pools only set focus on one specific facility type, e.g., the target benchmarking facilities of *Museum and Culture Institutions Benchmarking Program* are only museums and culture facilities. As discussed in the second chapter, the commercial (office & retail), educational and health-care facilities are the most popular benchmarking facility types. For this reason, our international FM benchmarking pool only integrates national or regional pools which collect data at least for these three facility types.

3. Region of the benchmarking data

   In order to make our international FM benchmarking pool more persuasive, there should be a wide range of data resources. On the other hand, to avoid repeated data in our international pool, only one benchmarking pool will be chosen as the member pool if there is more than one benchmarking pool in the same country or region.

4. Representation

   Since only one benchmarking pool in the same region will be chosen as the member pool, the selected one should be representative which can be judged by the organizer, the amount of data, the number of versions published, etc.

Eight national benchmarking pools are chosen as the members of our international FM benchmarking pool (Table 4.1) Most benchmarking pools are from Europe. FM benchmarking pools from Australia, New Zealand and Asia are not included in this study.

Table 4.1: Member benchmarking pools

No.	Member benchmarking pool	Data source
1	Benchmarks: Annual Facility Cost (IFMA)	North America
2	Operational costs benchmarking (KTI)	Finland
3	FM Monitor (Pom+)	Switzerland
4	fm.benchmarking (GEFMA etc.)	Germany
5	FM Austria (IBI)	Austria
6	NFC Index (NFC)	The Netherlands
7	Key-database (NBEF)	Norway
8	DEF-ratios (DEF)	Denmark

4.2.2 Facility management cost classification systems applied

Normally, when FM benchmarking pools choose FM cost KPIs, they would apply some FM cost classification standards such as ÖNORM 1801-2, DIN 18960 or DIN 32736, NEN 2748 or establish a FM cost classification system on their own such as IFMA.

One classification system may have several levels, e.g., ÖNORM 1801-2 (Table 4.2). One-figure level states a main component as

5. Operation cost.

Two-figure level states a service as

5.4 Cleaning cost.

In some other classification structures, there are more levels, e.g., DIN 18960 has three levels. Its division system of the main component "operation cost" is presented in the following.

Table 4.2: FM cost classification of ÖNORM 1801-2

1. Capital costs	1.1 External capital cost 1.2 Internal capital cost
2. Depreciable costs	2.1 Ordinary depreciable cost 2.2 Exceptional depreciable cost
3. Tax and fee	3.1 Tax 3.2 Fee
4. Management costs	4.1 Internal management cost 4.2 External management cost
5. Operation costs	5.1 Supply and disposal cost 5.2 Supervisory service cost 5.3 Technical service cost 5.4 Cleaning cost 5.5 other services cost
6. Maintenance cost	6.1 Cost of preventive maintenance cost 6.2 Repair cost 6.3 Renovation cost
7. Other costs	7.1 Other costs

3. Operation costs
3.2 Cleaning costs
3.2.1 Facades, roofs
3.2.2 Floors
3.2.3 ...
...

Usually, data collection is set in the second or third level, while KPIs published in reports are set on the basis of the first level including some important second level KPIs. In the following part, different FM cost classification structures applied by different benchmarking pools are presented.

Benchmarks: Annual Facility Cost (IFMA). This benchmarking program collects and publishes FM cost KPIs based on its own FM cost classifications. For most components, there is only one level in the FM cost system, but some components are divided in more detail. The detailed definitions of these costs are:

1. **Occupancy costs** which are also called lease cost. It is the annual cost of the lease, if the organization leases a facility (amount paid directly to land owner, including tax and expense escalations, if any). It is a first level FM cost component.

2. **Janitorial costs** are costs associated with the cleaning of offices, other work areas, restrooms and common support space. These include wages, benefits, staff support, supervision, administration, supplies, paper goods and non-capital equipment (e.g., brooms, floor polishers). It also includes contract service providers' costs and/or any supplemental cleaning services provided by the landlord. This part of cost is divided into two subcategories which are (2.1) annual janitorial costs except for cleaning costs of clean room and (2.2) janitorial costs of clean room.

3. **Utility costs** are costs associated with providing electrical power, water, central heating, cooling and sewage service for the facility. This part of cost is divided into eight subcategories which are (3.1) annual cost of electricit, (3.2) annual cost of fuel oil, (3.3) annual cost of gas, (3.4) annual cost of stea, (3.5) annual cost of chilled water, (3.6) annual cost of water, (3.7) annual cost of sewage and (3.8) annual cost of other utilities.

4. **Maintenance costs** are divided into five categories which are annual cost of (4.1) exterior building maintenance, (4.2) interior systems maintenance, (4.3) roads and grounds maintenance, (4.4) utility/central system maintenance and (4.5) process treatment and environment systems. The last two maintenance categories primarily apply to facilities with central plants and/or large manufacturing plants.

5. **Costs of providing the fixed asset** is the sum of all annual business capital costs and charges not related directly to the facility's operation. It does not include the actual purchased capital asset value (capitalization) but does include the following: (5.1) leasehold improvement amortization, (5.2) depreciable cost of new building or addition, (5.3) capital-related expense, (5.4) asset write-off/disposal, (5.5) taxes on building and contents, (5.6) insurance (fire/extended/terrorism coverage), (5.7) furniture/equipment depreciation charges and (5.8) interest expense for lease or purchase of building assets.

6. **Project costs** are improvements or the reconfiguration of existing space to meet new needs or requirements. Common project costs include expenses associated with moves, reconfiguration of space, energy improvements and safety and security-related projects. Some project costs are expensed and others are considered capital expenditures. For this category, only the expensed cost items that are incorporated in the annual operating budget are included. This cost component is also divided into two parts: (6.1) moves/additions/changes as well as (6.2) all other expensed project costs.

7. **Life and safety costs** are the costs associated with compliance to building regulations required by federal, state/provincial and municipal laws to maintain and operate the facility. Examples of such costs are safety equipment, fire and emergency requirements such as signal, exit doors and building alarms/strobes, mandated training, nurses, doctors and emergency medical technician crews. There is only a one level cost component. It is not further divided.

8. **Environmental costs** are the costs associated with providing the satisfactory levels of air and water quality, waste removal as well as ensuring regulatory compliance with federal, state/provincial and municipal laws. The specific six sub-categories are (8.1) monitoring/testing, (8.2) consulting fees, (8.3) remedial/abatement, (8.4) solid waste removal, (8.5) hazardous waste removal and (8.6) recycling.

9. **Emergency/disaster planning costs** are associated with audits, consulting, back-up equipment or supplies. They also include costs associated with the operation of work group recovery sites and any training undertaken in the last 12 months. There is only a one level cost component. It is not further divided.

10. **Physical security costs** are the costs related to protecting the facility, its contents and employees/tenants. They include the cost of direct labor as well as security equipment maintenance (Closed Circuit Television (CCTV), card access, security fence/barriers, and security software.) It is a one level cost component, and not further divided.

11. **Employee amenities costs** are the costs to provide or maintain amenities such as (11.1) cafeteria, food service operations; (11.2) break room, lounge, coffee bars, vending areas; (11.3) library, resource center; (11.4) Internet cafe/ stations; (11.5) employee store; (11.6) travel center; (11.7) Automated teller machine (ATM)/financial services; (11.8) multi-purpose space used for training and assembly; (11.9) day-care; (11.10) prayer room/privacy area; (11.11) employee health facilities; (11.12) nursing/lactation areas; (11.13) exercise, fitness area (e.g. lockers and/or shower areas); (11.14) outdoor recreation areas (jogging paths, sports courts, exercise park); (11.15) game room; (11.16) others.

12. **Space planning costs** are costs of these kinds of services: (12.1) facility planning, (12.2) furniture management, (12.3) relocation/migration planning and (12.4) others like plotting services, outside architectural services, real estate analysis.

13. **Facility management information technology costs** are costs of licenses, hardware and software upgrades, administration and support of all IT-related costs. There are eight sub-categories, which are (13.1) Computer Aided Design (CAD) software, (13.2) Computer Aided Facility Management (CAFM) software, (13.3) Computerized Maintenance Management System (CMMS) software, (13.4) Building Automation System (BAS) software, (13.5) Project management software, (13.6) Hardware

upgrades, (13.7) Administration and support of related IT costs and (13.8) Cabling upgrades (Specific to supporting FM technology).

Operational Costs Benchmarking (KTI). The division of operational costs in this benchmarking pool of *parasta kiinteistötietoa (in Finnish, and in English is KTI Property Information Limited Company)* (KTI) is completely based on the Finnish book-keeping law (30.12.1997/1339):

1. administration cost;
2. operation and maintenance cost;
3. outdoor maintenance cost(roadways, parking and grounds);
4. cleaning cost;
5. heating cost;
6. water and waste water cost;
7. electricity cost;
8. waste management cost;
9. insurance cost;
10. rent cost (ground rent, if applicable);
11. property tax;
12. other maintenance costs;
13. repairs cost;
14. activations cost.

There is also only one division level.

FM Monitor (pom+). The division of the operating cost of this benchmarking program of *pom+ consulting public limited company* (pom+) is based on DIN 18960 but not fully consistent. The following Table 4.3 shows the structure of DIN 18960, which contains four main parts and two levels.

In the FM Monitor report, the operating costs contain only two main parts which are (1) management costs and (2) operation costs. The latter contains (2.1) supply and disposal cost (2.1.1 energy cost, (2.2) cleaning cost, (2.3) inspection & preventive maintenance cost (2.4) care supervisor cost and (2.5) cost of tax and fee.

Table 4.3: FM costs classification of DIN 18960

1. Costs of capital	1.1 External 1.2 Internal
2. Management costs	2.1 Staff cost 2.2 Material cost 2.3 other management cost
3. Operation cost	3.1 Supply and disposal 3.2 Cleaning 3.3 Operating of technical equipments 3.4 Inspection and maintenance of building structures 3.5 Inspection and maintenance of technical equipments 3.6 Care supervisor 3.7 Tax and fee 3.8 Other operation costs
4. Repair cost	4.1 Building structures repair costs 4.2 Technical equipments repair costs 4.3 Outdoor installation repair costs 4.4 Furniture repair costs

fm.benchmarking report (GEFMA, etc.). During the process of data collection, the operating cost division of this benchmarking program of *German Facility Management Association* (GEFMA) is based on DIN 32736. In its publication of benchmarking results, the *cost of disposal and supply* is separated from the main component *cost of infrastructure and technical building management* and becomes the fourth main component. The costs of infrastructure building management are divided into two parts: object and user (Table 4.4).

Table 4.4: FM costs classification of fm. benchmarking program

1. Infrastructural building management cost (object)	
1.1 Catering service cost	
1.2 Care supervisor service cost	
1.3 Cleaning cost	1.3.1 Regular cleaning 1.3.2 Facades cleaning (without glass area)

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	1.3.3 Glass cleaning
	1.3.4 Basic cleaning
	1.3.5 Chimney cleaning
	1.3.6 Special cleaning
	1.3.7 Pest control
2. Infrastructural building management cost (user)	
2.1 Internal post cost	
2.2 Copying and printing service cost	
2.3 Data processing cost	
2.4 Moving service cost	
2.5 Warehouse and logistic service cost	
2.6 Central communication cost	
2.7 Parking service cost	
2.8 Transport cost	
2.9 Central archiving cost	
2.10 Security cost	
	2.10.1 Person and access control
	2.10.2 Building guard and key management
	2.10.3 Station service
	2.10.4 Work and health protection
	2.10.5 Fire watch and test alarm
3. Technical building management cost	
3.1 Maintenance cost	
3.2 Operation cost	
3.3 Recording cost	
3.4 Energy management cost	
3.5 Information management cost	
3.6 Cost of pursuing technical warranty	
4. Commercial building management cost	
4.1 Procuring management cost	
4.2 Planning and controlling cost	
4.3 Property accounting cost	
4.4 Contract management cost	
4.5 Capital cost	
4.6 Land tax cost	

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4.7 Building insurance cost
5. Supply and disposal cost
5.1 Electricity cost
5.2 Heating fuel cost
5.3 Fresh water cost
5.4 Disposal of waste cost
5.5 Sewage cost

FM Austria (IBI). During the process of data collection, the division of FM costs of this benchmarking pool of *Institute for Building Informatics* (IBI) are based on ÖNORM B 1801-2 (Table 4.2), but not all cost categories are selected.

1. Water cost (5.1.1)
2. Sewage cost (5.1.2)
3. Disposal cost (5.1.3)
4. Heating energy cost (5.1.4)
5. Hot water cost (5.1.5)
6. Cooling energy cost (5.1.6)
7. Electricity cost (5.1.7)
8. Care supervisor cost (5.2.1)
9. Garden service cost (5.5.1)
10. Cleaning cost (5.4)
11. Winter service cost (5.5.2)
12. Security service cost (5.2.2)
13. Facility management cost (4.)
14. Cost of inspection and preventive maintenance of technical equipments (6.1.1)
15. Cost of inspection and preventive maintenance of buildings (6.1.2)
16. Construction cost
17. Insurance cost (7.1.1)
18. Tax and fee (3)

19. Rent
20. Other costs (7.1.2)

In the report, only the following four KPIs are published.

1. Supply and disposal cost (5.1.1-5.1.7)
2. Cleaning cost (5.4)
3. Security services cost (5.2.1-5.1.2)
4. Maintenance cost (6.1.1-6.1.2)

NFC Index (NFCIC). The *Netherlands Facility Costs Index* (NFC Index) of *Netherlands Facility Costs Index Cooperative* (NFCIC) applies NEN 2748 to organize its database and calculate index, where FM costs are divided into the following five parts.

1. **Housing.** As provided by buildings and land, (1.1) insurances, (1.2) maintenance, (1.3) renovations, (1.4) energy and water, (1.5) management (in terms of rent, purchase and lease) and (1.6) interest from property.
2. **Services and Means.** As provided in (2.1) consumer services (corporate restaurant, catering, vending machines), (2.2) risk control (surveillance, protection and reception), (2.3) cleaning, (2.4) removals, (2.5) document management (creation, processing in the mail room, copies, management and filing), (2.6) managing residual substances, (2.7) provision of space, (2.8) office supplies, (2.9) plants and shrubs, (2.10) art and signs as well as (2.11) work uniforms.
3. **Information and Communication Technology.** It contains (3.1) ICT management and advice, (3.2) ICT service desk, (3.3) workplace management, (3.4)central and distributed services, (3.5) telemetry and (3.6) end user training.
4. **External Services.** As provided in (4.1) external accommodation (such as meeting accommodation and home workplaces) and (4.2) transport of passengers (business trips, home to work travel, air travel, public transport) but excluding company cars.
5. **Facility Management.** Integral management of the above mentioned categories as provided for in (5.1) facility policy, (5.2) marketing and innovation of facility management, (5.3) the provision of a business office for accounts, (5.4) planning and control, (5.5) secretarial support and (5.6) the human resources of the facility function, (5.7) provision of a help-desk, (5.8) provision of policy with regard to the environment and working conditions as well as (5.9) the management of risks, (5.10) procurement, (5.11) information and (5.12) quality.

Key-database (NBEF). The FM cost classification of this FM benchmarking database of *Norweigian Facility Management Association* (NBEF) is based on the national standard NS 3454, but it excludes the cost component *potential of the property*.

1. **Management Costs.** The costs are associated with (1.1) tax, (1.2) insurance and (1.3) administration.

2. **Operation Costs.** The costs are associated with (2.1) operation and minor maintenance, (2.2) cleaning service, (2.3) energy, (2.4) water and sewage, (2.5) garbage collection, (2.6) security and (2.7) outdoor.

3. **Maintenance Costs.** The costs are associated with (3.1) regular maintenance, (3.2) replacements and (3.3) outdoor.

4. **Development Costs.** The costs are associated with (4.1) current, (4.2) official rules requirements and (4.3) upgrading.

5. **Servicing and/or Support Costs.** The costs are associated with (5.1) administrative offices, (5.2) switchboard and services, (5.3) catering, (5.4) furniture, fixtures, (5.5) moving workplaces and/or rotation, (5.6) telecommunications and services, (5.7) Postal and messenger service and (5.8) printing and copying.

DEF-ratios (DEF). The KPIs of DEF-ratios, which organized by *Danish Facility Management Network* (DEF), focus more on the property operation and is organized based on DFM 19.12.2007 "Revised figure structure". The specific items are:

1. **Management Costs.**

2. **Operation Costs.** The costs are associated with (2.1) buildings and equipments operation as well as (2.2) care, control and investigation of operation.

3. **Maintenance Costs.** The costs are associated with (3.1) maintenance, building exterior, (3.2) maintenance, building indoors, (3.3) maintenance, construction & installations and (3.4) maintenance, terrain.

4. **Consumption Costs.** The costs are associated with (4.1) heating, (4.2) electricity, (4.3) water and sewage as well as (4.4) waste management.

5. **Cleaning Costs.**

6. **Service Costs.** The costs are associated with (6.1) safety and port service, (6.2) reception, (6.3) switchboard, (6.4) catering, (6.5) moving service and (6.6) postal service.

Based on the analysis of the above mentioned FM cost classification structures, *there seems to be a higher level of agreement between the subdivided cost components than the main cost components*, e.g., different benchmarking pools treat subdivided components such as electricity, heating, water & sewage, waste quite differently (Table 4.6). Some include them in the first-level components as KTI operational cost benchmarking; some range them in the second-level components as NBEF key-database; some arrange them in the third-level components as FM Monitor. Thus, it is recommended that *sub-level components are used as KPIs in the international FM benchmarking*.

Table 4.5: Classification levels of electricity, heating, water & sewage, waste in different benchmarking pools

Benchmarking pools	First-level components	Second-level components	Third-level components
KTI	7. heating 8. water & waste water 9. electricity 10. waste management		
DEF	4. consumption costs	4.1 heating 4.2 electricity 4.3 water & sewage	
NFC	1. housing cost	1.4 energy 1.5 water	
fm.benchmarking	5. supply and disposal costs	5.1 electricity 5.2 heating fuel 5.3 fresh water 5.4 disposal of waste 5.5 sewage	
NBEF	2. operation costs	2.3 energy 2.4 water & sewage 2.5 refuse collection	
IFMA	3. utilities cost	3.1 electricity 3.2 fuel oil 3.3 gas 3.4 steam 3.5 chilled water 3.6 water	

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		3.7 sewage 3.8 other utilities	
FM Monitor	3. operation cost	3.1 supply & disposal	3.1.1 water & sewage 3.1.2 heating 3.1.3 electricity 3.1.4 refuse collection
FM Austria	5. operation cost	5.1 supply & disposal	5.1.1 water 5.1.2 sewage 5.1.3 refuse collection 5.1.4 heating energy 5.1.5 hot water 5.1.6 cooling energy 5.1.7 electricity

4.3 Key performance indicators with the same name

Because of the differences in usage preference, some KPIs among different benchmarking pools have the same or similar names but actually measure different things.

1. Maintenance, Inspection, Repair

   Maintenance is a general concept. It can be classified by the location of maintained object like indoor maintenance or outside maintenance. It could also be demarcated by the type of the maintained object like building maintenance or equipment/installations maintenance. Furthermore, it has different performance levels which are very often used in German-speaking countries.

   Wartung, *Instandsetzung*, *Instandhaltung*, *Inspektion*, *Erhaltung* these five German words can all be translated as maintenance in English but they actually have different meanings.

   In Germany (DIN 18960), *Instandhaltung* is a general concept (maintenance). Its measures can be divided into the following three types: *Instandsetzung*, *Wartung*, and *Inspektion*. *Instandsetzung* should be more precisely translated as repair. It is a kind of process, in which a defective item is returned to its original working condition but without improving its original functions. *Wartung* is a kind of preventive measures to delay the degradation of the existing supply condition. It is a kind of security measure for a longer period. *Inspektion* is a kind of action to identify and assess the actual condition of an item including the determination of the causes of erosion and finding consequences for future use.

In Austria (ÖNORM 1801-2), *Instandhaltung* is not a general concept as in DIN 18960. It is a name of preventive measures to delay the degradation of the existing condition including repairs. It equals to *Instandsetzung* and *Wartung* in Germany. The definition of *Inspektion* here is the same with DIN 18960 while *Wartung* in Austria only means to replace expendable parts.

Table 4.6: Different concepts about Inspektion, Wartung, Instandhaltung, Instandsetzung, Restaurierung and Erhaltung between Germany and Austria

	Germany (DIN 18960)	Austria (ÖNORM 1801-2)
Inspektion	to identify and assess the actual condition of an item	the same as DIN 18960
Wartung	**preventive** measures to delay the degradation of the existing supply condition, without improvement	to **replace** expendable parts
Instandhaltung	general concept including Inspektion, Wartung, Instandsetzung	**preventive** measures to delay the degradation of the existing supply condition including repairs, without improvement
Instandsetzung	repair	**preventive** measures to improve
Restaurierung		restoration measures
Erhaltung		general concept including Instandhaltung, Instandsetzung and Restaurierung

In the fm.benchmarking report (GEFMA etc.), all levels of maintenance costs are included in one component: (3.1) Cost of maintenance. In FM monitor (pom+), only inspection and preventive maintenance costs are benchmarked while repair cost is excluded. In the report of FM Austria, inspection, preventive maintenance and repair costs are all collected. They are included in the operation cost, which is a little different from ÖNORM 1801-2.

2. Life and safety costs, physical security costs, security service costs

   In the IFMA's benchmark, a type of cost called *life and safety costs* is listed individually. It is quite different from safety/security costs defined by other benchmarking pools. It refers to costs associated with compliance to building regulations required by federal, state/provincial and municipal laws to maintain and operate the facility.

This kind of costs is not mentioned in other standards or benchmarking reports except in the fm.benchmarking report (GEFMA, etc.), where security service includes both of two parts: life and safety costs and physical security costs. *Security service costs* mentioned in *six other pools* are *equal* to the *physical security costs* in IFMA's benchmark.

4.4 Comparison platform

Since there is very little uniformity in the definitions about the first-level cost components, a framework is used to rearrange those similar sub-components, which is the *European-standard EN 15221-4 Taxonomy, Classification and Structures in Facility Management* (Table 4.7). It is supposed to be the most suitable framework to rearrange FM costs because most member benchmarking pools come from Europe. Different conditions of different countries must have been considered during the development process.

Table 4.7: EN 15221-4 taxonomy, classification and structures in Facility Management

Facility Management (Total support costs)																					
Space & Infrastructure											People & Organization						Central Function				
Space																					
Building initial performance	Asset replacement, refurbishment	Enhancement of initial performance	Property administration	Portfolio development	Maintenance and operation	Utilities	Outdoors	Cleaning	Workplace	Primary activity specific	Health, safety, security, environment	Hospitality	ICT	Logistics	business support	Organization specific	Sustainability	Quality standards and guidelines	Risk policy	Identify, Innovation	

Building initial performance cost. This kind of cost is associated with the possession of a building or rents that a user pays to a land owner every year. Project management costs for a new building are also included. Among those member benchmarking programs, the *Occupancy costs* (1) of IFMA, the *Rent* (10) of KTI and the *Rent* (-) of FM Austria are indicators to release this kind of cost information. The other five benchmarking programs do not collect this kind of cost information.

Asset replacement, refurbishment cost. This kind of cost is associated with the repair of the main structural elements of a building like building exterior, facade, roof and technical building equipment. Among those member benchmarking programs, the *Renovations cost* (1.3) of NFC and the *Current cost* (4.1) of NBEF are indicators to release this type of cost information. The other six benchmarking programs do not collect this kind of cost information.

Enhancement of initial performance cost. This type of cost is used to improve the building body and technical infrastructure including adaptation of existing installations, replacement by new installations with increased functionality and adding new types of installations. Among those member benchmarking programs, the *Project costs* (6) of IFMA, the *Activations cost* (14) of KTI and *Upgrading cost* (4.3) of NBEF are indicators to release this kind of cost information. The other five benchmarking programs do not collect this part of cost.

Property administration costs. This kind of cost is associated with management of land and real estate including all fees, taxes, insurance, property management, etc. The *Taxes on building and contents* (5.5), the *Insurance* (5.6) and the *Facility management information technology costs* (13) of IFMA, the *Administration costs* (1), the *Insurance* (9) and the *Property tax* (11) of KTI, the *Management cost* (2) and the *Tax and fee* (3.7) of FM Monitor, the *Commercial building management* (4) of GEFMA, the *Tax and fee* (3), the *Facility Management cost* (4), and the *Insurance* (7.1.1) of FM Austria, the *Insurance* (1.1), the *Management cost (in terms of rent, lease)* (1.5) and the *Facility management cost* of NFC, the *Tax* (1.1), the *Insurance* (1.2), the *Administration cost* (1.3) and the *Administrative office* (5.1) of NBEF are indicators to release this kind of cost information. DEF-ratios benchmarking program does not collect this kind of cost.

Portfolio development costs. This kind of cost is associated with strategic portfolio planning activities including purchase and sales activities. Among those member benchmarking programs, only NFC supply such kind of cost information, which is named *Management cost (in terms of purchase)* (1.5). The other seven benchmarking programs do not collect this part of cost.

Maintenance and operation cost. This kind of cost is associated with the operation and maintenance of buildings and their technical installations, which also includes help-desk systems and care supervisor. All eight member benchmarking programs collect this kind of cost. In the IFMA benchmarking program, they are *Exterior building maintenance* (4.1) and *Interior Maintenance* (4.2). In the KTI benchmarking program, they are *Operation and maintenance cost* (2), *Other maintenance* (12) and *Repairs* (13). In the FM Monitor of pom+, *Inspection & preventive maintenance* (2.3) are used to release this kind of cost information. The *care supervisor service cost* (1.2), *Maintenance cost* (3.1) and *Operation cost* (3.2) of GEFMA; the *Care supervisor service cost* (5.2.1), the *Inspection and preventive maintenance of technical equipments* (6.1.1) and the *Inspection and preventive maintenance of buildings* of FM Austria; the *Maintenance cost* (1.2) and the *Provision of a help-desk* (5.7) of NFC; the *Operation and minor maintenance* (2.1), the *Regular maintenance* (3.1) and the *Replacement* (3.2) of NBEF; the *Operation cost* (2) and the *Maintenance* (3) are used to release this kind of cost information.

Utilities costs. This kind of cost is associated with the supply of energy and water as well as handling of garbage. All eight member benchmarking programs collect this kind of cost but their classifications vary. In the IFMA benchmarking program, it is arranged into two categories which are *Utilities* (3) and *Waste removal* (8.2). In the KTI benchmarking program, it is classified into four categories which are *Heating* (5), *Water and waste water* (6), *Electricity* (7) and *Waste management* (8). In the FM Monitor of pom+, it is also arranged in one category but it is named *Supply and disposal*. In the fm.benchmarking report of GEFMA, it is classified as *Electricity* (5.1), *Heating fuel* (5.2), *Fresh water* (5.3) as well as *Disposal of waste* and *Sewage* (5.5). In the Report of FM Austria, this type of cost is subdivided into seven parts which are *Water* (5.1.1), *Sewage* (5.1.2), *Disposal of garbage* (5.1.3), *Heating energy* (5.1.4), *Hot water* (5.1.5), *Cooling energy* (5.1.6) and *Electricity* (5.1.7). In the NFC Index, this kind of cost is arranged into two categories which are *Energy and water* (1.4) and *Removals* (2.4). In the Key-database of NBEF, similar cost indicators are *Energy* (2.3), *Water and sewage* (2.4) and *Garbage collection* (2.5). In the benchmarking program DEF-ratios, this kind of cost is divided into four subcategories: *Heating* (4.1), *Electricity* (4.2), *Water and sewage* (4.3) and *Waste management* (4.4).

Outdoors costs. This kind of cost is associated with outdoor facilities including land and maintenance of parking and garden. Seven member benchmarking programs collect this type of cost information. *Roads and grounds maintenance* (4.3) of IFMA, *Outdoor maintenance (Roadways, parking and grounds)* (3) of KTI, *Exterior building and equipment cleaning* (4.1.1), *Garden service* (1.4.2), *Winter service* (1.4.3) and *Parking* (2.7) of GEFMA are indicators to release this kind of cost information. In the report of FM Austria, the similar cost indicators are *Garden service* (5.5.1) and *Winter service* (5.5.2). In the NFC Index, the similar cost indicators are *Plants and shrubs* (2.9) and *Art and signs* (2.10).

In the Key-database of NBEF, the similar cost indicators are *Outdoor operation* (2.7) and *Outdoor maintenance* (3.3). In the benchmarking program DEF-ratios, this kind of cost information are divided into two subcategories: *Maintenance, building exterior* (3.1) and *Maintenance, terrain* (3.4).

Cleaning costs. This kind of cost includes routine cleaning, special cleaning like facade and cover, equipment cleaning and contract cleaning like cleaning a construction site, cleaning a site after an accident or fire. The *Janitorial costs* (2) of IFMA, the *Cleaning costs* (4) of KTI, the *Cleaning cost* (2.2) of FM Monitor, the *Cleaning cost* (1.3) of fm.benchmarking, the *Cleaning cost* (5.4) of FM Austria, the *Cleaning cost* (2.3) of NFC, the *Cleaning service cost* (2.2) of NBEF and the *Cleaning cost, indoor* (5.1) of DEF-ratios are used to release this kind of cost information.

Workplace costs. This kind of cost is associated with supplement of usable workplace including change of properties, area management, installation and maintenance of furniture and office equipment. Among the eight member benchmarking programs, only three collect this kind of cost information, which are the indicator *Space planning* (12) of IFMA, the indicators *Provision of space* (2.7) and *Office supplies* (2.8) of NFC, and the indicator *Furniture, fixtures* (5.4) of NBEF.

Primary activity specific costs. This kind of cost is associated with organizational or industry specific services related to space and infrastructure. Among the eight member benchmarking programs, only IFMA collects the similar cost information, which are the indicators *Utility/central system maintenance* (4.4) and *Process treatment and environment system* (4.5).

Health, safety, security, and environment costs. This kind of cost is associated with protection from external threats, internal risk, protection assets and the health and welfare of the people to ensure a safe and sustainable environment. The seven of eight member benchmarking programs collect this kind of cost information. In the IFMA's benchmarking, this kind of cost are divided into two parts *Life and Safety* (7) and *Physical security* (10). In the other six benchmarking programs, only one indicator is used to collect this kind of cost, which are *Supervisory service* (2.4) of FM Monitor, *Security* (2.10) of fm.benchmarking of GEFMA, *Security service* (5.2.2), *Risk* (2.2) of NFC, *Security* (2.6) of Key-database of NBEF and *Security, safety and port service* (6.1) of DEF-ratios.

Hospitality costs. This kind of cost is used to provide a friendly working environment including reception, catering and vending machines, social activity room, uniforms, etc. Five of the eight member benchmarking programs collect this kind of cost information. In the IFMA's benchmarking program, this kind of cost indicator is named *Employee amenities* (11). In the GEFMA's fm.benchmarking program, this kind of cost indicator is named *Catering service*. In the NFC Index, two indicators *Consumer service* (2.1) and *Work uniforms* (2.11) are used to release this kind of cost information.

Information and communication technology costs. This kind of cost is associated with information and communication. Among the eight member benchmarking programs, four collect such kind of cost. In the IFMA's benchmarking program, this kind of cost information is subdivided into four categories: *Copy and printing service* (2.3), *Data processing* (2.3), *Central communication* (2.6) and *Information management* (3.5). In the NFC Index, the similar cost indicator is named as *Information and communication technology* (3). In the Key-database of NBEF, this kind of cost information are subdivided into three categories: *Switchboard and service* (5.2), *Telecommunications and services* (5.6) and *Printing and copying*. In the DEF-ratios, the similar cost indicator is *Switchboard* (6.3).

Logistics costs. This kind of cost is related to transportation of people and transportation and storage of material and information. Four of the eight member benchmarking programs collect this kind of cost information. In the fm.benchmarking program of GEFMA, this kind of cost information is subdivided into five categories: *Internal post* (2.1), *Moving service* (2.4), *Warehouse and logistic* (2.5), *Transport* (2.8) and *Central archiving* (2.9). In the NFC Index, this kind of cost information is subdivided into three categories: *Document management* (2.5), *External accommodation* (4.1) and *Transport of passengers* (4.2). In the Key-database of NBEF, this kind of cost information is subdivided into two categories: *Moving workplaces and/or rotation* (5.5) and *Postal and messenger* (5.7). In the DEF-ratios, this kind of cost information is subdivided into two categories which are *Moving service* (6.5) and *Postal service* (6.6).

Business support costs. This kind of cost is associated with services and activities to support the core business of the organization like finance, human resource management. None of the eight member benchmarking programs collect this kind of cost information.

Organization specific costs. This kind of cost is associated with various organization or industry specific services which make the comparison feasible across the industry. None of the eight member benchmarking programs collect this kind of cost information.

Sustainability costs. This kind of cost is associated with the development of a policy to reduce the resource consumption, use facilities economically (land and building) and increase health and human well-being. Only one of the eight member benchmarking programs collect this kind of cost information, which is the *Providing satisfactory levels of air and water quality* (8.1) of the IFMA's benchmarking program.

Quality standards and guidelines costs. This kind of cost is associated with the responsibility for (FM) quality management systems. None of the eight member benchmarking programs collect this kind of cost information.

Risk policy costs. This kind of cost is associated with the assessment and management of risks and threats to the (FM) organization. Only one of the eight member benchmarking programs collect this kind of cost information, which is the *Emergency/disaster planning* (9) of the IFMA's benchmarking program.

Identify, innovation costs. This kind of cost is associated with the establishment of brand like architecture and website fleet graphics. None of the eight member benchmarking programs collect this kind of cost information.

A detailed rearrangement of KPIs of different member benchmarking programs is listed in Table 4.8.

Table 4.8: Rearrangement of KPIs of different member benchmarking programs based on EN 15221

Headings	IFMA	KTI	FM Monitor	GEFMA	FM Austria	NFC	NBEF	DEF
Building initial performance	1.Occupancy costs	10.Rent	–	–	Rent	–	–	–
Asset replacement, refurbishment	–	–	–	–	–	1.3 Renovations	4.1 Current	–
Enhancement initial performance	6. Project costs	14. Activations	–	–	–	–	4.3 Upgrading	–
Property administration	5.5 Taxes on building and contents	1. Administration	2. Cost of management	4. Cost of commercial building management (4.1-4.7)	3. Tax and fee	1.1 Insurance	1.1 Tax	–
	5.6 Insurance	9. Insurance	3.7 Tax and fee		4. Cost of facility management	1.5 Management (in terms of rent, lease)	1.2 Insurance	
	13. Facility management information technology costs	11. Property tax			7.1.1 Insurance cost	5. Facility management	1.3 Administration	

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							5.1 Administrative office	
Portfolio development	–	–	–	–	–	1.5 Management (in terms of purchase)	–	–
Maintenance and operation	4.1 Exterior building maintenance	2. Operation and maintenance	2.3 Inspection & preventive maintenance	1.2 Care supervisor service	5.2.1 Care supervisor service	1.2 Maintenance	2.1 Operation and minor maintenance	2. Operation (2.1-2.2)
	4.2 Interior maintenance	12. Other maintenance		3.1 Maintenance	6.1.1 Inspection and preventive maintenance of technical equipments	5.7 Provision of a help-desk	3.1 Regular maintenance	3. Maintenance (3.1-3.4)
		13. Repairs		3.2 Operation	6.1.2 Inspection and preventive maintenance of buildings		3.2 Replacement	
Utilities	3. Utilities	5. Heating	2.1 Supply and disposal	5.1 Electricity	5.1.1 Water	1.4 Energy and water	2.3 Energy	4.1 Heating
	8.2 Waste removal	6. Water and waste water		5.2 Heating fuel	5.1.2 Sewage	2.4 Removals	2.4 Water and sewage	4.2 Electricity

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		7. Electricity 8. Waste management		5.3 Fresh water 5.4 Disposal of waste 5.5 Sewage	5.1.3 Disposal of garbage 5.1.4 Heating energy 5.1.5 Hot water 5.1.6 Cooling energy 5.1.7 Electricity		2.5 Garbage collection	4.3 Water and Sewage 4.4 Waste management
Outdoors	4.3 Roads and grounds maintenance	3. Outdoor maintenance (Roadways, parking and grounds)	–	4.1.1 Exterior building and equipment cleaning 1.4.2 Garden service 1.4.3 Winter service 2.7 Parking	5.5.1 Garden service 5.5.2 Winter service	2.9 Plants and shrubs 2.10 Art and signs	2.7 Outdoor operation 3.3 Outdoor maintenance	3.1 Maintenance, building exterior 3.4 Maintenance, terrain
Cleaning	2. Janitorial costs	4. Cleaning	2.2 Cleaning	1.3 Cleaning (1.3.1-1.3.7)	5.4 Cleaning	2.3 Cleaning	2.2 Cleaning service	5.1 Cleaning, indoor
Workplace	12. Space planning	–	–	–	–	2.7 Provision of space	5.4 Furniture, fixtures	–

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						2.8 Office supplies		
Primary activity specific	4.4 Utility/-central system maintenance 4.5 Process treatment and environment system	–	–	–	–	–	–	–
Health, safety, security, environment	7. Life and safety 10. Physical security	–	2.4 Supervisory service	2.10 Security (2.10.1-2.10.5)	5.2.2 Security service	2.2 Risk control	2.6 Security	6.1 Security, safety and port service
Hospitality	11. Employee amenities	–	–	1.1 Catering service	–	2.1 Consumer service 2.11 Work uniforms	5.3 Canteen and/or catering	6.2 reception 6.4 Catering
ICT	–	–	–	2.2 Copy and printing service	–	3. Information and communication technology	5.2 Switchboard and services	6.3 Switchboard

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				2.3 Data processing 2.6 Central communication 3.5 Information management			5.6 Telecommunications and services 5.8 Printing and copying	
Logistics	–	–	–	2.1 Internal post 2.4 Moving service 2.5 Warehouse and logistic 2.8 Transport 2.9 Central archiving	–	2.5 Document management 4.1 External accommodation 4.2 Transport of passengers	5.5 Moving workplaces and/or rotation 5.7 Postal and messenger	6.5 Moving service 6.6 Postal service
Business support	–	–	–	–	–	–	–	–

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Organization specific	–	–	–	–	–	–	–	–
Sustainability	8.1 Providing satisfactory levels of air and water quality	–	–	–	–	–	–	–
Quality standards and guidelines	–	–	–	–	–	–	–	–
Risk policy	9. Emergency/disaster planning	–	–	–	–	–	–	–
Identify, innovation	–	–	–	–	–	–	–	–

4.5 Principles of selecting key performance indicators for the international FM benchmarking

During the process of selecting KPIs for the international FM benchmarking, some principles need to follow.

1. Common KPIs of member FM benchmarking pools

   Since the indirect method is chosen to set up the international FM benchmarking pool, it is not allowed to generate new indicators. Only common KPIs of different national benchmarking pools can be the indicators of the international pool.

2. Feasibility of costs collecting

   Although there is a higher level of agreement between the subdivided cost components than the main cost components, the division should not be too fine. Some services may be separated from the aspect of characteristic but performed by one person or included in one service package. They cannot be evaluated separately.

3. Percentages of costs

   There can be a great number of indicators. Their influence, however, can be quite different, e.g., according to the data from the fm.benchmarking report, cleaning costs account for 27% (including routine cleaning, facade cleaning, glass cleaning and ground cleaning) while winter service costs account for less than 1% (Figure 4.2). It is obvious that there is more improvement potential in the field of cleaning service than winter service.

4. Flexibility

   Although KPIs are supposed to be steady, it cannot be avoided that KPIs sometimes need to be modified according to experiences after some years. As a result, the flexibility of KPIs should be considered when designing and selecting indicators.

4.6 Key performance indicators of international facility management benchmarking

Based on the analysis above, a new FM cost KPIs-system is established. In the Table 4.8, six cost components are a common interest of member benchmarking programs. They are

- Property administration,
- Maintenance and operation,

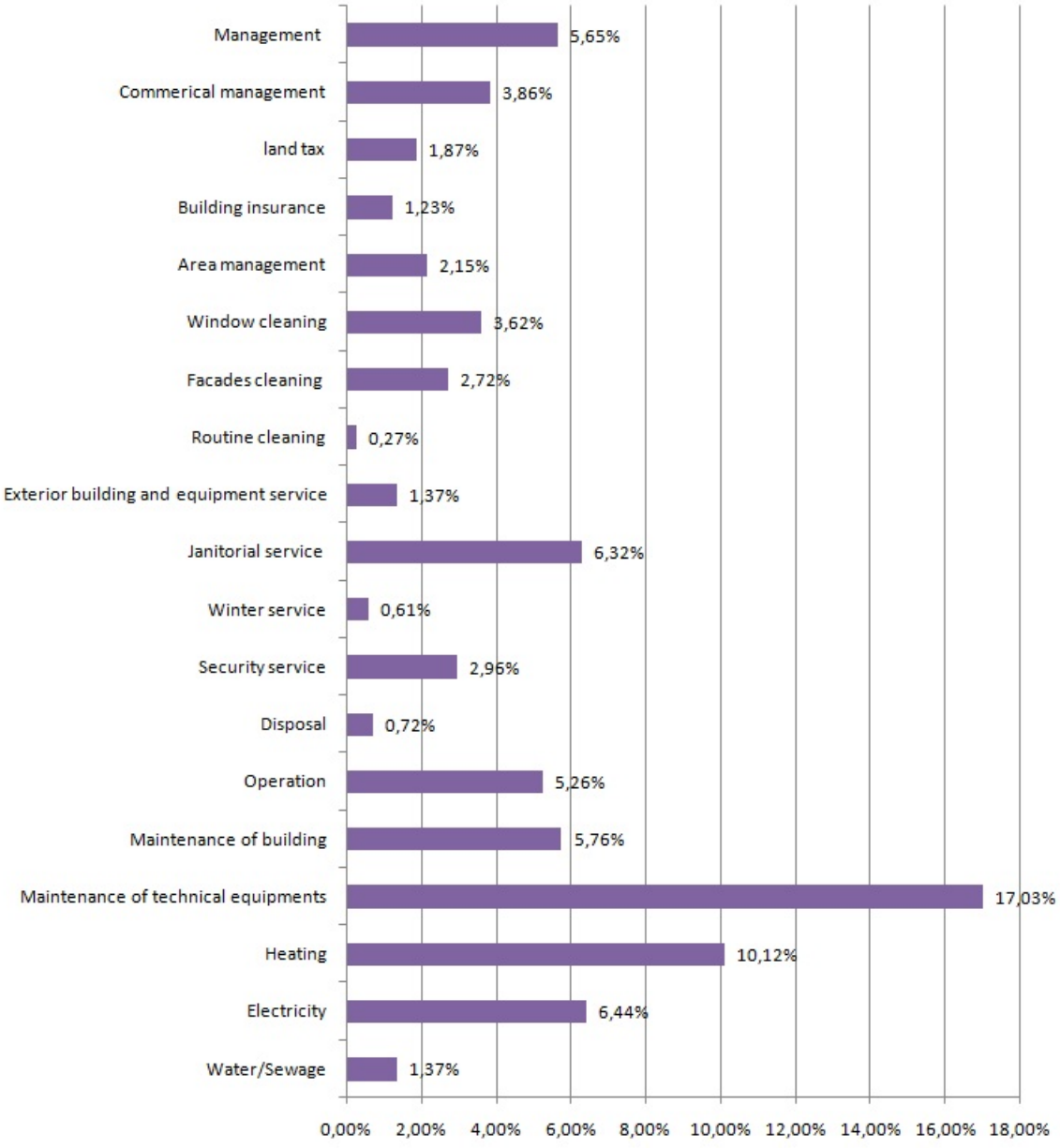

Figure 4.2: Percentages of FM services costs

- Utilities,
- Outdoors,
- Cleaning,
- Health, safety, security and environment.

Although these six main components are common interests, the arrangement of subdivided cost components is not identified. Detail-level KPIs should be picked out for each main component.

4.6.1 Selected key performance indicators

Property administration. In this category, there are three different sub-categories, which are *1) Tax and fee*, *2) Insurance* and *3) Cost of facility management*. These three cost categories are quite different, and it is better to collect data separately.

Maintenance and operation. Although the operation of building and equipment is an activity, its cost is normally not additionally calculated. It is part of the work of care supervisor or mechanics who have other tasks such as inspection, preventive maintenance, repairs, etc. It is better to compose a combination of operation, inspection and preventive maintenance. This kind of cost is usually included in the budget and the cost is predictable. On the other hand, repairs are not predictable and costs are quite random. It is better to separate this kind of cost from preventive maintenance.

According to the maintained objects such as building and installations, maintenance can be divided into two parts. Maintenance can also be divided based on the exterior and interior of buildings. Different benchmarking pools apply different division rules. In order to make the cross-countries comparison feasible, it is better not to subdivide. As a result, in this category, two KPIs are suggested, which are *1) Operation, inspection and preventive maintenance*, *2) Repairs*. However, many benchmarking pools did not collect the data of repairs cost. Therefore, it is recommended to use only the first KPI *Operation, inspection and preventive maintenance*.

Utilities. There are mainly three types of utilities which are energy, water & sewage and garbage collection. Some countries collect the total amount cost of utilities. Some countries divide energy into two categories (electricity and heating). Some benchmarking pools collect even more details. Because not every benchmarking program collects data in such detail, it is recommend to use a general KPI in this category, which is *cost of utilities*.

Outdoors. This type of cost is associated with outdoor facilities including land and maintenance of parking and garden. Some benchmarking pools, e.g. fm benchmarking of Germany, divide this type of cost in more detail such as cost of parking service, winter service and garden service. Some benchmarking programs collect more general cost information. In order to make the cross-countries comparison feasible, it is suggested to collect this type of cost in general, which is: *Outdoor costs*.

Cleaning. Every FM benchmarking program collects this part of cost. Most of them collect this type of cost in a general way while some programs such as fm.benchmarking collect the data more detail. To make the international comparison possible, it is better to set a more general indicator: *Cleaning*. What should be pointed out here is that all cleaning refers to indoors. Outdoor cleaning costs should be among the cost of outdoor.

Health, safety, security and environment. There are two subcategories of cost in this category. One is *life and safety cost* collected by IFMA, which is part of costs associated with compliance to building regulations required by federal, state/provincial and municipal laws such as exit door, building alarms, mandated training, etc. The other is *physical security costs*, which is mainly related to the facility protecting measures such as CCTV, card access, security fence etc. There are two benchmarking pools collecting both parts of cost while others only collect data for physical security costs. It is recommended to have only one KPI in this part, which is *physical security costs*.

4.6.2 Relationship of key performance indicators

In Table 4.9, the relationships between KPIs in our international FM benchmarking pool and in the national member benchmarking pools are presented.

Table 4.9: Relationships between KPIs in international FM benchmarking and in the national member benchmarking pools

Headings	IFMA	KTI	Pom+	GEFMA	IBI	NFC	NBEF	DEF
1. Tax and fee	5.5 Taxes on building and contents	11. Property	3.7 Tax and fee	4.6 Cost of land tax	3. Tax and fee	–	1.1 Tax	–
2. Insurance	5.6 Insurance	9. Insurance	–	4.7 Building Insurance	7.1.1 Insurance	1.1 Insurance	1.2 Insurance	–
3. Cost of FM	13. Facility management information technology	1. Administration	2. Management	4.1 Procuring management 4.2 Planning and controlling 4.3 Property accounting 4.4 Contract management	4. Facility management	1.5 Management (in terms of rent, lease) 5. Facility management	1.3 Administration 5.1 Administrative office	–
4. Operation, inspection and preventive maintenance	4.1 Exterior building maintenance 4.3 Interior maintenance	2. Operation and maintenance 12. Other maintenance	2.3 Inspection & preventive maintenance	1.2 Janitorial service 3.1 Maintenance	5.2.1 Janitorial service 6.1.1 Inspection and preventive maintenance	1.2 Maintenance 5.7 Provision of a help-desk	2.1 Operation and minor maintenance 3.1 Regular maintenance	2. Operation (2.1-2.2) 3.2 Maintenance, building indoor

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				3.2 Operation	6.1.2 Inspection and preventive maintenance of buildings			3.3 Maintenance, terrain
5. Utilities	3. Utilities 8.2 Waste removal	5. Heating 6. Water and waste water 7. Electricity 8. Waste management	2.1 Supply and disposal	5.1 Electricity 5.2 Heating 5.3 Fresh water 5.4 Disposal of waste 5.5 Sewage 5.6 Cooling energy 5.7 Electricity	5.1.1 Water 5.1.2 Sewage 5.1.3 Disposal of garbage 5.1.4 Heating energy 5.1.5 Hot water	1.4 Energy and water 2.4 Removals	2.3 Energy 2.4 Water and sewage 2.5 Garbage collection	4.1 Heating 4.2 Electricity 4.3 Water and sewage 4.4 Waste management
6. Outdoors	4.3 Roads and grounds maintenance	3. Outdoor maintenance	–	1.4.1 Exterior building and equipment cleaning	5.5.1 Garden service	2.9 Plants and shrubs	2.7 Outdoor operation	3.1 Maintenance, building exterior

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				1.4.2 Garden service 1.4.3 Winter service 2.7 Parking service	5.5.2 Winter service	2.10 Art and signs	Outdoor maintenance	3.4 Maintenance, terrain
7. Cleaning	2. Janitorial costs	4. Cleaning	2.2 Cleaning	1.3 Cleaning	5.4 Cleaning	2.3 Cleaning	2.2 Cleaning 5.1 Cleaning, indoor	
8. Physical security	10. Physical security	–	2.4 Supervisory service	2.10 Security	5.2.2 Security service	2.2 Risk control	2.6 Security	6.1 Security, safety and port service

4.7 Conclusion

Eight national FM benchmarking programs are investigated in this work. It can be concluded that there is a higher level of agreement between the subdivided cost components than the grouping in main cost components. The FM cost classification system EN 15221-4 is chosen as the framework to rearrange these similar components. Eight indicators are chosen as the KPIs.

Only a few KPIs are selected as the KPIs of our integrating international benchmarking program which may be one of the shortcomings of indirect method. The direct method allows for many KPIs in international benchmarking programs. However, cost saving, requirement of less data, easy to operate, etc. are great advantages of the indirect method. Thus, the indirect method is still worth applying.

5 AREA MEASUREMENT STANDARDS

To measure, analyze and report a building's performance, area measurement is a basic and fundamental task. There are not two identical properties in the world. Most key performance indicators (KPIs) of FM benchmarks are structured around indicators based on the area of space occupied, such as yearly cleaning cost per square meter, yearly heating cost per square meter, etc.

Currently there are almost as many area measurement standards as countries. Table 5.1 lists some of them:

Table 5.1: Area measurement standards of different countries

Country	Space Measurement Standards
Australia	Method of Measurement: Commercial
Austria	ÖNORM B 1800
China	GB/T 50353
Denmark	DS 13000
Finland	SFS 5139
Germany	DIN 277
The Netherlands	NEN 2748
New Zealand	Guide for the Measurement of Rent-able Areas
Norway	NS 3940
Singapore	Handbook on GFA
Sweden	SS 21054
Switzerland	SIA 416
UK	Code of Measuring Practice (RICS)
US	ASTM E1836

Some international organizations also published area measurement codes such as ISO 9836, EN 15221-6, and IPD Space Code from *Investment Property Databank Limited Company* (IPD) etc. However, according to the literature, none of these standards, have found widespread acceptance across national borders.

Measurement standards are different for each country. Consequently, area measurement data collected from different countries will result in inaccurate comparison results. Subsequently, an FM cost comparison across countries based on area indicators will also be inaccurate.

5.1 Examined standards

Since it is almost impossible to examine all existing area measurement standards in the world, the following nine standards are selected and examined based on the references of [24]:

- UK: Code of measuring practice (RICS code) (published by *yal Institution of Chartered Survey*);
- Germany: DIN 277;
- United States: ASTM E1836;
- Europe: EN 15221-6;
- International: IPD space code.
- Austria: ÖNORM 1800;
- Switzerland: SIA 416;
- China: GB/T 50353;
- Singapore: Handbook on GFA.

5.2 Regulation differences leading to differences of the numerical value

The proposed nine area measurement standards differ in various aspects such as language, context, expression, etc. Nevertheless, not all of these discrepancies are critical or will affect the final numerical value. Three categories of critical differences are identified in this study: unit differences, boundary lines differences, and components differences.

5.2.1 Unit differences

The metric units defined by the International System of Units is the most widely used measurement units system in the world. Most area measurement standards use this units system, e.g. DIN 277, ÖNORM 1800, IPD space code, RICS code, etc. However, some countries still prefer to apply the Imperial System of Units. This differences is easy to reconcile with the help of the conversion Table 5.2.

Table 5.2: Conversions of measurement units

Distances in Metric Units		**Distances in Imperial Units**	
Millimeter (mm)	0.001m	Inch (in)	2.5400cm
Centimeter (cm)	0.01m	Foot (ft)	0.2048m
Decimeter (dm)	0.1m	Yard (yd)	0.9144m
Meter (m)	1m	Mile (mi)	1.6093km
Decimeter (dam)	10m		
Hectometer (hm)	100m		
Kilometer (km)	1000m		
Areas in Metric Units		**Areas in Imperial Units**	
Square millimeter (mm^2)	0.000001 m^2	Square inch (sq in)	6.4516 cm^2
Square centimeter (cm^2)	0.0001 m^2	Square foot (sq ft)	0.0929 m^2
Square decimeter (dm^2)	0.01 m^2	Square yard (sq yd)	0.8361 m^2
Square meter (m^2)	1 m^2	Square mile (sq mi)	2.5900 km^2
Square decimeter (dm^2)	100 m^2		
Square hectometer (hm^2)	10000 m^2		
Square kilometer (km^2)	1000000 m^2		

5.2.2 Boundary lines differences

Area is the numerical expression of a two-dimensional closed surface defined by boundary lines. Therefore the measuring method of boundary lines influences the magnitude of the area. The measurement of boundary lines varies in terms of countries and types of walls. Many standards advocate measuring all walls to the limiting faces, some standard use the dominant portion of exterior surface [1] while some use the center line of walls to determine the boundary lines. The details are presented in Table 5.3.

Example. Here one example is used to illustrate how boundary lines influence the numerical value of area measurement. Figure 5.1 is a floor plan of a residential building. In

[1]The dominant portion is similar with the limiting face, which generally means the outside surface of exterior building walls, columns. The obvious difference between two kinds of boundary line is related to such building elements such as perimeter windows placed to the outside of the facade as Figure 5.1. When dominant portion is used to define boundary line, this kind of perimeter window is excluded from Gross Floor Area. On the the other side, when the limiting face is used to define boundary line, this kind of perimeter window is included into Gross Floor Area.

Table 5.3: Measuring of boundary lines according to different standards

	Exterior Walls	Structural Internal Walls	Non-Structural Walls
IPD Space Code	Limiting face	Limiting face	Central line
DIN 277	Dominant portion of exterior surface	Limiting face	Limiting face
ÖNORM 1800	Dominant portion of exterior surface	Limiting face	Limiting face
SIA416	Limiting face	Limiting face	Limiting face
RICS	Limiting face		Limiting face
EN15221-6	Limiting face	Central line	Central line
IFMA	Dominant portion of exterior surface	Limiting face	Central line
GB/T 50353	Dominant portion of exterior surface		
Singapore Handbook on GFA	Center line		

this example, external balconies and voids are excluded from Gross Floor Area (GFA) and the lift shaft is measured for each floor. All dimensions are listed in the plan.

By making use of the area calculation function of Auto CAD, three GFA are calculated which are 290.15 m^2, 281.73 m^2 and 259.75 m^2 respectively (Figure 5.4). There is only a tiny discrepancy between two kinds of GFA values measured by the limiting face and dominant portion (about 2.6%). Since most countries use these two kinds of boundary lines to determine GFA and their discrepancy is tiny, this category of difference could be ignored in the later modification. Nevertheless, if some countries like Singapore use the center line of walls to calculate GFA, it is suggested to make modifications because the difference has reached 7.8%.

Table 5.4: Influence degrees of boundary lines to GFA

	Limiting Face	Dominant Portion	Center Line of Party Walls
GFA	290.15	281.73	259.75
Deviation to the Average	4.7%	1.6%	-6.3%
Deviation to the Median	2.6%	0	-7.8%
Average	277.21		
Median	281.73		

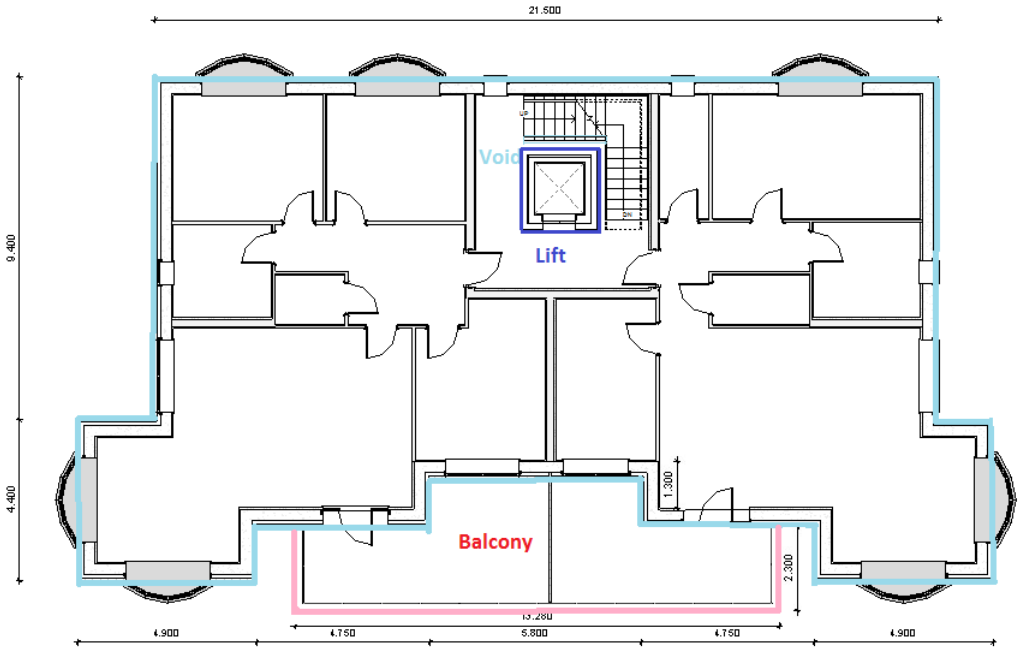

Figure 5.1: Floor plan of a residential building

5.3 Building components differences

A recent research conducted by *The European Council of Construction Economists* CEEC highlighted the fact that *most countries throughout the world use similar components to measure floor areas in buildings. The way these components are ordered and coded, however, differs vastly.*

5.3.1 Similar building area concepts

Different standards may use different names to define the same or similar building area definitions. Table 5.5 shows their corresponding relationships. In every row, the similar building area definitions are listed with their deviation.

Table 5.5: The corresponding relation of similar building area definitions

1	**GFA** (DIN277, ÖNORM 1800, EN 15221-6, Singapore's handbook on GFA)	**Total Floor Area** (IPD space code)	**Gross External Area** (RICS code)	**Floor Area** (SIA 416)	**Area of the Construction**(GB/T 50353)	**Exterior Gross Area** (ASTM E1836)
2	**Internal Floor Area** (EN 15221-6)	**Gross Internal Floor Area** (IPD space code)	**Interior Gross Floor Area** (ASTM E1836)			
3	**Net Floor Area** (DIN 277, ÖNORM 1800, SIA 416)	**Internal Floor Area** (IPD space code)	**Net Room Area** (EN 15221-6)	**Plannable Gross Area** (ASTM E1836)		
4	**Usable Floor Area- Hygiene Floor Area** (DIN 277, ÖNORM 1800)	**Usable Floor Area** (EN 15221-6, IPD space code)	**Net Internal Floor Area** (RICS code)	**Plannable Area** (ASTM E1836)		

5.3.2 Gross floor area matrix

There are many types of area measurement such as Gross Floor Area (GFA), Net Floor Area (NFA), Usable Floor Area (UFA), etc. In this study, the relationship between building components and GFA (Belong or Not Belong) are discussed firstly. GFA is used to represent all other similar building area definitions such as Total Floor Area, Gross External Area, etc.

By extensive research, 22 building components are abstracted and listed in the first column of the matrix (see Table 5.6). In the first row of the matrix, nine standards are chosen to make the comparison. When one kind of building component is included in GFA by one standard, "$\surd$" is marked, otherwise "$\times$". Besides those marks, the sources for determination are also listed in this matrix. This matrix allows the complete reconciliation among GFAs defined by various area measurement standards.

It is found out that the differences of GFA defined by different standards mainly exist in the following thirteen components:

1. voids,
2. mezzanine areas with permanent access,
3. stairwells, lift wells and the like,
4. external open-sided balconies,
5. internal balconies,
6. uncovered roof terraces,
7. loading platforms,
8. areas with a headroom of less than 1.5 m,
9. outbuildings which share at least one wall with the main building,
10. garages,
11. canopies,
12. fire stairs and
13. greenhouses, garden stores, fuel stores and the like vary from country to country.

Table 5.6: GFA matrix with basis of the estimation

Building elements	IPD space code	German DIN 277	Austria ÖNORM	Switzerland SIA416	UK RICS	EN 15221-6	ATSM E 1836	China GB/T 50353	Singapore
1. Perimeter walls (including enclosing curtain walls)	√/P.28	√/P.1(2.2)	√/P.6(4.4)	√/P.10(2.2)	√/P.8(1.1)	√/P.20(5.4)	√/P.4+3.2.4	√/3.0.1+3.0.2	√/3.1
2. External columns and piers	√/P.28	√/P.1(2.2)	√/P.6(4.4)	√/P.10(2.2)	√/P.8(1.3)	√/P.20(5.4)	√/P.4+3.2.17	√/Not in the excluding list of 3.0.24	√/5.22
3. Internal structural walls and partitions	√/P.28	√/P.1(2.2)	√/P.6(4.4)	√/P.10(2.2)	√/P.8(1.2)	√/P.20(5.4)	√/P.4+3.2.9	√/Not in the excluding list of 3.0.24	√/5.22
4. Internal unstructured columns and piers	√/P.28	√/P.1(2.2)	√/P.6(4.4)	√/P.10(2.2)	√/P.8(1.2)	√/P.20(5.4)	√/P.4+3.2.9	√/Not in the excluding list of 3.0.24	√/5.22
5. Atria and entrance halls	√[1]/P.20	√[1]/P.1(3.1.1-a)	√[1]/P.4(4.1.1-a)	√[1]/P50	√[1]/P.8(1.4)	√[1]/P.18 (5.3)	√/P.4+3.2.27	√[1]/3.0.7	√[1]/5.1
6. Voids	√/ P. 28	× /DIN 277-1 (2.1)	× /4.1.3-2	√/P.9 (Not in the excluding list)	×/P.8(1.19)	×/ P.18 (5.3)	√/P.4+3.2.27	√/3.0.15+3.0.23	x/3.1
7. Mezzanine areas with permanent access	√/P.20	N.M.[2]	N.M.[2]	N.M.[2]	√/ P.8(1.8)	N.M.[2]	√/P.4+3.2.12	√/3.0.3	√/5.08.2
8. Stairwells, Lift-wells and the like	√/ P. 28	√ DIN 277-1 (2.6)	√ /P.6(4.5.1)	√/P.50	√/P.8(1.3)	√ /P.20 (5.4)	√/P.4+3.2.13	√/3.0.15	√[3]/5.18+6.5+7.35
9. Equipment installation rooms inside building	√/ P. 28	√ DIN 277-1 (3.2.3)	√ /P.6(4.3.2)	√/P.50	√/P.8(1.9)	√/P.20 (5.4)	√/A1.4.1	√/3.0.13	√/5.11

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10. Basement	√/P.19	√ /DIN277-1(2 .1)	√P.14(Table B.2)	√/P.50	√/P. 8(1.13)	√/P.16(5.2)	√/A1.4.1	√/3.0.5	√/3.1
11. External open-sided balconies	×/ P. 25	√ /DIN277-2 (HNF1.1)	×/4.1.3-1	×/P.50	×/P.8(1. 16)	√/P.50(B.2)	x/A1.4.1	√ Half /3.0.18	√ with cover X without cover [10]/5.03
12. Internal balconies	N.M.	√/ DIN277-2 (HNF1.1)	√/P.5 (4.1.1 b or c + 4.1.3(2))	√/P.50	√/P. 8(1.5)	√/P.50(B.2)	√/P.4+3.2.6	√ Half /3.0.18	√/5.03
13. Uncovered roof terraces and the like	×/ P. 25	√/ DIN277-2(H NF1.1)	√ /P.5(4.1.3-3)+P.9 (5.5.1(Par.3))	×/P.50	×/P. 8(1.18)	√/P.50(B.2)	x/A1.4.1	×/3.0.24-4	x/5.03(Fig5-3)
14. Loading platforms	×/ P. 25	√/DIN277(A rea c based 3.1.1)	√/ P.5(4.1.1(c))	×/P.50	√/P. 8(1.11)	√ /P.50(B.2)	√[11]/A1.4.1	×/3.0.24-7	√/5.12+7.15
15. Areas with a headroom of less than 1.5 m	√/P.23+P.25	√ DIN 277-1(3.2.3)	√P.5 (Not in the excluding list 4.1.3 (2))	√/P.50	√/P. 8(1.12)	√/P13(5.1)	√/P.4+3.2.2 2	×[4]/3.0.1	x/7.16
16. Outbuildings sharing at least one wall	N.M.[2]	N.M.[2]	N.M.[2]	√/P.52	√/P. 8(1.10)	√/P.50(B.2 share ground and wall with the main building)	N.M.[2]	N.M.[2]	N.M.[2]
17. Garage	×/ P. 25	√/DIN277-2 (Table 2-7.4)	√ /P.4(4.1.2)	√/P.52	√/P. 8(1.14)	√ part of building X not part of building /P.53(B.3)	√/P.4+3.2.1 1	√/3.0.5	X[9]/7.7.1
18. Canopies	N.M.[2]	× /DIN 277-1(2.7)	×/P.5(4.1.3(1))	×/P.50	×/P. 8(1.17)	√ /P.50(B.2)	x/A1.4.1	√*[2] Half /3.0.16	X[6]/7.11
19. Outside Fire stairs	N.M.[2]	x /DIN 277-1(2.6)+ DIN 277-3 (Tabel1 524)	x/P.5 (4.1.3(1))	×/P.50	×/ P. 8(1.16)	√ /P.50(B.2 Share the ground floor with the main building)	x/A1.4.1	√ Half/3.0.17	√/7.32.3
20. Covered	N.M.*[7]	×/DIN 277-3	N.M.*[7]	×/P.50	×/P.	x /P.47 (6.2.c)	x/A1.4.1	N.M.*[7]	×/7.14.1

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ways		(Tabel1 521)			8(1.16)				
21. Open vehicle parking areas	×/ P. 25	× /DIN 277-3 (Tabel1 524)	×/P.4 (Not included in any type of floor area 4.1.1)	×/P.50	×/P. 8(1.18)	× /P.51(B.3)	x/A1.4.1	N.M.*[7]	x/7.7.2
22. Greenhouses, garden stores, fuel stores, and the like	×/ P. 25	× /DIN 277-3 (Tabel1 539)	N.M.*	√	×/P. 8(1.20)	x/ P.16(5.2 Separate building should be measured separately)	N.M.*	x /3.0.24-4	√/5.09+5.14

1. Atrium and entrance halls are measured but only at base level.

2. N.M. = Not mentioned directly

3. Usually, stairwells are included but there are some exceptional cases which are listed in 7.35, and the lift shaft is only measured once at 1st level.

4. In China, the standard is 1.2 m, which means areas with headroom of less than 1.2 m are not calculated in the GFA. Regarding areas with headroom of 1.2 - 2.1 m, only half of the areas are calculated.

5. When the distance between the outside line of the canopy and the structural line of the outside wall is larger than 2.1 m, half of the horizontal projected areas are calculated into GFA. When the distance is smaller than 2.1 m, the areas are not calculated.

6. Only one main entrance is exempted. When there is more than one, the second and subsequent entrances have to be included.

7. N.M.*=Not mentioned directly but not supposed to be included.

8. Singapore has two definitions of voids

1) 3.1 “The GFA is the total area of the covered floor space measured between the centre line of party walls, including the thickness of external walls but excluding voids”.

2) 5.08.5 “Enclosed dead space at any level (commonly annotated as void space)/ Covered enclosed space (regardless of accessibility use or height) constitutes GFA”.

According to this definition, we assume that the voids and cavities mentioned in the above table have similarities with the first one. Therefore, we mark the voids of Singapore space measurement as an exemption of GFA.

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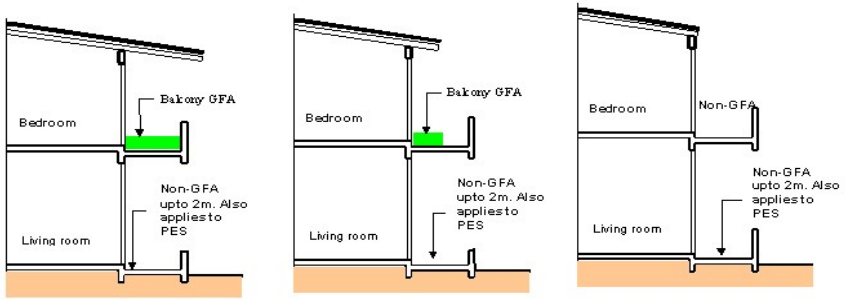
9. The exemption strictly applies to parking spaces and does not apply to terraces/patios and other areas adjoining the car porches/garages which are not used for car parking.

10. Singapore GFA treatment of balconies.



11. Only enclosed loading docks are included.

5.3.3 Building components causing differences in different standards

In this chapter, building components which cause differences in different standards are described. For each component, the relationship with GFA in different standards will be presented in a table, where "Including" means the component is included in GFA; "Excluding" implies it is excluded from the calculation of GFA; when some standards do not simply include or exclude the component but provide special calculating regulations, they are marked as "Special Calculation"; and "N.M." means not mentioned explicitly.

Voids. Voids inside of a building, e.g., stairwells (see Figure 5.2[2]) can be seen often.

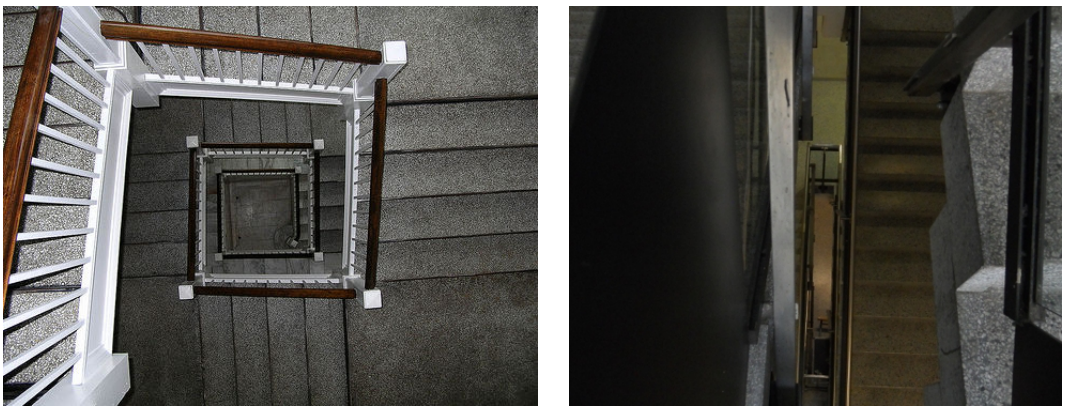


Figure 5.2: Voids around the stairwell

Table 5.7: Voids and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	4/9	5/9	–	–

Three of nine area measurement standards include voids in GFA, while five of nine standards exempt voids from GFA (see Table 5.7).

Mezzanine areas with permanent access. In architecture, a mezzanine is an intermediate floor between main floors of a building and typically not counted among the overall floors of a building. A mezzanine floor and the floor below share the same ceiling. It is usually used for storage and quite widely used in industrial buildings (see Figure 5.3[3]).

[2]The source of the image: `http://fitchicksandfastwomen.files.wordpress.com/2012/04/stairwell.jpg`.

[3]The previous image is from `http://www.americansurplus.com/_resources/common/user/image/Used\%20Mezzanine(3).jpg` and the latter image is from `http://www.hurst-house.co.uk/`

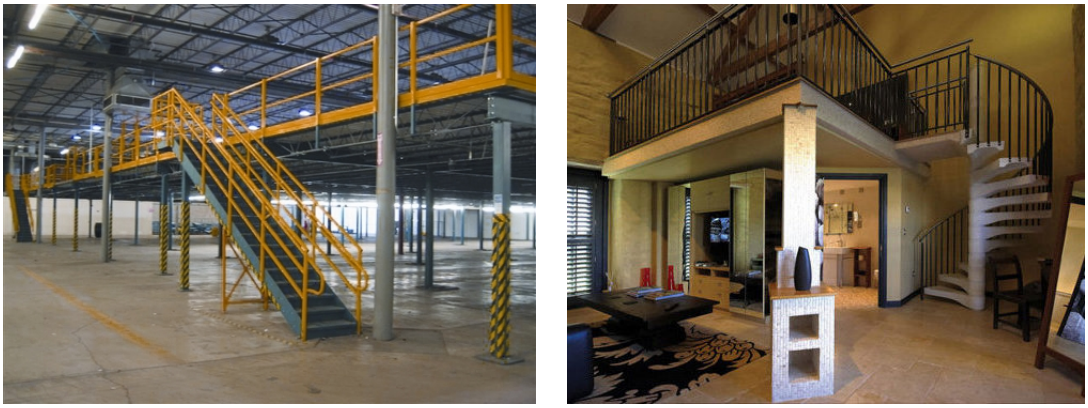


Figure 5.3: Mezzanines in industrial and residential buildings

Table 5.8: Mezzanines and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	5/9	–	–	4/9

Four of nine standards do not mention directly if mezzanines are accounted for in GFA but five other standards stipulate that this type of area is counted into GFA (see Table 5.8).

Stairwells, lift wells and the like. Stairwell, staircase, stairway, flight of stairs or simply stairs are names for a construction designed to bridge a large vertical distance by dividing it into smaller vertical distances (see Figure 5.4[4]). A lift well is a specially dug hole into which the lift is "housed".

Table 5.9: Stairwells/lift wells and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	8/9	–	1/9	–

Regarding stairwells and lift wells, most investigated standards are identical except Handbook on GFA from Singapore (see Table 5.9) where lift shafts are only measured once at the 1^{st} level. For stairwells there are also some exemptions which are described in the clause 7.35 of the standard.

images/mezzanine_2.jpg.

[4]The previous image is from http://homenist.com/exterior-stairs/ and the latter image is from http://megawattmedia.com.au/blog/wp-content/uploads/2010/03/shafted.jpg.

Figure 5.4: Stairwell and lift well

External open-sided balconies & internal balconies. The difference between external open-sided balconies and internal balconies is their relationship with the perimeter walls. The external open-sided balcony is a platform projecting from the wall of a building, supported by columns or console brackets, and enclosed with a balustrade. The internal balcony is inside the perimeter walls and it is usually covered (see Figure 5.5[5]).

Figure 5.5: External open-sided balcony and internal balcony

Five of nine standards state that external open-sided balconies are excluded from GFA while in other two standards this type of area is included in GFA. In China and Singapore, there are special stipulations for the area measurement of open-sided balconies (see Table 5.10). Seven of nine standards set that internal balconies are counted into GFA. One standard does not mention them directly. In China, only half of the internal balcony areas are counted into GFA (see Table 5.11).

[5]The previous image is from `http://www.glassonmetalworks.co.uk/images/balconies/balcony_panels3_large.jpg` and the latter is from `http://img5.house365.com/bbsuserpic/2010/05/28/12750400654bff914148b5f.jpg`.

Table 5.10: External open-sided balconies and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	2/9	5/9	2/9	–

Table 5.11: Internal balconies and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	7/9	–	1/9	1/9

Uncovered roof terraces. A terrace is an usable, outdoor extension of a building above the ground level. A terrace will generally be larger than a balcony and will have an "open-top" facing the sky. It can be used for a variety of activities including but not limited to: gardening, relaxation, entertaining guests, sunbathing and barbecuing. The terraces that are built on the roof are called roof terraces (see Figure 5.6).

Figure 5.6: Uncovered roof terraces

Only three of nine standards state that uncovered roof terraces are counted into GFA while the other six standards exclude them from GFA (see Table 5.12).

Table 5.12: Uncovered roof terraces and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	3/9	6/9	–	–

Loading platforms. A loading platform is an infrastructure in a building where trucks are loaded and unloaded, typically providing direct access to staging areas, storage rooms, and freight elevators. They are usually found in commercial and industrial buildings as well as warehouses (see Figure 5.7[6]).

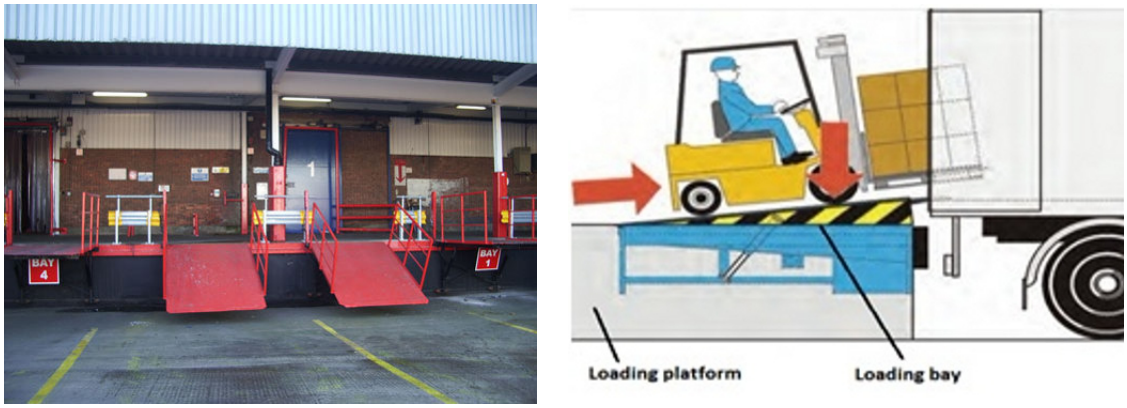


Figure 5.7: Loading platform

The RICS code does not point out the differences between a loading platform and a loading bay and includes the loading bay into the GFA. In the Singapore's standard, only the loading platform is contained and the loading bay is excluded. According to the RICS example, the loading bay mentioned in the RICS code has the same meaning with the loading platform defined by Singapore's standard. Thus, in this work, the name "loading platform" is used to represent this building component.

Six of nine standards stipulate that loading platforms are included in GFA while the other three standards set that GFA exclude this type of area (see Table 5.13).

[6]The previous image is from http://www.tradebarriers.co.uk/images/armco9.jpg and the latter is from http://www.crawfordsolutions.com/productdocumentation/COM/PD_DLVL_624_EN_ORG.pdf.

Table 5.13: Loading platforms and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	6/9	3/9	–	–

Areas with a headroom of less than 1.5 m. Areas with headroom of less than 1.5 m, like attic floors with peaked roofs can be seen frequently (see Figure 5.8[7]).

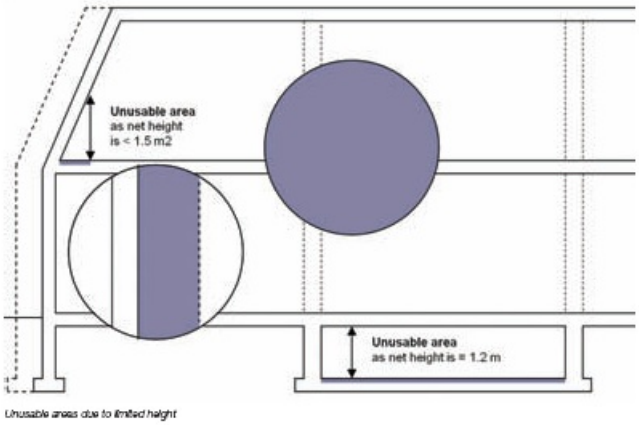


Figure 5.8: Areas with headroom of less than 1.5 m (picture source: [24])

Many standards differentiate this type of areas from other areas with normal headroom but still include them into GFA. Seven of the nine standards set that GFA includes these areas and one of them states that GFA excludes these areas. In China, this type of area is subdivided into two parts. One is the area with headroom of less than 1.2 m which is not counted into the GFA. The other one is the area with headroom of 1.2-2.1 m, half of which is included in GFA (see Table 5.14).

Table 5.14: Areas with a headroom of less than 1.5 m and GFA

	Including	Excluding	Special Calculating	N.M
Percent	7/9	1/9	1/9	–

[7]The source of the image is IPD area measurement code.

Outbuildings which share at least one wall with the main building. An outbuilding is a building subordinate to a main building, and usually for residential use (see Figure 5.9[8]).

Figure 5.9: Outbuildings which share at least one wall with the main building

Regarding to outbuildings sharing at least one wall with the main building, most of the standards (6 out of 9) have not indicated whether they are counted into GFA while the other three standards stipulate that this type of area is included in GFA (see Table 5.15).

Table 5.15: Outbuildings sharing at least one wall with the main building and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	3/9	–	–	6/9

Garages. A garage is designed or used for storing one or more vehicles. It may be a part of house, an associated building or the underground floor of the main building (see Figure 5.10[9]).

Six of nine standards state that garages are counted into GFA but two standards state the opposite. According to EN 15221-6, garages that are part of the main building like the underground floor of the main building are included into GFA. Otherwise they are exempted from GFA (see Table 5.16).

[8]The previous image is from http://p.rdcpix.com/v02/l1f038c43-m0m.jpg and the latter is from http://www.wetherbynews.co.uk/webimage/1.4249686.1329309274!image/490449947.jpg_gen/derivatives/landscape_595/490449947.jpg.

[9]The previous image is from http://2.bp.blogspot.com/-qSsoaGUHwNI/TzxwUYVa2eI/AAAAAAAADuM/I_hP5YTmImc/s1600/the-garage-1.jpg and the latter is from http://upload.wikimedia.org/wikipedia/commons/thumb/c/c2/Ravensburg_Tiefgarage_Marienplatz.jpg/220px-Ravensburg_Tiefgarage_Marienplatz.jpg.

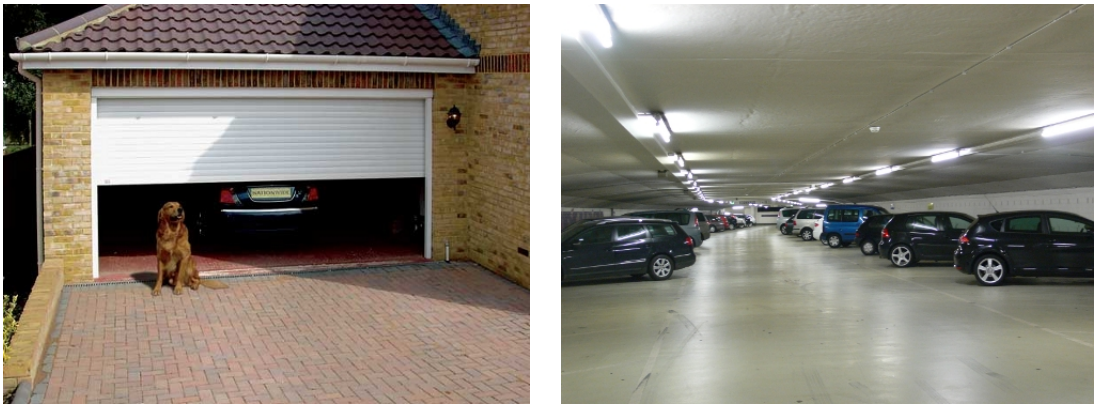


Figure 5.10: An associated building such as garage and underground garage

Table 5.16: Garages and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	6/9	2/9	1/9	–

Canopies. A canopy is an overhead roof or a structure over which a fabric or metal covering is attached. It can be parts of the main building as well as separated from the main building (see Figure 5.11[10]).

Figure 5.11: Canopies

Regarding canopies, standards differ from each other. One standard states that canopies are included in GFA while five standards state the opposite. One standard does not mention

[10]The previous image is from http://www.clovis-canopies.com/images/bespoke_glass_entrance_canopy-leicester-odi_02.jpg and the latter is from http://jogjahunian.com/wp-content/uploads/2011/11/canopy-1.jpg.

it directly. In China and Singapore, there are specific stipulations as to how to calculate this type of area (see Table 5.17).

Table 5.17: Canopies and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	1/9	5/9	2/9	1/9

Outside fire stairs. A fire escape is a special kind of emergency exit. It is usually mounted to the outside of a building or occasionally inside but separate from the main areas of the building. It provides a method of escape in the event of a fire or other emergency that makes the stairwells inside a building inaccessible (see Figure 5.12[11]).

Figure 5.12: Outside fire stairs

Four of nine standards have stipulation that fire stairs outside are included in GFA while four standards state that this type of area is exempted. Besides, one standard does not mention it directly (see Table 5.18).

Table 5.18: Relationship of outside fire stairs with GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	4/9	4/9	–	1/9

[11]The previous image is from `http://www.featurepics.com/FI/Thumb300/20060822/SpiralStairs66534.jpg`.

Greenhouses, garden stores, fuel stores, and the like. A greenhouse is a building in which plants are grown. It is a structure with different types of covering materials such as a glass or plastic roof and frequently glass or plastic walls. A garden store is a building installed in the garden and used for storing tools. A fuel store is a building installed in the garden for storing fuel (see Figure 5.13[12]).

Figure 5.13: Greenhouse, garden store and fuel store

Most standards (5 out of 9) set that this type of area is excluded from GFA and two standards state that GFA includes this type of area. The remaining two standards do not mention it directly (see Table 5.19).

Table 5.19: Greenhouses, garden stores & fuel stores and GFA

	Including	Excluding	Special Calculation	N.M.
Percentage	2/9	5/9	–	2/9

5.3.4 Examples

In the following, four examples illustrate that for the same building, numerical values of GFA can be different because different measuring standards have been used. Since different facility types have their preferable building components, four different facility types including industrial building/warehouse, residential building, office building and research/education building are selected.

1. **Industrial buildings/ warehouses**

   Items involved: loading platform, mezzanine and canopy (see Table 5.20).

[12]The previous image is from http://4.bp.blogspot.com/-wvpPGDheVkU/T3VKeGW9EVI/AAAAAAAAA2A/y4Fqd0CRaP8/s1600/greenhouse+mini+hobby.jpg , the middle image is from http://images.gardenchic.co.uk/images/products/medium/1329837037-66798100.jpg and

Table 5.20: Matrix of loading platform, mezzanine and canopy

	IPD	DIN	ÖNORM	SIA	RICS	EN	ASTM	GB	SG
Loading platform	×	√	√	×	√	√	√	×	√
Mezzanine	√	N.M.[1]	N.M.[1]	N.M.[1]	√	N.M.[1]	√	√	√
Canopy	N.M.[1]	×	×	×	×	√	×	√[2]	√[3]

[1] N.M.= Not mentioned directly.
[2] In China, when the distance between the outside line of the canopy and the structural line of the outside wall is larger than 2.1 m, half of the horizontal projected areas calculated into GFA. When the distance is smaller than 2.1 m, the areas are not calculated.
[3] In Singapore, only one main entrance is exempted, when there are more, the second and subsequent entrances have to be included.

Measures at Figure 5.14: X=15 m, Y=11 m, Z=2.5 m, a=3.7 m and b=0.8 m, m=4 m, f=10 m. Thus, Loading platform area (L)= 27.5 m^2; Canopy area (C)=2.96 m^2; Main building area (M)= 165 m^2; Mezzanine area (MZ)= 40 m^2.

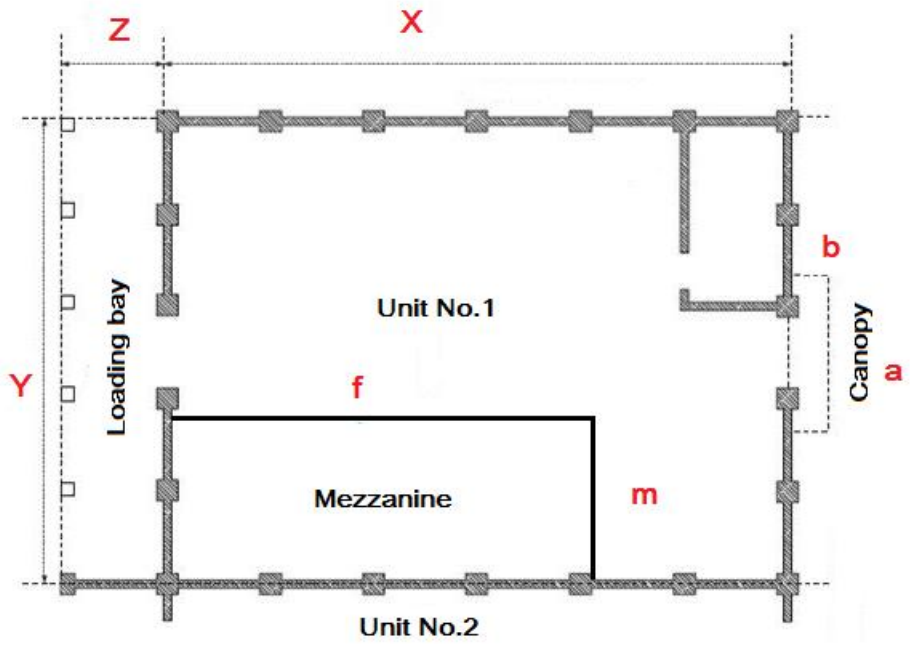


Figure 5.14: Example of an industrial building [31]

Because many codes do not mention, whether mezzanines are counted into GFA and

the latter is from http://www.stovesareus.co.uk/catalog/images/ref6313_garden_trading_log_store.jpg.

this area is relatively big (40 m^2/ 20.78%), it is more practical that mezzanines are measured separately. In Table 5.21, GFA is measured without mezzanines.

In the IPD space code, it is not stated clearly whether canopies are counted into GFA. Thus, based on IPD space code, GFA is an interval (165-167.96) instead of an exact number. In the Chinese code *GB/T50353*, there is a special stipulation as to how to calculate canopies: *When the distance between the outside line of the canopy and the outside structural line of the outside wall is larger than 2.1 m, half of the horizontal projected areas are calculated into GFA. When the distance is smaller than 2.1 m, those areas are not calculated.* In this example, the distance is only 0.8 m, so that the canopy is not accounted. According to the Singapore's standard, only when there is more than one canopy, the second and the subsequent canopies are included in GFA. In this example, there is only one canopy, so it will be exempted.

Although there are two different values of GFA according to the IPD space code, the medians in the two situations are the same: 192.5. It is also the mode[1].

In Table 5.21, it is shown whether canopies are counted into GFA or not and it slightly affects the final result (1.54%). However, loading platforms have a great influence (14.29%) on GFA. Therefore in later modification, the different stipulations about canopies will be ignored.

[1]The mode is the value that appears most often in a set of data.

Table 5.21: Numerical value difference of GFA caused by loading platforms, mezzanines and canopies

	IPD	**DIN**	**ÖNORM**	**SIA**	**RICS**	**EN**	**ASTM**	**GB**	**SG**
Formula	**M+(C)**	**M+L**	**M+L**	**M**	**M+L**	**M+L+C**	**M+L**	**M**	**M+L**
GFA	165-168.0	192.5	192.5	165	192.5	195.5	192.5	165	192.5
Average Deviation	-10.3%/ -8.6%	4.7%	4.7%	-10.3%	4.7%	6.0%	4.7%	-10.3%	4.7%
Median Deviation	-14.3%/ -12.8%	0	0	-14.3%	0	1.5%	0	-14.3%	0
Average	(183.7+184)/2=183.9								
Median	192.5								
Mode	192.5								
Loading Platform I.P.[1]	27.5/192.5= 14.3%								
Mezzanine I.P.[1]	40/192.5= 20.8%								
Canopy I.P.[1]	2.96/192.5= 1.5%								

[1] I.P.= Influence degree.

2. **Residential buildings**

Items involved: external open-sided balcony, lift-well, void (see Table 5.22).

Table 5.22: Matrix of external open-sided balconies, stairwells & lift wells and voids

	IPD	DIN	ÖNORM	SIA	RICS	EN	ASTM	GB	SG
External balconies	×	√	×	×	×	√	×	√ Half	S.C[1]
Stairwells, Lift-wells	√	√	√	√	√	√	√	√	√[2]
Voids	√	×	×	√	×	×	√	√	×

[1] S.C = Special calculation. Included in GFA when it has a cover, otherwise it is excluded.
[2] Normally, stairwell is included but there are some exemption cases which are listed in 7.35, and the lift shaft is only measured once at the 1^{st} level.

Building descriptions: It is a four-story residential building which has three upper floors and a basement. The lift is built for all four floors. The first floor and the second floor have balconies. In this example, we only compare the area of the first floor. Its floor plan is presented in Figure 5.15. The main building area (M) inside of the blue line is 274.32 m^2, the balcony (B) is 38.08 m^2, the lift-well (L) is 4.75 m^2 and void (V) is 0.35 m^2.

Most area standards state that lift shafts are measured at each level. However, according to the Singapore's code, lift shafts are measured only at the ground floor. It means that, for the same building, the lift area measured according to Singapore' code is only 1/n of the lift area measured based on other measurement codes, where n represents the number of floor that the lift passes through. In this case, n is 4. Because only GFA of the first floor is measured, 3/4 of the lift area on this floor should be exempted by following the Singapore's standard.

In Singapore, only the balconies with cover are included in GFA. In this example, the balcony of the first floor is counted in GFA.

For this residential building, GFA is measured according to different area measurement standards (Table 5.23). It can be identified whether voids are counted in GFA affects the final result of GFA only very slightly (0.12%) but external open-sided balconies have a great influence (13.50%). In later modifications, the diverse stipulations about voids among different standards therefore can be ignored.

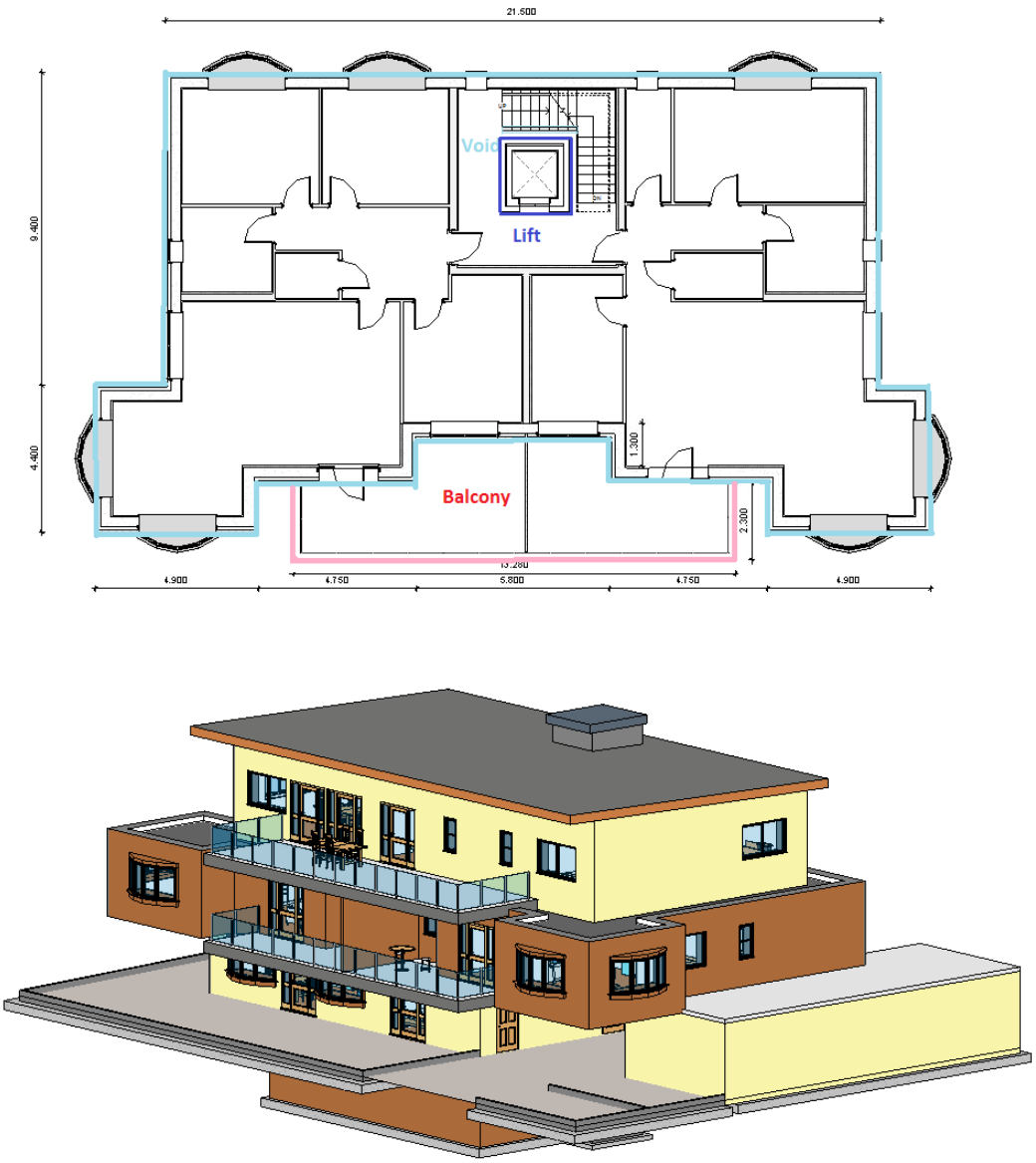


Figure 5.15: Floor plan and 3-D view of a residential building

Table 5.23: Numerical value difference of GFA caused by external open-sided balconies, stairwells & lift wells and voids

	IPD	**DIN**	**ÖNORM**	**SIA**	**RICS**	**EN**	**ASTM**	**GB**	**SG**
Formula	**M**	**M+B-V**	**M-V**	**M**	**M-V**	**M+B-V**	**M**	**M+$\frac{1}{2}$B**	**M-$\frac{3}{4}$L-V+B**
GFA	274.32	312.05	273.97	274.32	273.97	312.05	274.32	293.36	308.49
Average Deviation	-4.2%	9.0%	-4.3%	-4.2%	-4.3%	9.0%	-4.2%	2.4%	1.2%
Median Deviation	0	13.8%	-0.1%	0	-0.1%	13.8%	0	6.9%	12.5%
Average	288.5								
Median	274.3								
Mode	274.3								
External balcony I.P.[1]	38.08/274.3= 13.9%								
Lift-well I.P.[1]	4.75/274.3= 1.7%								
Void I.P.[1]	0.35/274.3= 0.1%								

[1] I.P.= Influence degree.

3. **Office Buildings**

Items involved: internal balconies, voids (see Table 5.24).

Table 5.24: Matrix of internal balcony and void

	IPD	DIN	ÖNORM	SIA	RICS	EN	ASTM	GB	SG
Internal balconies	N.M.	√	√	√	√	√	√	√ Half	√
Voids	√	×	×	√	×	×	√	√	×

[1] N.M.= Not mentioned directly.

Building descriptions: It is a three-story office building with two upper floors and a basement. In this case, only the area of the first floor with the internal balcony is measured (Figure 5.16), whose width X=12 m and length Y=20 m. The atrium on the stairwell (SA) of the ground floor is 1.1 m^2; the atrium of the entrance (EA) is 6.72 m^2; and the atrium of the courtyard (CA) is 22.62 m^2. So, the main building area (M) = 240 m^2; and total atrium area (A) = SA+EA+CA= 30.4 m^2. Besides, internal balcony (IB) is 1.75 m^2 and void (V) is 0.42 m^2.

In the IPD space code, it is not stated clearly whether internal balconies are counted into GFA. Thus, GFA is an interval (209.56-211.31) instead of an exact number based on the IPD space code.

In this example, the disparity among GFA measured by the following different area standards is not very significant (Table 5.25). It also reflects that internal balconies and voids only slightly influence the final result of GFA. Thus, in the modifications, the different stipulations about internal balconies and voids can be ignored.

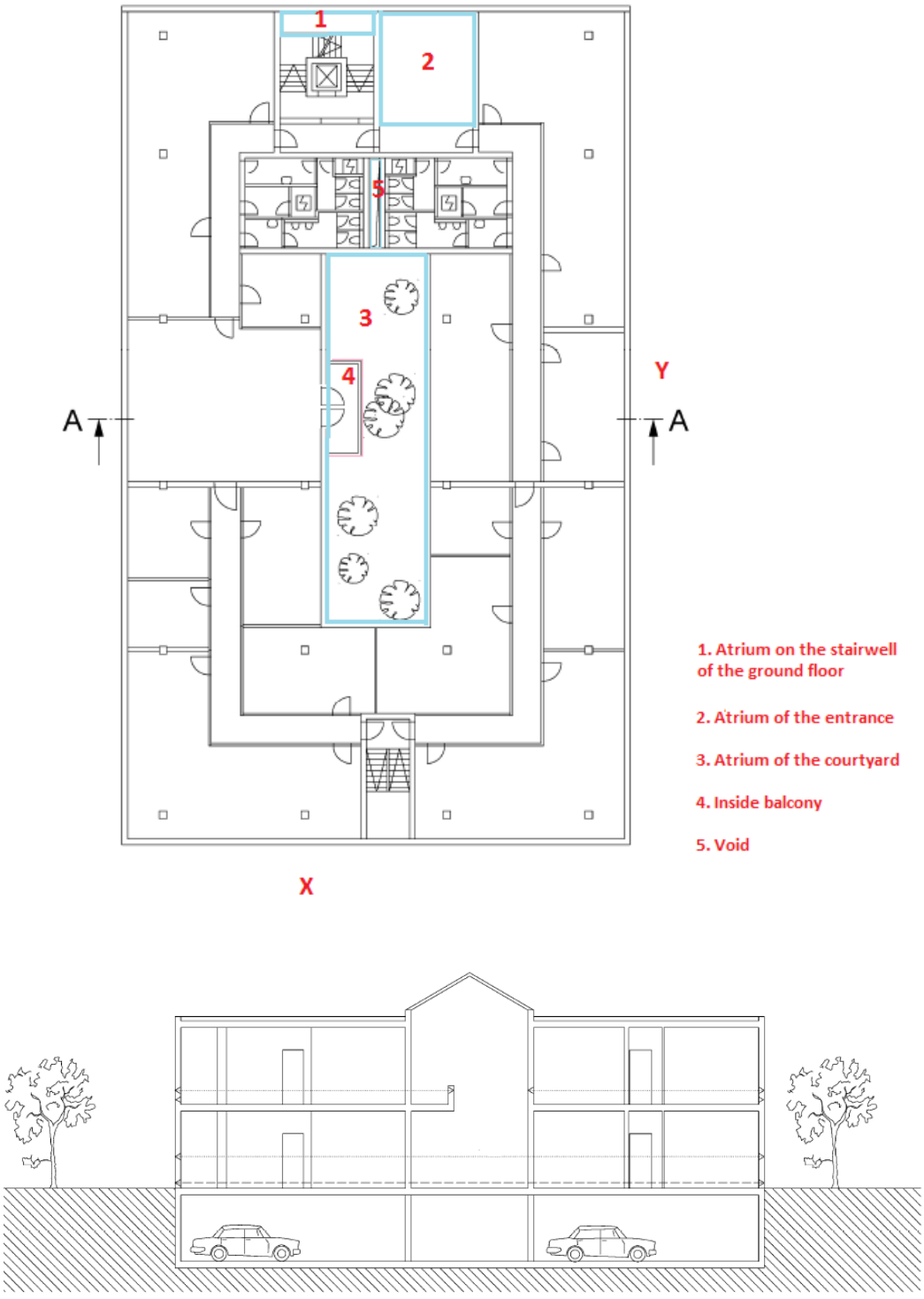


Figure 5.16: Floor plan and elevation of an office building [22]

Table 5.25: Numerical value difference of GFA caused by internal balconies and voids

	IPD	**DIN**	**ÖNORM**	**SIA**	**RICS**	**EN**	**ASTM**	**GB**	**SG**
Formula	**M-A(+IB)**	**M-A+IB-V**	**M-A+IB-V**	**M-A+IB**	**M-A+IB-V**	**M-A+IB-V**	**A-B+IB**	**M+$\frac{1}{2}$IB-A**	**M-A+IB-V**
GFA	211.31/ 209.56	210.89	210.89	211.31	210.89	210.89	211.31	210.43	210.89
Average Deviation	0.2%/-0.6%	0%	0%	0.2%	0%	-14.6%	0.2%	-0.2%	0%
Median Deviation	0.2%/-0.6%	0%	0%	0.2%	0%	-14.6%	0.2%	-0.2%	0%
Average	(211.0+210.8)/2 = 210.9								
Median	210.9								
Mode	210.9								
Internal balcony I.P.[1]	1.75/210.9= 0.8%								
Void I.P.[1]	0.42/210.9= 0.2%								

[1] I.P.= Influence degree.

4. **Research buildings**

Item involved: outside fire stairs, roof terraces, external-balconies, voids (see Table 5.26)

Table 5.26: Matrix of outside fire stairs, uncovered roof terraces, etc.

	IPD	DIN	ÖNORM	SIA	RICS	EN	ASTM	GB	SG
Outside fire stairs	N.M.[1]	×	√	×	×	√	×	√	√
Uncovered roof terraces	×	√	√	×	×	√	×	×	×
External balconies	×	√	×	×	×	√	×	√ Half	S.C.[2]
Void	√	×	×	√	×	×	√	√	×

[1] N.M. = Not mentioned directly.
[2] S.C. = Special calculation. Included in GFA when it has a cover, otherwise it is excluded.

Building descriptions: External balcony (B) is 119.47 m^2; terrace (T) is 127.08 m^2; fire stairs (S) is 34.23 m^2; void (V) is 3.6 m^2 and the main building (M) is 1178.79 m^2 (see Figure 5.17).

In the IPD space code, it is not stated clearly whether fire stairs outside are counted into GFA. Thus, based on IPD space code, GFA is an interval (1178.8-1213.0) instead of an exact number.

From Table 5.27, it can be identified whether outside fire stairs (2.7%) and voids (0.3%) are included in GFA affects the final result of GFA only slightly but the external open-sided balconies (9.4%) and roof terraces (10.0%) have a great influence on the final value of GFA. It is assumed that the different stipulations about outside fire stairs and voids among different standards can be ignored in the later modifications.

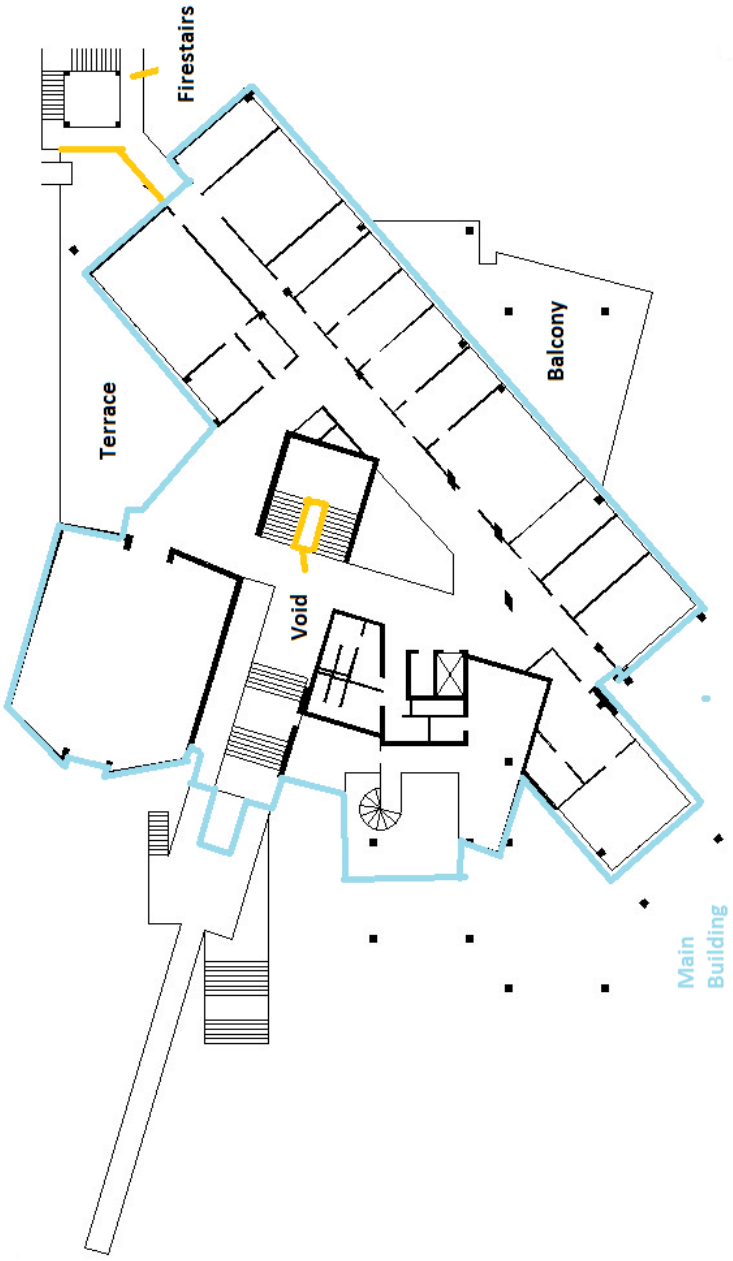


Figure 5.17: Floor plan of a research facility

Table 5.27: Numerical value difference of GFA caused by fire stairs outside, uncovered roof terraces, external open-sided balconies and voids

	IPD	**DIN**	**ÖNORM**	**SIA**	**RICS**	**EN**	**ASTM**	**GB**	**SG**
Formula	**M+(S)**	**M+B+T**	**M+T+S**	**M**	**M-V**	**M+T+B+S**	**M**	**M+S+$\frac{1}{2}$B**	**M+S+B**
GFA	1213.0/ 1178.8	1421.7	1340.1	1178.8	1175.4	1456.0	1178.8	1276.8	1332.5
Average Deviation	-5.5% / -8.2%	10.8%	4.4%	-8.2%	-8.4%	13.4%	-8.2%	-0.5%	3.8%
Median Deviation	-5.0%/ -7.7%	11.3%	5.0%	-7.7%	-7.9%	14.0%	-7.7%	0	4.4%
Average	(1285.3+1282.1)/2 = 1283.7								
Median	1276.8								
Mode	1178.8								
Outside fire stair I.P.[1]	34.23/1276.8= 2.7%								
Roof terrace I.P.[1]	127.08/1276.8= 10.0%								
External balcony I.P.[1]	119.47/1276.8= 9.4%								
Void I.P.[1]	3.6/1276.8= 0.3%								

[1] I.P.= Influence degree.

5.3.5 Influence analysis of building components

In Table 5.28, the influences of each building component are listed in four examples. It is quite clear which discrepancies can be ignored and which building components should be measured separately to facilitate the modification of GFA values in the international FM benchmarking program.

Table 5.28: Influence degree analysis of building components

Building component	Example 1	Example 2	Example 3	Example 4	Average
Voids, cavities		0.1%	0.2%	0.3%	0.2%
Mezzanines	20.8%				20.8%
Stairwells, lift-wells		1.7%			1.7%
External balconies		13.7%		9.4%	11.6%
Internal balconies			0.8%		0.8%
Roof terraces				10.0%	10.0%
Loading platforms	14.3%				14.3%
Areas with a headroom of less than 1.5 m					–
Outbuildings sharing walls					–
Garages					–
Canopies	1.5%				1.5%
Outside fire stairs				2.7%	2.7%
Greenhouses, garden stores, fuel stores					–

Based on the above influence analysis, some remarks are given:

- Due to the slight influences to final results of GFA, diversity of stipulations about 1) voids, 2) stairwells and lift wells, 3) internal balconies, 4) canopies, 5) outside fire stairs among different standards can be ignored;
- No matter what kind of building, no matter if counted into GFA or not, components 1) mezzanine with permanent access, 2) external-open sided balconies, 3) uncovered roof terrace, 4) loading platforms should be measured separately;

- The components 1) areas with headroom of less than 1.5 m, 2) outbuildings sharing at least one wall with the main building and 3) garages are not referred to in the proposed examples. However, considering the magnitude of area size and prevalent rules of existing standards, these three building components are suggested to be measured separately;
- The components greenhouses, garden stores, fuel stores are not referred to in the four examples. Usually, the areas of those components are relatively small, so that they are suggested to be ignored in this study.

5.4 Other floor area measurement parameters

For an international FM benchmarking program, one of the most important things is to find a uniform area measurement rule as basis for the comparison of FM costs. According to the analysis above, many differences exist in the stipulations about GFA across countries. Due to this fact, there is the question: whether there are fewer differences between *Net floor area* (NFA), *Usable floor area* (UFA) (these two definitions are accordant with the definition from EN 15221-6) and Rentable Floor Area (RFA). In this section, this question will be answered.

5.4.1 Net floor area

Net floor area (NFA) (similar terms: *internal floor area*, *net room area* and *plannable gross area*) is a part of GFA, which subtracts the external structure and internal structure from the latter (see Figure 5.18). Table 5.29 shows the corresponding relationships between building components and functions.

Compared with GFA, NFA excludes three types of building components from GFA, which are perimeter walls, external columns and piers with internal structural walls and partitions. However, all rules about these three types of building components in different standards are consistent (see Table 5.6). In other words, if NFA is chosen as the basis to compare FM costs for an international FM benchmarking program, the inaccuracy will not decrease but even increase since the identical part of the standards decreases.

5.4.2 Usable floor area

If *usable floor area* (UFA) is used as the basis to compare FM costs for an international FM benchmarking program, there will be more differences.

Table 5.29: Corresponding relation between different building elements and functions

Building component	**Function**	**Building component**	**Function**
Perimeter walls	External structure	External balconies	Usable area
External columns and piers	External structure	Internal balconies	Usable area
Internal structural walls and partitions	Internal structure	Uncovered roof terraces	Usable area
Internal unstructured columns and piers	Separating wall	Loading platforms	Usable area
Atria and entrance halls	Usable area	Areas with a headroom of less than 1.5 m	(Un-)usable areas
Voids	Unusable area	Outbuildings sharing walls	Usable area
Mezzanine areas	Usable area	Garage inside of building	Usable area
Stairwells, liftwells	Vertical circulation	Canopies	Usable area
Equipment rooms inside of building	Plant area	Outside fire stairs	Vertical circulation
Basement	Usable area	Greenhouses, garden stores, fuel stores	Usable area

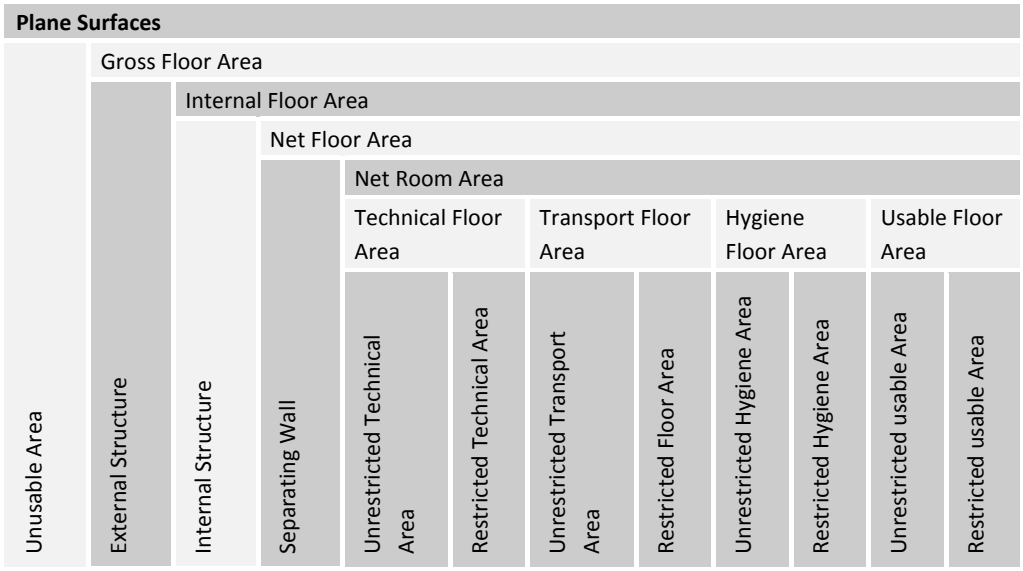


Figure 5.18: Function division of area according to EN 15221-6 [22]

First of all, different countries have different definitions of usable floor area. According to DIN 277, ÖNORM 1800 and SIA 416, UFA includes hygiene area while IPD code and EN 15221-6 state that hygiene area is excluded from UFA. In China, UFA includes technical and transport floor area.

Second, even if the definition in the EN 15221-6 is used, the differences existing in GFA still exist here. Take internal balconies, uncovered roof terraces and loading platforms as an example. If they are counted in GFA, they are surely counted in UFA (Table 5.29). Thus, if UFA is chosen as the basis to compare FM cost in the international FM benchmarking program, the differences of area measurement across countries cannot be minimized compared with GFA.

5.4.3 Rentable floor area

The differences in the definitions of *rentable floor area* (RFA) among countries are significant. The UK and Ireland link their RFA directly with UFA while Denmark links its rent with GFA (see Figure 5.19). As a result, it is not sensible to use RFA as the basis to compare FM costs for an international FM benchmarking program.

Based on the analysis above,

1. There are minimal differences across countries about the regulations of GFA, compared with NFA, UFA and RFA.

Countries	External Structure	Internal Structure	Vertical Circulation	Plant Area	Hygiene Area	Usable Floor Area
Austria	x	x	x	x	√	√
Belgium	√	x	√	√	√	√
Denmark	√	√	√	√	√	√
Finland	x	x	x	x	√	√
France	x	x	x	x	√	√
Germany	x	x	x	x	√	√
Greece	√	√	x	√	√	√
Ireland	x	x	x	x	x	√
Italy	√	√	x	x	√	√
Luxembourg	x	x	x	√	√	√
Netherlands	x	x	x	√	√	√
Portugal	x	√	x	x	√	√
Spain	√	√	x	x	√	√
Sweden	x	x	x	x	√	√
UK	x	x	x	x	x	√
Russia	√	√	x	x	√	√
South Africa	x	√	x	x	√	√
US	√	√	x	x	√	√

Figure 5.19: Rent-able floor area constituents of different countries [24]

2. GFA is the most widely used space measurement in the world.

In some national FM benchmarking programs, it was suggested that it is better to use NFA or UFA or RFA as measurement basis. However, in an international FM benchmarking program, GFA is still the most suitable one.

5.5 Modification solution

Although there are the least differences between standards in terms of GFA compared with other area measurement types, some discrepancies can not be ignored. The modification of GFA is required during the operation of an international FM benchmarking program.

5.5.1 Work flow

The work flow of the modification is divided into three steps (Figure 5.20). Firstly, a standard code **S** is selected among the standards involved in the comparison. The criterion of the selection is that the differences between this code and all other codes are the least, so that the modification can be reduced to the minimum level. Secondly, non-negligible differences between this standard code **S** with other standards are mapped. Due to this manipulation, it will be clear what kind of additional information is needed. Thirdly, improvement for those original national questions are made to obtain the additional area information. With these three manipulations, an international area comparison platform can be established.

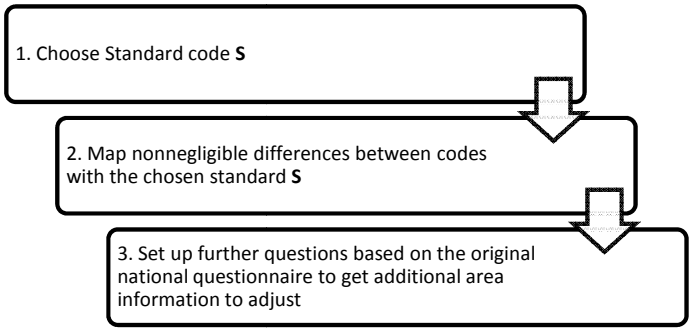


Figure 5.20: Work flow of the GFA modification

5.5.2 Standard code

To select the standard code, a probability code is generated. Its provisions about building components are determined by the probability of provisions of all standards involved in

the comparison. For example, five of nine codes set that voids are not counted into GFA. In this case, the probability code also stipulates that voids and cavities are exempted from GFA . Other components are determined similarly.

Table 5.30 shows details of them, which only includes the building components whose stipulations vary between one and another code. Because many codes have not clearly pointed out if they are counted into GFA, the components mezzanines and outbuildings sharing at least one wall with the main building are not considered in the probability code.

The standard code **S** is the one which has the least discrepancies with the probability code. From Table 5.30, it could be found that the RICS code and ÖNORM 1800 have minimum differences with the probability code. Due to the fact that RICS code is accepted in some other English-speaking countries, in this study, the RICS code is chosen as the standard code **S**.

Table 5.30: Comparison of the probability code with other space measurement standards

Space component	Probability code	IPD space code	German DIN 277	Austria ÖNORM	Switzerland SIA416	RICS code	EN 15221-6	ASTM E 1836	China GB/T 50353	Singapore
1. Voids	x 5/9	√	×	×	√	×	×	√	√	x
2. Mezzanine areas with permanent access	--	√	N.M[1]	N.M[1]	N.M[1]	√	N.M[1]	√	√	√
3. Stairwells, Lift-wells and the like	√ 7/8	√	√	√	√	√	√	√	√	√[2]
4. External open-sided balconies	x 5/9	×	√	×	×	×	√	×	√ Half	√ with cover X without cover
5.Internal Balconies	√ 7/9	N.M[1]	√	√	√	√	√	√	√ Half	√
6. Uncovered roof terraces and the like	x 6/9	×	√	√	×	×	√	×	×	x
7. Loading platforms	√ 5/9	×	√	√	×	√	√	√[7]	×	√
8. Areas with a headroom of less than 1.5 m	√ 7/9	√	√	√	√	√	√	√	×[3]	x
9. Outbuildings sharing at least one wall with the main building	-	N.M.[1]	N.M.[1]	N.M.[1]	√	√	√	N.M.[1]	N.M.[1]	N.M.[1]
10.Garage (part of the building)	√ 7/9	×	√	√	√	√	√	√	√	x
11. Canopies	x 5/9	N.M.[1]	×	×	×	×	√	x	√[4]	X[5]
12. Outside fire stairs	√4/9	N.M.[1]	×	√	×	×	√	x	√	√
13. Greenhouses, garden stores, fuel stores	x 5/9	×	×	N.M.*[6]	√	×	x	N.M.*[6]	x	√
Differences	--	5/11	3/11	1/11	4/11	1/11	3/11	4/11	6/11	6/11

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continued from previous page

1. N.M. = Not mentioned directly

2. Usually, stairwells are included but there are some exemption cases which are listed in 7.35, and the lift shaft is only measured once at the 1st level.

3. In China, the standard is 1.2 m, which means areas with headroom of less than 1.2 m are not calculated in the total floor area. Only half of the areas with headroom of 1.2 – 2.1 m are calculated.

4. When the distance between outside line of the canopy and the structural line of the outside wall is larger than 2.1 m, the half of the horizontal projected areas are calculated into GFA. When the distance is smaller than 2.1 m, the areas are not calculated.

5. Only one main entrance is exempted. When there is more than one, the second and subsequent entrances have to be included.

6. N.M.*=Not mentioned directly but not supposed to be included.

7. Only enclosed loading docks are included.

5.5.3 Mapping non-negligible differences with the standard code

In the following, standards will be compared to the RICS code. The attention is paid to the components whose differences between one code and another are non-negligible.

1. **IPD space code**

   Because the discrepancies between standards in terms of internal balconies, canopies and fire stairs can be ignored, non-negligible differences between IPD space code and RICS code are provisions about loading platforms, garages, and outbuildings (see Table 5.31).

Table 5.31: Differences between IPD space code with the standard code RICS

	IPD space code	**RICS code**
1. Internal balconies	N.M.[1]	$\surd$
2. Loading platforms	$\times$	$\surd$
3. Garages	$\times$	$\surd$
4. Canopies	N.M.[1]	$\times$
5. Outside fire stairs	N.M.[1]	$\times$
6. Outbuildings sharing walls	N.M.[1]	$\surd$

[1] N.M.= Not mentioned directly.

2. **DIN 277**

   The non-negligible differences between DIN 277 and RICS code are the rules about the building components mezzanines, external open-sided balconies, uncovered roof terraces, outbuildings sharing walls with the main building (see Table 5.32).

Table 5.32: Differences between DIN 277 code with the standard code RICS

	DIN 277	**RICS code**
1. Mezzanines	N.M.[1]	$\surd$
2. External balconies	$\surd$	$\times$
3. Uncovered roof terrace	$\surd$	$\times$
4. Outbuildings sharing walls	N.M.[1]	$\surd$

[1] N.M.= Not mentioned directly.

3. **ÖNORM 1800**

There are non-negligible differences in provisions about mezzanines, uncovered roof terraces as well as outbuildings sharing walls with the main building between ÖNORM 1800 and RICS code (Table 5.33).

Table 5.33: Differences between ÖNORM 1800 code with the standard code RICS

	ÖNORM 1800	**RICS code**
1. Mezzanines	N.M.[1]	$\surd$
2. Uncovered roof terrace	$\surd$	$\times$
3. Outbuildings sharing walls	N.M.[1]	$\surd$
5.Outside fire stairs	$\surd$	$\times$

[1] N.M.= Not mentioned directly.

4. **SIA 416**

SIA 416 differs from RICS code non-negligibly in the fields of mezzanines, and loading platforms (see Table 5.34).

Table 5.34: Differences between SIA 416 code with the standard code RICS

	SIA 416	**RICS code**
1. Voids, cavities	N.M.[1]	$\times$
2. Mezzanines	N.M.[1]	$\surd$
3. Loading platforms	$\times$	$\surd$
4. Greenhouses and the like	$\surd$	$\times$

[1] N.M.= Not mentioned directly.

5. **EN 15221-6**

The non-negligible discrepancies between standard EN 15221-6 and RICS code are the rules about mezzanines, external open-sided balconies and uncovered roof terraces (see Table 5.35).

Table 5.35: Differences between EN 15221-6 code with the standard code RICS

	EN 15221-6	**RICS code**
1. Mezzanines	N.M.[1]	$\surd$
2. External balconies	$\surd$	$\times$
3. Uncovered roof terraces	$\surd$	$\times$
4. Canopies	N.M.[1]	$\times$
5. Outside fire stairs	N.M.[1]	$\times$

[1] N.M.= Not mentioned directly.

6. **ASTM E1836**

The standard ASTM E1836 differs from RICS code in the rules about the building components loading platforms and outbuildings sharing walls with the main building (see Table 5.36).

Table 5.36: Differences between E1836 code with the standard code RICS

	ASTM E1836	**RICS code**
1. Voids	$\surd$	$\times$
2. Loading platforms	$\surd$ [1]	$\surd$
3. Outbuildings sharing walls with the main building	N.M. [2]	$\surd$
4. Green houses and the like	N.M.[2]	$\times$

[1] Only enclosed loading docks are included.
[2] N.M.= Not mentioned directly.

7. **GB/T 50353**

There are non-negligible differences between the standard GB/T 50353 and RICS code in terms of external open-sided balconies, loading platforms, areas with a headroom of less than 1.5 m and outbuildings sharing walls with the main building (see Table 5.37).

8. **Singapore Handbook of GFA**

The non-negligible differences between the standard Singapore Handbook of GFA and RICS code are the rules about external open-sided balconies, areas with a headroom of less than 1.5 m, garages and outbuildings sharing walls with the main building (see Table 5.38).

Table 5.37: Differences between GB/T 50353 code with standard code RICS

	GB/T 50353	**RICS code**
1. Voids, cavities	$\surd$	$\times$
2. External balconies	$\surd$ Half	$\times$
3. Internal balconies	$\surd$ Half	$\surd$
4. Loading platforms	$\times$	$\surd$
5. Areas with a headroom of less than 1.5 m	$\times$[1]	$\surd$
6. Canopies	$\times$ [2]	$\times$
7. Fire stairs outside	$\surd$	$\times$
8. Outbuildings sharing walls	N.M.[3]	$\surd$

[1] In China, the standard is 1.2 m, which means areas with headroom of less than 1.2 m are not calculated in the total floor area. And regards to areas with headroom of 1.2-2.1 m, only half of the areas are calculated.

[2] When the distance between outside line of the canopy and that of outside structural line of the outside wall is larger than 2.1m, the half of the horizontal projected areas are calculated into the total floor area. When the distance is smaller than 2.1m, the areas are not calculated.

[3] N.M.= Not mentioned directly.

Table 5.38: Differences between Singapore handbook of GFA with standard code RICS

	Handbook of GFA	**RICS code**
1. Stairwells, lift-wells	$\surd$[1]	$\surd$
2. External balconies	S.C.[2]	$\times$
3. Areas with a headroom of less than 1.5 m	$\times$	$\surd$
4. Garage inside of building	$\times$	$\surd$
5. Canopies	$\times$ [3]	$\times$
6. Outside fire stairs	$\surd$	$\times$
7. Outbuildings sharing walls	N.M.[4]	$\surd$

[1] Stairwells are included but there are some exemption cases which are listed in 7.35, and the lift shaft is only measured once at the 1^{st} level.

[2] S.C.= special calculation. The area is included in GFA when it has a cover, otherwise it is excluded.

[3] Only one main entrance is exempted. When there are more than one, the second and subsequent entrances have to be included.

[4] N.M.= Not mentioned directly.

5.5.4 Further data acquisition

After acknowledging those non-ignorable differences with RICS code, the next step is to improve those original questionnaires to get more detail area information. With this information, the modification of GFAs can be manipulated. These modified GFAs make international FM benchmarking programs more accurate and significant.

The modifying procedures of GFAs are quite similar. Take GFA measured by following the standard ÖNORM 1800 as an example. Because mezzanines, uncovered roof terraces and outbuildings are three critical discrepancies between ÖNORM 1800 and RICS code, the following four questions are recommended to be added to the original questionnaire in order to acquire additional area information.

1. Which area measurement standard is applied during the process of GFA measuring?
2. Is/are there **mezzanine(s)** in your building? How big is it/are they? Is it/Are they already included in your GFA calculation? (D1)
3. Is/are there **uncovered roof terrace(s)** in your building? How big is it/are they? Is it/Are they already included in your GFA calculation? (D2)
4. Is/are there **outbuilding(s) which share at least one wall with the main building** in your building? How big is it/are they? Is it/are they already included in your GFA calculation? (D3)

It is supposed that D0 is the numerical value of the original GFA. D1 is the floor area of mezzanines. D2 is the floor area of uncovered roof terraces and D3 is the floor area of outbuilding(s) which share at least one wall with the main building.

If we get the answer from the benchmarking participants that their GFA values are measured according to ÖNORM 1800. D1 and D2 are already included in the original GFA, while D3 is not. The new GFA value D0* which is consistent to RICS code (Area measurement standard can be used in the international FM benchmarking program according to this study) can be calculated as D0*= D0 -D2 +D3.

5.6 Conclusion

To achieve a reasonable and accurate FM benchmarking result, the area data must be comparable. It requires that these area data are measured directly by a unified measurement platform. However, this requirement cannot be met in many situations, e.g. in international comparison. A compromise suggested in this work is modifying the area data measured according to different standards. To modify those area data appropriately, the differences

between area measurement standards must be comprehensively understood. Nine representative area measurement standards are chosen to explore the critical discrepancies between standards.

Three categories of critical differences between area measurement standards are identified as unit differences, boundary lines differences and building components differences. The unit differences are easily reconciled with the conversion formula. For boundary lines differences, if the limiting face or dominant portion used as boundary lines to calculate GFA, the discrepancies of GFAs could be ignored. If the center line of walls is used to determine GFA, it is suggested to apply modification individually. The disparity of provisions about building components has the most significant influence on the differences of GFA values. This disparity is classified as ignorable and non-negligible. Area data need to be adjusted only for those non-negligible differences, which can simplify the adjusting procedure. The adjusting procedure is also discussed in this chapter.

6 CURRENCIES AND PRICE LEVELS

FM cost comparison is one of the most important tasks for FM benchmarking. Usually the comparison is done within one country. However, the situation is more complex during an international comparison. Besides the area measurement disparity, the discrepancy of currency between countries is another great problem. Most international FM benchmarking programs solve this problem by converting FM costs data collected from different countries into the same currency such as US dollars, Euros, etc. according to the market exchange rates of currencies. Some representatives are *FM Monitor International*, *DTZ Occupier Perspective Occupancy Cost*, *FM benchmarking* of FM Link, etc.

In addition to currency, the price level has a great impact on FM costs, e.g., when in one country the labor force is cheap, its labor-intensive services like building cleaning are also cheap. On the other hand, if this country has few natural resources, utilities costs like electricity cost will be more expensive.

One primary purpose of FM benchmarking is to find a leading model (Best Practice) which invests the smallest FM costs while keeping its facilities in good status.

$$\text{FM costs} = \sum(\text{FM service unit price} * \text{consumption volume})$$

The above equation shows that two notable factors determine the value of FM costs. One is *FM service unit price*, the other is the consumption volume. *FM service unit price* may be influenced by several factors which are service level, technology and local price level. Normally, technology and local price level cannot be affected by a single person or organization. Under this condition, the purpose of FM benchmarking can be expressed as finding a "best-practice" which has the smallest FM service consumption volume under a specific service level to keep its facilities in a good status.

However, for some FM services, consumption volume is difficult to be measured and compared. Even though it can be measured, the comparison will remain at a very detailed level. It is impossible to generate management level key performance indicators (KPIs) with volume measures. In this situation, it is more feasible to use price measures to do FM benchmarking. However, a hidden assumption is that all benchmarking participants are in the same price level environment.

Market exchange rate (MER) conversion methodology used by many international FM benchmarking programs has solved the currency problem but comes across the price level problem. Table 6.1 shows an example. The building cleaning costs of three countries are

all expressed in Euro (converted by MER). If the price level problem is not considered, the conclusion may be made that Germany shows the best performance among the three countries. Is this really true? It is well known that the price level in Switzerland is quite high, but how high it is and how it influences the FM benchmarking results is not easy to determine. These questions will be discussed in this chapter.

Table 6.1: Building cleaning costs/GFA in Euro (facility type: business and commercial buildings [33])

Building Cleaning Costs / GFA	**Germany**	**Austria**	**Switzerland**
Mean	9.50 Euro	14.80 Euro	11.40 Euro
Median	8.70 Euro	15.00 Euro	10.50 Euro

6.1 Methodology

In order to settle both the currency and price level problem simultaneously, *purchasing power parity* (PPP) methodology [14], [29], [16] is chosen as the conversion methodology in this work.

6.1.1 Introduction to purchasing power parity

PPP is an economic theory and a technique used to determine the relative value of currencies. It asks how much money would be needed to purchase the same goods and services in two countries, which will be used to calculate an implicit foreign exchange rate (PPP exchange rate). The purpose determines the goods in the "basket".

Up to now, no one uses PPP methodology to convert FM costs into a uniform currency in international FM benchmarking programs but it is already applied in many other international comparison programs. These are some examples:

- International Comparison Program;
- OECD PPPs Program;
- World Economic Outlook Database;
- The Big Mac Index;
- Prices and Earnings: A Comparison of Purchasing Power around the Globe;
- International Price Comparison for Retail Fixed-line and Mobile Telecommunications Services Report.

Among those six examples, five programs provide *purchasing power party exchange rates* (PPPs) calculated by each program, except *International Price Comparison for Retail Fixed-line and Mobile Telecommunications Services Report*, where PPPs published by *Organization for Economic Co-operation and Development* (OECD) are used. Most PPPs are calculated for *gross domestic products* (GDP), which means that a large number of goods and services are included in the "basket". Regarding *Big Mac Index*, only the price of one product - hamburgers is used to calculate PPPs. The program *Prices and Earnings* [16] is in the intermediate position, where PPPs are also calculated with a basket of goods and services but the number of goods and services is much smaller.

6.1.2 Purchasing power parity exchange rates for gross domestic products or for a specific industry

It has been pointed out that the purpose of the comparison determines the "basket of goods". Countries do not simply differ in general price level; instead, the difference in food prices may be larger than that in equipment prices (Table 6.2). What is included in the "basket" thus has a great impact on the value of PPPs. These existing PPP exchange rates are established mainly for GDP comparison, none of which is specified for an industrial sector except for construction projects. They are persuasive when they reflect whole economic situations of different countries but probably *cannot represent the price level discrepancies of the FM industry between one country and another*.

Table 6.2: Price level difference between food and equipment sectors

Sector	China	Austria	Price Level Ratio (C/A)
Food[1]	0.94 USD/kg	3.11 USD/kg	1:3.31
Equipment[2]	112 USD/pc.	66 USD/pc.	1:0.6

[1] Take tomato as an example.
[2] Take vacuuming as an example.

Under this consideration, the PPPs for the FM industry will be calculated in this work. Then it will be compared to PPPs for GDP from OECD. If the difference between two kinds of PPPs is large, it implies that the calculation of PPPs for the FM industry is essential and this kind of industrial PPPs are suggested to be used in international FM benchmarking programs. On the other hand, if their difference is negligible, it means that it is not necessary to calculate industrial PPPs. In this situation, the published PPPs for GDP can be applied in international FM benchmarking programs.

6.1.3 Calculation method of purchasing power parity exchange rates for the facility management industry

The existing industrial PPPs are calculated for the construction industry. To investigate if the PPPs calculation methodology used in the construction industry can be adapted to the FM industry, the similarity and diverseness between two industries are studied. Although there are some differences between the FM and the construction industry, they do have many similarities: a big number of suppliers, contractors and subcontractors, unique output, variations of productivity of labor, etc. The conclusion can be drawn that *the PPPs calculation methodology used in the construction industry can also be applied to the FM industry*.

Methods used in the construction industry. Three methods [36] are used to implement the PPPs calculation for the construction industry:

1. Pricing a basket of standard (hypothetical) construction projects

   The key of this approach is to price a number of standard construction projects according to the unit price approach. The instrument used in the pricing effort is called the bill of quantities (BOQ). BOQ for standard residential, non-residential and civil engineering projects are used for the price collection.

2. Pricing a basket of construction inputs - material, labor, and equipment

   The approach only requires to monitor the prices for goods and/or services included in the basket, and to compare them with prices at other places.

3. Pricing a basket of components

   This approach resembles the basket of construction inputs approach. It revolves around the concept of pricing a fixed set of components which are tangible units of a construction project that consume inputs such as material, labor, and equipment.

Method used in the price comparison of FM industry. In general, all of the three methods mentioned above can be used in the FM industry.

1. Pricing a basket of standard (hypothetical) FM projects

   According to this method, a standard FM project which including several popular FM services like building cleaning, maintenance, etc. is set. The prices of those FM services included in the standard FM project are collected. Because normally a FM project is not so complete as a construction project, this method is quite similar with the following third method "Pricing a basket of FM services".

2. Pricing a basket of FM service inputs - material (resource), labor, and equipment (tools)

   Due to the principle of this method, a list of FM related material (resources), labor and equipment (tools) should be made firstly. Then, the prices of the goods and services in the list are collected.

3. Pricing a basket of FM services

   Following this method, a list of representative FM services (common FM services across countries) should be made. Then, the prices of these services are collected.

The prices of FM services are seen as a commercial secret by some FM companies. It is difficult to collect enough price information without the support of authorities. On the other hand, the prices of FM service inputs are open to the public. Although the methods of pricing a basket of standard FM project and pricing a basket of FM services are comprehensive and accurate, the method of pricing a basket of FM service inputs is more feasible. Therefore, in this work, *the method of pricing a basket of FM service inputs* is chosen to calculate the PPPs for the FM industry.

6.1.4 Calculation procedure of purchasing power parity exchange rates

In the original method used in the construction industry, there is no weight difference among inputs. Considering that the FM industry is a labor-intensive profession and the cost of the labor force is the biggest part of expense compared with the cost of any other single input, FM services inputs are classified into two categories which are labor and non-labor inputs. When PPPs are calculated, the weights of two categories of inputs will be considered. The PPPs for the FM industry are calculated as follows:

- Step 1: Listing FM industry inputs;
- Step 2: Price collection of every single product;
- Step 3: Price calculation of each product;
- Step 4: Price calculation of each input ("basic heading");
- Step 5: PPPs calculation of each FM sub-industry;
- Step 6: PPPs calculation of the whole FM industry.

Individual inputs of FM services such as building cleaning workers, brooms are called the *basic headings* in the calculation procedure. Each input (basic heading) has several types. For example, the input "vacuum" has different motor types, some of which are lower than 1000 w and some of which are between 1000 w-1200 w. In this context, each type of input is referred as *one product*. Prices are collected for each product.

There are two aggregation steps. The first aggregation takes place when the PPPs for the FM sub-industries are calculated. The second one is implemented during the calculation of the PPPs for the whole FM industry.

List of FM inputs and weights. According to the method of pricing a basket of FM service inputs, the first important step is to confirm a list of FM service inputs and determine their weight. In order to create a accurate and comprehensive list, specific activities of FM services are investigated, and then workers involved, equipment/tools and materials/resources are listed in this study. The details are presented in appendix I.

Product specification. Most basic headings cover a wide range of products. It is difficult to select a subset of products for each basic heading to calculate PPPs because the products selected must be comparable across compared countries. Otherwise quality differences will be disguised as price differences, which leads to incorrect price relations. In order to avoid this, it is necessary to define each selected product precisely, which discussed in more detail in appendix II.

Source of price information. In these calculation procedures of PPPs for GDP, technical parameters and price information are usually obtained at the local shops across countries. Due to time cost and material consumption, the method used in this work is to acquire information from some big on-line shops like Amazon, eBay and some other national on-line shops. Unfortunately, not every country has a mature on-line shopping system yet, which makes it impossible to collect prices from the Internet for many countries at the moment. In this work, the prices of FM service inputs are collected for five countries which are *the UK*, *France*, *Germany*, *the US* and *China*. Table 6.3 lists the most frequently used on-line shopping systems for the price collection.

Number of price observations for each product. Normally, the number of price observations determines the reliability of its average price. The larger the number of observed prices, the more accurate the average price. The actual number depends on the degree to which the prices of the product vary. According to the experience of OECD, 10 is recommended as the minimum number of observations. It is also the observation number of this work. Since Internet resources are limited, some products may have less than 10 observed prices. If there are more than 5 observed prices, it is counted as valid, otherwise as invalid.

Table 6.3: Sources of the price collection

Country	On-line shopping system
US	1) http://www.amazon.com 2) http://www.ebay.com
UK	1) http://www.amazon.co.uk 2) http://www.ebay.co.uk 3) http://www.totalcleaningsupplies.co.uk 4) http://www.lakeland.co.uk
France	1) http://www.amazon.fr 2) http://www.ebay.fr 3) http://jardinage.twenga.fr/ 4) http://shopping.cherchons.com/
German	1) http://www.amazon.de 2) http://www.ebay.de 3) http://hygi.de
China	1) http://www.amazon.cn 2) http://www.taobao.com

Prices collected. The prices displayed by sellers are different. Some include delivery and installation costs while some exclude them; some include Value Added Tax (VAT) and other direct tax on products while some do not include them. Sometimes there are discounts. In this work, some rules are set:

- *Delivery costs are included* in purchaser's prices while installation costs are not.
- *VAT* is included in the transaction price.
- Discounts, surcharges and rebates should be included in the transaction price if they are available to all purchasers throughout most of the year. Otherwise they should be ignored.

6.2 Results

In order to compare prices from different countries, they should firstly be exchanged into a common currency. The exchange rates change every second. For the sake of uniformity, the average price is set to *August 28, 2012* in this study, which is listed in Table 6.4.

Table 6.4: Market exchange rates used in this dissertation

Currency	Exchange Rate to the USD
US Dollar (**USD**)	1.0000
British Pound (**GBP**)	1.5785
Euro (**EUR**)	1.2484
Chinese Yuan (**CNY**)	0.1573

6.2.1 Purchasing power parity exchange rates for the building cleaning sub-industry

The following equation is used to calculate PPPs for the building cleaning sub-industry:

$$\text{PPP exchange rate} = \text{IPLR} * \text{MER}.$$

MER is the market exchange rate between countries. Hier the rates in Table 6.4 are applied.

Integrate Price Level Ratio (IPLR) measures price level situations between two countries. There are large number of inputs in the building cleaning industry and their price level situations differ across countries. To have an exclusive index, we apply the weighting method here, where the weights of labor inputs and non-labor inputs are 80% and 20% respectively. Table 6.5 presents final results of PPPs for the building cleaning industry. All price level ratios are calculated on the basis of the US price level.

Table 6.5: IPLR and PPPs for the building cleaning industry

Country	Calculation of IPLR	IPLR	MER (USD/National Currency)	PPPs
US	1.00*0.8+1.00*0.2	1.00	1.00	1.00
UK	0.88*0.8+1.12*0.2	0.93	0.63	0.58
France	0.95*0.8+1.51*0.2	1.06	0.80	0.89
Germany	0.85*0.8+1.14*0.2	0.91	0.80	0.72
China	0.20*0.8+0.50*0.2	0.26	6.35	1.65

Labor aspect price level ratios of the building cleaning industry (1.00, 0.88, 0.95, 0.85, 0.20 of Table 6.5) are calculated using the *hourly wage rate*. Data are collected from national labor statistics of the government or some authoritative salary comparison websites. Salary information is expressed as monthly salary rate in some sources. In order to have a common basis for comparison, it is assumed that the monthly salary corresponds to for *a full-time employee, who works for 40 hours/week and 171.4 hours/month on average*.

Some websites compare net salaries while others release indexes of gross salaries. In this study, *the comparison is executed for gross salaries*. Details about the salary information of building cleaning workers are listed in Table 6.6, where salaries are all in US Dollar (converted with the market exchange rates fixed in Table 6.4).

Table 6.6: Salary information of building cleaning workers in five countries

Country	Normal Cleaner	Glass Cleaner	Average	Price Level Ratio
US	11.94 [1]	13.89[2]	12.92	1.00
UK	9.20[3]	13.45[4]	11.33	0.88
France	12.36[5]	12.36 [6]	12.36	0.95
Germany	10.27[7]	11.64[8]	10.96	0.85
China	2.62[9]	2.62[9]	2.62	0.20

[1] Data source: http://www.bls.gov/oes/current/oes372011.htm.
[2] Data source: http://www.bls.gov/oes/current/oes372019.htm.
[3] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/cleaner.aspx.
[4] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/windowcleaner.aspx.
[5] Data source: http://www.salairemoyen.com/en/salarybyjob-france-6510-Used_for_cleaning_.html#.UKytDYbGGz4.
[6] Data source: http://www.salairemoyen.com/en/salarybyjob-france-6522-Window_cleaner.html#.UKyqnYbGGz4
[7] Data source: http://www.gehaltsvergleich.com/gehalt/Gebaeudereiniger-Gebaeudereinigerin.html.
[8] Data source: http://www.gehaltsvergleich.com/gehalt/Glasreiniger-Glasreinigerin.html.
[9] Data source: http://beijing.baicai.com/salary/?jobKw1=\%E6\%B8\%85\%E6\%B4\%81\%E5\%B7\%A5&cityKw1=\%E5\%8C\%97\%E4\%BA\%AC

Non-labor aspect price level ratios (1.00, 1.12, 1.51, 1.14, 0.5 of Table 6.5) are calculated on the basis of non-labor inputs price collection and comparison of this study. Table 6.7 below provides a snapshot of price information of non-labor inputs of building cleaning services in five countries. Only the average price of each basic heading (each input) are provided and more detailed price information is listed in appendix III as a supplement. It is worth noting that all price information is in US Dollar.

Table 6.7: Price information of non-labor inputs of building cleaning services in five countries

Country	1) Broom		2) Dust Pan		3) Duster		4) Mop		5) Mop Pail		6) Janitorial Cart		7) Gloves	
US	22.82	1.00	12.91	1.00	15.83	1.00	20.61	1.00	20.86	1.00	160.67	1.00	11.27	1.00
UK	21.28	0.93	13.53	1.05	13.87	0.88	21.17	1.03	12.49	0.60	235.31	1.46	9.73	0.86
France	21.62	0.95	25.42	1.97	18.78	1.19	33.33	1.62	25.95	1.24	238.23	1.48	19.32	1.99
Germany	17.91	0.79	11.41	0.90	17.23	1.09	26.31	1.28	18.12	0.87	144.31	0.90	13.91	1.23
China	4.91	0.22	2.50	0.19	6.19	0.39	7.22	0.35	5.91	0.28	38.29	0.24	3.06	0.27
Country	8) Spray bottle		9) Squeegee		10) Scraper		11) Vacuum		12) Carpet cleaning machine		13) Tile & Hardwood cleaning machine		14) Scrubber	
US	7.74	1.00	20.52	1.00	6.19	1.00	67.57	1.00	386.46	1.00	506.07	1.00	18.75	1.00
UK	7.18	0.93	15.21	0.74	4.94	0.80	90.43	1.34	521.89	1.35	689.94	1.36	8.64	0.46
France	12.84	1.66	22.31	1.09	7.90	1.28	70.88	1.05	924.98	2.39	1323.34	2.61	27.51	1.47
Germany	10.70	1.38	26.61	1.30	7.52	1.21	66.96	0.99	400.13	1.04	787.96	1.14	17.70	0.94

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China	2.67	0.34	5.01	0.24	1.8	0.29	112.36	1.66	709.42	1.84	514.70	1.02	2.23	0.12		
Country	15) Pole		16) Ladder		17) Bath-room cleanser		18) Cook-tops cleanser		19) Glass cleanser		20) Floor waxing agent		21) Carpet cleanser			
US	26.76	1.00	144.69	1.00	7.27	1.00	20.60	1.00	5.56	1.00	24.36	1.00	12.63	1.00		
UK	54.52	2.04	117.91	0.81	14.82	1.94	29.90	1.29	7.35	1.11	17.75	0.67	14.58	0.94		
France	47.95	1.79	127.09	0.88	16.02	2.10	30.98	1.34	6.33	0.96	16.45	0.62	21.79	1.49		
Germany	53.84	2.01	144.02	1.00	11.48	1.50	41.85	1.81	4.54	0.69	21.94	0.83	8.19	0.53		
China	8.23	0.31	46.20	0.32	5.15	0.67	15.46	0.67	2.82	0.43	8.40	0.32	2.42	0.16		
Country	Average price level of un-labor inputs															
US	1.00															
UK	1.12															
France	1.51															
Germany	1.14															
China	0.50															

6.2.2 Purchasing power parity exchange rates for the building maintenance sub-industry

The calculation procedure of PPPs for the building maintenance industry is quite similar to that of the building cleaning industry. Only the weights between labor inputs and non-labor inputs change from 80%/ 20% to 60%/40%. Table 6.8 presents final results of PPPs for the building maintenance industry. All price level ratios are calculated on the basis of the US price level.

Table 6.8: IPLR and PPPs for building maintenance industry

Country	Calculation of IPLR	IPLR	MER (USD/National Currency)	PPPs
US	1.00*0.6+1.00*0.4	1.00	1.00	1.00
UK	0.80*0.6+1.06*0.4	0.90	0.63	0.57
France	0.73*0.6+1.41*0.4	1.00	0.80	0.80
Germany	0.69*0.6+1.13*0.4	0.87	0.80	0.70
China	0.16*0.6+0.38*0.4	0.25	6.35	1.59

Similar to the building cleaning industry, *labor aspect price level ratio* (1.00, 0.80, 0.73, 0.69 and 0.16 of Table 6.8) is obtained by comparing salaries of a full-time employee, who works for 40 hour/week and 171.4 hours/month on average (Table 6.9). All salary information is presented in the form of gross hourly wage rate and converted into US Dollars with MERs fixed in Table 6.4. *Non-labor aspect price level ratio* (1.00, 1.06, 1.41, 1.13 and 0.38 of Table 6.8) is calculated on the basis of the non-labor inputs price collection and comparison of this study. Table 6.10 provides the average prices of each basic heading and all are expressed in US Dollars.

Table 6.9: Salary information of building maintenance workers

Country	Plumber	Electrician	Carpenter	Average	Price Level Ratio
US	24.92 [1]	26.15[2]	18.67 [3]	23.24	1.00
UK	19.76[4]	19.60 [5]	16.38 [6]	18.58	0.80
France	16.46 [7]	18.37 [8]	15.80[9]	16.87	0.73
Germany	14.90 [10]	18.15[11]	15.19[12]	16.08	0.69
China	3.44 [13]	4.00[14]	3.91 [15]	3.78	0.16

[1] Data source: http://www.bls.gov/oes/current/oes472152.htm.

[2] Data source: http://www.bls.gov/oes/current/oes499052.htm+http://www.bls.gov/oes/current/oes499051.htm+http://www.bls.gov/oes/current/oes492094.htm.

[3] Data source: http://www.bls.gov/oes/current/oes472141.htm.

[4] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/plumber.aspx.

[5] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/electrician.aspx.

[6] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/painteranddecorator.aspx+https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/carpenterorjoiner.aspx.

[7] Data source: http://www.salairemoyen.com/en/salarybyjob-france-5363-Plumber_.html#.ULNQTIbGGz5.

[8] Data source: http://www.salairemoyen.com/en/salarybyjob-france-5221-Electrician_.html#.ULNvsYbGGz5.

[9] Data source: http://www.salairemoyen.com/en/salarybyjob-france-5349-Carpenter.html#.ULNwLIbGGz5.

[10] Data source: http://www.gehaltsvergleich.com/gehalt/Kundendienstmonteur\\-Kundendienstmonteurin-Klempner-Installateur.html.

[11] Data source: http://www.gehaltsvergleich.com/gehalt/Starkstromelektriker-Starkstromelektikerin.html.

[12] Data source: http://www.gehaltsvergleich.com/gehalt/Maurer-Maurerin.html.

[13] Data source: http://beijing.baicai.com/salary/?jobKw1=\%E7\%AE\%A1\%E9\%81\%93\%E5\%B7\%A5&cityKw1=\%E9\%87\%8D\%E5\%BA\%86

[14] Data source: http://beijing.baicai.com/salary/?jobKw1=\%E7\%94\%B5\%E5\%B7\%A5&cityKw1=\%E6\%B7\%B1\%E5\%9C\%B3

[15] Data source: http://beijing.baicai.com/salary/?jobKw1=\%E6\%9C\%A8\%E5\%B7\%A5&cityKw1=\%E9\%87\%8D\%E5\%BA\%86

Country	1) Measuring tape		2) Telescoping basin wrench		3) Flashlight, pocket style		4) Key hole saw		5) Pocket knife		6) Eye protection		7) Gloves	
US	15.48	1.00	24.55	1.00	8.43	1.00	16.79	1.00	14.01	1.00	8.22	1.00	11.21	1.00
UK	13.78	0.89	32.82	1.34	7.54	0.89	17.56	1.05	15.49	1.11	9.98	1.21	9.73	0.86
France	25.77	1.66	48.21	1.96	12.52	1.48	22.65	1.35	23.88	1.70	14.13	1.72	19.32	1.71
Germany	16.63	1.07	36.93	1.50	7.51	0.89	13.95	0.83	20.48	1.46	10.36	1.26	13.91	1.32
China	4.06	0.26	4.20	0.17	4.11	0.49	5.15	0.31	5.37	0.38	5.25	0.64	3.06	0.27
Country	8) 2 way screw-driver		9) Adjustable wrench		10) Air pressure gauge		11) Hammer		12) Chisel		13) Groove joint pliers		14) Hack-saw frame	
US	6.90	1.00	25.74	1.00	18.23	1.00	18.90	1.00	22.36	1.00	12.25	1.00	16.91	1.00
UK	4.04	0.59	27.25	1.06	24.07	1.32	17.50	0.93	14.73	0.66	15.05	1.23	14.07	0.83
France	7.59	1.10	27.74	1.08	27.18	1.49	19.70	1.04	23.82	1.07	25.60	2.09	22.63	1.34
Germany	9.38	1.36	32.17	1.25	31.71	1.74	16.63	0.88	15.08	0.67	14.90	1.22	20.77	1.23
China	3.91	0.57	8.15	0.32	4.94	0.27	6.40	0.34	5.91	0.26	4.77	0.39	3.59	0.21
Country	15) Hex key set		16) Level torpedo		17) Nut driver		18) Pipe wrench		19) Lineman pliers		20) Saw ABS/PVC		21) Spray bottle	
US	10.65	1.00	9.61	1.00	7.24	1.00	31.06	1.00	15.33	1.00	19.16	1.00	7.74	1.00
UK	14.88	1.40	9.86	1.03	9.26	1.28	32.55	1.05	18.82	1.23	17.12	0.89	7.18	0.93
France	14.99	1.41	11.16	1.16	10.02	1.38	37.56	1.21	20.10	1.31	32.14	1.68	12.84	1.66
Germany	14.99	1.41	12.21	1.27	9.14	1.26	33.55	1.08	18.30	1.19	10.70	1.38		
China	3.42	0.32	2.90	0.30	2.27	0.31	14.46	0.47	5.47	0.36	6.32	0.33	2.67	0.34
Country	22) Strap wrench		23) Tin snips		24) Tub cutters		25) Water pressure gauge		26) Fish tape		27) Volt/amp multimeter		28) Voltage detector-non contact	

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US	13.11	1.00	14.50	1.00	30.27	1.00	10.09	1.00	20.14	1.00	11.93	1.00	18.44	1.00
UK	14.40	1.10	14.52	1.00	11.30	0.37	15.59	1.55	15.53	0.77	17.83	1.50	14.71	0.80
France	22.42	1.71	24.75	1.71	23.19	0.77	17.84	1.77	32.91	1.63	17.83	1.50	18.48	1.00
Germany	14.77	1.13	22.92	1.58	16.62	0.55	15.66	1.55	16.05	0.80	20.12	1.69	9.57	0.52
China	7.80	0.59	6.40	0.44	7.03	0.23	4.59	0.46	4.25	0.21	9.03	0.76	6.53	0.35

Country	29) GFCI Plug tester		30) Wire strippers		31) Diagonal cutting pliers		32) Cordless drill		33) Chalkline		34) Nail puller		35) Generator	
US	9.95	1.00	13.43	1.00	13.26	1.00	78.25	1.00	10.52	1.00	10.90	1.00	241.93	1.00
UK	9.84	0.99	9.18	0.68	12.93	0.98	93.60	1.20	10.93	1.04	7.33	0.67	697.89	2.88
France	20.99	2.11	14.37	1.07	18.12	1.37	79.53	1.02	16.97	1.61	14.40	1.32	306.97	1.27
Germany	17.62	1.77	9.66	0.72	10.11	0.76	53.66	0.69	14.84	1.41	9.61	0.88	256.11	1.06
China	5.58	0.56	3.17	0.24	3.72	0.38	49.38	0.63	4.38	0.42	3.76	0.34	179.24	0.74

Country	36) GFCI Plug tester		37) Wire strippers		38) Diagonal cutting pliers		39) Cordless drill		Average
US	187.56	1.00	69.93	1.00	47.73	1.00	144.69	1.00	1.00
UK	173.36	0.92	94.88	1.36	47.57	1.00	117.91	0.81	1.06
France	199.44	1.06	97.62	1.40	58.29	1.22	127.09	0.88	1.41
Germany	194.74	1.04	67.86	0.97	41.00	0.86	144.02	1.00	1.13
China	67.89	0.36	31.95	0.46	13.13	0.28	46.20	0.32	0.38

Table 6.10: Non-labor inputs of price information of building maintenance service in five countries

6.2.3 Purchasing power parity exchange rates for the building security sub-industry

Because the security guard labor is regarded as the exclusive input of the security management service, the corresponding PPPs are calculated directly with the salary information of security guards.

The price level comparison is performed quite similarly to the labor aspect price level comparison of building cleaning and building maintenance industries (Table 6.11). Table 6.12 shows PPPs for the building security industry.

Table 6.11: Salary information of building security guards

Country	Security Guards	Price Level Ratio
US	13.00 [1]	1.00
UK	13.43 [2]	1.03
France	13.60 [3]	1.05
Germany	13.32 [4]	1.02
China	2.94 [5]	0.23

[1] Data source: http://www.bls.gov/oes/current/oes339032.htm.
[2] Data source: https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/securityofficer.aspx.
[3] Data source: http://www.salairemoyen.com/en/salarybyjob-france-3610-Employee_of_guarding.html#.ULOOx4bGGz5.
[4] Data source: http://www.gehaltsvergleich.com/gehalt/Wach-Sicherheitsfachmann-Wach-Sicherheitsfachfrau.html.
[5] Data source: http://beijing.baicai.com/salary/?jobKw1=\%E4\%BF\%9D\%E5\%AE\%89&cityKw1=\%E9\%87\%8D\%E5\%BA\%86

Table 6.12: PPPs exchange rates for the building security industry

Country	Price Level Ratio	MER (USD/National Currency)	PPPs
US	1.00	1.00	1.00
UK	1.03	0.63	0.65
France	1.05	0.80	0.84
Germany	1.02	0.80	0.82
China	0.23	6.35	1.46

6.2.4 Purchasing power parity exchange rates for the utilities sub-industry

Seven utility services are regarded as the basic headings of the utilities sub-industry, which are electricity, fuel, gas, water/sewage, telephone, Internet and waste removal (appendix I).

The prices of these utility services are normally open to the public, and in many countries, prices of utility services are determined and managed by authorities instead of the market. It is more persuasive to calculate price level ratios by comparing the service prices directly, which is the method used in this study.

In most countries, the tariff of waste removal is charged by volume of the waste but it is quite different in France. Although the operational responsibility for this service is often contracted out to private companies, the service is charged through the tax called Taxe d'enlèvement des ordures méngagères (TEOM). Its calculation is tied to the ratable value of the property. It means that **the amount of waste is irrelevant**. Some places do not have such door-to-door collection services and people do not pay this kind of tax. For this reason, it is impossible to compare these service tariffs between countries.[1] Thus, *in this study, the tariff of waste removal is not included in the comparison list*.

It is also not very easy to compare the prices of the rest of utility services, since normally the prices are tied to the service conditions/packages. In order to enable cross-country comparisons of utility services, standardized consumption baskets should be developed, e.g., in the OECD fixed-line voice benchmarking [43], each basket includes a certain number of local, national, international and fixed-to-mobile calls. Because the price comparison of utility services is complicated, and it is not the main purpose of this study, the results of other utility service price comparison studies will be used. Here, only the results (Table 6.13 and Table 6.14) are presented, and the detailed procedure is introduced in the appendix IV.

Table 6.13: Price level ratios of six utility services compared to US

Country	Electricity	Gas	Water	Telephone	Internet	Fuel	Average
US	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UK	1.73	2.81	1.51	0.70	0.70	1.09	1.42
France	1.18	2.72	1.56	0.89	0.48	1.12	1.33
Germany	2.03	3.49	1.83	0.86	0.52	1.10	1.64
China	1.49	2.35	0.17	0.70	0.23	1.11	1.01

6.2.5 Whole facility management industry

The PPPs for the whole FM industry are aggregated based on the above four sub-industries. Before the aggregation, the weights of four parts have to be defined.

In this work, the weights of different parts are decided by the consumption amounts of four parts based on the FM Monitor 2008 (Table A.1, Table A.3, Table A.5 and Table A.6).

[1] http://www.french-property.com/news/tax_france/tax_waste_collection_teom/.

Table 6.14: PPP exchange rates calculation for utilities services

Country	Price Level Ratio	MER (USD/National Currency)	PPPs
US	1.00	1.00	1.00
UK	1.42	0.63	0.90
France	1.33	0.80	1.06
Germany	1.64	0.80	1.31
China	1.01	6.35	6.39

Table 6.15: Aggregation weights of sub-industries

Sub-industry	Amount	Calculation of Aggregation Weight	Weights
Building Cleaning	28%	28%/(28%+20%+4%+22.8%)	37.5%
Building Maintenance	20%	20%/(28%+20%+4%+22.8%)	36.7%
Building Security	4%	4%/(28%+20%+4%+22.8%)	5.3%
Utility service	22.8%	22.8%/(28%+20%+4%+22.8%)	30.5%

With the weights of the four parts (Table 6.15), the PPPs for the whole FM industry are easy to be figured out. The results are presented in Table 6.16.

Table 6.16: PPPs calculation for the FM industry

Country	Cleaning	Maintenance	Security	Utility	Whole FM
US	1.00	1.00	1.00	1.00	1.00
UK	0.58	0.57	0.65	0.90	0.68
France	0.89	0.80	0.84	1.06	0.92
Germany	0.72	0.70	0.82	1.31	0.90
China	1.65	1.59	1.46	6.39	3.07

For the developed countries like the UK, France and Germany, the PPPs for the FM industry are bigger than PPPs for GDP, while for the developing countries like China, they are smaller (Table 6.17). The main reason is the labor cost. The FM industry is labor-intensive industry. The cost of the labor force in the developed countries is quite high, which makes to the PPPs for the FM industry slightly higher than the PPPs for GDP which is an average level of the whole country. The cost of labor in the developing countries like China, however, is relatively low, which makes the PPPs for the FM industry lower than the average level of the country.

Based on the results of Table 6.18, several conclusions can be made:

Table 6.17: Comparison between PPPs for the FM industry and PPPs for GDP

Country	PPPs for FM industry	PPPs for GDP [29]	Difference
US	1.00	1.00	0
UK	0.68	0.68	0
France	0.92	0.87	5.7%
Germany	0.90	0.80	12.5%
China	3.07	4.17	-26.4%

Table 6.18: Overview of the differences between PPPs for GDP and PPPs for FM industry/sub-industries

Country	Building cleaning	Building maintenance	Building security	Utilities	Whole FM
US	0	0	0	0	0
UK	-14.7%	-16.2%	-4.4%	31.9%	0
France	2.3%	-8.0%	-3.5%	22.0%	5.7%
Germany	10%	-12.5%	2.5%	64.0%	12.5%
China	-60%	-61.87%	-65.0%	53.3%	-26.4%

- When comparing total FM costs, it is best to use PPP exchange rates for the FM industry in order to carry out the currency and price level modification. If they are not available, for developed countries, it is acceptable to use PPPs for GDP to make a similar modification, while for developing countries, more consideration is necessary. Because the biggest influence factor is the cost of the labor force, the value of PPPs for GDP of this developing country must be multiplied by a discount factor. How big this discount factor is, should be studied in more detail.

- When comparing a single cost like cleaning cost or building maintenance cost, it is better to use PPP exchange rates for the sub-industries since there are also considerable gaps between PPPs for the whole FM industry and PPPs for FM sub-industries.

- When PPPs for sub-industries are not available, for developed countries, it is acceptable to use PPPs for GDP to do a similar modification except for utility services. There are significant gaps between PPPs for GDP and PPPs for utility services for both developed and developing countries.

6.3 Examples

In this section, three examples are presented to illustrate how to apply PPP exchange rates for FM industry (or any sub-industry) in the course of international FM benchmarking.

6.3.1 Modification to the existing international benchmarking pool

FM Monitor International is a benchmarking publication which surveys the key facility management indicators throughout the German-speaking countries (Germany, Austria and Switzerland) making comparisons across borders.

To establish a uniform comparison platform, some modifications and adjustments are made in the report. In terms of currency, MER is used to convert Swiss Francs circulated in Switzerland into Euro which is the currency of Germany and Austria. However, in the report it has not been pointed out clearly which exchange rate is used and the price level problem is not referred to. Table 6.19 shows an example of FM cost comparison between three countries.

Table 6.19: Maintenance costs / GFA in Euro (facility type: business and commercial buildings [33]

Maintenance Costs / GFA	**Germany**	**Austria**	**Switzerland**
Mean	9.30 Euro	8.90 Euro	11.60 Euro
Median	8.60 Euro	3.40 Euro	12.40 Euro

At the moment, there are no PPPs for the FM industry for all three countries. Considering that Germany, Austria, and Switzerland are all developed countries and the comparison is about "maintenance costs" (not utility service), PPPs for GDP of the year 2008 established by OECD (Table 6.20) can be used to carry out the modification. PPPs for GDP from OECD are all on the basis of the US Dollar. In this example, it is best to have PPPs based on one currency of the three German-speaking countries. Here the German Euro is chosen as the basis.

Table 6.20: PPPs for GDP 2008 of Germany, Austria and Switzerland [29]

	Germany	**Austria**	**Switzerland**
National Currency per US Dollar	0.8116507	0.8524937	1.5486637
National Currency per GEuro [1]	1.00	1.05	1.91

[1] GEuro = German Euro.

In order to apply PPPs to the adjustments of the currency and price level, it is necessary to convert all FM costs back into their original currencies. We suppose that the average exchange rate between Euro and Swiss francs of the year 2008 is used in the report, which is *1 Euro=1.586 CHF*. Table 6.21 shows the "maintenance costs" expressed in national currencies. The final result expressed in a uniform currency and price level platform (currency is Euro and the price level is the condition of Germany in 2008) is presented in Table 6.22.

Table 6.21: Maintenance costs / GFA in national currencies (facility type: business and commercial buildings)

Maintenance Costs / GFA	**Germany**	**Austria**	**Switzerland**
Mean	9.30 Euro	8.90 Euro	18.39 CHF
Median	8.60 Euro	3.40 Euro	19.67 CHF

Table 6.22: Maintenance costs / GFA in GEuro [1] (facility type: business and commercial buildings)

Maintenance Costs / GFA	**Germany**	**Austria**	**Switzerland**
Mean	9.30 GEuro	8.48 GEuro	9.62 GEuro
Median	8.60 GEuro	3.23 GEuro	10.30 GEuro

[1] GEuro = German Euro.

Although the sequence of "maintenance costs" from low to high does not change when PPPs are applied instead of MERs, the difference between Germany and Switzerland has decreased significantly. Switzerland has a much higher cost when MER conversion methodology is applied because its price level is significantly higher than that of the two other countries.

After PPPs remove the impact of price level, the conclusion can be made that companies and organizations in Austria spent least on maintenance while the situations in Germany and Switzerland were quite similar in the year of 2008.

There is another similar example (Table 6.23) which can shows more differences caused by the application of different exchange rates. When the building cleaning costs of the three countries are compared at a uniform currency and price level platform (currency is Euro and the price level is the condition of Germany in 2008), the sequence of the building cleaning costs from low to high changes (Table 6.24). Switzerland took the first place among the three countries although the gap between Switzerland and Germany is not very big.

Table 6.23: Building cleaning costs / GFA in Euro (facility type: business and commercial buildings [33])

Building Cleaning Costs / GFA	Germany	Austria	Switzerland
Mean	9.50 Euro	14.80 Euro	11.40 Euro
Median	8.70 Euro	15.00 Euro	10.50 Euro

Table 6.24: Building cleaning costs / GFA in GEuro [1] (facility type: business and commercial buildings)

Building Cleaning Costs / GFA	Germany	Austria	Switzerland
Mean	9.50 GEuro	14.09 GEuro	9.47 GEuro
Median	8.70 GEuro	14.29 GEuro	8.71 GEuro

[1] GEuro = German Euro.

6.3.2 Integration of national/regional benchmarking pools

The main purpose of this work is to establish an international FM benchmarking pool by integrating existing national/regional FM benchmarking pools. Here we take the indicator *building cleaning cost for office building* as an example.

The first line of Table 6.25 shows the benchmarks of the annual building cleaning costs which are acquired from a US benchmarking program and a German benchmarking program respectively. There are many incomparable aspects between the two benchmarks. Firstly, the area unit is different. The imperial unit is used in the US while the metric unit is applied in Germany. Secondly, area measurement types used in these two benchmarking programs are not uniform. *Area Cleaned* is used in the US while *GFA* is preferred in Germany. Thirdly, currencies and price level situations of the two countries are not the same.

The first problem is easy to be dealt with by applying the conversion formula of the two unit systems, where $1 ft^2$= 0.0929 m^2. In this US benchmarking report, the proportions between Area Cleaned and GFA are not pointed out. Since the area measurement problem is not the main focus in this example, we suppose that Area Cleaned/ GFA = 80%. After these two modifications, we have the new benchmarking values (the second line of Table 6.25).

Now, four options are available to conduct the currency and price level modification, which are MER, PPPs for GDP from OECD, PPPs for FM industry and PPPs for building cleaning industry (Table 6.26).

Table 6.25: Benchmarks of building cleaning costs of the US and Germany

	US (Cost per Area Cleaned)	Germany (Cost per GFA)
Median Cost [1]	1.19 USD /ft^2 [3]	11.07 Euro/m^2 [4]
Median Cost [2]	16.01 USD /m^2	11.07 Euro/m^2

[1] Median cost in original form.
[2] Median cost after two-steps modification.
[3] Data source: `http://www.fmlink.com/article.cgi?type=Benchmarking&title=Benchmarking\%20Your\%20Janitorial\%20Trends&pub=FM\%20BENCHMARKING&id=44342&mode=source`.
[4] Source: FM Monitor International 2009.

Table 6.26: Four types of currency transformation

Median Cost Type	ER[1]	US	Germany	Difference
MERs in USD	0.77	16.01	14.47	9.6%
PPPs for GDP in USD	0.80	16.01	13.84	13.6%
PPPs for FM industry in USD	0.90	16.01	12.30	23.2%
PPPs for cleaning industry in USD	0.72	16.01	15.38	3.9%

[1] ER = Exchange rate.

The difference about building cleaning costs between the US and Germany is even greater when PPPs for GDP and PPPs for FM industry are used to remove the discrepancies caused by currency and price level compared with MER. Reversely, this difference is smaller when PPP for building cleaning industry is applied. Since it is only the comparison of building cleaning cost, it is certain that PPPs for building cleaning industry is the most accurate conversion methodology. If MER is used to do the modification, there is a greater gap between the US and Germany (9.6% compared to 3.9%) because it does not consider the price level difference between the two countries. Prices of goods and services in Germany are higher than in the US and hence the purchasing power of the Euro in its national market is lower than the same amount of US Dollar (converted by MER) in the US. In this example, the correct conclusion is that the building cleaning costs spent by organizations in the US and Germany are similar with slight differences.

6.3.3 Comparison between the facility management developing and developed countries

There may be no national FM benchmarks in many countries. When organizations in such countries want to implement FM benchmarking programs, they have to know how to compare their own performances with benchmarks of other countries.

For example, a company in China would like to compare its building cleaning cost of a residential building with the benchmark published by fm. Benchmarking Report of Germany. The building cleaning cost of this residential building is CNY 9.281 per GFA[2], while the benchmark of Germany is Euro 3.572 per GFA[3]. If MER methodology is chosen to unify currencies, the wrong conclusion may be made that the FM level of the building cleaning in China is higher than that of Germany (See Table 6.27).

Table 6.27: Building cleaning cost comparison between China and Germany by using MER

	China	**Germany**
Building Cleaning Costs/GFA [1]	9.28 CNY	3.57 Euro
MER to USD	0.1573	1.2484
Building Cleaning Costs/GFA [2]	1.46	4.46

[1] Costs are presented in national currency.
[2] Costs are presented in US Dollar.

We may guess that this result may be caused by the lower price level of China. However, how exactly does the price level influence the result? PPPs can help to answer this question. Considering that only the building cleaning cost is compared, PPPs for building cleaning industries are the best choice to remove the impact of the price level.

Table 6.28: Building cleaning cost comparison between China and Germany by using PPPs for building cleaning industry

	China	**Germany**
Building Cleaning Costs / GFA [1]	9.28 CNY	3.57 Euro
USD PPPs for Building Cleaning	1.65	0.72
Building Cleaning Costs / GFA [2]	5.62	4.96

[1] Costs are presented in the national currency.
[2] Costs are presented in USD PPPs for building cleaning industry.

As Table 6.28 shows, after removing the influence of price level, the building cleaning cost of this Chinese residential building is 13% higher than the median value of Germany. There is still room for significant improvement for this Chinese company.

[2]Source: `http://www.taodocs.com/p-1305665.html`
[3]Data is from page 179 of fm. Benchmarking report of Germany 2012/2013.

6.4 Conclusion

In most of the international (FM) benchmarking/comparison programs, MER methodology is used to convert original monetary benchmarks in different currencies into one set currency in order to make the cross-country comparison possible. However, this method evades the fact that the price level situations vary between countries, which can lead to inaccurate even wrong conclusions.

In this study, the PPP methodology is chosen to conduct the conversion between benchmarks acquired from different currency and price level environments. It considers not only the transformation but also the discrepancies of price levels between countries.

Existing PPPs are all used for GDP comparisons. However, countries do not simply differ in a uniform price level. The price differences between countries vary from one industry to another. Those PPPs for GDP cannot represent the price level differences of the FM industry between countries. Under this consideration, PPPs for the FM industry are calculated in this study. The suitabilities of different kinds of PPPs are also discussed.

The discrepancies of price levels between countries may greatly impact the international benchmarking results. This fact has not yet gained enough attention. This may be caused by many reasons. The lack of methods may be one of them. The aim of this study is to make a contribution.

7 CONCLUSION

With the development of the FM industry, a variety of FM benchmarking pools have appeared and focus on different areas such as FM cost, space utilization, energy consumption, etc. One thing they have in common is that they usually provide only national or regional benchmarks. Only very few published FM benchmarks cross national borders. However, the demand of international FM benchmarks is increasing gradually. One important reason is that more and more companies own global properties. Such companies desire to know which facilities run efficiently and how to improve their operation. Second, more "Best Practices" can be found worldwide. In order to set up world-class facility management, the prospect must be international. Furthermore, benchmarking pools are the result of a mature industry. Organizations in countries where the FM industries are still immature should adopt international benchmarks or benchmarks from other countries as their own benchmarks when they implement a FM benchmarking program.

The goal of this study is to explore whether it is possible to establish an international FM benchmarking pool by integrating existing national/regional FM benchmarking pools. In other words, what is need in order to compare FM benchmarks of different countries will be investigated. Specifically, the study tries to answer the following three questions:

- How to select key performance indicators (KPIs) for the integrating international FM benchmarking pool?
- How to compare benchmarks which are obtained on the basis of different area measurement standards?
- How to establish a uniform currency and price level platform for existing national/regional FM benchmarking pools, in order to conduct cross-country comparison?

In this work, chapter 2 introduces the concepts of FM and Benchmarking. The author tries to build a conceptual framework for FM benchmarking in order to provide the background of this study for the readers.

In chapter 3, the best known FM benchmarking reports are introduced. Thus, readers get a sense of what the existing FM benchmarking pools work on and what their interests, problems, etc. are.

Chapter 4 deals with the question of how to select KPIs for an integrated international FM benchmarking pool. Eight national benchmarking programs are studied. There is a higher level of agreement between the subdivided cost components than the main cost

components. Due to this fact, those sub-level components are suggested to be KPIs in the international FM benchmarking. The FM cost classification system EN 15221-4 is used as the framework to rearrange similar sub-components.

In chapter 5, the in-comparability problem caused by discrepancies of area measurement standards applied by different FM benchmarking pools is solved. Based on the comparison analysis, the uniformity and differences between nine area measurement standards are presented. The *Code of measuring practice* published by RICS (RICS code) from the UK is chosen as the standard code of the integrating international benchmarking pool in the study. By comparing the RICS code and other area measurement standards, adjustment methods of benchmarks are suggested.

In chapter 6, the methodology of the solution to currency and price level problems is analyzed. Purchasing power parities exchange rates (PPPs) for the FM industry including four sub-industries are calculated in order to solve the in-comparability problem caused by different currencies and different price levels.

7.1 Main questions and remarks

Question 1: How to select KPIs for the integrating international FM benchmarking pool?

Answer 1: it is indicated that there is a higher level of agreement between the subdivided cost components than the grouping in main cost components. Eight national FM benchmarking programs are chosen for the case study in this work. Their FM cost classification systems are systematically investigated and the above conclusion is obtained.

Answer 2: Eight indicators are chosen as the KPIs of the integrating international FM benchmarking pool and their relationships with indicators in national pools are presented. According to the principles of selecting KPIs for the international FM benchmarking established in this study, eight indicators are chosen as the KPIs. The FM cost classification system EN 15221-4 is selected as the framework to rearrange similar components.

Question 2: How to compare different benchmarks which are obtained on the basis of different area measurement standards?

Answer 1: The critical regulation differences leading to the numerical value differences are identified. Three different categories are investigated in the study, which are unit differences, boundary lines differences and components differences. Regarding unit differences, it is easy to reconcile them by using the conversion formula. As regards to boundary lines differences, whether conversion is need depends on different situations. If limiting face or dominant portion is used to measure boundary lines, the discrepancy of gross floor area

(GFA) values can be ignored. If a few countries like Singapore use the center line of walls to determine GFA, it is suggested to make some modifications individually, which is however not discussed in detail in this study. This study focuses on the inconsistency caused by component differences.

Answer 2: The building components causing the disparity of area measurement standards are identified. Based on the GFA components matrix made by this study, it is shown that the differences of GFA mainly exist in the following thirteen components 1) voids, 2) mezzanine areas with permanent access, 3) stairwells, lift wells and the like, 4) external open-sided balcony 5) internal balcony, 6) uncovered roof terrace, 7) loading platform, 8) areas with a headroom of less than 1.5 m, 9) outbuildings which share at least one wall with the main building, 10) garage, 11) canopy, 12) outside fire stairs, 13) greenhouses, garden stores, fuel stores, and the like.

Answer 3: The influence of building components is analyzed and important differences of building components are identified. Four examples which represent four different facility types are used to illustrate to which extent the different arrangements of building components will influence the value of GFA. It is identified that differences about components 1) mezzanine with permanent access, 2) external open-sided balcony, 3) uncovered roof terrace, 4) loading platforms, 5) areas with headroom of less than 1.5 m, 6) outbuildings sharing at least one wall with the main building and 7) garages cannot be ignored and should be measured separately.

Answer 4: The differences of other area measurement types between countries are investigated. Although some have suggested that it is better to use net floor area (NFA) or usable floor area (UFA) or rentable floor area (RFA) as the measurement basis in some national FM benchmarking programs, GFA is still the most suitable measurement type in an international FM benchmarking.

Answer 5: The modification solution to solve the in-comparability problem caused by area measurement standards is established. The RICS code is chosen as the standard code in the integrating international FM benchmarking program. Then, the non-negligible components differences between other national codes and the RICS code are mapped. Based on the mapping, the additional questions are designed to get further area information in order to make the adjustment of GFA possible.

Question 3: How to establish a uniform currency and price level platform for existing national/regional FM benchmarking pools in order to conduct cross-country comparisons?

Answer 1: The application of PPP as the conversion methodology is confirmed. The market exchange rates (MERs) and PPPs have their own advantages and disadvantages. In terms of procurement and the difficulty of application, the method of MER has its advantages. However, the MER method cannot solve the in-comparability problem caused by

different price levels. To remove the price level factor from the international FM benchmarking program, PPP are chosen as the conversion methodology.

Answer 2: It is decided that PPPs for the FM industry will be calculated in the study. The existing PPPs are mainly for GDP comparison. However, price level differences between different industries are significant. The existing PPPs are great when reflecting the whole economic situation of different countries but cannot present the real price level differences of the FM industry between one country and another. Out of this consideration, PPPs for FM industry are calculated.

Answer 3: The list of FM service inputs is identified, which is used to calculate PPPs for the FM industry. The FM industry is divided into four major parts which are building cleaning, building maintenance, building security and utilities. By considering their specific activities, a comprehensive list of those FM services inputs is made.

Answer 4: The price information for labor in FM industry and utilities is collected. The cost of labor is reflected through salary which is mainly collected from national websites. Utility services are normally provided through service packages with service provisions and their prices differ accordingly. The comparison of utility service prices is therefore complex. With some adjustments, the achievements of other studies in this field are referred to.

Answer 5: The price information for tools/equipment/materials of the FM industry is collected. Each FM service input (basic heading) has a wide range of products. Their prices must be comparable across countries. Otherwise the quality differences will be seen as a price difference leading to incorrect price relations. To avoid this, each product selected is defined precisely. The number of products to be priced per input depends on the heterogeneity of the products. Every country has its own representative products for each input, which may not be representative or even not available in other countries. In this study, only common representative products are counted into the calculation. Due to the limitations of human and material resources, it is impossible to collect price information in local shops worldwide. The method used in this study is acquiring information from big on-line shops. For the prices collected, the delivery costs, VAT and permanent discounts are included.

Answer 6: PPPs for FM industry/sub-industries are calculated. Furthermore, the suitability of different kinds of PPPs are discussed. Instances are used to show how these PPPs can be applied in an international FM benchmarking.

7.2 Implication of the study

Up to now, there are only a few international FM benchmarking programs. Most of them are established based on a uniform area measurement platform. In terms of currency, they use MER to conduct the conversion. IPD benchmarking is one representative. This

kind of international benchmarking requires its organizer to have a great number of data resources and it cannot make use of existing achievements by other national benchmarking pools. Another shortcoming is the unresolved price level issue. Some international FM benchmarking programs may touch this problem in the explanation of results but they have no idea to which extent the price level impacts the results.

Some international FM benchmarking programs like FM Monitor International compare benchmarks in a specific region. They ignore the differences of area measurement and use MER to perform the currency conversion. Although there might be few differences of area measurement standards in this case, this method cannot be widely spread.

There are many national FM benchmarking pools. It would be beneficial to apply the achievements made by those national benchmarking pools. Under this consideration, this study tries to establish a system with which national FM benchmarks can be compared across countries. Three main in-comparability problems are discussed, which are the inconsistency of FM cost classifications and area measurement standards applied by different benchmarking programs and different currencies and various price level situations across countries. Based on the system established by this study, national benchmarks can be compared directly with few and easy adjustments. It is easy to operate and hence has a great practical value. For example, the performance of a facility is measured in a specific country and it can be compared with benchmarks in any other country by very few and easy adjustments which are established in this study. Another example is that the benchmarks of different countries can be compared by excluding the inconsistent factors. It will be identified which country has a higher performance level in a specific field. Then, people can focus on technologies, machines, management procedures and methods used in these countries to find out the fields that are worth learning. The comparison results would be reliable.

7.3 Limitations of the study

1. Using the method pricing FM service inputs instead of pricing FM services to calculate PPPs for the FM industry.

   The method of pricing FM services is more direct and has more comprehensive considerations. However, the prices of FM services might be the trade secret of an FM service company. Normally, their price information is not made public in the same way as the price information of goods, products used in the FM industry. At the current stage, the method of pricing FM service inputs is more feasible. Maybe in the not too distant future, it will also be feasible to use the method of pricing FM services to calculate PPPs for the FM industry.

2. Price level comparisons are only made for five countries.

   In this study, price information is collected from big on-line shops like Amazon, eBay, etc. However, not every country has a mature on-line shopping syste, so that it is impossible for the author to collect price information from the Internet to conduct price level comparison for many countries at the moment. In this study, price information of five countries is collected, which are the United States, the United Kingdom, France, Germany and China. It may be one of the limitations of this study. However, the main purpose of the study is to establish the method. With the quick development of Internet and logistics, this method can surely be widely applied.

3. Some other in-comparability problems across countries are not discussed in the study.

   The inconsistency of FM cost classification and area measurement standards, different currencies and price level situations faced by different benchmarking programs may be the most critical in-comparability problem in international FM benchmarking programs. They are discussed in this study but some other in-comparability problems such as tax, climate, service time, service quality level, etc. are not discussed due to the time cost and work quantity.

7.4 Future study

One of the most important fields of further study is to investigate the influence of some other in-comparability problems such as tax, climate, service time, service quality level etc. on final results of FM benchmarks.

This study suggests to modify GFA by adding or deleting some areas of specific building components. The information of building components is obtained by adding more questions to original questionnaires. It is best to find out if there are some empirical values such as adjustment coefficients based on the experience of data collection. It will greatly reduce the complexity of the adjustment.

Since there is a lot of data processing work, another area for further study is to develop a software for the adjustment procedure.

According to this study, it is possible to establish an international FM benchmarking pool by integrating existing national/regional FM benchmarking pools with some systematic adjustments. The most critical in-comparability problems are 1) FM cost classification, 2) area measurement standards and 3) currency and price level. These issues are discussed systematically and solutions are proposed. Although they are not perfect, a framework for further study in this field is established.

A APPENDIX I: LIST OF FM INPUTS AND WEIGHTS

In order to make a comprehensive and accurate FM inputs list, it is necessary to know the specific activities of FM services. In the following, major FM services are introduced and involved workers, equipment/tools and materials/resources are presented.

A.1 Building cleaning

Building cleaning cost is one of the most expensive components of facility operating especially for offices and hospital buildings (Table A.1).

Table A.1: Building cleaning service expense proportion [33]

Building Types	**Proportion of Cleaning Service Expense**
Office Building	50%
Industrial Building	9%
Education, Research Building	18%
Hospital Building	55%
Residential Building	10%
Average	28%

A.1.1 Weights of inputs

It is said that labor costs generally represent about 80% of the total operation costs in the building cleaning industry[1]. It is supposed that the consumption of equipment/tools and materials accounts for the residual 20%. The aggregation weights of PPPs calculation for FM sub-industry (Step 5) is as follows

$$\text{Labor} : (\text{Equipment} + \text{Materials}) = 80\% : 20\%.$$

[1] http://www.franchisehelp.com/industry-reports/cleaning-industry-report.

A.1.2 List of the building cleaning service inputs

Cleaning services can be divided into several sub-categories which are routine cleaning, glass/window cleaning, floor cleaning. Different cleaning services require different workers and corresponding tools/equipment and consumptive materials which are listed as follows:

Table A.2: Final list of the building cleaning service inputs

Labor inputs	1) Normal cleaning workers	2) Glass cleaning workers of high-rise building	
Non-labor inputs	1) Broom	2) Dust pan	3) Towel
	4) Duster	5) Mop	6) Mop pail
	7) Gloves	8) Spray bottle	9) Squeegee
	10) Scraper	11) Vacuum	12) Carpet cleaning machine
	13) Pole	14) Ladder	15) Scrubber
	16) Bucket	17) Floor waxing machine	18) Tile floor cleaning machine
	19) Wood floor cleaning machine	20) Bathroom cleanser	21) Counter-tops cleanser
	22) Glass detergent cleanser	23) Floor waxing agent	24) Carpet cleanser

A.2 Building maintenance

Building maintenance is another important responsibility of facility management. For some types of buildings, the cost for maintenance are nearly a third of the total operation costs (Table A.3).

Table A.3: Building maintenance service expense proportion [33]

Building Types	Proportion of Maintenance Service Expense
Office Building	16%
Industrial Building	27%
Education, Research Building	29%
Hospital Building	13%
Residential Building	15%
Average	20%

A.2.1 Weights of inputs

According to Building Maintenance Direct Labor Organizations-A management Handbook [7], the cost of building maintenance is divided into five main categories as shown in Figure A.1, which are 1) wages, 2) direct wage related overheads, 3) materials, 4) transport and 5) indirect overheads, where wages and direct wage-related overhead costs take up nearly half of all the operating costs (46%), and other three types of costs accounts for 33%, 9% and 12%, respectively. To simplify the procedure of calculation, only labor costs and non-labor costs are considered. The proportions of these two kinds of inputs can thus be expressed as

$$\text{Labor} : (\text{Equipment} + \text{Materials}) = 46\% : 33\% \approx 60\% : 40\%$$

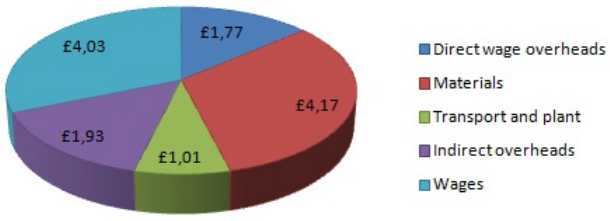

Figure A.1: Five main categories of costs in building maintenance [7]

A.2.2 Representative maintenance workers and list of inputs

Building maintenance tasks are mainly done by three types of technicians, which are plumbers, electronic technicians, and carpenters. Each type of technician has their own typical tools and equipment.

1. Plumbers

   Plumbers install, service and repair water and gas systems for homes, commercial buildings and industrial facilities.

   Requirements for workers: Most plumbers are trained by apprenticeships lasting generally 4-5 years, which normally require 500 to 700 hours of in-class instruction and 7500 to 8000 hours of on-the job training. Once the formal training is completed, in most cases they are required to be licensed.

2. Electricians

   An electrician is a tradesman specializing in the electrical wiring of buildings, stationary machines and related equipment. Electricians may specialize in construction or repair, though they often perform both functions.

   Requirements for workers: Electricians are usually trained by apprenticeships, which normally require up to 600 hours of in-class instruction on safety principles, electrical circuits, blueprint reading and on-the job training. Once the formal training is completed, in most cases they must be licensed.

3. Carpenters

   A carpenter (builder) is a skilled crafts-person who works with timber to construct, install and maintain buildings, furniture and other objects. Their work may involve manual labor and work outside.

   Requirements for workers: Carpentry skill is gained through experience and study. In some countries (such as the US and China), there are no formal training requirements, while in other countries (such as Germany, Japan and Canada), there are strict standards.

Different technicians require different tools and equipment. Table A.4 shows the final list of building maintenance service inputs.

Table A.4: Final list of the building maintenance service inputs

Labor inputs	1) Plumber	2) Electrician	3 Carpenter
Non-labor inputs	1) Measuring tape	2) Telescoping	3) Flashlight
	4) Key hole saw	5) Pocket knife	6) Eye protection
	7) Gloves	8) 2 way pocket screwdriver	9) Adjustable wrench
	10) Air pressure gauge	11) Hammer	12) Chisel
	13) Faucet handle puller	14) Groove joint pliers	15) Hack saw frame
	16) Hex key set	17)Level torpedo style	18) Nut driver
	19) Pipe wrench	20) Lineman pliers	21) Saw - ABS/PVC
	22) Spray bottle	23) Strap wrench	24) Tin snip
	25) Tubing cutters	26) Water pressure gauge	27) Fish tape
	28) Volt/Amp/Ohm multimeter	29) Voltage tester-non contact type	30) GFI Plug tester
	31) Wire strippers	32) Diagonal cutting pliers	33) Cordless drill
	34) Drywall saw	35) Chalk line	36) Cat's paw
	37) Generators	38) Air compressor	39) Circular saw
	40) Reciprocating saw	41) Electric drill	42) Ladders

A.3 Building security

Security management is the process of identifying, implementing and monitoring systems to protect people and building assets against loss, misuse, damage, etc. As presented in Table A.5, the expense spent on security management is relatively small compared to other FM services.

Table A.5: Building security service expense proportion [33]

Building Types	**Proportion of Security Service Expense**
Office Building	5.2%
Industrial Building	3.6%
Education, Research Building	4.0%
Hospital Building	4.9%
Residential Building	2.5%
Average	4.0%

Usually the following services are considered as important to the operation of a security system:

- Monitoring (visualized surveillance and management of access and hazard detection system, as well as CCTV)
- Mobile security patrols
- Provision of static security personnel.

Figure A.2[2] shows the cash flow of a regular security company. Depreciation can be seen as annual equipment/tools costs. Although there are many tools and equipment such as communication radios, pepper spray, restraining devices, stun gun, CCTV cameras, etc., its cost proportion is very small (1%/99%) compared to labor costs (payroll, payroll taxes, employee benefits, training, license and permits). In order to simplify the process of calculation, **the security guard labor** is regarded as the exclusive input of the security management service.

[2] http://www.bplans.com/security_guard_business_plan/financial_plan_fc.php#.UGxDOFGtZKY.

Pro Forma Profit and Loss			
	Year 1	Year 2	Year 3
Sales	**$932,999**	**$1,387,599**	**$2,003,690**
Direct Cost of Sales	$40,701	$61,051	$88,524
Security Guard Labor	$513,149	$763,180	$1,102,029
Total Cost of Sales	**$553,850**	**$824,230**	**$1,190,553**
Gross Margin	$379,149	$563,369	$813,137
Gross Margin %	40.64%	40.60%	40.58%
Expenses			
Payroll	$72,000	$231,000	$260,000
Marketing/Promotion	$33,000	$30,000	$35,000
Depreciation	$703	$11,133	$12,800
Rent	$0	$24,000	$25,200
Utilities	$0	$1,200	$1,260
Insurance	$4,800	$15,000	$18,000
Surety Bond	$1,200	$1,200	$1,200
Payroll Taxes	$87,772	$149,127	$204,304
Employee Benefits	$58,515	$99,418	$136,203
Training	$6,000	$2,000	$3,000
Licenses and Permits	$16,900	$20,000	$25,000
Total Operating Expenses	**$280,890**	**$584,078**	**$721,967**
Profit Before Interest and Taxes	$98,259	($20,709)	$91,169
EBITDA	$98,962	($9,576)	$103,969
Interest Expense	$555	$4,245	$7,200
Taxes Incurred	$29,311	$0	$25,191
Net Profit	**$68,393**	**($24,954)**	**$58,779**
Net Profit/Sales	**7.33%**	**-1.80%**	**2.93%**

Figure A.2: Cash flow of a regular security firm

A.4 Utility services

Utility cost is another significant component of facility operation expenses. In the report of *FM Monitor* (pom+) , it takes second place (Table A.6). In some other FM reports from the US, it even wins first place.

Table A.6: Utility services expense proportion [33]

Building Types	**Proportion of Utility Services Expense**
Office Building	17.1%
Industrial Building	31.9%
Education, Research Building	17.2%
Hospital Building	34.9%
Residential Building	13.1%
Average	22.8%

In most cases, utilities include supply and/or disposal of the following matters:

- Electricity
- Fuel
- Gas
- Water/Sewage
- Telephone
- Internet
- Waste removal.

These seven services are seven basic headings of supply and/or disposal of utilities.

B APPENDIX II: PRODUCT SELECTION FOR THE TOOLS, EQUIPMENT AND MATERIALS

Price collection for PPPs calculation is a complicate procedure and requires extensive considerations. Most basic headings cover a wide range of products, e.g., the basic heading *mop* has many forms, which include twist mop, roller mop, flat mop, rotating mop, wet mop and automatic sponge mop, etc (Figure B.1).

	A	B	C	D	E
Type	Twist mop	Roller mop	Flat mop	Rotating mop	Wet mop
Mop head made from	Microfiber	Absorbent, tear resistant sponge	Microfiber pad	Microfiber	Cotton/microfiber
photos					

Figure B.1: Products under the basic heading "Mop"

Faced with such an array, selecting a subset of products for a basic heading that can be priced for a number of countries is difficult. Besides, the products priced must be comparable across the countries. If they are not, quality differences will be disguised as price differences leading to incorrect price relations. Price levels will be too high for countries pricing superior quality products and too low for countries pricing inferior quality products.

B.1 Product specifications

To avoid the above mentioned situation, each product selected needs to be defined precisely. Firstly, product specifications are defined according to different types of brand. In the OECD PPPs calculation procedure, the types of brand are divided into *Well-known brands* and *Brand-less*. Since FM service tools, equipment and materials are not high-tech product, every country or even every region within a country has their own producers. All products are marked as *Brand-less* in this study, which means products without brand or with a label which is meaningless to consumers.

In Figure B.2, some examples of product specifications are listed. Other details are included in appendix III.

B.2 Number of products to be priced for facility management service input

In Figure B.2, only two products are listed for each FM service input. In fact, the number of products to be priced for each basic heading vary (Figure B.3, Figure B.4 and Figure B.5). It depends on the heterogeneity of products and the importance of the basic heading.

It has to be noted, that in this study *one product does not mean a specific product but a kind of product that has the same or very similar technical parameters listed*. There are so many goods and services on the market, which makes it impossible to collect price information for all of them. Through this method, some goods having different brands but similar functions are regarded as one product. This also creates the possibility for international comparison.

B.3 Representative problem

Each country has its own representative products for each input, which may not be representative or even not available in other countries. According to the OECD method [30] of PPPs calculation, a product list for each basic heading will be made for each country, and the lists will be put together for a comparison. Representative and unrepresentative products are treated differently.

In this study, the author would like to simplify the procedure. Only *representative products* are considered. For each basic heading, the author tries to list all products which can present price variance, then collects prices for each product. *If there is adequate price*

Basic headings	Product A technical parameters	Product B technical parameters
Mop	Brand: Brandless Mop head made from: Washable microfiber pad type: Flat Reference quantity: one mop 	Brand: Brandless Mop head made from: Washable microfiber type: Twist Reference quantity: one mop 
Broom	Brand: Brandless Length: 100-150 cm Lobby made from: corn Handle made from: wood Type: corn broom Reference quantity: one broom 	Brand: Brandless Length: 100-150 cm Lobby made from: polymer fibers Handle made from: metal/steel Type: angle broom Reference quantity: one broom 
Gloves	Brand: Brandless Made from: Nitrile Life cycle: Disposable Function: cleaning Reference quantity: 100 gloves/box 	Brand: Brandless Made from: Rubber Life cycle: Repeatable Function: Cleaning Reference quantity: 1 pair of gloves 

Figure B.2: Product specifications

information of products, it means that the product is representative in this country, otherwise it is unrepresentative. After collecting price information for this basic heading in all compared countries, only common representative products are calculated.

The amount of on-line price information can reflect the utilization extent of the product. As a result, it is assumed that the product is representative when more than five single prices can be obtained in a country, otherwise it is unrepresentative.

	A	B	C	D
Brand	Brandless	Brandless	Brandless	Brandless
Length	100-150 cm	100-150 cm	100-150m	100-150cm
Lobby made from	Corn	Polymer fiber	Horsehair/boar hair	PVC
Handle made from	Wood	Metal/steel	Metal/steel/wood	Metal/steel/wood
Type	Corn broom	Angle broom	Polished floor broom	Push broom
				

Figure B.3: Products to be priced for the basic heading "Broom"

	A
Brand	Brandless
Made from	Plastic
Size	12-24 oz
Trigger	With
	

Figure B.4: Products to be priced for the basic heading "Spray bottle"

Take the basic heading "dust pan" as an example (Table B.1). At the beginning, 6 products (A-F) are checked, but not all of them are representative in all five compared countries.

	A	B	C	D
Brand	Brandless	Brandless	Brandless	Brandless
made from	Plastic	Plastic	Metal	Plastic
Handle	With	Without	Without	With
Additional function	Flexible handle	Without	Without	With wheels
				
	E	**F**		
Brand	Brandless	Brandless		
made from	Plastic/metal	Plastic		
Handle	With	With		
Additional function	With wheels and cover	No		
				

Figure B.5: Products to be priced for the basic heading "Dust Pan"

Seven prices are available for product D in the UK, therefore this product is representative in UK. Only two prices are available for product F in the US, thus it is unrepresentative in US. In this example, only product B and C are equally representative products in all five compared countries. The average price of the basic heading "dust pan" is calculated only with prices of these two products.

Table B.1: Representative products of different countries

Dust Pan							
Products		A	B	C	D	E	F
Product specifications	*Brand*	Brand-less	Brand-less	Brand-less	Brand-less	Brand-less	Brand-less
	Made from	Plastic	Plastic	Metal	Plastic	Plastic/Metal	Plastic
	Handle	With	Without	Without	With	With	With
	Additional function	Flexible handle	No	No	With wheels/ standing	With wheels and cover	No
							
Price collection from US (USD)	*Price 1*	14.97	4.39	10.73	26.12	29.63	1.80
	Price 2	9.98	15.93	10.18	25.71	16.75	3.73
	Price 3	21.48	6.03	15.68	25.04	39.7	
	Price 4	13.86	4.63	19.37	25.14	35.19	
	Price 5		8.15	23.11	44.77	44.77	
	Price 6		17.18	17.88	23.38	83.52	
	Price 7		18.97	15.20	19.56	52.99	
	Price 8		6.52	13.47	24.98	65.73	
	Price 9		13.21	10.28	22.46	30.65	

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	Price 10	13.92	13.28	19.42	32.01
	Average	**10.89**	**14.92**	**25.66**	**43.09**
1.0000	*Average in USD*	10.89	14.92	25.66	43.09
	Price level	1.00	1.00	1.00	1.00
	Price 1	6.71	6.80	13.10	39.99
	Price 2	7.10	8.36	38.98	46.88
	Price 3	6.58	4.59	16.74	44.64
Price	*Price 4*	7.44	9.41	35.94	22.94
collection	*Price 5*	5.46	9.14	26.66	16.49
from UK	*Price 6*	6.02	21.34	20.98	14.00
(GBP)	*Price 7*	6.79	9.48	33.41	13.74
	Price 8	7.99	9.99		19.48
	Price 9	6.77	11.15		47.94
	Price 10	6.94	13.31		19.91
	Average	**6.78**	**10.36**	**26.54**	**28.60**
1.5785	*Average in USD*	10.70	16.35	41.90	45.15
	Price level	0.98	1.10	1.63	1.05
	Price 1	10.89	12.09	67.63	
	Price 2	24.82	8.32	20.45	
Price	*Price 3*	21.29	12.32	36.39	
collection	*Price 4*	18.40	28.46		
from France	*Price 5*	23.92			
(Euro)	*Price 6*	24.82	15.36		

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	Price 7		16.32			
	Price 8		21.12			
	Price 9		36.72			
	Price 10		22.56			
	Average	**20.62**	**20.03**			
1.2484	*Average in USD*	25.83	25.01			
	Price level	2.37	1.68			
Price collection from Germany (Euro)	*Price 1*	7.34	8.77	58.90	17.60	7.20
	Price 2	11.03	6.09	12.73	18.89	18.09
	Price 3	15.80	10.05		14.68	6.40
	Price 4	6.53	13.85		17.17	14.85
	Price 5	9.31	8.04		62.03	
	Price 6	8.81	13.85		41.8	
	Price 7	3.89	12.94		22.70	
	Price 8	15.80	9.99		55.55	
	Price 9	6.53	8.20		13.95	
	Price 10	10.85	9.85		44.45	
	Average	**8.94**	**9.34**		**36.81**	
1.2484	*Average in USD*	11.16	11.16		36.81	
	Price level	1.02	0.78		0.85	
	Price 1	12.80	20.10	80.00	71.00	28.90
	Price 2	16.50	13.00	56.00	38.00	76.80
	Price 3	17.90	15.50	60.00	43.00	35.00

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Price collection from China (CNY)	*Price 4*	16.90	13.00	54.20	44.80
	Price 5	18.40	10.00	54.00	17.50
	Price 6	10.50	45.00	45.00	19.00
	Price 7	23.50	14.50	50.00	19.00
	Price 8	14.00	24.00	46.00	23.88
	Price 9	25.80		51.00	23.50
	Price 10	8.80		42.80	21.00
	Average	**14.16**	**17.58**	**44.50**	**29.04**
0.1573	*Average in USD*	2.76	2.76	7.00	4.57
	Price level	0.20	0.19	0.16	–

C APPENDIX III: PRICE INFORMATION FOR INPUTS OF BUILDING CLEANING INDUSTRY

Price collection for the FM industry is an essential part of this study. In this appendix, price information of tools, equipment and materials for the building cleaning industry is shown.

Basic Heading		1) Broom				
Products		A	B	C	D	
Product Specifications	Brand	brandless	brandless	brandless	brandless	
	Length	100-150 cm	100-150	100-150		
	Lobby made from	corn	polymer fibers	horsehair/boar hair	PVC	
	Handle made from	wood	metal/steel	metal/steel/wood	metal/steel/wood	
	Type	corn broom	angle broom	polished floor broom	push broom	
						
US	Price 1	10.25	12.99	24.98	12.05	
	Price 2	9.93	12.99	28.57	20.16	
	Price 3	10.34	15.04	60	22.98	
	Price 4	14.09	13.29	43.99	31.09	
USD	Price 5	9.82	14.99	30.89	19.24	
	Price 6	17.56	10.75	36.99	49.99	
	Price 7	11.53	17.15	25.67	18.99	
	Price 8	16.88	16.59	40.11	22.75	
	Price 9	16.03	14.99	34.4	50.84	
	Price 10	18.07	15.25	44.92	15.46	
	Average	13.45	14.40	37.05	26.36	22.82
1	Average in USD	13.45	14.40	37.05	26.36	22.82
	Relative price level	1.00	1.00	1.00	1.00	1.00
UK	Price 1	12.53	11.99	35.5	10.8	
	Price 2	14.79	5	19.85	6.99	
	Price 3	17.22	9.98	30.42	13.99	
	Price 4	13.99	7.48	20.99	6.99	
GBP	Price 5	9.93	9.94	31.97	8.95	
	Price 6	14.99	15.84	31	8.39	
	Price 7	11.99	14.18		10.09	
	Price 8	17.45	12.47		13.99	
	Price 9	16.98	13.95		8.33	
	Price 10				18.91	
	Average	14.43	11.20	28.29	10.74	16.17
1.5785	Average in USD	22.78	17.68	44.65	16.96	25.52
	Relative price level	1.69	1.23	1.21	0.64	1.12
France	Price 1	12.89	9.39	23.51	13.7	
	Price 2	13.13	14.2	18.3	17.34	
	Price 3	15.98	22.48	18.95	16.29	
	Price 4	14.46		20.9	17.31	
Euro	Price 5	17.09		19.18	23.98	
	Price 6	7.93		14.22	15.58	
	Price 7	29.14		18.27	19.99	
	Price 8	25				
	Price 9	18.48				
	Price 10					
	Average	17.12	15.36	19.05	17.74	17.32
1.2484	Average in USD	21.38	19.17	23.78	22.15	21.62
	Relative price level	1.59	1.33	0.64	0.84	0.95
Germany	Price 1	10.4	12.45	22.85	15.88	
	Price 2	9.5	15.69	19.99	16.09	
	Price 3	13.01	15.32	14.71	12.96	
	Price 4	10.6	16.9	13.96	17.43	
Euro	Price 5	9.44	14.9	14.9	13.93	
	Price 6	11.25	11.45	19.8	19.95	
	Price 7	8.5	12.5	19.89	14.9	
	Price 8	10.8	17.89	26.77	11.01	
	Price 9	8.8	17.89	19.75	13.4	
	Price 10	8.89	14.9	11.1	16.9	
	Average	10.12	14.99	18.37	13.91	14.35
1.2484	Average in USD	12.63	18.71	22.94	17.36	17.91
	Relative price level	0.94	1.30	0.62	0.66	0.79
China	Price 1	37	20.9	45.9	36	
	Price 2	28	23.5	39.5	18.8	
	Price 3	33	32.9	49.5	20	
	Price 4	30	33.5	47	17.3	
CNY	Price 5	30	25.9	59	17	
	Price 6	34	17.9	52.85	40.9	
	Price 7	49	20.93	27.8	28	
	Price 8	35	20	27	29	
	Price 9	45	32	28	19.8	
	Price 10	28	28	45	22.8	
	Average	34.9	25.55	42.16	22.16	31.19
0.1573	Average in USD	5.49	4.02	6.63	3.49	4.91
	Relative price level	0.41	0.28	0.18	0.13	0.22

Basic Heading		2) Dust pan			2) Dust pan
Products		A	B	C	D
Product Specifications	Brand	brandless	brandless	brandless	brandless
	Made from	plastic	plastic	metal	plastic
	Handle	with	without	without	with
	Additional function	flexible handle	no	no	with wheels standing
					
US	Price 1	14.97	4.39	10.73	26.12
	Price 2	9.98	15.93	10.18	25.71
	Price 3	21.48	6.03	15.68	25.04
	Price 4	13.86	4.63	19.37	25.14
USD	Price 5		8.15	23.11	44.77
	Price 6		17.18	17.88	23.38
	Price 7		18.97	15.2	19.56
	Price 8		6.52	13.47	24.98
	Price 9		13.21	10.28	22.46
	Price 10		13.92	13.28	19.42
	Average		10.89	14.92	25.66
1	Average in USD		10.89	14.92	25.66
	Relative price level		1.00	1.00	1.00
UK	Price 1		6.71	6.8	13.1
	Price 2		7.1	8.36	38.98
	Price 3		6.58	4.59	16.74
	Price 4		7.44	9.41	35.94
GBP	Price 5		5.46	9.14	26.66
	Price 6		6.02	21.34	20.98
	Price 7		6.79	9.48	33.41
	Price 8		7.99	9.99	
	Price 9		6.77	11.15	
	Price 10		6.94	13.31	
	Average		6.78	10.36	26.54
1.5785	Average in USD		10.70	16.35	41.90
	Relative price level		0.98	1.10	1.63
France	Price 1		10.89	12.09	67.63
	Price 2		24.82	8.32	20.45
	Price 3		21.29	12.32	36.39
	Price 4		18.4	28.46	
Euro	Price 5		23.92	27.03	
	Price 6		24.82	15.36	
	Price 7			16.32	
	Price 8			21.12	
	Price 9			36.72	
	Price 10			22.56	
	Average		20.69	20.03	41.49
1.2484	Average in USD		25.83	25.01	51.80
	Relative price level		2.37	1.68	2.02
Germany	Price 1		7.34	8.77	58.9
	Price 2		11.03	6.09	12.73
	Price 3		15.8	10.05	
	Price 4		6.53	13.85	
Euro	Price 5		9.31	8.04	
	Price 6		8.81	13.85	
	Price 7		3.89	12.94	
	Price 8		15.8	9.99	
	Price 9		6.53	8.2	
	Price 10		10.85	9.85	
	Average		8.94	9.34	
1.2484	Average in USD		11.16	11.66	
	Relative price level		1.02	0.78	
China	Price 1		12.8	20.1	80
	Price 2		16.5	13	56
	Price 3		17.9	15.5	60
	Price 4		16.9	13	
CNY	Price 5		18.4	10	
	Price 6		10.5	45	
	Price 7		23.5	14.5	
	Price 8		14	24	
	Price 9		25.8		
	Price 10		8.8		
	Average		14.16	17.58	
0.1573	Average in USD		2.23	2.76	
	Relative price level		0.20	0.19	

Basic Heading			
Products	E	F	
Product Specifications	brandless	brandless	
	plastic/metal	plastic	
	with	with	
	with wheels and cover	no	
			
US	29.63	1.80	
	16.75	3.73	
	39.7		
	35.19		
USD	44.77		
	83.52		
	52.99		
	65.73		
	30.65		
	32.01		
	43.09		12.91
1	43.09		12.91
	1.00		1.00
UK	39.99		
	46.88		
	44.64		
	22.94		
GBP	16.49		
	14		
	13.77		
	19.48		
	47.94		
	19.91		
	28.60		8.57
1.5785	45.15		13.53
	1.05		1.05
France			
Euro			
			20.36
1.2484			25.42
			1.97
Germany	17.6	7.2	
	18.89	18.09	
	14.68	6.4	
	17.17	14.85	
Euro	62.03		
	41.8		
	22.7		
	55.55		
	13.95		
	44.45		
	29.49		9.14
1.2484	36.81		11.41
	0.85		0.90
China	71	28.9	
	38	76.8	
	43	35	
	54.2	44.8	
CNY	54	17.5	
	45	19	
	50	19	
	46	23.88	
	51	23.5	
	42.8	21	
	44.50	29.04	15.87
0.1573	7.00	4.57	2.50
	0.16		0.19

Basic Heading		3) Duster				
Products		A	B	C	D	
Product Specifications	Brand	brandless	brandless	brandless	brandless	
	Made from	eletrostatically-charged fibers	lambswool	microfiber	feather	
						
US	Price 1	7.65	13.04	23.94	5.4	
	Price 2	11.79	12.54	12.96	21.9	
	Price 3	10.29	19.06	24	13.66	
	Price 4	19.47	12.64	15.51	35.94	
USD	Price 5	14.39	12.91	18.19	12.52	
	Price 6	12.64	10.73	28.93	18.74	
	Price 7	17.93	18.9	9.64	5.86	
	Price 8	14	10.9	16.39	14.95	
	Price 9	21.98	13.44	14.23	11.9	
	Price 10	9.98	12.23	18.16	12.08	
	Average	14.01	13.64	18.20	15.30	15.83
1	Average in USD	14.01	13.64	18.20	15.30	15.83
	Relative price level	1.00	1.00	1.00	1.00	1.00
UK	Price 1	3.89	9.12	6.5	13.78	
	Price 2	5.8	5.25	10.5	10.78	
	Price 3	9	7.19	6.99	11.99	
	Price 4	3.2	7.99	12	19.98	
GBP	Price 5	8.5	6.99	6.95	5.45	
	Price 6	8.99	18.25	13.94	2.78	
	Price 7	8.99	9.44	7.75	11.4	
	Price 8	4.58	10.48	5.21	5.45	
	Price 9	7.98	16.02	7.99	13.59	
	Price 10	9	6.64	8.33	12.33	
	Average	6.99	9.74	8.62	10.75	8.79
1.5785	Average in USD	11.04	15.37	13.60	16.97	13.87
	Relative price level	0.79	1.13	0.75	1.11	0.88
France	Price 1	15.74	40.8	12.65	28.9	
	Price 2	12.33		12.17	11.48	
	Price 3	20.82		4.36	14.69	
	Price 4	18.53		12.69	7	
Euro	Price 5	10.95		10.6	30.93	
	Price 6	5.5		21.98	24.17	
	Price 7			10.5	34	
	Price 8			18.3	10.13	
	Price 9			5.46	21.64	
	Price 10			12.8	28.64	
	Average	13.98		12.15	18.99	15.04
1.2484	Average in USD	17.45		15.17	23.71	18.78
	Relative price level	1.25		0.83	1.55	1.19
Germany	Price 1	8.95	17.9	8.99	35.85	
	Price 2	9.64	17.92	20.93	20.9	
	Price 3	3.5	19.78	8.85	31.2	
	Price 4	6.43	14.76	9.64	18.85	
Euro	Price 5	5.75	13.05	4.24	15.1	
	Price 6	10.95	30.83	8.09	25.8	
	Price 7	6.89	37.97	23	22.4	
	Price 8	10.83	16.61	12	19.17	
	Price 9	14.52	14.5	13.93	28.9	
	Price 10	18.72	14.9	20.45	26.83	
	Average	8.17	18.37	11.62	21.61	13.80
1.2484	Average in USD	10.19	22.94	14.51	26.98	17.23
	Relative price level	0.73	1.68	0.80	1.76	1.09
China	Price 1	37	38.9	26	35	
	Price 2	47	43.9	24.86	90	
	Price 3	29	60	13.5	175	
	Price 4	27	69	53	60	
CNY	Price 5	10	70	17.8	62	
	Price 6	18	75	14	86	
	Price 7	28	70	64	58	
	Price 8	50	85	21.8	78	
	Price 9	20	76	25.6	49	
	Price 10	23.6	41	22	59	
	Average	26.16	55.88	21.86	69.40	39.14
0.1573	Average in USD	4.11	8.79	3.44	10.92	6.16
	Relative price level	0.29	0.64	0.19	0.71	0.39

Basic Heading		4) Mop						
Products		A	B	C	D	E	F	
Product Specifications	Brand	brandless	brandless	brandless	brandless	brandless	brandless	
	Mop head made from	microfiber	sponge	microfieber pad	microfiber	cotton	sponge	
	Type	twist mop	roller mop	flat mop	rotating mop	wet mop	sponge mop	
								
US	Price 1	15.66	25.06	20.45	19.93	24.13	16.52	
	Price 2	12.7	22.87	31.49	17.42	13.31	27.12	
	Price 3	12.99	9.44	37.65	19.92	14.73	25.12	
	Price 4	22.49	23	18.72	23.54	24.92	21.44	
USD	Price 5	11.99	20.08	29.99	27.42	11.2	15.36	
	Price 6	13.45	29.99	25.05	17.1	26.64	21.61	
	Price 7	11.59	18.92	21.33	21.72	5.16	32.32	
	Price 8	11.58	18.98	28.99	12.83	12.87	30.52	
	Price 9	11.85	13.65	35.68	26.99	15.25	24.46	
	Price 10	11.89	29.99	20.86	18.97	20.91	21.08	
	Average	13.62	21.20	27.02	20.58	16.91	23.56	20.61
1	Average in USD	13.62	21.20	27.02	20.58	16.91	23.56	20.61
	Relative price level	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UK	Price 1	6.49	11.49	12	7.95	8.53	6.98	
	Price 2	12	11.84	15.23	6	1.99	5.7	
	Price 3	17.97	16.99	22.42	11.49	7.5	13.98	
	Price 4	11.41	11.99	20.99	13.99	5.99		
GBP	Price 5	5.99	13.5	14.99	8.94	2.45		
	Price 6	4.59	16.99	34.07	7.98	13.2		
	Price 7	8.9	14.94	10.92	7.78	8.63		
	Price 8	4.5	10.79	12.99	6.89	12.76		
	Price 9	9.97	10.98	29.95	10.99	9.94		
	Price 10	4.5	12.97	10	7.98	7.95		
	Average	8.63	13.25	18.36	9.00	7.89		13.41
1.5785	Average in USD	13.63	20.91	28.97	14.20	12.46		21.17
	Relative price level	1.00	0.99	1.07	0.69	0.74		1.03
France	Price 1	18.9	17.59	29.98	16.95	9.97	46.8	
	Price 2	40	19.19	22.4	25.49	7.71	54.7	
	Price 3	40	19.49	19.95	19.4	17.5	35.9	
	Price 4	40	19.49	15.8	19	30.04		
Euro	Price 5	41	24.9	22.5	19.99	27.74		
	Price 6		19.94	24.9	25.49	8.98		
	Price 7		15.68	18.89	34.95	44.99		
	Price 8		34.6	42	34.95	17.1		
	Price 9		20	15.8	44.9			
	Price 10			16.8	40			
	Average	35.98	21.21	22.90	28.11	20.50		26.70
1.2484	Average in USD	44.92	26.48	28.59	35.10	25.60		33.33
	Relative price level	3.30	1.25	1.06	1.70	1.51		1.62
Germany	Price 1	7.89	13.84	29.76	56.94	7.49		
	Price 2	19.9	21.98	9.68	18.02	9.64		
	Price 3	7.94	28.89	18.72	43.85	7.4		
	Price 4	8.5	12.99	34.39		17.98		
Euro	Price 5	7.94	19.99	24.98		7.9		
	Price 6	12.94	29.5	16.49		15.89		
	Price 7	7.89	29.9	21.73		10.5		
	Price 8	7.88	17.8	64.26				
	Price 9	13.94	34.89	19.6				
	Price 10	6.2	41.9	39.99				
	Average	10.10	25.17	27.96		10.97		21.08
1.2484	Average in USD	12.61	31.42	34.91		13.70		26.31
	Relative price level	0.93	1.48	1.29		0.81		1.28
China	Price 1	37	39	59.5	31.9	35		
	Price 2	28.8	29.8	29.9	28	59		
	Price 3	32.8	71.55	56.8	38.8	79		
	Price 4	35.5	35.9	40	39.9			
CNY	Price 5	47	88	79	41.5			
	Price 6	26	28	60.93	50.1			
	Price 7	32.9	46	45	51.5			
	Price 8	34	69	59.56	75			
	Price 9	50	63.7	56.44	39			
	Price 10	24.9	38	64	31			
	Average	31.60	50.90	55.11	42.67			45.87
0.1573	Average in USD	4.97	8.01	8.67	6.71			7.22
	Relative price level	0.36	0.38	0.32	0.33			0.35

Basic Heading		5) Mop pail				6) Janitorial cart		
Products		A	B			A	B	
Product Specifications	Brand Wringer Caster	brandless with without	brandless without without		Brand Wringer Caster Size	brandless with with big	brandless with with small	
								
US	Price 1	22.62	18.99			109.22	45.07	
	Price 2	17.17	11.62			166.75	35.98	
	Price 3	40.27	23.42			225.57	62.29	
	Price 4	17.5	19.88			356	186.04	
USD	Price 5	38.05	14.17			172.71	99.22	
	Price 6	22.23	8.03			148.64	56.65	
	Price 7	21.93	14.95			260.65	174.65	
	Price 8	24.28	10.35			265.63	54.84	
	Price 9	22.03	26.35			293.5	107.56	
	Price 10	23.34	19.94			302.34	90	
	Average	24.94	16.77	20.86		230.10	91.23	160.67
1	Average in USD	24.94	16.77	20.86		230.10	91.23	160.67
	Relative price level	1.00	1.00	1.00		1.00	1.00	1.00
UK	Price 1	7.29	4			240.4	55.95	
	Price 2	9.72	4.44			265.58	55.59	
	Price 3	12.08	1.99			231.97	37.98	
	Price 4	19.98	7.38			266.02	58.29	
GBP	Price 5	12.98	4.8			249.98	37.98	
	Price 6	6.5	4.24			240.84	40.45	
	Price 7	10.82	10.44			155.98	46	
	Price 8	8.98	6			472.95	39.49	
	Price 9	6	7.58			202.4	48.49	
	Price 10	4.99	8.07			195.65	39.49	
	Average	9.93	5.89	7.91		252.18	45.97	149.07
1.5785	Average in USD	15.68	9.30	12.49		398.06	72.57	235.31
	Relative price level	0.63	0.55	0.60		1.73	0.80	1.46
France	Price 1	24.9	18.85			221.44	66.59	
	Price 2	39.95	12.73			246.19	52.61	
	Price 3	20.45	16.01			397.08	78.07	
	Price 4	37.15	16.43			198.49	52.41	
Euro	Price 5	14.61	24.7			343.49	100.46	
	Price 6	42.8	20.4			204.03	148.49	
	Price 7	11.53	3.11			322.52	110.29	
	Price 8	13.29	17.17			240.91	90	
	Price 9		12.71			336	84.99	
	Price 10		17.8			387.58	135	
	Average	25.59	15.99	20.79		289.77	91.89	190.83
1.2484	Average in USD	31.94	19.96	25.95		361.75	114.72	238.23
	Relative price level	1.28	1.19	1.24		1.57	1.26	1.48
Germany	Price 1	12.4	5.48			122.99	155.92	
	Price 2	14.44	11.68			312.8	74.95	
	Price 3	49.39	14.01			183.99	64.5	
	Price 4	12.95	7.25			273.69	32	
Euro	Price 5	10.5	16.85			159.95	57.85	
	Price 6	12.94	8.39			81.87	133.95	
	Price 7	13.89	6.4			85.85	69.99	
	Price 8	28.97	9.8			115.99	39.99	
	Price 9	16.7	17.98			115.19	44.71	
	Price 10	13.8	6.43			115.8	69.99	
	Average	18.60	10.43	14.51		156.81	74.39	115.60
1.2484	Average in USD	23.22	13.02	18.12		195.76	92.86	144.31
	Relative price level	0.93	0.78	0.87		0.85	1.02	0.90
China	Price 1	46	40			380	160	
	Price 2	46	32.2			218	106	
	Price 3	38	41			400	140.01	
	Price 4	56	30			310	192	
CNY	Price 5	24.8	27.5			310	178	
	Price 6	79	27.7			388	110.01	
	Price 7	39	34.85			260	196	
	Price 8	43	29			370	153	
	Price 9	28	24.14			275	193	
	Price 10	38	27.25			335	195	
	Average	43.78	31.36	37.57		324.60	162.30	243.45
0.1573	Average in USD	6.89	4.93	5.91		51.06	25.53	38.29
	Relative price level	0.28	0.29	0.28		0.22	0.28	0.24

Basic Heading		7) Gloves				8) Spray bottle		
Products		A	B	C			A	
Product Specifications	Brand	brandless	brandless	brandless		Brand	brandless	
	Made from	nitrile	rubber	rubber		Made from	plastic	
	Disposable/Repeatable	disposable	repeatable	repeatable		Size	12-24oz	
	Quantity	100/box	1 Pair	1 Pair		Trigger	with	
	Function		cleaning	heavy duty				
								
US	Price 1	17.84	7.2	12.24			6.39	
	Price 2	9.32	3.55	14.45			7	
	Price 3	9.19	8.88	7.89			10.98	
	Price 4	17.57	13.95	20.64			3.41	
USD	Price 5	18.98	5.41	7.26			6.95	
	Price 6	19.98	3.18	20.64			13.95	
	Price 7	18.54	3.99	17.29			6.94	
	Price 8	13.69	7.75	10.18			7.21	
	Price 9	12.49	3.45	21.15			7.44	
	Price 10	13.13	7.78	28.45			7.13	
	Average	15.07	6.51	16.02	11.27		7.74	7.74
1	Average in USD	15.07	6.51	16.02	11.27		7.74	7.74
	Relative price level	1.00	1.00	1.00	1.00		1.00	1.00
UK	Price 1	9.99	6.94	5.95			5.27	
	Price 2	6.4	3.24	13.98			4.31	
	Price 3	9.79	2.27	16.99			4.87	
	Price 4	5.98	3.46	5.11			4.94	
GBP	Price 5	7.1	3.08	10.18			3.48	
	Price 6	7.13	4.95	2.05			3.17	
	Price 7	8.48	5.81	5.11			4.99	
	Price 8	4.9	3.99	6.63			5.35	
	Price 9	6.99	3	7.5			4.5	
	Price 10	8.95	3.18	9.88			4.6	
	Average	7.57	3.99	8.34	6.17		4.55	4.55
1.5785	Average in USD	11.95	6.30	13.16	9.73		7.18	7.18
	Relative price level	0.79	0.97	0.82	0.86		0.93	0.93
France	Price 1	20.31	12.45	9.06			6.12	
	Price 2	49.00	15.3	9.13			9.17	
	Price 3	7.68	19.9	21.52			13.08	
	Price 4		7.48	15.67			6.1	
Euro	Price 5		23.85	20.15			15.51	
	Price 6		12.32	22.63			11.98	
	Price 7		20.19	23.84			9.48	
	Price 8		14.14	8.6			10.6	
	Price 9		13.37	9.32			8.69	
	Price 10		7.98	22.63			12.15	
	Average		14.70	16.26	15.48		10.29	10.29
1.2484	Average in USD		18.35	20.29	19.32		12.84	12.84
	Relative price level		2.91	1.54	1.99		1.66	1.66
Germany	Price 1	7.99	2.54	10.89			6.95	
	Price 2	12.8	13.99	8.82			7.95	
	Price 3	10.54	12.85	7.94			7.99	
	Price 4	12.7	5.53	15.59			10.37	
Euro	Price 5	9.48	13.11	15			5.86	
	Price 6	7.99	5.7	4.98			6.79	
	Price 7	23.4	21.99	25.5			8.24	
	Price 8	15.91	7.03	11.6			6.85	
	Price 9	21.79	4.09	9.89			15.85	
	Price 10	9.47	15.85	9.89			8.85	
	Average	13.21	10.27	12.01	11.14		8.57	8.57
1.2484	Average in USD	16.49	12.82	14.99	13.91		10.70	10.70
	Relative price level	1.09	1.97	0.94	1.23		1.38	1.38
China	Price 1	53.5	30.01	28			9	
	Price 2	55	9.4	14.5			14.5	
	Price 3	38.5	14.48	10.88			16	
	Price 4	52.3	23.2	21			13	
CNY	Price 5	53.3	23	10.39			15	
	Price 6	38	10.4	29			15.5	
	Price 7	40	13.9	16			23	
	Price 8	65	18.33	45			25	
	Price 9	48	10.96	28			18	
	Price 10	42.9	20.8	11.8			20.5	
	Average	48.65	17.45	21.46	19.45		16.95	16.95
0.1573	Average in USD	7.65	2.74	3.38	3.06		2.67	2.67
	Relative price level	0.51	0.42	0.21	0.27		0.34	0.34

Basic Heading		9) Squeegee				10) Scraper	
Products		A	B	C		A	
Product Specifications	Brand	brandless	brandless	brandless	Brand	brandless	
	Scrubber	without	with	with	Made from	plastic/steel	
	Telescopic pole	without	without	with			
	Head size	10-14 Inch	10-14 Inch	10-14 Inch			
							
US	Price 1	11.98	14.1	22.97		15.43	
	Price 2	19.98	34.49	14.39		4.77	
	Price 3	11.24	12.79	16.94		4.61	
	Price 4	14.75	26.99	17.06		5.2	
USD	Price 5	23.83	29.49	17.33		4.79	
	Price 6	14.98	13.9	61.13		6.9	
	Price 7	17.2	18.96	22.99		3.74	
	Price 8	14.95	34.14	26.19		4.61	
	Price 9	26.24	21.14	26.72		6.99	
	Price 10	11.15	21.49	18.35		4.9	
	Average	16.63	22.75	24.41	20.52	6.19	6.19
1	Average in USD	16.63	22.75	24.41	20.52	6.19	6.19
	Relative price level	1.00	1.00	1.00	1.00	1.00	1.00
UK	Price 1	9.56	10.97	10.99		2.82	
	Price 2	13.89	10.98	9.48		3.5	
	Price 3	5.76	8.24	12.95		3.08	
	Price 4	12.1	13.48	12.95		2.46	
GBP	Price 5	5.69	9.29	12.38		2.85	
	Price 6	2.28	21.98	8.94		2.98	
	Price 7	3.27	14.98	11.98		2.98	
	Price 8	12.37	11.98	14.98		3.34	
	Price 9	4.2	3.97	10.95		4.23	
	Price 10	2.99	7.35	14.98		3.08	
	Average	7.21	11.32	12.06	9.63	3.13	3.13
1.5785	Average in USD	11.38	17.87	19.03	15.21	4.94	4.94
	Relative price level	0.68	0.79	0.78	0.74	0.80	0.80
France	Price 1	11.5	48.6	14.8		5.7	
	Price 2	7.25	19.95	27		7.1	
	Price 3	18.7	40.9	20		3.49	
	Price 4	7.12	28.58	30		9.16	
Euro	Price 5	9	17.49	27.89		5	
	Price 6	10	28.74	28.8		7.49	
	Price 7	7.7	24.99	26.49		7.8	
	Price 8	11	34.22	30.98		4.9	
	Price 9	13.4	36.2	13.15		4.85	
	Price 10	17.8	28.74	24.78		7.8	
	Average	11.35	30.84	24.39	17.87	6.33	6.33
1.2484	Average in USD	14.17	38.50	30.45	22.31	7.90	7.90
	Relative price level	0.85	1.69	1.25	1.09	1.28	1.28
Germany	Price 1	10.64	18.71	25.4		7.03	
	Price 2	21.89	18.65	24.78		8.46	
	Price 3	9.24	8.89	34.95		10.67	
	Price 4	11.39	34.15	33.8		6.58	
Euro	Price 5	12.95	29.19	31.8		7.38	
	Price 6	13.33	25.97	28.96		4.99	
	Price 7	8.83	26.79	22.94		3.99	
	Price 8	17.95	24.47			3.66	
	Price 9	14.32	14.3			4.88	
	Price 10	16.28	25.05			2.62	
	Average	13.68	22.62	28.95	21.31	6.03	6.03
1.2484	Average in USD	17.08	28.24	36.14	26.61	7.52	7.52
	Relative price level	1.03	1.24	1.48	1.30	1.21	1.21
China	Price 1	11.5	25	38		8	
	Price 2	35	21	37.54		12	
	Price 3	38.6	44	52		11	
	Price 4	10.5	27.8	54		11	
CNY	Price 5	13.5		54		10	
	Price 6	11.8		35.01		7	
	Price 7	10		48.36		8	
	Price 8	13.88		44		13.8	
	Price 9	35		49.5		23	
	Price 10	10.5		34.8		10.5	
	Average	19.03		44.72	31.87	11.43	11.43
0.1573	Average in USD	2.99		7.03	5.01	1.80	1.80
	Relative price level	0.18		0.29	0.24	0.29	0.29

Basic Heading		11)Vacuum			
Products		A	B	C	
Product Specifications	Brand	brandless	brandless	brandless	
	Watt	<1000w	1000w~1200w	1200w	
	Weight	< 10 pounds	10 ~ 25 pounds	10 ~ 25 pounds	
	Power cord	<=20 foot	20~29 foot	20~29 foot	
					
US	Price 1	38.99	89.99	299	
	Price 2	33.98	59.87	399	
	Price 3	49	59	432.98	
	Price 4	29.99	154.53	479	
USD	Price 5	32.08	129	289.99	
	Price 6	51.09	58.98	329.99	
	Price 7	23.09	75	379	
	Price 8	63.51	149.99	399	
	Price 9	49.99	89.99	225.99	
	Price 10	33.4	79.99	245.98	
	Average	40.51	94.63	347.99	67.57
1	Average in USD	40.51	94.63	347.99	67.57
	Relative price level	1.00	1.00	1.00	1.00
UK	Price 1	28.82	47.99	265.16	
	Price 2	29.4	95.99	125.99	
	Price 3	23.99	64.99	203.99	
	Price 4	28.98	115.99	123.69	
GBP	Price 5	41.99	54.98	234.5	
	Price 6	53.99	44.98	279.99	
	Price 7	51.58	124	197.99	
	Price 8	27.99	102.78	336.98	
	Price 9	29.99	74.98	299.99	
	Price 10	37.98	64.33	163.4	
	Average	35.47	79.10	223.17	57.29
1.5785	Average in USD	55.99	124.86	352.27	90.43
	Relative price level	1.38	1.32	1.01	1.34
France	Price 1	35.89	53.9	292.47	
	Price 2	44.9	46.5	247.89	
	Price 3	22.9	80.98	298.79	
	Price 4	45.99	132.89	278.5	
Euro	Price 5	39.9	68.99	221.9	
	Price 6	32.41	62.19	322.27	
	Price 7	27.15	77.47	329	
	Price 8	37	85	289	
	Price 9	38	84.59	278.5	
	Price 10	29.8	89.01	336.18	
	Average	35.39	78.15	289.45	56.77
1.2484	Average in USD	44.19	97.56	361.35	70.88
	Relative price level	1.09	1.03	1.04	1.05
Germany	Price 1	22.72	79	248	
	Price 2	21.98	105	319.9	
	Price 3	22.98	69	369.9	
	Price 4	45.96	46	299.9	
Euro	Price 5	27.99	92	359.9	
	Price 6	67.79	82.99	387.95	
	Price 7	26.89	76.33	359.9	
	Price 8	27.79	70.99	286.9	
	Price 9	28.9	54.98	334.99	
	Price 10	26.4	76.98	329	
	Average	31.94	75.33	329.63	53.63
1.2484	Average in USD	39.87	94.04	411.52	66.96
	Relative price level	0.98	0.99	1.18	0.99
China	Price 1	296	645		
	Price 2	224	1929		
	Price 3	1011	1992		
	Price 4	575	971		
CNY	Price 5	292	322		
	Price 6	194	698		
	Price 7	370	796		
	Price 8	200	1194		
	Price 9	213	1121		
	Price 10	189	1054		
	Average	356.40	1072.20		714.30
0.1573	Average in USD	56.06	168.66		112.36
	Relative price level	1.38	1.78	0.00	1.66

Basic Heading		12) Carpet cleaning machine			
Products					
Product Specifications	Brand	brandless	brandless	brandless	
	Watt	<2300w	2300w ~4600w	>4600w	
	Pump	*	100 -180 PSI	500 PSI	
	Level	household	professional small	professional big	
					
US	Price 1	139.98	510.46	1404.59	
	Price 2	168.98	543.15	1499	
	Price 3	152.74	534	1304.49	
	Price 4	103.86	595	2089.99	
USD	Price 5	225.54	428.22	1938.99	
	Price 6	139.99	520.12	1242.6	
	Price 7	219.98	698	1709.99	
	Price 8	149	833.49	1066.04	
	Price 9	89.92	1030.99	2078.99	
	Price 10	92	553.73	1970	
	Average	148.20	624.72	1630.47	386.46
1	Average in USD	148.20	624.72	1630.47	386.46
	Relative price level	1.00	1.00	1.00	1.00
UK	Price 1	107.99	511.11	1545	
	Price 2	136.95	397	1434	
	Price 3	209.99	429	1740	
	Price 4	72.72	699.99	1395	
GBP	Price 5	172.97	468.99	2892.8	
	Price 6	189.97	468.99	1812.8	
	Price 7	129.99	458	1844	
	Price 8	99.97	781.95	1434	
	Price 9	67.99	695	1999	
	Price 10	73.98	439.99	1299.99	
	Average	126.25	535.00	1739.66	330.63
1.5785	Average in USD	199.29	844.50	2746.05	521.89
	Relative price level	1.34	1.35	1.68	1.35
France	Price 1	106.2	1049.39	1517.2	
	Price 2	114.94	1444.53		
	Price 3	148.19	1378.87		
	Price 4	351.4	1305.63		
Euro	Price 5	506.56	1186.73		
	Price 6	255	1108.77		
	Price 7	247	1271.33		
	Price 8	119.09			
	Price 9	148			
	Price 10	329			
	Average	232.54	1249.32		740.93
1.2484	Average in USD	290.30	1559.65		924.98
	Relative price level	1.96	2.50		2.39
Germany	Price 1	136.9	398	1770	
	Price 2	119.99	379	1241.29	
	Price 3	168.12	598	1370.17	
	Price 4	134.8	648.9	1913.45	
Euro	Price 5	112.49	418.99	3558.1	
	Price 6	199.49	499.01		
	Price 7	129.99	512.1		
	Price 8	87.98	397.89		
	Price 9	106.4	499		
	Price 10	196.9	666.4		
	Average	139.31	501.73	2059.20	320.52
1.2484	Average in USD	173.91	626.36	2570.71	400.13
	Relative price level	1.17	1.00	1.58	1.04
China	Price 1	3850	5960	16000	
	Price 2	3600	3130	13100	
	Price 3	2415	5030	25900	
	Price 4	3100	4540	23588	
CNY	Price 5	3900	5020	13000	
	Price 6	3860	6880	16920	
	Price 7	3150	6930	12900	
	Price 8	3893	6650	19050	
	Price 9	4091	6520	15088	
	Price 10	2700	4980	13880	
	Average	3455.90	5564.00	16942.60	4509.95
0.1573	Average in USD	543.61	875.22	2665.07	709.42
	Relative price level	3.67	1.40	1.63	1.84

Basic Heading		13) Tile & hardwood cleaning machine				14) Scrubber	
Products		A	B	C		A	
Product Specifications	Brand	brandless	brandless	brandless	Brand	brandless	
	Motor/watt	<400	400~800	>=800	Size	14-18 inch	
	Weight	<18 pounds	18~35 pounds	>30 pounds			
	Level	household	professional	professional			
							
US	Price 1	133.47	299	481		18.99	
	Price 2	179	205.88	760.62		12.02	
	Price 3		219	552.49		20.94	
	Price 4		159	716.26		20.31	
USD	Price 5		399	1215.4		13.65	
	Price 6		199.98	838.15		14.89	
	Price 7		185	789.55		20.71	
	Price 8		225.99	609.02		28.7	
	Price 9		252.75	1004.25		18.27	
	Price 10		284	725		18.99	
	Average		242.96	769.17	506.07	18.75	18.75
1	Average in USD		242.96	769.17	506.07	18.75	18.75
	Relative price level		1.00	1.00	1.00	1.00	1.00
UK	Price 1	69.95	174.99	1195		4.95	
	Price 2	84.95	178.98	514.99		5.06	
	Price 3	80.16	154.49	850		5.08	
	Price 4	80.54	154.5	973.28		7.07	
GBP	Price 5	79.85	151.88	749.72		7.68	
	Price 6	69.9	155.13	795		3.76	
	Price 7	69.95	154.99	699		3.28	
	Price 8	85.99	93.98	328		6.64	
	Price 9	79.95	99.99	643.54		5.35	
	Price 10	87.99	174.99	499.21		5.7	
	Average	78.92	149.39	724.77	437.08	5.46	5.46
1.5785	Average in USD	124.58	235.82	1144.06	689.94	8.61	8.61
	Relative price level		0.97	1.49	1.36	0.46	0.46
France	Price 1		774.15	1517.2		9.58	
	Price 2		1190.9	1105.92		13.49	
	Price 3		1118.6	1339.39		25.75	
	Price 4		773.62	1290.8		25.9	
Euro	Price 5		812.86	449.85		19.8	
	Price 6		980	1580.54		20.42	
	Price 7		1108	1535.39		24.04	
	Price 8		840.9	1580.54		31.8	
	Price 9		773.97	1230		29.85	
	Price 10		749	449		19.77	
	Average		912.2	1207.863	1060.03	22.04	22.04
1.2484	Average in USD		1138.79	1507.90	1323.34	27.51	27.51
	Relative price level		4.69	1.96	2.61	1.47	1.47
Germany	Price 1	362.52	151.39	449.95		16.47	
	Price 2	345.9	423.83	479		23.98	
	Price 3	429	212	297.6		7.29	
	Price 4	349	249	1302.9		19.4	
Euro	Price 5	348.88	421.9	569		13.85	
	Price 6	364.8	525	1195		12.75	
	Price 7	199	188.28	925		12.2	
	Price 8	465	155	1995		11.65	
	Price 9	371	443	1395		13.45	
	Price 10	408	450.59	795		10.75	
	Average	364.31	322.00	940.35	631.17	14.18	14.18
1.2484	Average in USD	454.80	401.98	1173.93	787.96	17.70	17.70
	Relative price level		1.70	1.03	1.14	0.94	0.94
China	Price 1	539	2682.75	5500		14	
	Price 2	498	935	7550		11	
	Price 3	498	1910	3300		11	
	Price 4	968.6	3577	4530		15	
CNY	Price 5	498	3980	5560		17	
	Price 6	478.24	3340	1980		11.4	
	Price 7	999	2026	3008		14.88	
	Price 8	859	1364	2600		14.8	
	Price 9	498	1880	2649		15	
	Price 10	638		4660		17.5	
	Average	647.38	2410.53	4133.70	3272.11	14.16	14.16
0.1573	Average in USD	101.83	379.18	650.23	514.70	2.23	2.23
	Relative price level		1.56	0.85	1.02	0.12	0.12

Basic Heading		15)Telescopic poles			
Products		A	B	C	
Product Specifications	Brand	brandless	brandless	brandless	
	Maximum length	15-20 Feet	11-14 Feet	4-8 Feet	
					
US	Price 1	41.85	32.66	18.49	
	Price 2	28.98	18.29	24	
	Price 3	61.06	18.24	9.25	
	Price 4	39.74	19.19	11.16	
USD	Price 5	42.4	19.78	10.95	
	Price 6	37.7	29.98	18.96	
	Price 7	36.75	17.49		
	Price 8	32.35	22.49		
	Price 9	41.51	35.49		
	Price 10	44.46	27.63		
	Average	40.68	24.12	15.47	26.76
1	Average in USD	40.68	24.12	15.47	26.76
	Relative price level	1.00	1.00	1.00	1.00
UK	Price 1	45.88	43.75	15.49	
	Price 2	39.39	41.48	33.59	
	Price 3	47.73	31.13	21.73	
	Price 4	52.64	37.99	40.65	
GBP	Price 5	32.49	22.98	54.34	
	Price 6	23.51	24.49	9.9	
	Price 7	24.79	30.4	37.11	
	Price 8	63.33	35.66	22.4	
	Price 9	49.15	29.16	26.55	
	Price 10	47.39	29.37	21.7	
	Average	42.63	32.64	28.35	34.54
1.5785	Average in USD	67.29	51.52	44.74	54.52
	Relative price level	1.65	2.14	2.89	2.04
France	Price 1	39	40.46	22.22	
	Price 2	60.9	31.1	24.9	
	Price 3	50.82	51.68	34.58	
	Price 4	30.11	52.51	49.7	
Euro	Price 5	49.16	31	35.1	
	Price 6		54.94	16.99	
	Price 7		49.84	36.63	
	Price 8		29.14	28.27	
	Price 9		27.62	16.39	
	Price 10		37.9	21.3	
	Average	46.00	40.62	28.61	38.41
1.2484	Average in USD	57.42	50.71	35.71	47.95
	Relative price level	1.41	2.10	2.31	1.79
Germany	Price 1	40.61	22.7	40.65	
	Price 2	51.9	47	20.45	
	Price 3	53.8	42.39	20.44	
	Price 4	66	42.38	22.69	
Euro	Price 5	73.8	42.4	28.9	
	Price 6	73.79	44.67	28.74	
	Price 7	76.14	47	28.75	
	Price 8	64.86	32.99	29.9	
	Price 9	59.05	42.45	30	
	Price 10	46.25	42	31.2	
	Average	60.62	40.60	28.17	43.13
1.2484	Average in USD	75.68	50.68	35.17	53.84
	Relative price level	1.86	2.10	2.27	2.01
China	Price 1	81	48	34	
	Price 2	63	58	26	
	Price 3	85	48	26	
	Price 4	63	60	26	
CNY	Price 5	77	51	19	
	Price 6	90	53	22	
	Price 7	70	57.5	46	
	Price 8	98	53	28	
	Price 9	79	48	20	
	Price 10	58	50	33	
	Average	76.40	52.65	28.00	52.35

Basic Heading		116) Ladder				
Products		A	B	C	D	
Product Specifications	Brand	brandless	brandless	brandless	brandless	
	size	4.5-8 m	2.8-4m	<2.8m	3 -Step	
	made from	aluminum	aluminum	aluminum	platinum/aluminum	
	telecoping	yes	yes	no	no	
	platform	without	without	without	with	
						
US	Price 1	216	114	93.8	59.99	
	Price 2	119.98	173.82	79.99	70.9	
	Price 3	159.58	172.53	86.98	72.96	
	Price 4	165.53	176.11	91.98	72.98	
USD	Price 5	339.99	111.94	105.05	34.99	
	Price 6	259.99	148.23	127.88	52.97	
	Price 7	358.99	170.99	123.55	46.95	
	Price 8	246.87	239.99	109.4	52.66	
	Price 9	228.83	249.99	54.05	27.54	
	Price 10	399	170.99	136.67	62.99	
	Average	249.48	172.86	100.94	55.49	144.69
1	Average in USD	249.48	172.86	100.94	55.49	144.69
	Relative price level	1.00	1.00	1.00	1.00	1.00
UK	Price 1	139.99	68.74	56.99	19.9	
	Price 2	85.95	93.97	61.16	19.99	
	Price 3	99.99	67.99	61.94	20.86	
	Price 4	149.99	88.94	59.99	20.69	
GBP	Price 5	116.99	89.65	33.99	20.3	
	Price 6	114.99	114.91	82.5	29.99	
	Price 7	141.83	64	45.98	33.59	
	Price 8	142.99	75.99	79.99	40.79	
	Price 9	118.74	148.05	62.99	42.75	
	Price 10	119.99	59.95	68.93	20.95	
	Average	123.15	87.22	61.45	26.98	74.70
1.5785	Average in USD	194.38	137.68	96.99	42.59	117.91
	Relative price level	0.78	0.80	0.96	0.77	0.81
France	Price 1	95	105.17	97.2	36.9	
	Price 2	132.39	93.22	79.99	76.1	
	Price 3	205.99	84.8	91.98	41	
	Price 4	194.49	136	115.14	54.3	
Euro	Price 5	99.99	92	194.49	51.5	
	Price 6	228.99	93.22	55.26	49.9	
	Price 7	210.59	95.8	84.8	60	
	Price 8	81.89	132	64.99	38.9	
	Price 9	75.98	86.15	95.85	46.9	
	Price 10	204.81	141.17	104.5	42.9	
	Average	153.01	105.95	98.42	49.84	101.81
1.2484	Average in USD	191.02	132.27	122.87	62.22	127.09
	Relative price level	0.77	0.77	1.22	1.12	0.88
Germany	Price 1	74.85	79.94	152.9	39.99	
	Price 2	258	76.89	49.19	43.65	
	Price 3	214	74.9	53.99	22.29	
	Price 4	193.5	187	56.96	22.99	
Euro	Price 5	229.9	74.8	101	21.95	
	Price 6	349.99	65.9	137.94	35.98	
	Price 7	279.99	139.9	145.9	51.98	
	Price 8	248.9	99	115	57.41	
	Price 9	239.9	155.9	87.9	56.43	
	Price 10	198.9	67.85	29.15	21.95	
	Average	228.79	102.21	92.99	37.46	115.36
1.2484	Average in USD	285.63	127.60	116.09	46.77	144.02
	Relative price level	1.14	0.74	1.15	0.84	1.00
China	Price 1	380	285	273	159	
	Price 2	390	259	150	178	
	Price 3	300	258	225.01	138.6	
	Price 4	349	247	245	150	
CNY	Price 5	379.05	299	288	110	
	Price 6	369	600	269	198	
	Price 7	310	379	283	138	
	Price 8	395	468	258	98	
	Price 9	598	418	230	222	
	Price 10	680	365	278	129	
	Average	415.01	357.80	249.90	152.06	293.69
0.1573	Average in USD	65.28	56.28	39.31	23.92	46.20
	Relative price level	0.26	0.33	0.39	0.43	0.32

Basic Heading		17) Bathroom cleanser (Price /1)			18) Cooktops cleanser			19) Glass cleaner	
Products		A			A			A	
Product Specifications	Brand	brandless		Brand	brandless		Brand	brandless	
	Type	fluid		Type	fluid		Type	fluid	
							Package type	refill	
									
US	Price 1	3.96			20.76			5.68	
	Price 2	4.53			18.22			4.46	
	Price 3	11.44			25.01			3.04	
	Price 4	3.51			27.46			6.71	
USD	Price 5	6.34			15.63			11.18	
	Price 6	3.51			8.01			5.15	
	Price 7	11.63			19.42			4.57	
	Price 8	4.75			32.79			5.55	
	Price 9	8.96			10.99			5.18	
	Price 10	14.06			27.74			4.03	
	Average	7.27	7.27		20.60	20.60		5.56	5.56
1	Average in USD	7.27	7.27		20.60	20.60		5.56	5.56
	Relative price level	1.00	1.00		1.00	1.00		1.00	1.00
UK	Price 1	2			27.76			2.27	
	Price 2	8.38			24.62			3.12	
	Price 3	4.23			24.93			5.37	
	Price 4	16.28			22.50			9.00	
GBP	Price 5	17.09			19.26			5.00	
	Price 6	9.51			26.90			5.97	
	Price 7	11.99			10.62			6.50	
	Price 8	10.46			12.74			2.45	
	Price 9	7.50			9.09			2.79	
	Price 10	6.47			10.98			4.09	
	Average	9.39	9.39		18.94	18.94		4.65	4.65
1.5785	Average in USD	14.82	14.82		29.90	29.90		7.35	7.35
	Relative price level	2.04	2.04		1.45	1.45		1.32	1.32
France	Price 1	14.2			32.20			3.26	
	Price 2	13.85			31.76			2.80	
	Price 3	3.80			25.78			6.97	
	Price 4	15.96			26.40			5.36	
Euro	Price 5	7.95			21.53			4.89	
	Price 6	17.46			28.35			4.54	
	Price 7	15.27			41.80			5.43	
	Price 8	15.91			12.67			4.95	
	Price 9	11.13			20.19			6.11	
	Price 10	12.76			7.48			6.38	
	Average	12.83	12.83		24.82	24.82		5.07	5.07
1.2484	Average in USD	16.02	16.02		30.98	30.98		6.33	6.33
	Relative price level	2.20	2.20		1.50	1.50		1.14	1.14
Germany	Price 1	5.08			37.40			9.27	
	Price 2	4.00			43.60			2.64	
	Price 3	17.20			14.16			2.89	
	Price 4	12.78			19.96			2.50	
Euro	Price 5	4.00			75.60			3.30	
	Price 6	10.89			40.50			3.12	
	Price 7	12.13			45.96			2.16	
	Price 8	1.90			23.74			5.28	
	Price 9	15.88			20.40			3.18	
	Price 10	8.08			13.90			1.99	
	Average	9.19	9.19		33.52	33.52		3.63	3.63
1.2484	Average in USD	11.48	11.48		41.85	41.85		4.54	4.54
	Relative price level	1.58	1.58		2.03	2.03		0.82	0.82
China	Price 1	51.40			73.54			23.25	
	Price 2	19.44			138.00			10.00	
	Price 3	39.80			129.96			7.50	
	Price 4	29.80			81.23			10.58	
CNY	Price 5	13.16			86.07			14.55	
	Price 6	22.51			115.00			7.40	
	Price 7	72.60			64.00			20.50	
	Price 8	27.50			185.00			42.00	
	Price 9	25.68			76.92			27.92	
	Price 10	25.42			33.33			15.79	
	Average	32.73	32.73		98.31	98.31		17.95	17.95
0.1573	Average in USD	5.15	5.15		15.46	15.46		2.82	2.82
	Relative price level	0.71	0.71		0.75	0.75		0.51	0.51

Basic Heading		20) Floor waxing agent			21) Carpet cleanser		
Products		A	B			A	
Product Specifications	Brand	brandless	brandless		Brand	brandless	
	Type	agent/fluid	agent/fluid		Type	shampoo	
	Floor type	wood	tile/linoleum				
							
US	Price 1	18.16	16.88			16.17	
	Price 2	15.96	18.16			32.89	
	Price 3	17.14	17.14			8.49	
	Price 4	22.77	67.32			11.55	
USD	Price 5	67.32	32.77			6.97	
	Price 6	18.81	7.10			8.20	
	Price 7	32.77	25.25			10.33	
	Price 8	8.85	9.24			15.34	
	Price 9	24.19	30.38			8.99	
	Price 10	17.62	29.61			7.40	
	Average	24.36	25.39	24.36		12.63	12.63
1	Average in USD	24.36	25.39	24.36		12.63	12.63
	Relative price level	1.00	1.00	1.00		1.00	1
UK	Price 1	8.30	40.15			15.49	
	Price 2	7.38	10.55			10.50	
	Price 3	40.15	6.15			9.16	
	Price 4	17.27	4.73			12.33	
GBP	Price 5	3.71	5.60			3.00	
	Price 6	14.50	7.00			5.66	
	Price 7	5.60	3.99			10.56	
	Price 8	4.29	4.29			8.52	
	Price 9	6.60	3.92			5.50	
	Price 10	4.65	2.57			11.66	
	Average	11.24	8.89	11.24		9.24	9.24
1.5785	Average in USD	17.75	14.04	17.75		14.58	14.58
	Relative price level	0.73	0.55	0.73		1.15	1.15
France	Price 1	4.40	18.45			20.45	
	Price 2	10.88	6.99			22.65	
	Price 3	11.20				22.25	
	Price 4	10.00				8.64	
Euro	Price 5	8.70				22.65	
	Price 6	20.40				27.95	
	Price 7	21.58				20.45	
	Price 8	10.96				17.18	
	Price 9	16.20				8.65	
	Price 10	17.41				3.64	
	Average	13.17		13.17		17.45	17.45
1.2484	Average in USD	16.45		16.45		21.79	21.79
	Relative price level	0.68		0.68		1.49	1.49
Germany	Price 1	23.57	23.57			4.62	
	Price 2	22.98	24.40			1.96	
	Price 3	24.40	6.52			10.26	
	Price 4	30.56	7.12			11.20	
Euro	Price 5	6.52	9.21			4.74	
	Price 6	9.13	22.65			7.90	
	Price 7	7.12	29.97			10.68	
	Price 8	9.21	6.42			9.96	
	Price 9	19.60	7.12			1.94	
	Price 10	22.65	7.89			2.35	
	Average	17.57	14.49	17.57		6.56	6.56
1.2484	Average in USD	21.94	18.08	21.94		8.19	8.19
	Relative price level	0.90	0.71	0.90		0.65	0.65
China	Price 1	103.17	32.23			17.17	
	Price 2	37.37	29.89			13.50	
	Price 3	90.79	13.76			7.63	
	Price 4	16.51	15.53			18.49	
CNY	Price 5	47.00	37.37			12.37	
	Price 6	31.70	85.77			8.16	
	Price 7	38.46	47.00			26.46	
	Price 8	50.75	35.75			23.50	
	Price 9	36.77	38.46			17.20	
	Price 10	81.67	29.89			9.26	
	Average	53.42	36.57	53.42		15.37	15.37
0.1573	Average in USD	8.40	5.75	8.40		2.42	2.42
	Relative price level	0.34	0.23	0.34		0.19	0.19

D APPENDIX IV: PPP EXCHANGE RATES CALCULATION FOR UTILITY SERVICES

D.1 Electricity and natural gas

The price information of electricity and gas of five countries is obtained mainly from the report *2011-2012 International Electricity & Natural Gas Report & Price Survey* [4].

D.1.1 Electricity price comparison

All electricity prices in this survey are presented in US cents per kilowatt hour and exclude VAT. The used MERs are those published on the 1st of June 2012 in the Wall Street Journal. They are listed in the second and third column of Table D.1.

Table D.1: International electricity price comparison

Country	Cost excl. VAT (US cent)	MER	Cost excl. VAT (National cent)	VAT	Cost incl. VAT (National cent)
US	8.89	1.0000	8.89	0	8.89
UK	12.45	1.5362	8.10	20%	9.72
France	8.76	1.2435	7.04	19.6%	8.42
Germany	15.15	1.2435	12.18	19%	14.49
China				17%	84.40

The survey price excludes VAT. However, for most countries, electricity service is charged including VAT. *In this study, it is preferred to compare prices including VAT*. In reference to the VAT rates [1] listed in the fifth column of Table D.1, electricity prices including VAT in national currencies are easily worked out.

There is no price information of Chinese electricity in this report. According to the comparison condition set by this survey (*p*rices of 1st June 2012 for the supply of 1,000 kW

[1] Source: `http://www.uscib.org/index.asp?documentID=1676`

with 450 hours of use), the electricity price of China is collected by this study. The electricity supply in China is controlled by the government. Although some slight differences of electricity prices exist between different cities, the price generally follows the guiding price made by the government. Considering that 1000 kW with 450 hours of use is too much for a residential customer and too little for a industrial user, the business customer is set as the target of the survey. *The Chinese electricity price including VAT is CNY 0.844*. [2]

D.1.2 Natural gas price comparison

All gas price information in the survey is presented in US cents per kilowatt hour excluding VAT and the used MERs are the ones published on the 1st June 2012 in the Wall Street Journal, which is the same with the electricity survey. In the sixth column of Table D.2, gas prices including VAT in their national currencies are listed.

Table D.2: International natural gas price comparison

Country	Cost excl. VAT (US cent)	MER	Cost excl. VAT (National cent)	VAT	Cost incl. VAT (National cent)
US	1.83	1.0000	1.83	0	1.83
UK	4.18	1.5362	2.72	20%	3.26
France	4.15	1.2435	3.34	19.6%	3.99
Germany	5.33	1.2435	4.29	19%	5.11
China				17%	27.31

There is no Chinese gas price information in this survey. In China, gas is priced according to volume (cubic meter) instead of heating capacity. The heating capacity of natural gas in most countries is set as 1 cubic meter of natural gas = 9.3 kWh [3], with which the unit of the gas sold can be unified. There is no uniform price of natural gas in China. An average price of the five representative cities *Beijing*, *Shanghai*, *Shenzhen*, *Chongqing*, and *Nanjing* is worked out, which is 27.31 CNY cent/kWh (Table D.3), in order to represent the price level of China.

[2] http://www.12398.gov.cn/html/information/840626356/840626356201000002.shtml.
[3] http://www.chachaba.com/news/tools/qifei/20101021/14721.html.

Table D.3: Natural gas price of some Chinese cities

City	Price (CNY/m3)	Price (CNY cent/kWh)
Beijing	2.2 [1]	23.656
Shanghai	2.5 [2]	26.882
Shenzhen	3.5 [3]	37.634
Chongqing	2.3 [4]	24.731
Nanjing	2.2 [5]	23.656
Average	2.5	27.31

[1] Source: `http://www.egas.cn/jshi/jyh/200809/2062.html`.
[2] Source: `http://www.xxpi.com/zjyn/ShowArticle.asp?ArticleID=6307`.
[3] Source: `http://www.gaszx.com/article/1139.html`.
[4] Source: `http://www.cqgas.cn/zh/news/web_print_174.shtml`.
[5] Source: `http://www.njcitygas.com/home.go?sfbz=`.

D.2 Water and sewage

The price information of water and sewage of five countries is mainly obtained from the report *Global water tariffs continue upward trend* [44](Figure D.1).

The combined tariff consists of four parts: water and waste water fixed costs, water variable costs, waste water variable costs and total sales tax. The price information is for the year 2011, but the used MERs are the daily average exchange rate on the 1st July 2010 in this report (in order to have a comparison with the year 2010), which is listed in the third column of Table D.4. These prices can be presented in their national currencies.

Table D.4: Water/sewage tariffs in national currency

Country	Cost (USD/m^3)	MER	Cost (National Currency/m^3)
US	2.98	1.000	2.98
UK	4.27	1.498	2.85
France	4.56	1.225	3.72
Germany	5.36	1.225	4.38
China	0.46	0.147	3.13

D.3 Telephone and Internet

The price information of telephone and Internet of five countries is mainly based on the report *International Price Comparison Fixed Line and Mobile Services 2011* [43].

Average tariffs ($/m^3) and water usage in selected major countries

Country	Combined tariff	Water tariff	Wastewater tariff	Change %	Domestic use l/head/day	No. of cities
Denmark	$8.83	$4.32	$4.52	0.1%	114	2
Australia	$5.78	$3.14	$2.65	11.5%	605	5
Germany	$5.36	$3.33	$2.02	1.8%	151	10
France	$4.56	$3.24	$1.31	-0.6%	232	7
United Kingdom	$4.27	$2.07	$2.19	3.9%	139	8
Czech Republic	$3.63	$1.86	$1.78	5.7%	213	3
Canada	$3.14	$1.95	$1.19	7.5%	778	5
Poland	$3.12	$1.44	$1.68	17.8%	149	6
United States	$2.98	$1.29	$1.69	8.1%	616	27
Japan	$2.56	$1.48	$1.08	0.2%	373	13
Portugal	$2.27	$1.62	$0.65	0.6%	308	3
Spain	$2.13	$1.47	$0.66	1.9%	342	6
Turkey	$2.14	$1.38	$0.76	10.5%	238	8
Italy	$1.81	$0.94	$0.87	11.6%	483	6
Russia	$1.00	$0.61	$0.39	21.9%	368	13
South Korea	$0.76	$0.56	$0.20	0.2%	552	7
Mexico	$0.69	$0.65	$0.04	2.8%	200	11
China	$0.46	$0.34	$0.12	5.7%	95	25
India	$0.15	$0.14	$0.01	1.8%	139	17

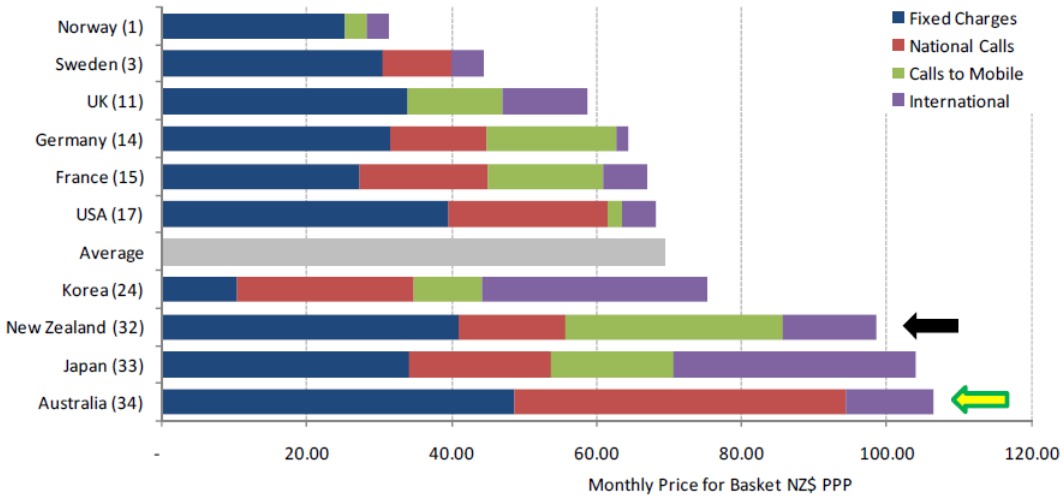
Figure D.1: Water/sewage tariffs in US dollars of selected countries [44]

D.3.1 Telephone

There are comparisons of fixed-line and mobile services in the report. Telephone cost in facility management is mostly related to fixed-line voice service. In order to compare fixed-line voice service across countries, the OECD has developed a number of standardized consumption baskets, which are "20 calls", "140 calls", "420 calls" and "260 calls business" per month respectively (Figure D.3). In this study, only the 140 calls package (medium usage) is used to make the comparison (Figure D.2).

In this report, the monthly prices are all expressed in NZ$ PPP according to the OECD PPPs for GDP. In order to get price level ratios based on the US price level, the price data are transferred back into the national currencies according to a series of mathematical calculations (details are listed in Table D.5).

There is no Chinese telephone price in this report. In this work, the Chinese price information is collected according to the service basket definition of the OECD, which is a fixed monthly cost of accessing a fixed-line and the variable cost for the different call types included in the basket. It is assumed that every call lasts 5 minutes and 140 calls last for about 700 minutes, of which 400 minutes are fixed to local, 110 minutes are fixed to national, 160 minutes are fixed to mobile and 30 minutes are fixed to international calls. The Chinese fixed-line voice service prices of different calling areas are listed in Table



Source: Teligen T-Basket

Figure D.2: OECD fixed-line voice benchmarking - 140 calls basket [43]

	Call distribution			
Basket (calls per month)	**Fixed to fixed Local**	**Fixed to fixed National**	**Fixed to mobile**	**International**
20 calls	61%	20%	17%	2%
140 calls	58%	15%	23%	4%
420 calls	73%	17%	8%	2%
260 calls business	43%	23%	25%	9%

Source: Teligen

Figure D.3: Fixed-line OECD usage baskets [43]

Table D.5: Mathematical handling of the OECD fixed-line voice price data

Country	NZ $ PPP Price	US $ PPP Price[1]	US Dollar Price[2]	MER[3]	National Currency Price
US	68	104	104	1.00	104
UK	59	72	72	1.58	46
France	67	102	102	1.37	74
Germany	64	98	98	1.37	72

[1] NZ$ PPP = 1.5300557 US$ PPP in 2011 (OECD).
[2] USD = US$ PPP.
[3] Annual average MER in 2011 is used.

D.6 [4]. Because there is no price difference between mobile and fixed-line in China, the 160 minutes fixed to mobile are divided into two parts: 130 minutes local and 30 minutes national, which is also based on the distribution model of the OECD.

Table D.6: Chinese fixed-line voice service prices

Calling Area	Price (CNY)
Local	0.2 per min
National	0.07 per 6 second
International	0.8 per second
Accessing fee	20

The cost of fixed-line voice 140 calls basket in China is

$$530 * 0.2 + 140 * 0.07 * (60/6) + 30 * 0.8 * (60/6) + 20 = 464.$$

The monthly prices for fixed-line voice (140 calls) of five countries are presented in Table D.7 .

Table D.7: Monthly prices for fixed-line voice -140 calls basket of five countries

	US	UK	France	Germany	China
National Currency Price	104	46	74	72	464

[4] http://gd.189.cn/internet/guhua_intro.html.

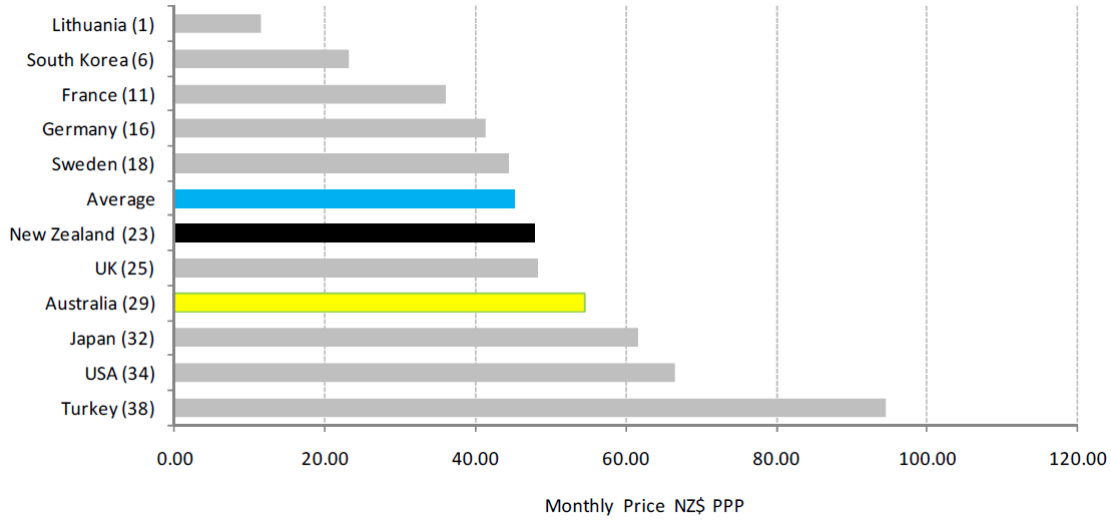


Figure D.4: OECD fixed-line 10 GB basket naked broadband price [43]

D.3.2 Internet

The Internet cost in facility management is mostly related to fixed line brand broad service. Similar to the fixed-line voice benchmarking, the OECD also developed a number of standardized fixed-line broadband consumption baskets, which are 2 Gigabyte(GB), 10 GB, and 60 GB per month, respectively. In this study, only the data of the 10 GB package (medium usage) are used to make the comparison.

The fixed-line brand broad service prices of the report are also expressed in NZ$ PPP like the fixed-line voice service (Figure D.4). Thus, the data treatment procedure is similar to the telephone service (details are listed in Table D.8). The Chinese fixed-line brand broad for the same quality is CNY 3594 every other year, therefore it costs about CNY 148 per month[5].

D.4 Fuel

The fuel price information is easy to be obtained from the Internet. Table D.9 shows the detailed price information.

[5]Source: `http://www.sznet10000.com/adsl.html`.

Table D.8: Mathematical handling of the OECD fixed-line naked broadband price data

Country	NZ $ PPP Price	US $ PPP Price[1]	US Dollar Price[2]	MER[3]	National Currency Price
US	67	103	103	1.00	103
UK	48	73	73	1.58	46
France	36	55	55	1.37	40
Germany	40	61	61	1.37	43
China					148

[1] NZ$ PPP = 1.5300557 US$ PPP in 2011 (OECD).
[2] USD = US$ PPP.
[3] Annual average MER in 2011 is used.

Table D.9: Fuel price information for five countries

Country	Price (National cent/L)
US	105.0 [1]
UK	72.6 [2]
France	94.4 [3]
Germany	92.2 [4]
China	739.8 [5]

[1] Source: http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=M_EPD2F_PRS_NUS_DPG&f=M.
[2] Source: http://www.boilerjuice.com/heatingOilPrices.php.
[3] Source: http://www.prixfioul.fr/.
[4] Source: http://www.tecson.de/pheizoel.html.
[5] Source: http://energy.cngold.org/chaiyou.html.

D.5 Utility services prices summary

six utility services prices in their national currency are summarized in Table D.10. Table D.11 and Table D.12 show prices presented in US dollar and also US price level ratios.

Table D.10: Utility services prices in national currency[1]

Country	Electricity (N.c/kWh)	Gas (N.c/kWh)	Water[2] (N.C/m3)	Telephone (N.C/Mo)	Internet (N.C/Mo)	Fuel (N.c/L)
US	8.89	1.83	2.98	104	103	105.0
UK	9.72	3.26	2.85	46	46	72.6
France	8.42	3.99	3.72	74	40	94.4
Germany	14.49	5.11	4.38	72	43	92.2
China	84.40	27.31	3.13	464	148	739.8

[1] N.c = National cent & N.C. = National Currency & Mo=Month.
[2] Here Water fee is also including sewage fee.

Table D.11: Utility services prices in US Dollar[1]

Country	Electricity (USc/kWh)	Gas (USc/kWh)	Water[2] (US-D/m3)	Telephone (US-D/Mo)	Internet (US-D/Mo)	Fuel (USc/L)
US	8.89	1.83	2.98	104	103	105.0
UK	15.34	5.15	4.50	72.61	72.61	114.60
France	10.51	4.98	4.64	92.38	49.94	117.85
Germany	18.09	6.38	5.47	89.88	53.68	115.10
China	13.28	4.30	0.49	72.99	23.28	116.37

[1] USc = US cent & Mo=Month.
[2] Here Water fee is also including sewage fee.

Table D.12: Price level ratios of six utility services compared to US

Country	Electricity	Gas	Water	Telephone	Internet	Fuel	Average
US	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UK	1.73	2.81	1.51	0.70	0.70	1.09	1.42
France	1.18	2.72	1.56	0.89	0.48	1.12	1.33
Germany	2.03	3.49	1.83	0.86	0.52	1.10	1.64
China	1.49	2.35	0.17	0.70	0.23	1.11	1.01

LIST OF FIGURES

LIST OF TABLES

REFERENCES

[1] John Astin, Yonas Biru, and Jacob Ryten. International Comparison Program Operational Manual. Technical report, World bank, 2005.

[2] Brian Atkin and Adrian Brooks. *Total Facilities Managment*. UK: Wiley–Blackwell, 2009.

[3] Elisabeth Beusker, Christian Stoy, and Spiro N. Pollalis. Estimation Model and Benchmarks for Heating Energy Consumption of Schools and Sport Facilities in Germany. *Building and Environment*, 49:324–335, 2012.

[4] NUS consulting group. 2011-2012 International Electricity & Natural Gas Report & Price Survey. Technical report, NUS consulting group, 2012.

[5] Zurich: Swiss Engineer and Architecture Association. SIA 416: Areas and volumes of the building. Technical report, Zurich: Swiss Engineer and Architecture Association, 2003.

[6] Institute for building informatics. FM Austria. Technical report, Graz University of Technology, 2009.

[7] The Audit Commission for Local Authorities in England and Wales. *Building Maintenance Direct Labour Organisation- A Management Handbook*. London: Her Majesty's Stationery office, 1989.

[8] British Council for Offices. BCO Guide to Specification. Technical report, British Council for Offices, 2009.

[9] German Institute for Standardization (DIN). DIN 32736. Technical report, German Institute for Standardization (DIN), 2000.

[10] The German Institute for Standardization (DIN). DIN 18960. Technical report, The German Institute for Standardization (DIN), 1999.

[11] German Facility Management Association (GEFMA). GEFMA 100-1. Technical report, German Facility Management Association (GEFMA), 2004.

[12] German Facility Management Association (GEFMA). GEFMA 200. Technical report, German Facility Management Association (GEFMA), 2004.

[13] Trosten Henzelmann and Sven.A Teichmann. FM in Europe from Pre-Emerging to Pioneer Markets. http://www.rolandberger.com, 2007.

[14] Alan Heston. The Flaw of One Price: Some Implications for MER-PPP Discussions. https://pwt.sas.upenn.edu/papers/Stanford4.pdf, 2004.

[15] Daniel C.W. Ho, Edwin H.W. Chan, Nicole Y. Wong, and Man wai Chan. Significant Metrics for Facilities Management Benchmarking in the Asia Pacific Region. *Facilities*, 18:545–555, 2000.

[16] Andreas Höfert and Daniel Kalt. Prices and Earnings: A Comparison of Purchasing Power around the Globe. Technical report, CIO Wealth Management Research, 2012.

[17] IFMA. Strategic Facility Planning: A White Paper. http://www.ifma.org, 2009.

[18] Austrian Standards Insitute. ÖNORM B 1801-1. Technical report, Austrian Standards Insitute, 1995.

[19] Austrian Standards Insitute. ÖNORM B 1801-2. Technical report, Austrian Standards Insitute, 1997.

[20] Austrian Standards Insitute. ÖNORM B 1800. Technical report, Austrian Standards Insitute, 2002.

[21] Austrian Standards Institute. ÖNORM EN 15221-4. Technical report, Austrian Standards Institute, 2011.

[22] Austrian Standards Institute. ÖNORM EN 15221-6. Technical report, Austrian Standards Institute, 2011.

[23] ASTM International. E1836/E1836M-09. Technical report, ASTM, 2009.

[24] Investment Property Databank Limited (IPD). IPD Space Code - Measuring the Space Performance of Buildings. Technical report, Investment Property Databank Limited (IPD), 2009.

[25] Investment Property Databank Limited (IPD). IPD Cost Code. Technical report, Investment Property Databank Limited (IPD), 2009.

[26] Keith Massheder and Edward Finch. Benchmarking Metrics Used in UK Facilities Management. *Facilities*, 16:123–127, 1998.

[27] Michael Meyer. 2011 European Facility Management. http://www.slideshare.net, 2011.

[28] Jens Nävy. *Facility Managment*. Berlin: Springer, 2006.

[29] OECD. PPPGDP: Purchasing Power Parities for GDP. http://stats.oecd.org, 2012.

[30] OECD and Eurostat. *Eurostat-OECD Methodological Manual on Purchasing Power Parities*. Luxembourg: Publications Office of the European Union, 2012.

[31] Royal Institution of Chartered Surveyors (RICS). Code of Measuring Practice: A Guide for Property Professionals. Technical report, Royal Institution of Chartered Surveyors (RICS), 2007.

[32] Ministry of Housing and Urban-Rural Development of the People's Repbublic of China. GB/T 50353. Technical report, Ministry of Housing and Urban-Rural Development of the People's Repbublic of China, 2005.

[33] pom+ Consulting AG. FM Monitor. Technical report, pom+ Consulting AG, 2008.

[34] pom+ Consulting AG. FM Monitor Interational. Technical report, pom+ Consulting AG, 2009.

[35] Barbara Santa. Whitestone Building Operations Cost Reference. Technical report, Whitestone Research, 2009-2010.

[36] Anil Sawhney and Kenneth D. Walsh. An Implementation Framework for the Basket of Construction Components Approach. Technical report, The African Development Bank & The World Bank Group, 2004.

[37] Gunnar Siebert, Stefan Kempf, and Oliver Massalski. *Benchmarking: Leitfaden für die Praxis*. Carl Hanser Verlag, 2008.

[38] Urban Redevelopment Authority Singapore. Handbook on the Gross Floor Area. Technical report, Urban Redevelopment Authority Singapore, 2010.

[39] Sven A. Teichman. FM-Volumen in Europa. http://www.facility-manager.de, 2009.

[40] Sven A. Teichmann. Integriertes Facilities Management in Europa, 2009.

[41] Ueli Walder and Karolina Lorenz. Facility Management für Bauingenieure und Architekten. Technical report, Institute for Building Informatics, Graz University of Technology, 2005.

[42] Norwegian Nordic FM workgroup. FM Benchmarking in Nordic Countries. Technical report, Norwegian Nordic FM workgroup, 2009.

[43] Commerce Commission New Zealand. International Price Comparison for Retail Fixed-line and Mobile Telecommunications Services 2011. Technical report, Commerce Commission New Zealand, 2011.

[44] David Zetland. Global Water Tariffs Conitnue Upward Trend. *Global Water Intelligence*, 12, 2011.