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Building a climate-neutral future together

Sino-Swiss Cooperation on Zero Emissions Building

Technical Report

Facility Management and Low Emission Operation

Swiss Experiences

ENGLISH VERSION

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Building a climate-neutral future together

This report has been produced within the framework Sino-Swiss Zero Emissions Building Project; an international collaboration funded by the Swiss Agency for Development and Cooperation in partnership with the Chinese Ministry of Housing and Urban-Rural Development.

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The Sino-Swiss Zero Emissions Building Project is an international collaboration funded by the Swiss Agency for Development Cooperation in partnership with the Chinese Ministry of Housing and Urban-Rural Development. The project aims to reduce greenhouse gas emissions and enable carbon neural development of the building sector in China by sharing Swiss know-how on sustainable and zero emission building.

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Cover image: ZEB China Demonstration project. Training building, Long Shan Shu Yuan Middle School, Shoaxing, Zheijiang Province. Courtesy of Shaoxing Future Community Development and Construction Co..

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1. INTRODUCTION

1.1. Sino-Swiss Zero Emission Building (ZEB) Project

To jointly address global climate change and to strengthen the cooperation between China and Switzerland in the field of energy efficient building, the Ministry of Housing and Urban-Rural Development of the People' s Republic of China (MoHURD) and the Swiss Federal Department of Foreign Affairs (FDFA) signed a Memorandum of Understanding (MoU) on 24 November 2020. Within the framework of this MoU, the Swiss Agency for Development Cooperation (SDC) initiated and funded the Sino-Swiss Zero Emission Building (ZEB) Project. The purpose is to support China in formulating technical standards for ZEB and developing long-term roadmaps for reducing greenhouse gas (GHG) emissions in the real estate sector. More details about the project background can be found on the Swiss federal website.[1]

Switzerland contributes to the project by sharing knowledge and use cases for projects in different climate zones. There is an insightful exchange between experts from both countries. Intep-Skat as the implementing consortium closely collaborates with scholars and industry experts from both China and Switzerland. The cooperation includes workshops, research papers, development of concepts and continuous dialogs. The project poses a great opportunity for both countries to further develop their standards and strategies regarding achieving the goal of ZEB.

As part of the cooperation, ten demonstration projects in four typical climate zones across China were chosen. All of them are expected to become ZEB. Among them are various property types, for instance a museum, a public building, and a sport center. The Sino-Swiss ZEB team takes on a consulting role for these projects. They support the development and construction teams of the demonstration projects with the most suitable ZEB-concepts. Furthermore, the Sino-Swiss team had the opportunity to visit some of the construction sites, to get even better insights.

Buildings can only remain at net zero GHG emissions if the post-construction period is planned well. To guarantee long-term success with ZEB, facility management (FM) plays a key role. Switzerland has an advanced FM sector with approved regulations and standards. The Swiss marked also places a high priority on sustainability and energy efficiency. Such expertise is currently sought after in China' s rapidly developing real estate sector. Therefore, the Sino-Swiss team assists in the structuring and development of FM concepts and regulations.

This booklet was developed as part of the Sino-Swiss ZEB project and gives insight into Swiss and German practices and standards. It further explores the potential of FM for ZEB. For this, various industry standards and research papers are cited. The content is extended by intep' s knowledge and experience in the field of FM and sustainability. In addition, Sino-Swiss demonstration projects are spotlighted.

1.2. Definition of facility management (FM)

Nävi[2] defines FM as a strategic concept that describes the management, administration, and organization of all material resources within a company.

ISO 41011:2017 EN[3] defines FM accordingly:" Facility management is the organizational function which integrates people, place and processes within the built environment with the purpose of improving the quality of life for people and the productivity of the key activities of the organization."

More specific definitions can vary quite a lot, since there is an overlap between FM and other real estate-related management categories and services. For example, some would place rental contracts under FM and others would place them under property management. Depending on the size or branch of an organization, other services are needed. As a result, there are many ways to organize FM.

In bigger organizations FM is often organized as a single department or it is outsourced to an external service provider. This helps an organization to

1 https://www.eda.admin.ch/deza/en/home/projekte/projekte.html/content/dezaprojects/SDC/en/2020/7F10301/phase1

2 Nävi, J. (2018). Facility Management (Springer Verlag)

3 ISO 41011:2017 Facility management — Vocabulary

focus on its key activities. FM is needed to guarantee a safe and clean environment, functioning infrastructure, and well-organized occupation. This can positively impact the efficiency of the workforce or enhance the user experience. The goal is to find the ideal solution for the individual demands of the occupants and operators. Therefore, the role of FM depends heavily on the function of a building. Buildings like hospitals, high security buildings or large multipurpose constructions call for more complex FM.

The following chart divides facility management into four strategic units. The units are strictly theoretical; in practice, divisions are usually divided differently. In Figure 2 are few exemplary tasks listed for each unit.

Maintaining the facilities in a proper and safe manner is the most important aspect of FM. Supplementary people' s services unburden occupants and enhance their experience within the facilities. Administration is necessary to successfully plan and operate facility services. Furthermore, administration forms a bridge to other departments like asset management and can support them with additional tasks. Lastly, the strategy affects all parts of FM. The development and adaptation of the strategy is an integrated and flexible process, designed to achieve the desired quality of FM in the long term.

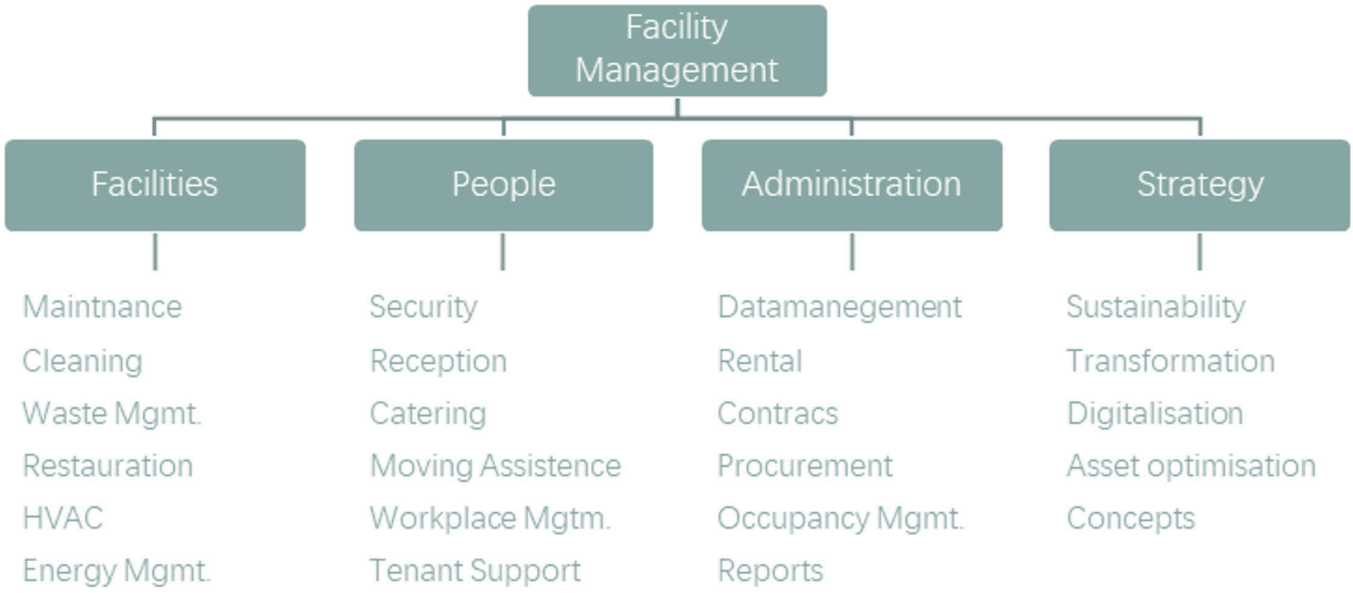

Figure 1. Strategic units

1.2.1. Standards for processes in facility management

Standards are designed to create more structure and a collective understanding. For instance, if a standard service agreement is used, third parties can better relate to the subject matter. The terminology does not need to be clarified and navigation in a familiar structure is easier. This helps avoid misunderstandings, which can obviate mistakes or legal conflicts. Choosing a well-established standard can bring about higher acceptance with third parties, since it is already tried and tested. Another advantage is that using a standard is more time efficient than setting up your own system.

1.2.2. The process and service model ProLeMo

The Swiss Center for Rationalization in Construction (CRB) and the International Facility Management Association (IFMA) developed the ProLeMo process model in collaboration with many partners, among them René Sigg (managing director of intep). The abbreviation ProLeMo translates into process and service model. The publication defines and categorizes the most common FM processes and is a renowned model in Switzerland. It can be used as a basis for terminology, further education, cost structures, service level agreements or other FM concepts. The e-book with the detailed description of all the processes, can be acquired on the website of the Swiss Center for Rationalization in Construction (CRB).[4]

Please note, that there is no official Englisch translation available. However, on the next page an unreviewed English translation can be found. The different elements of the model are briefly described below.

4 Sigg, R., and CRB (2022) ProLeMo auf den neusten Stand gebracht: https://www.crb.ch/Stories/ProLeMo.html

Environment

This layer shows general topics that influence businesses. Developments like natural disasters, pandemics or new laws fall under this category. It is critical to adapt to changes in the environment if a corporation wants to stay successful. Thus, these topics are essential for sustainability.

Management Processes

The next layer is on a corporate level. Management processes are the framework for FM and are only indirectly involved in the operative level of FM. For example, they define the budget, determine the business area, and provide an underlying strategy.

Business Processes

These are the core FM processes. Vertically they are divided into three categories. Each field can be seen as a subset of FM activities.

“Strategy and controlling” organizes the FM including the future development.

“Space and infrastructure” are tied to the building. These are key activities to ensure that the building can operate long term.

“People and organization” tailors to the needs of the people and organization.

Supporting Activities

Unlike management, they provide supportive services and are not superior.

1.3. Sustainable facility management

Facility management (FM) plays a significant role in sustainability. Firstly, the operational phase accounts for a considerable proportion of the total costs and therefore impacts on the value of a building. Secondly, it has an influence on the occupants and therefore holds social responsibility. Lastly, it has an impact on emissions and resource management.

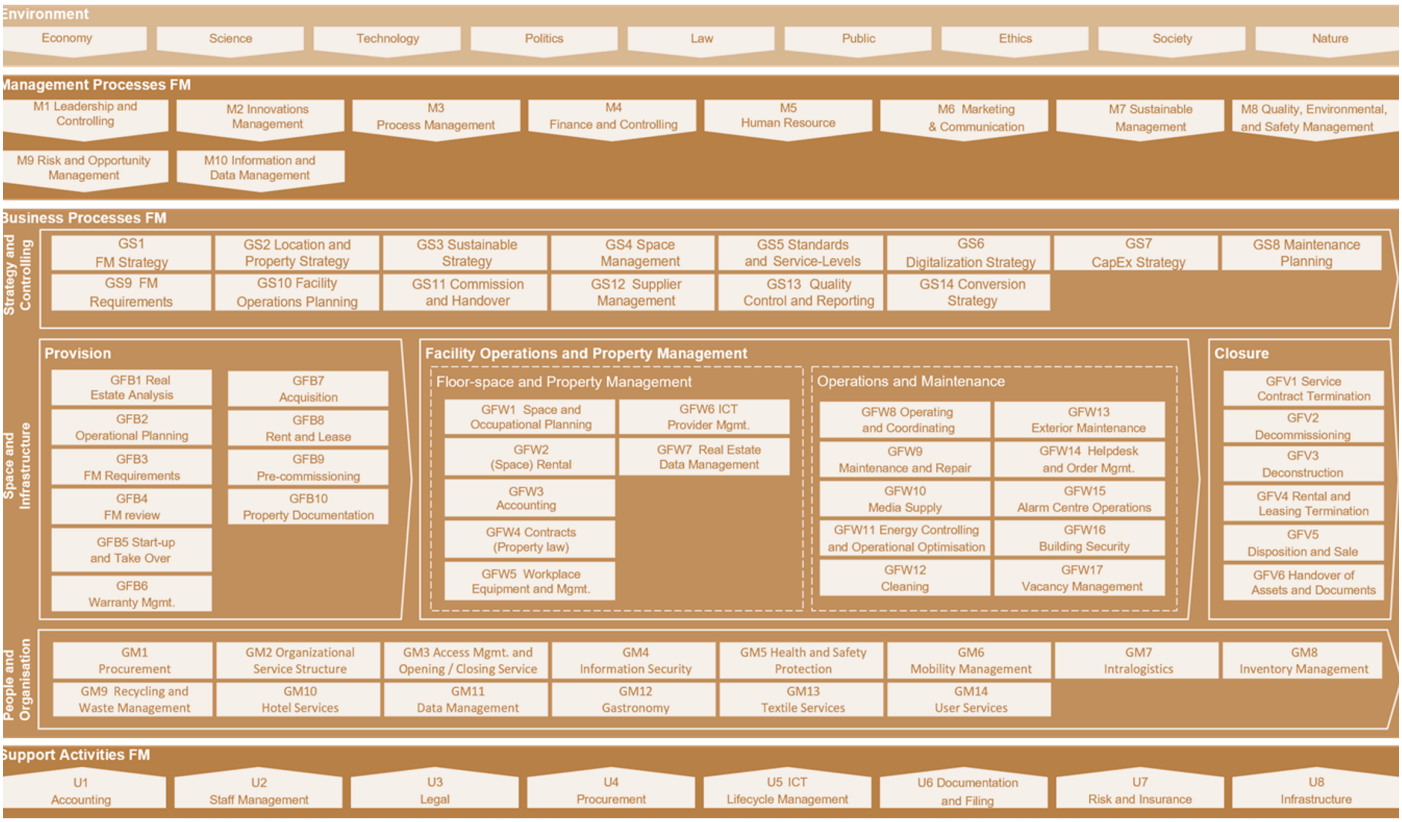

Figure 2. ProLeMo. Source: Sigg, R., and CRB (2022) ProLeMo brought up to date: https://www.crb.ch/Stories/ProLeMo.html

1.3.1. Environment

Environmentally friendly processes are the first step towards sustainability. Measurements include waste separation or environmentally friendly operating materials. Operating heating, ventilation, and air conditioning (HVAC) cause GHG emissions. To reduce GHG emissions, it is important to monitor and analyze energy data. Crucial topics are the optimization of capacity utilization, quality controls, maintenance, improved efficiency, energy source and user behavior. Maintenance and care taking can increase the durability of building components and therefore reduce wastage and embodied energy. Regarding restoration, topics like circular economy or materialization need be considered.

1.3.2. Economy

To reduce operational costs, documentation and monitoring are required. This is the basis to develop an optimization strategy. Solutions might include a change in processes, user behavior or adaptation of the facilities. For instance, more efficient processes reduce labor costs. FM also has an impact on income. Optimizing FM can reduce vacancies and fluctuation of tenants. For this it is important to get user opinions, to satisfy their needs and to do quality controls. Supplementary services can also add value and generate extra income. Lastly, FM is crucial to maintain a building long-term. If maintenance is not done properly, the value of the building will decrease and costs for restoration will increase.

1.3.3. Society

Fair working conditions should be the basis of every FM. This includes a safe workplace, fair wages, and equality. Through diversity and education, a positive impact can be created.

FM has an impact on inclusion. In general, facilities should be accessible, welcoming, and equipped with the necessary infrastructure. For example, facilities should be barrier free, allowing people with disabilities to access them. Also, signs should be designed in a way that visually impaired people or foreigners can understand them.

Safety and health are important for users as well as the workforce. Topics like ergonomics, air quality, emergency procedures, hygiene, and temporary barriers need to be considered. Regarding security topics, sufficient lighting, surveillance, or safe spaces can be considered.

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2. SECTOR OVERVIEW

2.1. History of facility management

2.1.1. Facility management in the 20th century

In Switzerland, high rises only slowly became popular in the fifties.[5] Most buildings were not as complex as they are today, which creates a different base line. There has always been knowledge on how to operate buildings in the past, but facility management was not always viewed as an independent scientific field. Often the owner or the tenant just managed the facilities themselves as a part of their daily business. Also, the management process was different since there were little to no ITC-tools available.

The term facility management was formed between 1950 and 1970 in the USA. Early on, the focus was on the link between facilities and productivity. In 1980 the International Facility Management Association (IFMA) was founded in the USA. Soon they established local chapters across the world, like the Hong Kong chapter in 1992 .[6]

Around that time, some independent, national FM organizations were formed in Asia and Europe. For example, in Japan a national organization was formed in 1987. In 1989 the German Facility Management Association (GEFMA) was founded. The standards and definitions created by GEFMA played a key role in organizing the German FM market. More specifically, they laid the groundwork for educational programs, research and nationally recognized job outlines and brought more clarity for market players .[7]

2.1.2. Transformation of facility management

Over the course of the 20th century buildings became more complex. Thus, new challenges arose, creating the need for better organized FM. IT-infrastructure, technical facilities and building automation widely spread. Also, factors like workplace requirements, urbanization, and socio-economic trends played a role in the development of FM. Examples include concepts like assisted living or flexible working. Technologies like sensors, monitors and robotics have opened new possibilities to operate buildings and collect data. With digitalization programs in the field of computer-aided facility management (CAFM), new possibilities were created. This data can be analyzed and used for optimization and controlling. There has been a trend towards outsourcing over the past years. Owners of large portfolios or complex facilities require well-organized and large-scale facility management, for which they often choose an external service provider. There is also an increasing demand for service providers who have high expertise in the field of technology, digitalization, and emission reduction.[8]

In the early 21st century, FM has established itself as an important sector with a broad variety of services, job opportunities, research, and educational programs. The transformation of FM is still ongoing, with further changes expected in digitalization and building technology. Climate change and energy prices continue to attract more attention on carbon reduction and energy management.

2.2. Classification within Real Estate Management

Preuss and Schöne describe several ways to organize FM. A fully in-house FM has become quite rare, since the financial pressure is high. Facility services like cleaning or maintenance are often outsourced since external companies usually provide the service cheaper. The question of in- or outsourcing the strategic level of FM is more complex. Determining factors are resources, quality control, adoptability and dependance of partners. If all levels of FM are outsourced, this is called total facility management. In this case the owner is only tasked with the controlling and can hence focus on the core business. [9]

The figure below by Teichmann shows an overview of different management disciplines in real estate. The pyramid shows on which level they operate. The bottom levels are closer to the specific object and the top levels are closer to the investors. FM

5 SRF (online) https://www.srf.ch/news/panorama/hochhaeuser-die-geschichte-der-schweizer-hochhaeuser

6 Nävy, J. (2018) Grundlagen, Informationstechnologie, Systemimplementierung, Anwendungsbeispiele

7 Nävy, J. (2018) Grundlagen, Informationstechnologie, Systemimplementierung, Anwendungsbeispiele

8 Pfnür, A., Eberhardt, M. und Herr, T. (2022) Transformation der Immobilienwirtschaft. Springer

9 Referenced in: Preuß, & N., Schöne, L. (2022) Real Estate und Facility Management (Springer)

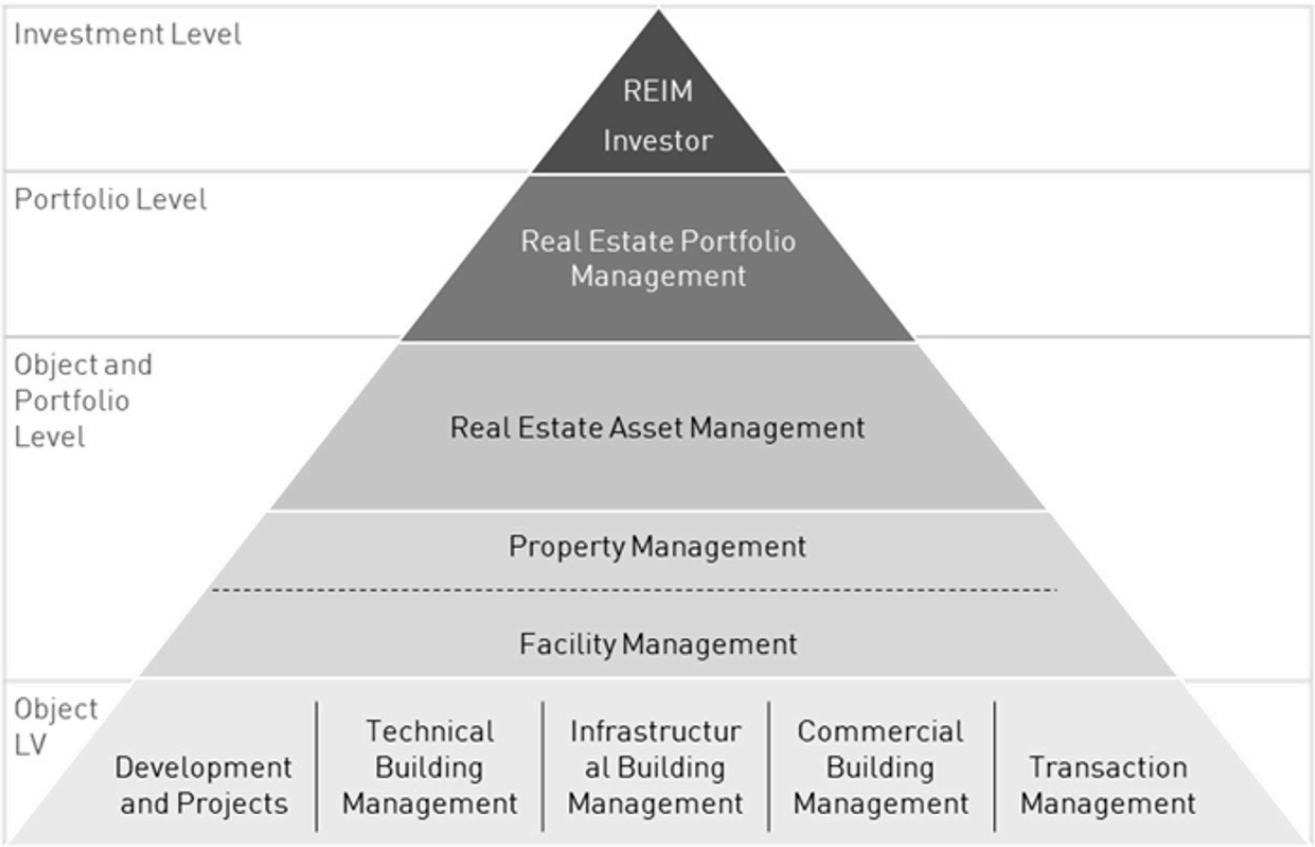

Figure 3. Overview management levels. Source: Teichmann, S. (2007) German Journal of Property Research

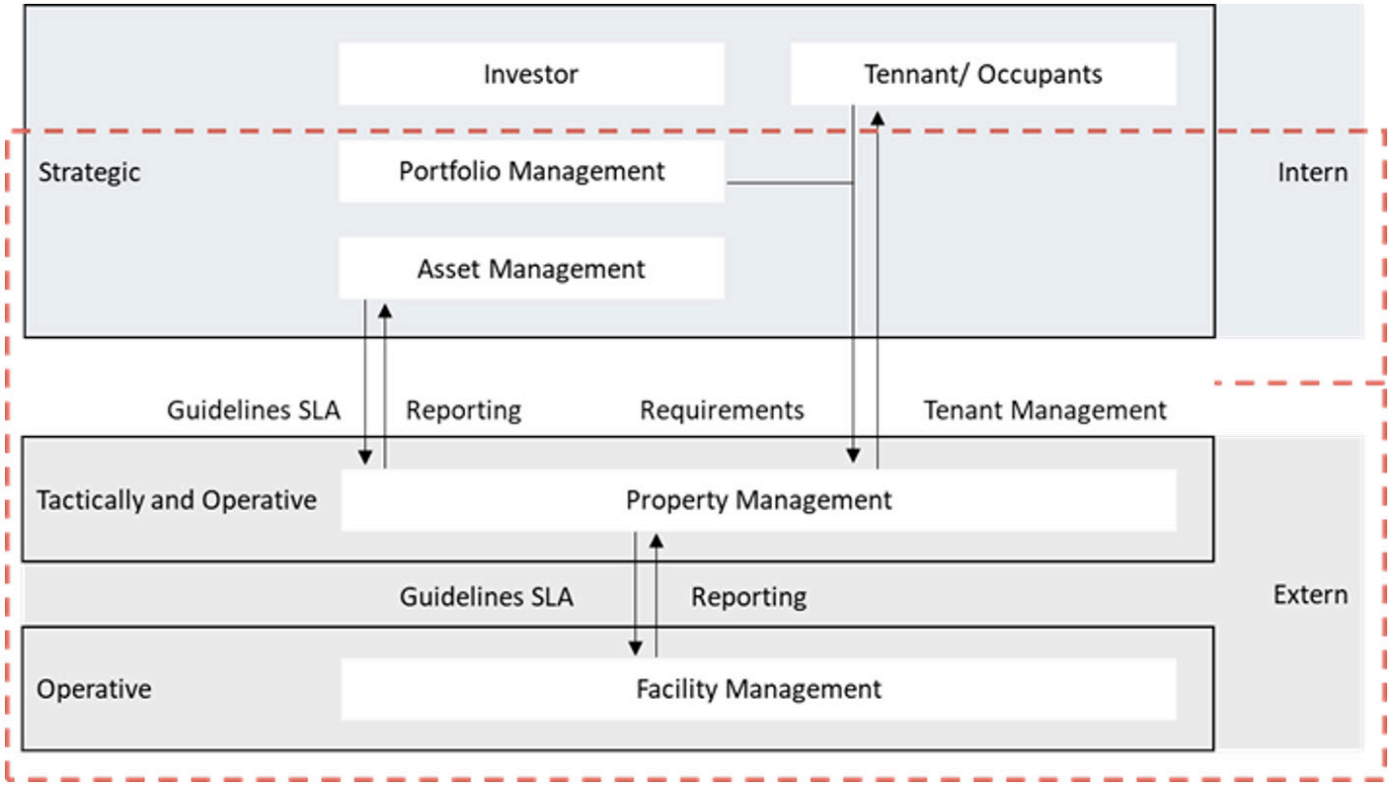

Figure 4. Stakeholders on real estate management. Source: Teichmann, S. (2007) German Journal of Property Research

and property management are on the same block because it is difficult to distinguish them clearly.

Each role is briefly described below. Please note that this is a simplification and there are many overlaps between the roles.

- Investors define the strategic framework and determine the financial resources.
- Indirect investors invest their money and have certain expectations in return. Direct investors are usually a bit more involved. Depending on the business, direct investors might take on any of the other roles described.
- Portfolio Management controls portfolios according to the investor' s strategy.
- Smaller portfolios are often managed by the owner directly. However, for larger portfolios, professional portfolio management is needed to act on the interest of the investors. They control the performance of the portfolio and set requirements for asset and property management.
- Asset Management coordinates the strategy of each property within the portfolio.
- Asset management is often directly allocated to portfolio management. Since they develop and control the strategies on a property level, they must actively work together with property management.
- Property Management manages properties from an organizational standpoint.
- They typically do a lot of administrational work and look after the tenants. Often, they also employ and control facility management. They also report back to asset management and thus help with performance management.
- Facility Management operates and maintains the building.
- They need to implement the strategic requirements and report back about the state of the property. Ideally, they participate in the development of property strategies since they understand the building best. Furthermore, they manage external facility services. As part of their job, they also directly encounter the tenants.

2.3. Facility management industry

2.3.1. International Facility Management Association (IFMA)

IFMA is the largest association for facility management worldwide and is present in more than one hundred countries with around 24,000 members. Membership allows networking opportunities through events and online forums. Members also get access to career resources, learning materials and industry news. For example, IFMA recently released an Asia-focused Operations and Maintenance Benchmarking Report. [10]

Worldwide, IFMA has many local chapters which are embedded in the international organization. These often operate on a national level and function as a professional association. In Europe, there are eleven local IFMA chapters. In Asia there are twelve local IFMA chapters situated in China, Singapore, India, and Malaysia.

The Swiss chapter is the leading Swiss professional association for FM. Professionals can get examined by IFMA to become a "Certified Facility Manager". They offer national as well as local events, with workshops, seminars, and networking opportunities. Members also get access to a variety of publications and guidelines. Furthermore, IFMA is also engaged in the educational sector. They certify educational programs and work together with universities. [11]

2.3.2. German Facility Management Association (GEFMA)

GEFMA is an independent organization and is the leading German professional association in the field of FM. Like IFMA they also offer memberships with benefits like events, publications, and know-how exchanges. However, they are a completely independent company. GEFMA is also dedicated towards the standardization of facility management and writes many guidelines in Germany. [12]

10 IFMA (2022). Asia-focused Operations & Maintenance Benchmarking Report: https://www.ifma.org/news/whats-new-at-ifma-new/ifma-releases-first-ever-asia-focused-operations-maintenance-benchmarking-report/

11 IFMA Swiss Chapter (online). https://www.ifma.ch/de/

12 GEFMA (online). https://www.gefma.de/

The GEFMA guidelines can be categorized into the following topics:

- Terminology and service specifications,
- cost, cost calculation, cost categories and cost recording,
- facility management and law,
- Computer-aided facility management (CAFM),
- tender, commissioning, and contracts,
- training and education,
- quality management,
- industry standards and
- marked reports.

GEFMA also published the guideline 162-1:2021-01 on carbon management in FM. The guideline describes different methods on how to reduce carbon emissions with facility services. It can be used both in the planning and operating phase of a building.

2.3.3. Swiss Society of Engineers and Architects (SIA)

SIA is the Swiss Society of Engineers and Architects. They developed a comprehensive collection of standards. Although not legally required, it is customary practice in Switzerland to follow the SIA guidelines. The standard SIA 113 (2010) contains guidelines about FM related requirements during the development and specifically the construction period. The standard SIA 390 and its revision SIA 2040 offer guidelines about energy efficiency in the building sector.

2.3.4. German Institute for Standardization (DIN)

DIN is the German Institute for Standardization. Although not legally binding, it is still relevant. The series DIN EN 15221 contains several FM related standards.

2.3.5. Education

In Switzerland, there are various educational programs with a strong practical focus. Apprenticeship diplomas can be acquired for titles like caretaker, maintenance worker, technician or cleaner. In addition to an apprenticeship diploma, one can obtain further education to pursue jobs like head of maintenance or head of facility management. At the Zurich University of Applied Sciences (ZHAW), it is also possible to acquire a bachelor or master' s degree in FM. A university degree is helpful for working in strategic facility planning or to manage especially large FM operations.

Globally there are various universities that offer FM programs. Below a few examples are listed.

- Hong Kong Polytechnic University (PolyU) Master of Science in Facility Management
- Zürich University of Applied Sciences (ZHAW) Bachelor in Facility Management Master of Science in Real Estate & Facility Management
- Georgia Institute of Technology (Georgia Tech) Master of Science in Building Construction and Facility Management
- University of Kaiserslautern-Landau (RPTU) Bachelor Real Estate and Facilities - Management and Technology
- Singapore University of Social Sciences (SUSS) Bachelor Facilities Management

Furthermore, there are many educational programs that are related to FM like hospitality management, real estate management or building technology. Subjects like these allow for lateral entry or specialization.

3. STRATEGIC FACILITY PLANNING

3.1. Planning and construction

Planning and construction accompanying Facility Management is a recognized field of FM in Switzerland and Germany. Throughout this paper the unofficial abbreviation PcFM is used for “Planning and construction accompanying Facility Management”.

Costs of FM can be best influenced during project development. Post-construction adjustments are usually expensive and laborious. If the layout and construction have an adverse impact on the indoor climate, this needs to be compensated with technology or an energy renovation. If the layout is impractical or there is not enough space, changing the layout is challenging. Therefore, FM should already set requirements during project development. If the building is well suited for maintenance and for the occupant’ s needs, this can reduce the operating costs and carbon emissions. Furthermore, the well-being of the future occupants can be increased. Regarding occupants and operators, it is also important to think about flexibility since requirements might change over time.

Von Euw emphasizes that the planning phase should be an integrated process. To develop a low emission project, it is especially important that architects, building engineers and building technicians work together. Buildings are complex and the different elements influence each other. Factors like compactness of a building, orientation of windows and the material of the exterior walls influence the temperature in the building. The goal is to balance the different components and to therefore achieve the optimal solution.

Lastly, inventory documentation is necessary during PcFM. The inventory is needed to later operate and maintain the building. It can contain information like expected life, material characteristics or maintenance effort.

3.1.1. FM-Review

Through FM-reviews after different planning stages, the construction plans can be optimized for FM. One should check if the plans meet all the FM requirements. The feedback can then be taken into consideration by the planning team. The goal is to develop a building that is beneficial for users and operators. Topics like system separation, low maintenance materials, practical floor plans, safety requirements, building technology, energy management, and CAFM should be addressed. FM concepts should be developed appropriately to the size and complexity of the project. Appropriate to temporal progression and complexity of the project, these concepts need to be more detailed. It is also possible to develop different scenarios or variations to find the most suitable solution.

3.1.2. Life Cycle Cost Estimation

An estimation of the life cycle cost (LCC) at certain stages of the project helps to optimize and control costs. The LCC can be compared with benchmarks to identify cost drivers. Based on the analysis, problems can be detected early on, and optimization strategies can be developed.

An early estimation of the LCC is a great controlling method. The result allows to compare the project to benchmarks. If costs are too high, one can discuss ways to reduce them. Concrete numbers also help to show the necessity of changes in the dialog with the owner and the development team.

3.2. Facility management concepts

3.2.1. Owner, operator, and user responsibility

From the beginning on it must be clear how the roles are divided between owner, operating companies, and occupants. Otherwise, there is a risk of work duplication, conflicts, or unallocated services. This is especially important for multi-tenant buildings with public and semipublic areas or flexible occupation. The concept can be written from the view of the landlord or from the view of the operator. It is best to develop this concept during planning or when implementing a new FM.

3.2.2. Operator concept

The operator concept describes everything that is necessary to operate the building. It should already be created during early planning and then updated and reworked over the whole lifecycle. Different planners and operators can be involved in the developing process. This is essential to estimate resources like personnel, equipment, and infrastructure. Inefficient or unnecessary FM services are expensive, and a lack of FM services causes deficiencies and reduces the value of the facility for tenants. To run a sustainable operation, one must find the right amount of facility services. It also holds important

information about the building and the strategy, which is described in various sub concepts. A good concept enables efficient management, creates value for the occupants and helps in the planning process.

Examples of sub-concepts are listed below:

- Building automation concept
- HVAC concept
- Emergency plan
- Neighborhood agreement
- Utilization concept
- Mobility concepts
- System manual

For example, the utilization concept contains an occupation plan which defines how and when the different areas are used by whom. This helps to identify conflicts or synergies between users. Especially semipublic areas shared by different tenants should be analyzed. The utilization concept also shows how intensely the facilities are used, which is fundamental to create an operator concept. Analyzing the user' s needs also helps to identify specific facility services that are needed.

3.2.3. Sino-Swiss ZEB project demonstration concept

In the appendix, the table of contents for two operational guidelines is given. They show an example of how such a concept might be structured.

3.3. Conditions for low emission operations

3.3.1. Zero emission building

Zero emission building (ZEB) is a term that is differently used in literature. In this paper the term is defined as a building that emits net zero greenhouse gases over the course of its lifetime. For a comprehensive analysis, the construction, the operations, and de-construction need to be considered. Furthermore, it is important to look at the whole value chain, e.g., scope one, two and three.

There are different ways to evaluate the net GHG emissions. Differences may occur because of the purpose of the calculation, the calculation method, data quality, laws, regulations, and bias. Especially the practice of compensating emissions can vary a lot. Without compensation it is extremely difficult to reach net zero GHG emissions. Depending on the regulations, emissions can be compensated with revegetation, natural materials like wood, or certificates. In this paper the focus is on emission reduction.

Swiss authorities have developed a cantonal building energy performance certificate called GEAK. It is used to grade buildings on their general energy efficiency, the efficiency of the building exterior and on direct carbon dioxide emissions. Buildings are rated from A to G, with A being the best grade. It is also possible to choose other certificates, for example for international comparison.

3.3.2. Location

Local mapping services and statistics are useful when searching for the ideal location. Switzerland has a public geographical information system (GIS) that is very practical for a first analysis. The GIS for the region of Zurich contains information about climate, area planning, pollution, media supply, culture, demographics, traffic, addresses, vegetation, building statistics and topography. Thus, the location has an impact on the emissions. For example, transport and travel distance have an impact on emissions.

3.3.3. Architecture

Adjusting architecture is the first step towards reducing GHG-emissions during the operational phase. The shape and volume of a building impacts the heat loss over the building envelope. When designing the exterior structure, topics like heat permeability, thermal bridges, water permeability, thermal protection, sound insulation and heat storage should be considered. This can reduce the dependence on heating and cooling systems. When deciding for components, one must consider both the embodied energy and the energy efficiency during operations and calculate which effect has more leverage.

3.3.4. Environment

During planning it is advised to analyze the microclimate and the surrounding area. Problems like local heat accumulation or high air pollution need to be identified. Early on one should analyze potential for natural cooling, ventilation, and lighting to create synergies. This can be achieved by using the surroundings and physics to one' s advantage. The effect can be further enhanced with variable shading elements. Additionally, terraforming and landscape architecture have an impact on the microclimate. Such solutions can be useful to create

low-tech buildings with low energy consumption.

3.3.5. Building technology

Technology creates opportunities for automatization, monitoring, and comfort. Buildings should be equipped for the future. The development of factors like demand, climate, resources, demography, and politics should be taken into consideration. For example, one might plan more power plugs for electrical vehicles if the demand is expected to rise.

Correct dimensioning from the start is important. If systems are dimensioned too small, this decreases the quality. If systems are dimensioned too large, they consume more energy than needed. Variable efficiency stages allow for more flexibility. For example, if only half of the rooms are occupied, only half as much ventilation is needed.

Another factor is the efficiency of technological systems. Also, the carbon emitted in the production process and transport should be considered when choosing a product. Product labels can help with choosing efficient models.

System separation improves maintainability. Technical components should be easily accessible. For example, pipes should be placed next to the wall where they can be easily repaired if necessary. If the pipe is inside the wall, routine inspections are not possible, and the wall must be destroyed for pipe repair. Furthermore, a system with replaceable components is preferable since defects can be repaired.

Smart buildings are a rapidly developing field. Sensors collect data that can be used for optimization and automatization. For example, the ventilation can be adjusted to the real time level of carbon dioxide in a room. With video surveillance or thermal imaging, it is possible to monitor the number of people in a room. This allows for automized adjustment of systems according to the occupation.

3.3.6. Indoor climate

The ideal indoor climate creates high comfort for occupants and is beneficial for the infrastructure. For example, the humidity and temperature should not cause mold. Settings need to be adjusted according to the occupation and external factors. Cooling is only needed in occupied rooms when the weather is hot. Regarding indoor climate, topics like activity of occupants, internal heat sources or humidity need to be considered. In regions with cold winters and warm summers it is important to balance measurements for heat protection and cold protection since they might cancel each other out.

Controlling indoor climate can become more complicated when occupants have conflicting interests. Topics like manual airing, blinds and lighting often cause conflicts. Individual preferences differ and might conflict with the most energy efficient solution. FM needs to find a compromise that is energy efficient but also satisfies most occupants. This requires a dialogue with both building technicians and tenants.

A big challenge is the controlling of user behavior. One approach is to educate occupants about sustainability. This could include topics like how to efficiently air out rooms. Furthermore, dependent costs of GHG emissions might motivate tenants to save energy. However, if the measurements are too drastic, this might frustrate the tenants. A reasonable compromise should be found.

3.3.7. From low emission building to low emission district

To achieve sustainability, one must look at the big picture. When planning a whole district, many synergetic effects can be created. This can enhance the quality of a whole area.

With enough occupants, sharing possibilities can be created, e.g., car sharing. Also, a district heating system can be planned from the start. Forming a heating cooperation later can prove more difficult. Another advantage is that the district is evaluated as a whole unit. If one building performs better than another, this can be used as compensation.

FM is more complicated in a large district. In the case of a centralized FM, an area manager can coordinate tasks across different facilities. If several independent FM providers are present, a clear allocation of responsibilities is especially important. Also, infrastructure can be centralized, for example energy supply and disposal. Equipment that is stored locally can be shared, resulting in less downtime.

Other advantages are reachability and travel distances. Large district developments can be planned to suit everyday life. A district can offer space for residences, public areas, playgrounds, greenery, commercial use, offices, bistros, etc. Bicycle trails can be included, making travel even more convenient. This reduces travel induced GHG emissions. Cooperation with local authorities can be helpful for planning districts. If a new train or bus station is planned alongside the district, occupants can more easily reach distant destinations without using a car.

3.4. Obligations and responsibility

GEFMA 190 (2022) defines operator obligation as property specific duties that are necessary to ensure a safe, sustainable, and lawful building operation. Operator responsibility defines the liability of operators to fulfill their obligation rightfully. Additionally, there are entrepreneurial duties, which occur for each company that occupies a building. Regarding FM, this includes duties like workplace safety of the company employees.

Lawfully, the property owner takes responsibility for the property. Through contracts, responsibility can be transferred to third parties such as service providers or tenants. The main obligation of FM is to preserve functionality and to operate the facility. Common laws must be followed. To avoid legal risks, topics like property rights, health, labor, and safety need to be addressed. Moreover, there are obligations concerning sustainability, like emission reduction, equality, or professional training.

3.4.1. Consequences of neglected obligations

Neglected maintenance tasks can go unnoticed in years. When not attended to, they can cause safety hazards, inefficiency, legal problems, or deterioration of the building quality. This can lead to high expenses and negatively impact the environment. For example, if the air conditioning system is not properly maintained, this negatively impacts its efficiency leading to higher energy usage. Also, it reduces air quality, which is bad for the wellbeing of occupants. Furthermore, habit can lead to inefficient operations. It is important to periodically check if there are new requirements or possibilities to optimize the operations. For example, if there is a change in occupation, the heating needs to be adjusted accordingly. To save energy and money, the rooms should only be heated when they are occupied.

3.4.2. Allocation of responsibility

FM has a variety of processes to be organized. In multi-tenant buildings this gets more complicated. Usually, the landlord is responsible for the building construction, public areas, and centralized facilities like HVAC. This responsibility can be transferred to one or multiple service providers. Additionally, tenants have their own facilities that they are responsible for. The border between responsibilities in different areas is not always clear. Therefore, a clear allocation of responsibilities is needed. It is advised to create a concept which precisely defines the different roles and responsibilities. It can hold organizational charts, an analysis of interfaces, a process overview, and a clear documentation of responsibilities and obligations.

If tasks are not clearly assigned, nobody feels responsible, and tasks are neglected which can lead to conflicts. This further demonstrates the importance of a responsibility concept. Additionally, service level agreements clarify exactly who needs to provide which services, when, and with which quality. Furthermore, good management and communication are essential. For example, tenants need to be informed if there are any tasks in their responsibility. Or in case of absence the transfer of tasks to other staff members needs to be coordinated.

3.4.3. Commissioning

The selection of an FM provider is significant for successful implementation of FM. After organization and strategy are defined, the tendering procedure can be started. If the tender is not public, appropriate bidders need to be contacted. All the service levels and selection criteria need to be defined beforehand. Criteria might include staff training, data management, knowhow, price, company size, credit rating, references, and organization strategy. To be more sustainable, environmental, social, and governance (ESG) requirements should be included. The FM provider should match the long-term strategy of a building. To reduce travel distances and to support the local economy, local companies should be preferred.

In Switzerland, public tenders are regulated by law. The purpose of this law is to enable fair competition, without corruption, discrimination, or foul play. Furthermore, it aims for more transparency and a sustainable allocation of public resources. In addition, regional authorities publish helpful information and guidelines about public tendering. The Swiss government provides an online platform for public tendering, called simap.ch.

The process of private tenders is up to the owner. It is possible to follow the protocol for public tenders but is not mandatory. Industry standards and guidelines are helpful for successful tendering. For example, GEFMA published an exemplary facility management contract, which can as a basis for the development of FM contracts in Germany. For detailed service descriptions standards like ProLeMo can be used as a template.

3.5. Lessons learned from China' s demonstration projects

The selected demonstration projects (DP) under the framework of the Sino-Swiss ZEB Project will prove that zero-carbon buildings are indeed possible and can be achieved in different building types. To achieve this goal, it is not enough to only consider design, calculations, and simulations in the planning phase.

Only when the project adheres to the operating mode set during the planning phase and implements sustainable and zero-carbon operating process will the carefully crafted ZEB measures become visible in practice. A successful zero-carbon goal-oriented operation must be based on strict and thoughtful operational guidelines and successful training for operators and end-users. Well managed usage process is the key of the sustainable and low-carbon operation of the building.

As part of a case study, the Swiss team selected the Shaoxing and Shanghai demo projects (DP) to analyze the operational emission performance of the school rooms (Shaoxing DP) and the kitchen area in the market hall (Shanghai DP) and suggested a structure for an operational guideline with the goal of carbon reduction. In Appendix A.1 and A.2 you can find the content of these two guidelines which are under testing by the FM teams of both demo projects.

In general, the following key points should be considered in operational guidelines:

- Clear outline who will operate the building in the future, who are the regular users, and who else will enter and use the building in addition to regular users.
- Clear description of the building usage time, including the opening and closing time of the entrance (that is the time when people are allowed to enter and use the building), e.g., usage hours of each classroom and other rooms for the Shaoxing DP.
- Clear description about what continuous temperature and humidity should be maintained indoors and what are the natural ventilation requirements, as well as what are the related monitored values.
- Further define when to start air conditioning and heating equipment for preheating and precooling before people arrive indoors.
- Further define when the cooling and heating equipment can be turned off before people leave the room.
- Further describe what is automatically controlled and what needs to be manually controlled by the users to maintain a good quality of the indoor conditions.
- A detailed description of operational tasks, especially regarding maintenance and restoration schedules.

4. FACILITY OPERATIONS

4.1. Business administration

4.1.1. Management

Good management is the key to a successful application of the FM strategy and ESG requirements. Therefore, well-trained, and experienced personnel are needed. Training programs and a good onboarding process of new employees helps to maintain a well-qualified work force. For instance, an ESG-workshop can help to build up the necessary know-how in this field. Additionally, a CAFM tool can help a lot with managing facilities successfully.

GEFMA names the following management activities:

- Leadership and supervision
- Providing IT-tools
- Tracking support tickets
- Data management
- Quality management
- Environment protection
- Operational safety
- Medical care

4.1.2. Administrational tasks

Administrational tasks like accounting, data management and contract management need to be done with great care. This is important to maintain order, for monitoring performance and to find ways to optimize operations.

GEFMA names the following administrative activities:

- Property management
- Tenant support
- Asset management
- Controlling and accounting
- Contract management
- Warranty management
- Human resource management

4.1.3. Start-up and handover

During handover, topics like contracts, service level agreement, reporting and scheduling need to be addressed. The startup phase begins prior to the handover and ends after a few weeks or months. Responsibilities, obligations, and property features need to be documented carefully to avoid conflicts in the future. A detailed property tour helps to clarify property-specific features. After the handover operations should be optimized.

4.1.4. Computer Aided Facility Management (CAFM)

CAFM is a specific kind of enterprise resource planning (ERP) system. It is primarily used by the facility management team and is integrated into their processes. Usually, it also has interfaces to third parties like property management, who need certain data for analytics. Also, an integration within building information modelling (BIM) is possible . CAFM helps to design more efficient processes and save valuable resources. A good documentation of the building is the basis for successful maintenance. Data like maintainability, compatibility, and age help to increase the service life of different building components and systems. Also, monitoring of carbon emissions and energy consumption relies heavily on digital tools. This shows that CAFM can help to achieve zero emission operations.

If it is not implemented well, even the best CAFM program will be of no help. CAFM should already be set up during planning and construction. Here it is important to carefully document data regarding the building, including a full inventory. One must define which data is needed and therefore collected. Third parties like asset or property management usually want data regarding topics like capital expenditure (capex), maintenance cost or energy management. Normally, they need this data periodically for performance measurement, resource allocation, appraisal, and adjustment of property strategies. Therefore, data format and interfaces need to be defined early on.

4.1.5. CAFM Systems in Switzerland

There are various CAFM solutions on the market. The following three CAFM solutions are commonly used in the Swiss market.

Planon

SAP is one of the world's leading providers for ERP-systems. They developed Planon, a real estate management system. It is offered as a service and

can be used in exchange for a user fee. It is well suited for both portfolio management and facility management. It has various tools in the field of data management and space planning. Regarding sustainability it can be used for processes like ESG reporting, energy monitoring or cost reduction.

Campos

Campos is a Swiss based CAFM platform by the company ICFM AG. They offer different modules to which users can subscribe. The following modules are offered: activities, contract, cost, space, operator responsibility, capex, BIM, maintenance, inventory, energy, warranty, helpdesk cleaning, workplace, moving, health and safety, security, occupation, and tenants. This allows for a custom-tailored experience.

FMS@ISS

ISS developed their own in-house system called FMS@ISS. For large FM companies it can be useful to setup their own systems, since they can tailor it to their needs. Also, they are no longer dependent on a provider.

4.2. Maintenance

4.2.1. Maintenance activities

DIN 31051 defines four main activities for maintenance. These include inspections, care taking, restoration and improvement. Inspections are necessary to monitor the state of a component. Components should be checked periodically for efficiency, functionality, and defects. Caretaking is needed to keep the subject in a proper state. This includes activities like cleaning, adjustments, or refills of working materials. Even with diligent care, most components need restoration after a certain amount of time. Depending on the state, this is done by replacement or repair. Instead of restoration there is also the possibility of improvement. This could be an additional function, better quality, or higher efficiency.

4.2.2 Sustainable maintenance

Adjusting settings can reduce carbon emissions and save costs. Systems should only be running when they are needed, e.g., heating in cold weather. When components are taken care of well, their expected lifetime can be increased. This means that the component needs to be replaced fewer times, proportionately reducing embodied energy. If possible, components should be repaired, creating less waste material. If that is not possible, replacement or upgrading are the only options. Possible criteria for the new purchase include local production, fair trade, short transport routes, recycling, energy efficiency, pollutants, and materialization. Furthermore, exterior maintenance is a wonderful opportunity to enhance biodiversity. Topics like local species, natural habitats, greenery, and compost can be considered. Especially trees, grassland and water sources can positively impact the microclimate.

4.2.2. Maintenance example

Maintainability depends heavily on the specific component. For example, a massive parquet floor requires a disproportionately high amount of cleaning. However, inspections are not necessary since occupants and cleaning personnel detect the defects easily. There are no technical components that need replacing, and the expected life is relatively long which makes restoration rather simple. Improvement can be achieved in style or with more sustainable materials.

A ventilation system requires different maintenance. It is not necessary to clean it daily, but depending on the model, air filters need to be replaced regularly. Settings need to be adjusted to match the occupation. Periodic inspections and services are necessary, since small defects are not necessarily noticed in daily business. Also, some of the working materials need refilling. Furthermore, there are many technical components, and they might need repair or replacement at different points in time. Lastly there is a variety of options for improvement. A new system might have more advanced air filtering, higher efficiency, more capacity, less noise, or better adjustment settings.

4.3. Supply and disposal

4.3.1. Media supply

If possible, natural energy sources should be used on the property, e.g., heat pumps or solar panels. If not possible, alternatives like direct energy from sustainable sources or pellets heating might be an option. In the same way, water sources might be used for natural cooling. These options emit less GHG. Even with such systems in place, there is still an external energy demand. The source of energy that is bought influences the quantity of GHG emissions.

Sensors and CAFM help with collecting data. This data needs to be tracked over extended periods of time and analyzed. Changes might indicate problems which need to be addressed. Ideally, a GHG-balance is calculated periodically. This is

a great way to check if the net zero emission goal was reached and if reduction measures had the intended effect. Furthermore, the GHG balance can be disclosed in the reporting for investors. Building certificates can be helpful in the same way. Besides carbon management, they might also take more qualitative criteria into consideration.

The German Sustainable Building Council (DGNB) is a German label for buildings in the operational stage. In covers on topics like energy management, carbon emissions and sustainability in general. There are many other Swiss and international sustainable building certificate. Various aspects and topics are focused on depending on the certificate.

4.3.2. Waste management

Waste separation is a standard practice in Switzerland. Usually glass, PET, cans, fabrics, paper, and cardboard are separated. There are also rules for special waste like batteries, metals etc. For bio waste there is a garden waste collection system in Switzerland. It is also possible to manage a private composter. Adequate space is needed for bins used in waste separation.

4.4. Services

Lastly, there are a many supplementary services which can be provided. Usually, they have a smaller leverage on carbon emissions. However, topics like transport, resource consumption and value chain are still applicable. Most services are connected to people. Therefore, social sustainability is a much bigger topic. Covering the social dynamics of FM goes beyond the scope of this paper. Nonetheless, it is an extremely important topic, which should not be neglected.

The following exemplary services are listed, which are a part of the GEFMA service specifications.

- Safety and security services
- Alarm center operations
- Workplace management
- Event management
- Key administration
- Catering
- Helpdesk and order management
- Moving services

5. CONCLUSION

5.1. Strategic facility planning

Already in strategic planning the building should be optimized for FM. Therefore, the according FM and building technology experts should be included in the planning process. FM reviews, LCC and FM concepts are adequate tools during the planning process.

To begin with, it is important to plan enough space for facility operations. Components with effortful maintainability should be easily accessible. System separation allows for more efficient maintenance. Furthermore, the building should be optimized for the ideal microclimate. This can later reduce the energy consumption needed for HVAC. Regarding HVAC and technological components, models with high energy efficiency should be chosen. When choosing materials, factors like embodied energy, heat permeability and maintainability should be considered.

Lastly, commissioning should be well organized during planning and construction. A responsibility concept is the fundament for a clear organization. In the tendering a well-qualified service provider should be chosen. It is advisable to support the implementation, as last changes can be made. As part of the commissioning, a CAFM system should be chosen.

5.2. Facility operation

The strategy and concepts developed during planning and construction need to be implemented well post-construction.

A well-qualified workforce and a comprehensive service level agreement enable successful operation. It is important that responsibilities are clearly allocated. A CAFM system can further improve management efficiency. Following industry standards or getting certified periodically can help to reach ESG goals and to maintain high quality in the long term. If the operations are not well organized, crucial activities might be neglected, resulting in higher GHG emissions.

Energy management is the most important driver when it comes to direct GHG emissions. Energy efficient technologies, proper dimensioning and user-depending settings help to reduce energy consumption. CAFM, sensors and building automatization present a great opportunity in this field. Choosing a sustainable energy source further reduces GHG-emissions. If possible, energy should be sourced on site, e.g. through heat pumps. Consistent monitoring helps to identify drivers and therefore to optimize energy consumption.

Facilities contain a lot of embodied energy. Inspections, care taking, and repairs can increase the lifetime of components and therefore reduce embodied energy. Restoration creates an opportunity for modernization or more energy efficient components.

Annex 1.
Content Structure of the Operation Guideline Shaoxing DP

Detailed project information please see Summarizing Report for Sino-Swiss ZEB Demo Project “Training Building of Long Shan Shu Yuan Middle School in Shaoxing, Zhejiang”

Following the table of content shows how to structure a guideline regarding zero emission operation for the Shaoxing demo project of Sino-Swiss ZEB Project:

- Description of operator and user
- Using time
- Indoor comfortable micro-climate
- Energy-saving use of lighting systems
  - List all lighting equipment planned in the building with pictures
  - Guide of purchasing lighting equipment
  - Guidelines for using lighting equipment
  - Maintenance and replacement instructions
  - Guidelines for Disposal of Waste Lighting Equipment
- Guide of zero-carbon operation of other appliances and energy supply equipment
  - List of all other electrical equipment planned in the building with plans
  - Guide of equipment purchasing
  - Guide for usage of the devices
  - Maintenance and replacement instructions
  - Guidelines for Disposal of Waste Lighting Equipment
- Guidelines for opening windows
  - Yearly heating and cooling plan
- Guide of Automation control system operation
  - Plan of all sensors
  - Principles of automated control operations
  - Responsibilities of the operator
  - Troubleshooting
- Conclusion

Annex 2.
Content Structure of the Operation Guideline Shanghai DP

Detailed project information please see Summarizing Report for Sino-Swiss ZEB Demo Project “Public and Residential Building District, Jiading, Shanghai”

Following the table of content shows how to structure a guideline regarding zero emission operation for the Kitchen Area in Market Hall Building in the Shanghai demo project:

- Description of operator and end-user
- Kitchen units and their operating time
  - Kitchen units
  - Operating time
- Overview known energy consuming equipment in the kitchen area
- Guidance for usage of the kitchen and devices
  - General recommendation
  - Special recommendation
  - HVAC recommendation
- Responsibilities of operator and end-user
  - Responsibility of operator
  - Responsibility of end-user/Restaurant Keeper
- Maintenance, replacement, and disposal instructions
- Training plan for operator and restaurant keepers
  - Handover operation manual
  - Training course
  - Structure of training courses
- Conclusion

Annex 3.
Glossary

BIM	Building Information Modelling
CAFM	Computer Aided Facility Management
Capex	Capital expenditure
CRB	Swiss Center for Rationalization in Construction
DP	Demonstration Project
DGNB	German Sustainable Building Council
DIN	German Institute for Standardization
ESG	Environmental, social, and governance
ERP	Enterprise Resource Planning
FM	Facility management
GEFMA	German Facility Management Association
GHG	Greenhouse gas
GIS	Geo-information System
HVAC	Heating, Ventilation, and Air-conditioning
ICT	Information and communications technology
IFMA	International Facility Management Association
LCC	life cycle cost
Mgmt.	Management
MoU	Memorandum of Understanding
PcFM	Planning and construction accompanying Facility Management
ProLeMo	process and service model for facility management
SDC	Swiss Agency for Development and Coordination
SIA	Swiss Society of Engineers and Architects
ZEB	Zero emission buildings
Mohurd	Ministry of Housing and Urban-Rural Development of the People’ s Republic of China
Intep	Integrated Planning Ltd.
Skat	Skat consulting Ltd.
CINB	Verein der chinesischen Ingenieure für nachhaltiges Bauen e.V.
FDFA	Federal Department of Foreign Affairs
MoU	Memorandum of Understanding
ISO	International Organization for Standardization
IT	Information technology
EN	European Standard
GEAK	Gebäudeenergieausweis der Kantone (Building Certificate of Swiss Canton)

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