Methodologies of Sustainable Planning for Operational and Service-Optimized Building Design

A-Rum Krause-Cha[*1,2], Dominik Matt[1,2] and Daniel Krause[2]
Arum.Krausecha@natec.unibz.it, dominik.matt@unibz.it, Daniel.Krause@fraunhofer.it
[1] Faculty of Science and Technology, Free University of Bolzano, Italy
[2] Innovation Engineering Center, Fraunhofer Italia Research s.c.a.r.l., Bolzano, Italy

Abstract: Consideration of the whole life cycle is necessary to obtain sustainability for buildings. Within the life cycle, there are different phases: concept, design, construction, operational and recycling. Among these phases, the operational phase is the longest and most expensive one. Therefore a building cannot be sustainable if the operational phase is not sustainable and optimized. The operational phase can only be optimized if operation-oriented decisions are taken during the design and construction phase. In practice, decisions during the design and construction phase are taken without knowing the real consequences on the operational phase. Some of these decisions are wrong and make future building operation, such as operational Facility Management (FM), difficult or even impossible. These wrong decisions can be seen as design failures (e.g. uncleanable facades, long service provider routes, etc.), even if there are no errors in construction or design. Therefore many methodologies have been recently developed to create a FM-oriented approach to design and construction. This paper introduces these methodologies and discusses whether they are suitable to achieve design optimization and to reduce design failures in the operational phase.

Keywords: Facility Management, Building Design, Building Design Methodology, Optimization of Operational Phase, Green Building, Operational Phase.

Introduction

The sustainability of a building can only be reached, if all phases of the life cycle of a building are considered. This starts with the concept phase and goes on with the design phase (including the authorization phase), the construction phase, the operational phase (including the implemention phase) and ends with the demolition/ recycling phase (figure 1). But often, the operational phase is not considered during the design of a building and within the operational phase, facilities management (FM) plays a big role.

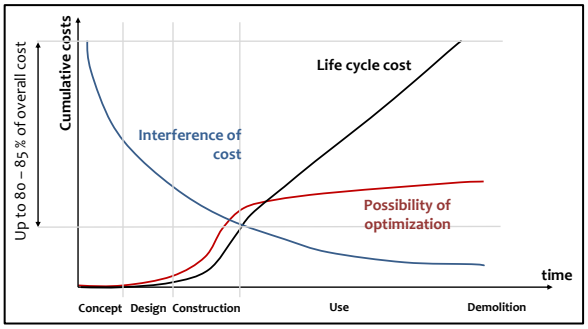

Figure 1. Life Cycle Cost of a Building (BMVBS, Jones Lang LaSalle 2012)

This paper describes the state of the art of operational and service–optimized planning, how FM is currently integrated within the design phase and where the according problems are. After having identified the problems, existing solutions and methodologies will be introduced and analyzed. Finally, conclusions and recommendations will be given at the end of the paper including advice about which methodologies can be used to obtain service-optimized construction and how they can be modified.

History of Life Cycle Consideration of Buildings

From a historical point of view, one of the first approaches that considered the building life cycle and its phases was introduced in the 1960's, when the U.S. Army established rules for public procurement that considered the life cycle cost (Koenig 2009). Further occurrences, such as toxic contaminated building materials from 1950 – 1980, led to sensitization on the whole life cycle of the building. These toxic contaminated building materials were harmful during the operational phase for users and increased the demolition cost disproportionately. The energy crisis from 1973 raised awareness for the energy performance of the building and its energy cost during the operational phase. At the end of the 20th century, the first Public Private Partnership (PPP) projects started. In a PPP project, the government awards a contract, which includes funding, construction and the operation of a building as one project. The contract has a duration of 20 – 50 years and all phases of the life cycle have to be considered.

Consideration of FM Cost in Addition to Energy Cost

Within the operational phase there are a lot of costs besides energy cost. But until the end of the 20th century the optimization of the operational phase focused mainly on energy costs. With the start of the commercial crisis in 2007 it became more apparent that it was not enough just to consider energy cost during operational phase. Designers have to take into account the whole FM cost of the operational phase. As a result, by the example of Germany, standards such as DIN 18960 "Nutzungskosten im Hochbau" (2008) and the Green Building label DGNB, which considers FM during the operational phase, were implemented. Another effective way to decrease FM costs during the operational phase is its integration already during design and construction phase. With the integration, an operational and service-optimized building design can be obtained.

State of the Art

Comparison to Mechanical Industry and the Reason for a Missing Adaption

In the field of mechanical industry, the whole production is adapted to the product and its usage (e.g. car-series or industrial production in general). For buildings, this usage oriented and optimized production is missing. During the design and construction phase, the biggest target is optimized construction cost. The usage oriented production is disarranged in a second row. The reasons for this fact may be the following:

- Defining the role of a building is difficult, because this changes during its life cycle. The building itself is a product while the life cycle of a building is a process (König *et al.* 2009). Therefore the definition of building usage can be different.
- In industry, the aim of the project group is to develop a product for certain groups of customers. But for the building sector, there are many stakeholders with different aims and expectations including the owner, architects, the structural designer, external consultants, the building operator, the contractor, tenants, etc. And each of them might have different aims. For example, the owner's or investor's aim is a low investment and a high profit. The architect is usually focusing on aesthetics. The structural designers have to achieve a safe structure and the building operator needs enough space and routes for the building operation. The various stakeholders also have different time expectations (table 1) and different involvement time in a building.
- Each building is unique and a standardization is difficult

Due to the reasons above, a building project is complex and a definition of one role and one costumer is difficult. Further, an overview of all stakeholders and action throughout whole life cycle of a building is missing. Therefore a usage oriented production of a building is a challenge throughout all building phases.

Table 1. Excerpt of Time Expectation of a Building (König *et al.* 2009)

Participants	Time expectation
Tenants (residents)	5 - 30 years
Tenants (non residents)	1 - 20 years
Estate agent	1 – 2 years
Building contractor	1 – 5 years (warranty)
Facility Manager	1 – 5 years (contract)
Designer	1 – 25 years (1st Repair)
PPP – Participants	10 – 50 years (contract)
Owner	25 – 50 years (generation)

Usage Oriented Production in Building Sector and Related Problems

Treating the usage of a building as operation of a building, the course for an optimized usage is already set during the concept and design phase. In that time, the significant stakeholders for operation (e.g. user, building operator, Facility Manager) are not involved in the project team and the other participants pursue different goals. And at that time usually the most important type of cost is the invest cost of a building. This fact leads to design decisions without the consideration of the consequences on the operational phase. Therefore an optimization of the operational phase of a building is generally hard to be reached. Some of the decisions, which are done without consideration of operation are wrong and make future building operation, difficult or even impossible. Examples for these wrong decisions in practice are as follows:

- Not cleanable façade or windows or façade
- Façade or windows are only cleanable by special workers (climbers) or by special utilities
- Long routes for service providers
- Transport of wares, such as office supplies or hygiene products, can only be done by special utilities or machines
- Missing plug sockets for vacuum cleaner (usually in open space offices)
- Corners and places, which cannot be cleaned

These wrong decisions can be seen as design failures, even if there are no errors in construction or design. Currently, there are several approaches to eliminate such design failures and to avoid wrong decisions during design and construction phase. In

the following paragraph these approaches will be shown, classified, explained and analyzed.

Existing Approaches

Existing approaches can be classified into three groups (figure 2). These approaches are usually done in bigger building projects of office buildings. The project size should be big enough to allow a Green Building labelling.

The approaches are acting in different phases of life cycle of building. The three groups are:

- Methodologies of Green Buildings
- Integration of consultants and experts of operational phase during design and concept phases
- Calculation methods, such as Life Cycle Analysis, Life Cycle Cost, Benchmarks and single variant-calculations

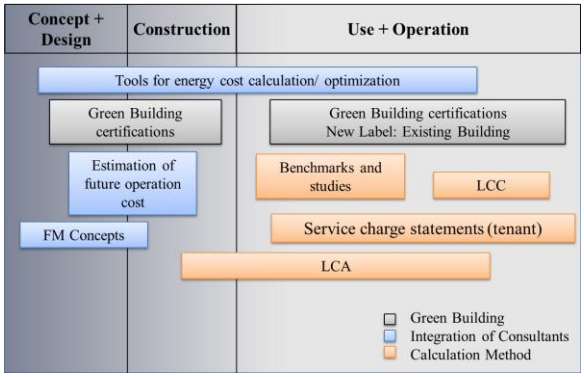

Figure 2. List of Existing Methodologies for Operation Oriented Planning

Methodology of Green Buildings

There are more than 60 Green building labels worldwide. The oldest certification label is BREEAM (Building Research Establishment Environmental Assessment Method) launched in 1990 in the UK. BREEAM considers nine categories (Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Pollution and Land Use & Ecology.), which are called qualities in Green building labels. BREEAM focuses on environment (Luft 2009). The most common Green building label worldwide is LEED (Leadership in Energy and Environmental Design), which was founded in 1993. LEED considers seven qualities (Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental quality, Innovation in Design and Regional Priority) and focusses also on environment (Luft 2009). The most modern label of the three major green building label is the DGNB (German Society for Sustainable Building), which was founded in 2007. It considers 6 qualities (Environmental, Economic, Sociocultural and Functional, Technical, Process and Site). Unlike the two aforementioned labels, DGNB focuses on sustainability. Therefore, this paper will discuss in detail on the Green Building Label DGNB and examines its methods for operational and service-oriented planning.

The Green building label DGNB has 37 schemes for buildings (e.g. Office and administration buildings in use, Office new buildings, retail buildings, etc.) (DGNB 2014). For the evaluation of these schemes 41 core criteria are given (figure 3). Out of these 41 core criteria, following eight criteria deals with FM and will be explained and examined in this paper:

- Life Cycle Cost (Number ECO 1.1)
- Flexibility and Adaptability (Number ECO 2.1)
- Safety and Security (Number SOC 1.7)
- Cleaning and Maintenance (Number TEC 1.5)
- Integrated Design (Number PRO 1.2)
- Design Concept (Number PRO 1.3)
- Documentation for FM (Number PRO 1.5)
- Systematic Commissioning (Number PRO 2.3)

Criterion: Life Cycle Cost (Economic Quality)

This criterion has a high importance factor (3) as well as a large share of overall evaluation (9.6% of the overall). It examines the whole life cycle cost of a building starting with construction cost and ending with recycling cost. The obvious aim is to consider the whole life cycle of a building and to make decisions, which considers some operational cost as well. The costs are structured by standard. For the structure of construction cost, the German standard DIN 276-1 (2008) is used. The basis for the structure of operation cost is also a German standard DIN 18960. The calculation basis for these costs is the cash method which also includes price development. Finally these costs will be compared with the benchmarks of DGNB and evaluated.

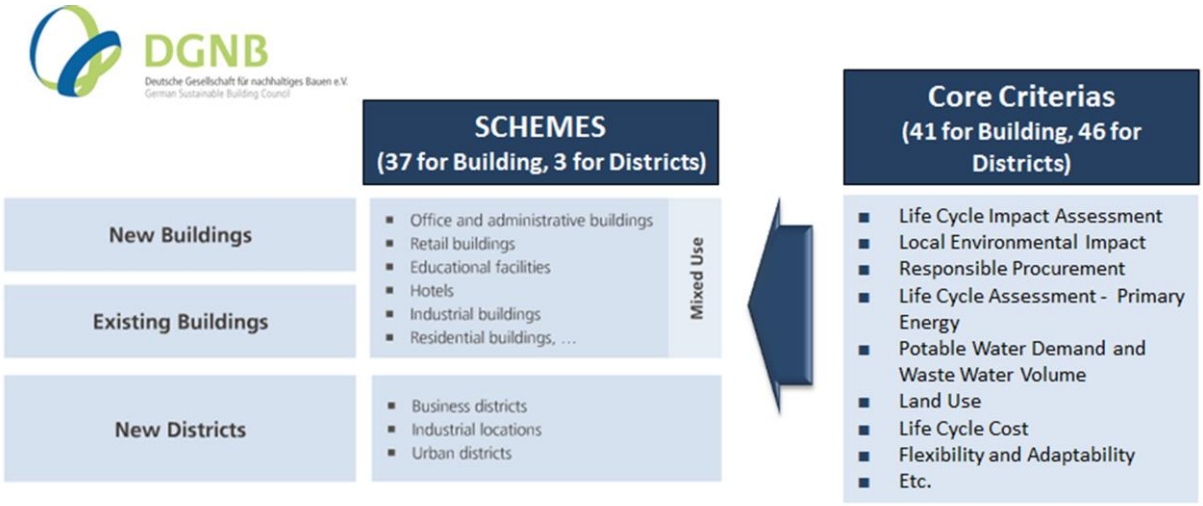

Figure 3. Application of the DGNB Certification System (DGNB 2014)

For the operational cost, the following costs will be evaluated:

- Supply and disposal cost
- Cleaning and care of the building
- Operation, inspection and maintenance
- Repair

This criterion is an important criterion regarding the topic of this paper as it forces the applicant to consider operational costs to obtain a Green building label. It also tries to find a way to make buildings comparable with each other.

Criterion: Flexibility and Adaptability (Economic Quality)

This criterion evaluates the feasibility of conversion and has also a high importance factor (3) as well as a large share of overall evaluation (9.6% of the overall). The idea is that if a conversion is easily done, the usable area can be easily adapted and optimized to the type of usage. By optimizing space allocation, significant savings of resources can be achieved.

If the conversion and the flexibility of usage are considered, the consideration of the usage and operation is obligatory. Therefore this criterion can be used to consider the usage and operation of future building already in concept and design phase.

Criterion: Safety and Security (Sociocultural and Functional Quality):

The criterion Safety and Security deals with subjective feeling of safety of the user and has a share of overall evaluation of 0.9%. Provisions, such as clear routing, sign-posting, safety lighting, technical safety devices, security services help to achieve credit points for the certification. Accordingly, security measures for cases of damage or emergency are also mentioned in this criterion, such as guide books for ventilation and air conditioning installations and evacuation plans.

This criterion forces the planners to issue building security aspects already during the design phase and to develop a security concept, which combines the technical safety devices with security services already at the time of certification.

Criterion: Cleaning and Maintenance (Technical Quality)

This criterion deals with cleaning and maintenance friendliness of a building and has a share of overall evaluation of 4.1%. The cleaning and maintenance friendliness has a high impact on the operation cost, as well as on the environment. For the evaluation of this criterion, the building is divided into the following three types of components:

- Supporting structure
- Non-loadbearing external structure including windows and doors
- Non-loadbearing construction inside.

The different types of components of the building are considered separately.

This criterion is an important one regarding the topic of this paper. Buildings, which cannot be cleaned and maintained due to non-accessibility, have design failures. Through this criterion such non-accessible areas can be found already in the design phase and if possible, eliminated. Unfortunately, not the whole building but single components are considered separately and therefore a holistic consideration of accessibility is missing. Additionally only accessibility is considered.

Criterion: Integrated Design (Process Quality):

With this criterion, DGNB recognizes the importance of integrated design. The share of overall evaluation of this criterion is 1.4%. This criterion considers the integration and improved coordination on all participants and optimization of the planning process.

It evaluates the following four aspects on the basis of an evaluation scale:

- Interdisciplinary planning team
- Integration of user (user's planning partner/ building operator/ Facility Manager)
- Participation of the public
- Development of functional specification

Being a part of the planning team, a Facility Manager and user can improve the design and has the opportunity to optimize it.

Criterion: Design Concepts (Process Quality):

Since there is no standard solution for the construction of a sustainable building, concepts and variant studies are important methods for optimization. Therefore this criterion list needed concepts for sustainability. It has a high importance factor (3) and a share of overall evaluation of 1.4%. Out of listed concepts, following concepts are related to FM:

- Safety concept
- Energy concept
- Disposal concept
- Concept for cleaning and maintenance friendliness
- Life Cycle cost planning during design phase

In addition to the criteria mentioned above, this criterion ensures the consideration of FM concepts during the design phase.

Criterion: Documentation for FM (Process Quality):

One of the common problems at the commissioning phase and at the beginning of the operation phase of a building is missing documentation for operation. Having involved the operator or Facility Manager during the design phase or tendering phase, this problem can be solved. This criterion, which has a share of overall evaluation of 1.0% manages the documentation of used materials, auxiliary supplies and safety data sheets for the life cycle phase and possibly conversion and dismantling for the building during the design phase so that these documentation can be provided for the operation.

Systematic Commissioning (Process Quality):

This criterion deals with commissioning and start of the operation, which has to be planned and managed in advance. It also considers the first optimization of operation after 10 – 14 months after commissioning. It has a high importance factor (3) and a share of overall evaluation of 1.4%. This criterion helps to optimize the commissioning, but plays a minor role in operational and service-optimized construction.

Conclusion

The percentage of evaluation of these eight criteria is nearly 30% of overall criteria of this Green Building scheme "New Office and Administrative Buildings" (DGNB 2012). Consequently, the impact of FM on DGNB Green Building level is high. Thus, an applicant of a Green Building label DGNB is forced to consider FM (consequently operation) to obtain a certificate.

Integration of Consultants and Experts

An integration of consultants and experts at the right time during the concept and design phase is the most effective method to prevent design failures. This approach is known as "FM during the design and construction phase". FM during the design and construction phase begins with requirements management and ends with the introduction of the operator in the building.

Generally, FM during the design and construction phase starts with FM - concepts. The FM - concepts generate constructional, technical and organizational requirements according to operational and service-optimized planning and are basis for the estimation of future operation cost (figure 4). The development also contains the building operation simulation so that wrong decisions and design failures (according to operation) can be found at an early phase. Thus, these failures can be avoided in advance in most cases through simple measures or changes in the design. If this is not possible, at least the potential consequences can be verified. The following concepts are usually considered within FM - concepts (Häusser 2012):

- Building access concept
- Security concept
- Cleaning concept
- Disposal concept
- Supply chain/ ware and logistic concept
- Maintenance and operation concept

To develop these concepts plans are analyzed and evaluated from the perspective of FM.

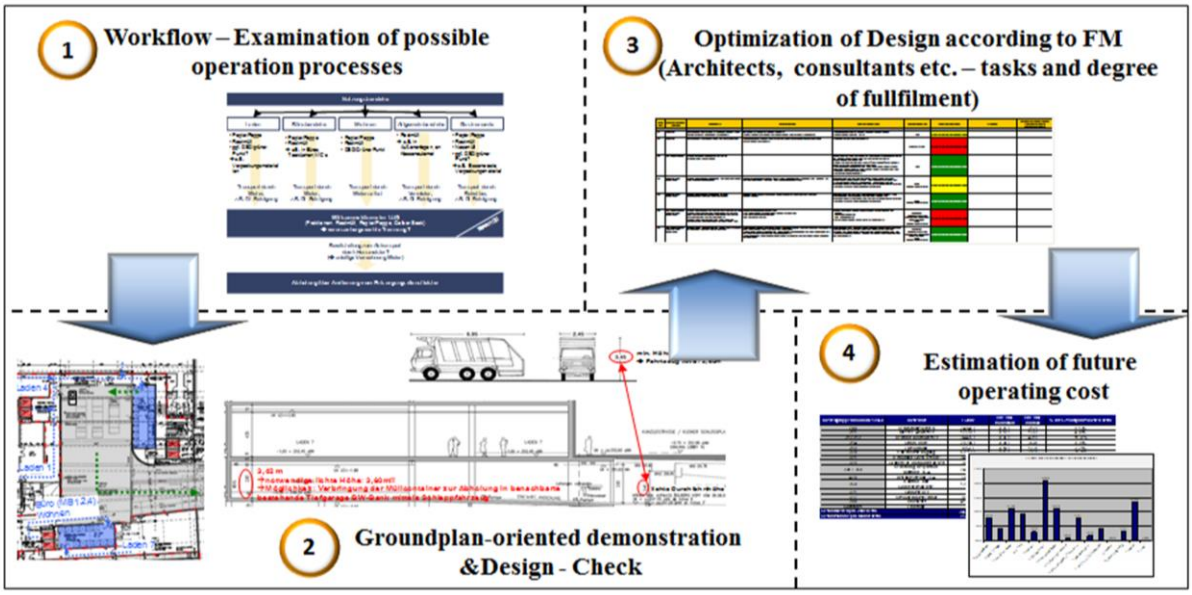

Figure 4. Process of Facility Management During Design and Construction Phase (Häusser 2012)

Building Access Concept

In the building access concept, access routes of various user groups (e.g. visitors, service operator, workers, etc.) and various transport access possibilities (e.g. public transport, car, bicycle, etc.) are investigated. Also barrier-free access, signage concept and reception workstations play a crucial role in this concept.

Security Concept

The safety concept identifies different security zones in the building and gives suggestions about the possible technical safety equipment. Here, special attention is paid to separation of operation and public zones, so that no security vulnerabilities occur due to unauthorized access.

Cleaning Concept

The cleaning concept plays an important role. This is because most design failure exist in the façade concept where some walls or glass parts cannot be reached easily for cleaning. This has to be verified and possible solutions have to be found so that all parts can be cleaned. Accordingly, the feasibility of routine cleaning, e.g. to existing facilities, fittings, door mats is investigated. The cleaning concept includes also green space maintenance, winter maintenance and possible service levels for the routine cleaning, which is helpful for future tendering.

Disposal Concept

Apart from the design failure of non-reachable façade parts, the second most common design failure is the wrong-sizing and wrong concept development of waste spaces. This is examined in a disposal concept. A disposal concept plays also a major role in Green building Certification because most of the Green building labels require it. The disposal concept also includes processes of disposal from work station to collection point where waste containers were collected by disposal companies. The abidance by the requirements of hazardous waste and as well as barrier–free disposal routes is mandatory in disposal a concept.

Supply Chain/ Ware and Logistic Concept

Same as disposal route, the supply route and supply area have to be also barrier-free and easily reachable. These barrier–free routes as well as further access possibilities for supply (e.g. lifts) were examined within the supply chain / ware and logistic concept. Accordingly the dimensions of supply area and dock possibilities for trucks are investigated.

Maintenance and Operation Concept

The maintenance and operational concept manages the feasibility of the technical operations as well as the existing rooms and tools for maintenance.

Estimation of Future Operation Cost

If FM-concepts are developed and necessary information about future operation given, the future operation cost can be simulated and calculated. For example, future price lists for operation services such as cleaning, security, reception, etc. can be filled with average costs to determine a realistic cost of future operation.

The German standard DIN 18960 (2008) “Nutzungskosten im Hochbau”/ User costs of building or GEFMA Standard 200 gives a good

overview of possible operation cost. The most important ones are:

- Electricity, water and heating supply
- Waste and sewage
- Cleaning (routine cleaning, glass cleaning, façade cleaning)
- Cleaning and maintenance of outdoor facilities (paved surfaces, plants and green space)
- Operation, inspection and maintenance (operation of technical facilities, inspection and maintenance of technical and construction facilities)
- Security services
- Repair (construction and technical facilities)

FM during the design and construction phase can be optimized by continuous consulting throughout the concept, design and construction phases by a FM consultant.

Integration of consultants and experts is the most effective method to optimize the future operation, but this method is also the most expensive one. And each solution is a unique solution depending on each project. Currently a standardization method for FM is not available.

LCA and Other Calculations

There are lots of methodologies and calculations that deal with operational costs. The most common calculations are:

- Life Cycle Cost Calculation
- Service charge statement of tenants
- Benchmarks (e.g. Oscar, etc.)

But since these calculations deal with past operational costs, which occurred already, none of these methods can be used to detect design failures.

The Life Cycle Assessment (LCA) is a good basis to consider the life cycle of a building. But usually LCA is just an environmental life cycle assessment and focusses just on energy.

Conclusions and Recommendations

Sustainable planning for operational and service-optimized building design is still a challenge in each building project and is not considered in every project even though there are some attempts to push operational and service-optimized planning such Green Building labels, FM-consultants and various calculations.

Nowadays, a Green Building label acts as a marketing tool for the buyer and investor of a building. New buildings without a Green Building label will have difficulties in selling. And, as shown in this paper, Green Building labels consider Facility Management with several of its criteria. Therefore they can be a door opener for considering FM during concept and design phase. But if more detailed information and further requirements of future operation and FM are needed, Green Building labels are not enough because not all design failures due to operation and FM can be found and solved with only the application of Green building labels. Thus, the Green building label is a trendsetter and driver of operational and service-optimized planning.

The best method to find and correct design failures is the integration of FM consultants and experts by developing FM-concepts. But this method is unique and has to be developed for each project. Standardization in advance is not possible.

Other methodologies are calculations, such as Life Cycle Analysis or Life Cycle Cost. None of these calculations deal directly with sustainable planning for operational and service-optimized construction. But these data can be used to obtain a basis for an optimization.

The main challenges in the future will be the standardization of a method that verifies design failures according to operation and numbers them in advance in the design phase. Accordingly the awareness of operational and service optimized planning must be increased. To increase this awareness, the following approaches can be taken:

- Increase of importance factor of some FM related criteria in Green Building labels. This option might be a way to lead buyers and investors to spend more money during the design and construction phase for FM optimization.
- Creating a label for operating phase: Within a Green Building label, a new certification system can be developed where operation and service of a building will be evaluated.
- Definition of general baseline for building operation cost for comparison: To be able to measure FM optimization, which is related to the decisions during design and construction phase, a baseline of operation cost must be defined. The best solution is a possibility to collect real data easily, e.g. internet based platform, where the Facility Manager can enter his operation cost.
- Invest more in education, which deals with FM during design and planning phase: A great opportunity to force the operational and service-optimized building design would be a special subject, which deals with FM during design and construction phase. This subject can be integrated in a FM degree, architecture as well as civil engineering.

References

DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen - DGNB e.V.) (2013) certification system *"New Office and Administrative Buildings*, Version 2012 with Upgrade of 31st of July 2013"

Häusser, T. (2012) *Vorgehen Nebenkostenschätzung*, Drees & Sommer Advanced Technology GmbH, Stuttgart

König, H. (2009) *Entwicklung einer Methodik zur Bestimmung von Orientierungswerten für Lebenszykluskosten*, BMVBS, BBSR, BBR, Germany

König, H., Kohler, N., Kreißig, J., Lützendorf, T. (2009) *Lebenszyklus-analyse in der Gebäudeplanung*, Detail Green Books, München Germany

Luft, Christian (2013) Das DGNB System im internationalen Vergleich: ein Überblick, Retrieved June 30, 2014 from: www.dgnb.de/fileadmin/de/dgnb_ev/Veranstaltungen/eigene_veranstaltungen/dgnb-impuls/Vortraege_Impuls/Praesentation_Impuls_System_im_intern_Vergleich.pdf

DIN 18960 (2008-02) *Nutzungskosten im Hochbau/ User costs of building* (DIN 18960:2008-02)

DIN 276-1 (2008-12) *Kosten im Bauwesen – Teil 1: Kosten im Hochbau/ Building costs – Part 1: Building construction* (DIN 276-1:2008-12)

GEFMA 200 (2004-07) *Kosten im Facility Management - Kostengliederungsstruktur zu GEFMA 100* (GEFMA 200:2004-07)

BMVBS, Jones Lang LaSalle (2012-08) Lebenszykluskosten: Gebäude ganzheitlich planen und bewerten. Retrieved December 1, 2013 from: www.architektur-online.com/aktuelles/edv/1747-lebenszykluskosten-gebaeude-ganzheitlich-planen-und-bewerten