Metropolia University of Applied Sciences

Hochschule für Technik und Wirtschaft Berlin
University of Applied Sciences

Impacting the Energy Systems of Existing Real Estates by Optimising the Management of its Service Operations

Master's Thesis

International Master of Science in Construction and Real Estate Management Joint Study Programme of Metropolia UAS Helsinki and HTW Berlin

Faculty 2

from

Francisco José Núñez Lara

581349

Date:

Berlin, 07.07.2023

1st Supervisor: Prof. Dr.-Ing. Markus Krämer

2nd Supervisor: MSc. Richa Srivastava

Acknowledgements

I would like to express my most profound appreciation to Prof. Dr.-Ing. Markus Krämer for his guidance and feedback through the elaboration of this thesis as well as for putting a good word for me at the Max-Planck Institute. These aspects were essential to fulfilling my research. I am also extremely grateful to MSc. Richa Srivastava, who generously provided feedback and support to accomplish this study.

Additionally, thanks should also go to Mr. Jörg Tellmann and the Technische Dienste department at Max-Planck-Institute for Human Development for their patience, support and knowledge. Having collaborated with them provided the required insights and information to make this study meaningful.

I would be remiss not to acknowledge the support of my parents, who have been there for me every step of the way in both my education and career. I am also grateful to my sister, whose encouragement inspired me to pursue this master's degree. I would also like to acknowledge my wife, without whose unconditional support, this work would not have been accomplished. Lastly, I would like to recognise all my family and friends in México and a special mention to my grandpa, whose memory and teachings are always with me.

International Master of Science in Construction and Real Estate Management
Joint Study Programme of Metropolia Helsinki and HTW Berlin

date 29/01/2023

Conceptual Formulation
Master Thesis for Mr./Ms. Francisco José Núñez Lara
Student number 581349 (HTW) / 2104690 (Metropolia)

Topic:
Impacting the Energy Systems of existing Real Estates by optimising the Management of its Service Operations

Energy Management in Facilities Management [Online Image]. (2022). Real Estate.

Signature of the 1st Supervisor

Richa Srivastava
Signature of the 2nd Supervisor

Background

Among Europe's cultural variety and history, one of its main features is its real estate portfolio, which is distinctive and multi-faceted. Additionally, it is outdated and does not change rapidly. Two hundred twenty million buildings in the EU were constructed prior to 2001, representing 85% of the current real estate assets. As many as 85-95% of the buildings standing today will still exist in 2050. It is estimated that most of those existing buildings are not energy-efficient, among other shortcomings. Fossil fuels are still utilised for air conditioning and heating. Approximately 40% of the EU's total energy consumption and 36% of the EU's greenhouse gas emissions are attributed to buildings [1]. This factor, along with challenges such as rising costs, denser population and higher turnaround, puts more and more pressure on facility managers to manage their buildings more efficiently than before.

Building energy use is dominated by heating, ventilation, and air conditioning, accounting for 35% of the total; lighting accounts for 11%; major appliances (water heating, refrigerators, dryers) account for 18%; electronics account for 36% of the remaining energy. As a part of integrated building systems, system components can be enhanced both in performance (e.g., lighting devices can be improved in efficiency) and in how they are controlled (e.g., sensors that adjust light levels based on occupancy) [2]. This is where the role of a facility manager can be of the utmost importance for the organisation.

According to the latest definition of facility management, it is a profession that integrates people, place, process, and technology to ensure the functionality of the built environment. By maintaining the functionality of Real Estates and optimizing other services and processes while operating at three levels within the company, it can impact the processes at all levels of the organization [3]. These are defined as strategic, tactical, and operational. A facility management strategy can present numerous benefits, including cost-effectiveness, productivity, efficiency, and an improved work environment.

Several studies have shown that human actions (both those of occupants and facility managers) determine the amount of energy used by buildings. This could prevent optimal building operation, leading to excess energy consumption and defeating the purpose of technological investments (Azar and Menassa, 2012; Augenbroe et al., 2009; Levine and Urge-Vorsatz, 2007). While 'technological' strategies have been implemented in buildings (Augenbroe et al., 2009; Levine and Urge-Vorsatz, 2007; Henze, 2001), there has been a significant difference between desired and actual energy levels due to the lack of understanding and account of human actions.

International standards such as ISO 50001 as well as the European Standard DIN EN 15221 provide guidelines to assist Facilities Management organizations in improving their FM processes to support their primary responsibilities. Processes related to Facility Management are defined in EN 15221-3 and EN 15221-4. Depending on the context of the organization (and its primary processes), and the status of the organization (expanding, stagnating, or shrinking), the relevance of the processes varies. The functional aspects of Facility Management include operations and maintenance, which are determined by tangible assets, resources, conditions, and data. This information is used to define a workflow of activities for monitoring and optimizing all services [6].

Metropolia

htw. Hochschule für Technik und Wirtschaft Berlin University of Applied Sciences

Research Questions

- At what level do enterprises manage their service process in relation to their energy management strategy?
- How are facility management processes from strategical and tactical level influence the energy management strategy?
- What is the implementation degree at the operational level of strategic and tactical specifications?
- How can operational services be organised/set up in order for them to have an impact on the Building Energy systems?

Methodology

The objective of this study is to develop, on a planning perspective, a strategic Facility Management Framework in order to identify, analyse and enhance services and processes that have a direct impact on an organization's energy management. In order to accomplish this, a review of scientific literature related to the strategic management of real estate operations will be undertaken. Additionally, it is important to review and analyze the international norms and standards that are used for developing strategies and implementing processes within an enterprise at a strategic, tactical, and operational level. Following the above discussion, it will be necessary to identify the operational management processes which influence the energy efficiency of a building as well as the required service levels.

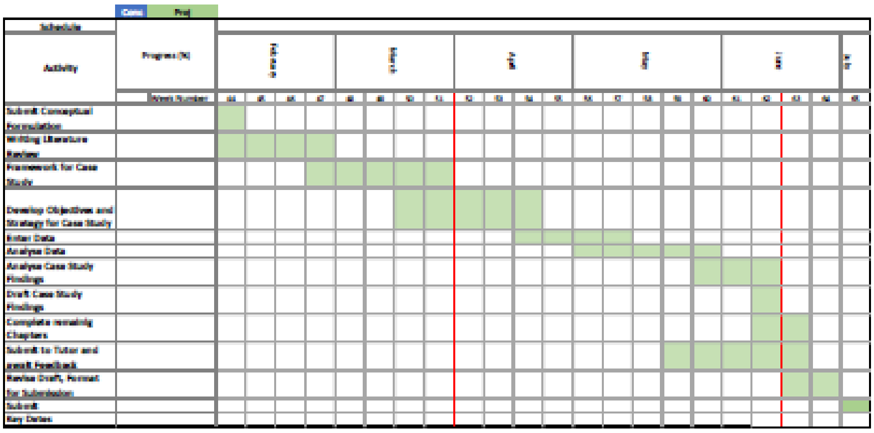
Once the relevant processes and services have been identified, a model will be developed that outlines the strategy, illustrates the processes that will be implemented, and specifies the levels of service, in order to identify the systems that are involved in the building's energy management and those that are not. Additionally, relevant case studies will be investigated and the model developed will be tested to determine its feasibility and potential for replication. The model will also be assessed for feasibility through the use of a physical case study with access to real-time data.

Both evaluations will conclude with possible key performance indicators being identified, and further recommendations will be formulated to implement the model systemically.

Metropolia

htw. Hochschule für Technik und Wirtschaft Berlin
University of Applied Sciences

Schedule



Resources

The resources to be used to carry out the study are as follows:

1. Library as well as e-libraries accesses for research
2. Data from above mentioned Case Study
3. Required softwares
4. Analytical tools for data processing

References

[1] P. Bertoldi, M. Economidou, V. Palermo, B. Boza-Kiss, and V. Todeschi, 'How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU', WIREs Energy Environ., vol. 10, no. 1, Jan. 2021, doi: 10.1002/wene.384.

[2] M. Tscherkassky-Aleksić, 'Internet of Things for Facility Management', Journal for Facility Management, vol. 1, no. 16, Art. no. 16, Jul. 2018, doi: 10.34749/jfm.2018.2805.

[3] D. G. Cotts, K. O. Roper, and R. P. Payant, The facility management handbook, 3rd ed. New York: American Management Association, 2010.

[4] Azar, E., Menassa, C.C., 2012. A comprehensive analysis of the impact of occupancy parameters in energy simulation of office buildings. Energy Build. 55, 841–853.

[5]Augenbroe, G., Castro, D., Ramkrishnan, K., 2009. Decision model for energy performance improvements in existing buildings. J. Eng. Des. Technol. 7, 21–36.

[6] Facility Management – Part 5: Guidance on Facility Management processes
English translation of DIN EN 15221-5:2011-12.

Abstract

Buildings in Europe consume 40% of the overall energy used, with a quarter of the building stock being non-residential. This industry has a high consumption rate but also holds significant potential for savings and efficiency improvements. However, energy efficiency (EE) is often overlooked, especially in the operational aspect.

Integrating an energy management system (EMS) can improve a building's operational energy (OE) usage. The operation services or facility services (FS) are primely situated to contribute to an EE due to their linkage to OE. Guidelines and processes of facilities management (FM) ensure that the FS is executed efficiently, which also enriches an EMS.

The purpose of this study was to develop a framework that helps enterprises bridge the gap between EMS state-of-the-art practices and FM to improve OE consumption with the assistance of FS. In order to do this, thorough research regarding FM processes, FM guidelines and EMS standards was conducted to create this framework. It was then refined through a second literature review. Finally, field research was conducted at a prominent research institute in Germany to validate and show the significance of this approach.

Keywords

Buildings, operational energy, energy efficiency, energy management system, facility services, facilities management.

Table of Contents

Abstract ..... **VIII**

Table of Contents ..... **IX**

Table of Figures ..... **XI**

List of Tabulations ..... **XIII**

List of Abbreviations ..... **XIV**

1 Introduction **1**

1.1 Research Methodology 3

2 Literature Review **6**

2.1 FM Processes 6

2.1.1 Process Modelling 8

2.1.2 Process Performance 11

2.1.3 Process Mapping 14

2.2 Standards on FM 21

2.2.1 The FM Strategical Level 25

2.2.2 The FM Tactical Level 29

2.2.3 The Operational FM Level 32

2.3 Energy Management 36

2.3.1 PDSA Cycle 37

2.3.2 Energy Management 40

2.3.3 Energy Management Systems, Norms and Best Practices 42

2.4 Energy and Operation Services of Buildings 47

2.4.1 Operational Energy and Energy Systems 48

2.4.2 Operation Services 52

3 The Framework **58**

3.1 Identifying Building Operation Services with Impact on Energy 60

3.2 Initial Framework 63

3.3 Refinement of the Framework.. 69

3.3.1 Strategical Refinement 69

3.3.2 Tactical Refinement... 73

3.3.3 Operational Refinement 79

4 Validation of the Framework.. 89

4.1 Field Research: Local FM Department 90

4.2 Discussion 102

4.3 Answering the Research Questions... 105

5 Conclusion 108

Declaration of Authorship.. 109

List of Literature 110

Table of Figures

Fig. 1: Research Methodology (by Author). 5
Fig. 2: Generic Process as per ISO 9000:2015; adopted from (CEN, 2015). 7
Fig. 3: Modelling the five critical stages of performing FM with the aid of IDEF0 (Alexander, 2008). 9
Fig. 4: Modelling the five critical stages of performing FM with the aid of IDEF0 (Alexander, 2008). 11
Fig. 5: General model beginning for Process Performance (IFMA, 2005). 13
Fig. 6: Level of Detail of Process Maps (Alexander, 2008). 14
Fig. 7: Identified high level activities (Alexander, 2008). 16
Fig. 8: Generic Process Protocol (Alexander, 2008). 20
Fig. 9: FM concept adopted from IFMA (Patanapiradej, 2006). 21
Fig. 10: FM Model (CEN, 2011). 23
Fig. 10: FM Processes at the operational level and FS (CEN, 2011). 34
Fig. 12: Deming Cycle (Moen and Norman, 2006). 38
Fig. 13: PDSA Cycle and Model for Improvement adapted from Moen and Norman (2006). 39
Fig. 14: Energy Management in an Organisation (VDI, 2018). 40
Fig. 15: Model of an EMS used for the Standard; adopted from (DIN EN ISO, 2018) 44
Fig. 16: Integrative framework for managing energy in companies (Schulze et al., 2016). 46
Fig. 17: Energy consumption according to type of construction and industry in the year 2021 Buildings (IEA, 2021) 47
Fig. 18: Identified building services by Vérez and Cabeza (2021). 53
Fig. 19: Proposed Process Flowchart for Identifying Possible Building Operation Services that might have an effect on OE management (by Author). 62
Fig. 20: Framework for an EMS (by author). 68
Fig. 21: Pareto analysis to determine the SEU (Mkhaimer et al., 2017). 75
Fig. 22: Definition of EEM adopted from (“5 Energy Efficiency Measures for Buildings - ClevAir Blog,” 2021). 79
Fig. 23: Pyramid of EEMs adopted from Parrish and Whelton (2013). 80
Fig. 24: EEMs identified through the operational refinement (by Author). 88

Fig. 25: Refined proposed EMS framework (by Author)... 89
Fig. 26: MPIB organisation concerning the technical services (by Author). 91
Fig. 27: Humidity and temperature measurements extracted from the BAS. 95
Fig. 28: Cooling cycle of the building displaying the changed set-point temperature from BAS. 95
Fig. 29: Developed Operational EEMs framework applied to MPIB (by Author). 99
Fig. 30: Developed framework applied to MPIB EMS practices (by Author). 101

List of Tabulations

Tab. 1: Phases for FM processes developed by Alexander (2008). 18
Tab. 2: Activity zones for FM processes developed by Alexander (2008). 20
Tab. 3: Strategic FM Processes (DIN EN, 2011). 27
Tab. 4: Alignment with the organisation's strategy and changes (DIN EN, 2011). 28
Tab. 5: Development of internal FM standards (DIN EN, 2011). 29
Tab. 6: FM processes at the Tactical Level (DIN EN, 2011)............................. 31
Tab. 7: FM processes at the Operational Level (DIN EN, 2011). 33
Tab. 8: Minimum requirement for an energy management plan (Schulze et al., 2016). 42
Tab. 9: Energy systems and energy consumption (by author). 51
Tab. 10: Identified activities in an EMS (by author). 66

List of Abbreviations

AHU	Air Handling Unit
API	Application Programming Interface
BAS	Building Automation System
BEEP	Building Energy Efficiency Programme
CAFM	Computer-Aided Facility Management
CAV	Constant Air Volume
CEN	European Committee for Standardization
CSR	Corporate Social Responsibility
DIN	Deutsche Institut für Normung (German Institute for Standardisation)
EE	Energy Efficiency
EEM	Energy Efficiency Measures
EMS	EMSs
EN	European Standard
EnPI	Energy Performance Indicator
ESA	Energy Saving Activity
EU	European Union
FCU	Fan Coil Unit
FM	Facility or Facilities Management
FS	Facility Service
GEFMA	German Facility Management Association
GLT	Gebäudeleittechnik
HE	Higher Education
HQ	Headquarters
HSSE	Health, Safety, Security & Environment
HVAC	Heating, Ventilation and Air Conditioning

ICT	Information and Communications Technology
IDEF	Integration Definition for Process Modelling
IEA	International Energy Agency
IFMA	International Facility Management Association
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
IWFM	Institute of Workplace and Facilities Management
IWMS	Integrated Workplace Management System
KPI	Key Performance Indicator
LC	Life Cycle
MEL	Miscellaneous Electric Load
MPG	Max-Planck-Gesellschaft
MPIB	Max-Planck-Institut für Bildungsforschung (Max-Planck-Institute for Human Development)
NPV	Net Present Value
OE	Operational Energy
O&M	Operations and Maintenance
PDCA	Plan-Design-Check-Act
PLC	Plug-in cluster fluorescent lamps
PV	Photovoltaic
RES	Renewable Energy Sources
SEU	Significant Energy User
SLA	Service Level Agreement
SMART	Specific, Measurable, Achievable, Relevant, and Time-Bound
SME	Small and Medium Enterprise
TD	Technische Dienste (Technical Services)

USD	United States Dollar
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
VSD	Variable Speed Drive

1 Introduction

Energy efficiency improvement and promotion of renewable energy sources (RES) are critical components of European energy policies (European Commission, 2006). The 2007 Climate and Energy Package foresaw a 20% reduction in primary energy consumption in buildings by 2020. It also foresaw a 20% increase in renewable energy production and a 20% decrease in greenhouse gas emissions from 1990 levels. The 2030 Climate and Energy Framework has updated the targets. This ambitious package fixes the reduction of greenhouse gas emissions at 40% from 1990 levels, the share of renewable energy at 27%, and the improvement in EE at 27%. Special attention is devoted to buildings due to a large amount of energy consumption and estimated energy savings in this sector in Member States (MS) (Standardisation, 2008).

In Europe, buildings consume approximately 40% of primary energy, making them among the largest end-use consumer sectors. Non-residential buildings account for 25% of the European building stock. Given the low rate of new construction and the long lifetime of buildings, with estimates showing that at least 75% of the current European Union (EU) building stock will still stand in 2050, existing buildings represent the most significant challenge and opportunity (Urge-Vorsatz et al., 2012).

Considering this sector's typically high energy usage, the energy savings that may be achieved through efficiency measures are substantial. The Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C (IPCC, 2018) confirms that due to the substantial energy efficiency (EE) potential of the present building stock, energy improvements are seen as crucial to achieving carbon neutrality (He et al., 2019).

As a result of energy renovations or energy retrofits, buildings can also reduce emissions, reduce pollution, and experience other co-benefits (Kerr et al., 2017). It has been noted, however, that initiatives that promote retrofits below a minimum level may render much of a building's mitigation potential unalterable, failing to achieve the required level of emission reductions (Huovila et al., 2009). Despite this, extensive evidence shows that many buildings perform poorly and generate far more CO2 than anticipated during actual operation. Although stringent construction laws and standards for new structures and retrofits of old buildings are vital, there is an urgent need to solve these significant EE gaps for existing buildings.

Throughout its entire cycle, a building primarily utilises two types of energy. The first is construction energy, often known as embodied energy. The energy consumed by the building services during the operation phase is known as operational energy (OE) (Praseeda et al., 2016). According to Stephan and Stephan (2016), operational energy is the primary form of energy use during the lifetime of a facility. Eighty to ninety per cent of the building's total energy usage occurs throughout its use period (Brady and Abdellatif, 2017).

Direct and immediate energy consumption can be reduced most effectively with energy management. Specifically, it emphasizes the importance of maximizing EE, utilisation of energy, and optimum management of energy resources. Management of energy refers to the existing sources, consumption, as well as planning and operation of energy related to the sources. A building's energy management system (EMS) focuses on reducing energy costs without jeopardizing the operation of the building (Siregar et al., 2019). Among facilities' operations and maintenance functions, energy management is becoming increasingly important.

In fact, facilities management, or facility management (FM), may offer essential contributions in facing these challenges. Every 20–30 years, commercial buildings undergo considerable renovations, driven mainly through the requirement for heating, ventilation and air conditioning (HVAC) equipment upgrades (NEEA, 2014). However, further options to cut energy prices and carbon emissions should not be missed in the interim. FM may deliver continual improvements in building performance via low- or no-cost maintenance solutions, retrofits, commissioning, and proactive operational management and maintenance (O&M).

Moreover, FM may bridge the gap between sustainability and energy standards compliance with actual building operations by incorporating energy management strategies into the processes and activities inherent to FM duties. Finding the link between FM and energy management can render a plethora of benefits to contribute to the optimal operation of services and systems while also enhancing the energy management of the buildings.

1.1 Research Methodology

The primary aim of this study is to establish a comprehensive and detailed framework that can provide valuable assistance to organisations and enterprises seeking to enhance their energy management practices. The said framework is specifically tailored to have a positive impact on both the building operation services and the operational processes of these organizations.

In order to guarantee that the framework is efficient and can be utilised in different situations, it is crucial to conduct a comprehensive review of the literature to identify potential FM process methodologies. These methodologies should serve as the essential foundation upon which the framework can be constructed.

In adherence to the research methodology, a literature review was undertaken to acquire an in-depth comprehension of facility management. The review was designed to amass data on the diverse functions and processes integral to facility management, aiming to identify the most effective practices. To conduct a comprehensive analysis, multiple norms were scrutinised, as well as standards and other relevant sources of information that pertained to facility management, including DIN (German Institute for Standardisation) EN 15221:2011. These standards provide the basic guidelines for FM in Germany and are taken from the European EN standards developed by CEN (European Committee for Standardisation).

The next step in the research was to explore the intricate world of energy management and its associated systems, such as EMSs (EMS). The primary aim was to uncover the most effective ways these practices could be integrated across all facets of an organisation to optimise EE. In order to gain a comprehensive understanding of the technical and operational facets of energy management, a thorough analysis of current industry norms, standards, and certification frameworks, such as ISO 50001, was conducted. This detailed examination enabled pinpointing the key components of EMS implementation and how they can be utilized to develop and maintain a successful energy management strategy.

Following the initial literature review, the first framework to aid in the analysis and systematic approach to successfully comply with the research goals was developed. To ensure the framework accurately reflected real-world scenarios, it underwent a refinement process after a comprehensive review of case studies. The framework was

improved and expanded as a result. The framework underwent validation through a real-life case study conducted as field research. The study involved performing assistant activities within the local FM department of a renowned Research Institute in Berlin, Germany.

Once the field research had been conducted and the data collection was finished, the subsequent step was to scrutinise the findings of the study. This entailed examining the gathered data, recognising any recurring patterns or themes, and drawing inferences regarding the research questions. The aim of discussing the outcomes was to ascertain the significant insights that could be acquired from the investigation and to comprehend how the findings correspond to real-life scenarios.

Upon completion of the research, the study culminated in a concluding chapter that provided a comprehensive summary of the findings. The final remarks emphasized the importance and relevance of the selected study in the current context, shedding light on its potential impact and significance in the field.

The research methodology has been clearly defined and explained in the accompanying Figure (1). The figure effectively depicts the interconnected steps of the methodology, forming a cohesive research process. By referring to this figure, one can easily comprehend the step-by-step approach undertaken by the researcher to conduct their study.

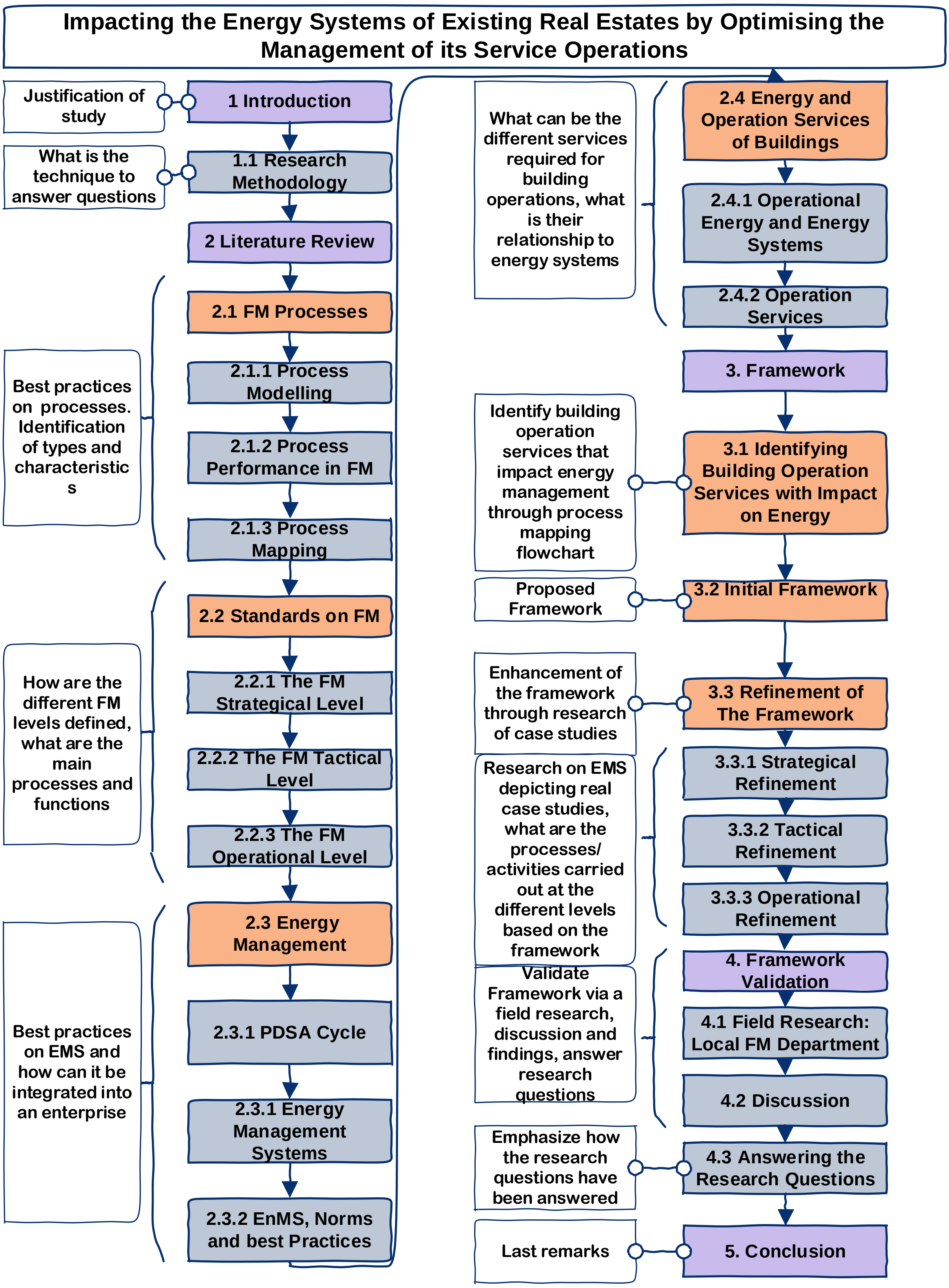


Fig. 1: Research Methodology (by Author).

2 Literature Review

The purpose of this literature study is to give a thorough summary of the available information regarding real estate operations and facility management procedures. This research is necessary to comprehend the interaction between energy management, facility management, and operation services. These are crucial for lowering energy consumption and improving the functioning of energy systems and building processes. The evaluation centred on identifying the fundamental facilities management process strategies in the real estate market. Standard methodologies for process analysis, such as process modelling, process mapping, and process performance, were utilised to examine and find possibilities to increase building EE. This study assessed the current facility management process strategies in the real estate business and connected them to EE enhancement adjustments.

The assessment also examined the present facility management norms and standards to determine the essential components that may be used to establish a framework for identifying energy management activities that might influence energy consumption in real estate operations. In this context, ISO 50001 was evaluated to determine its functionality and viability as a framework for energy management in facility management. The literature research concluded by examining the interaction between generic operation services and energy systems. The objective is to identify actions that may be implemented to influence company energy management. The literature study is a crucial stage in developing a complete framework that can direct real estate activities within the scope of facility management procedures.

2.1 FM Processes

ISO 9000:2015 defines a process as a collection of interdependent or interacting actions that turn inputs into outputs. It may be considered as a systematic series of events that occur inside an organisation in order to attain particular goals.

Furthermore, in the context of ISO 9001 and quality management systems, a business process is a set of operations carried out inside an organisation to achieve a specific business aim or deliver a particular product or service. These processes may incorporate a variety of inputs, such as information, materials, and resources, and they are

intended to create consistent, desirable outputs. Figure 2 provides a graphic description of a generic process.

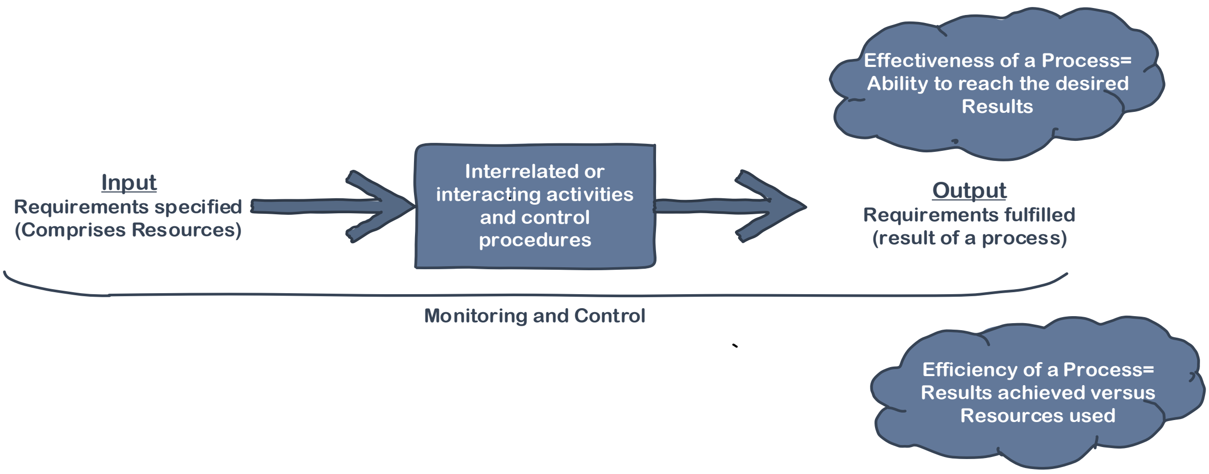


Fig. 2: Generic Process as per ISO 9000:2015; adopted from (CEN, 2015).

A business process is a set of activities that, when combined, create a product or service. The activities in the process can be either manual or automated and are typically linked together in a logical sequence. Each activity is designed to add value to the product or service and typically has an input, a set of actions, and an output. The output of one activity is usually used as an input into the next activity in the sequence. The overall aim of the business process is to produce a desired outcome and satisfy customer requirements.

Keith Alexander, a renowned expert in FM, led a research study in 2008 to develop a comprehensive framework based on different approaches and best practices. This research aimed to offer a practical guide to managers managing their facilities efficiently. To achieve this, Alexander reviewed various manuscripts and publications on facilities management from different countries. Additionally, he extensively analysed various case studies to identify the underlying patterns and best practices. Keith Alexander's research culminated in developing a facilities management framework widely adopted by facilities management professionals across many industries. Keith Alexander distinguished between various process approaches, including process modelling, process mapping, and process performance evaluation, highlighting the unique benefits and limitations of each to support effective process management.

2.1.1 Process Modelling

The process model is a map that specifies a benchmark or allusion point for evaluating performance and changing it. It serves as a visual representation of the activities and processes that must be completed to achieve the desired outcome. A blueprint or map may be of great assistance in guiding a business from its current location to its desired future location. The process model also enables the organisation to identify and close gaps between current and desired performance. In addition, it may be used to identify areas for development and create plans to guarantee that the intended results are attained.

The structured analysis and design method approach, also called integrated definition for process modelling (IDEF0), is shown in Alexander (2008) as an example of how integrated definition contributes to process modelling. IDEF0 is one of various approaches or protocols for modelling databases and systems with efficient software, including data exports. Product modelling employs IDEF0 to describe the building and facility-related procedures through which product data are defined and transferred. IDEF0 models display a set of connected and hierarchically arranged activities illustrated by rectangles. Fundamentally, an activity transforms inputs into outputs through the use of machines and people (actors), known collectively as mechanisms. In addition to regulating how these activities are performed, controls specify the conditions that govern their performance. Using IDEF0 tries to disclose the meaning of the task and represent the type of information, material, or energy delivered via the activity's confluence (arrows).

A method that starts from the top and goes to the bottom in IDEF0 promotes general reasoning and flattened perspectives. In IDEF0, a procedure may be viewed as a stratified set of related actions. This allows users to observe the relationships among activities and processes and encourages them to look at the big picture before delving into the details. Using a top-down approach, users can understand the context of the activities and processes and develop a holistic understanding of the system.

Applying process models in practice has made significant observations about their effectiveness and communication power. Alexander (2008) draws two conclusions from this. Involving stakeholders in mapping activities that have an impact on them is a notable strategy for establishing commitment and credibility. The IDEF0 notations are

basic enough for practitioners to be handled through the models in order to collect their feedback. This methodology enables them to understand the process better and suggest improvements. Secondly, regardless of the level of detail in the process model, it remains an abstraction of the real world. As complex as reality is, its essential elements can be presented to divert focus from redundant information and details without distraction. The top-down approach eases concern over detail capture.

Atkin & Brooks (2005) proposed to adopt the core business owner perspective when examining FM as a process. The rationale behind it is that owners are responsible for driving the process. The model's highest level comprises the key inputs that allow the FM function: business requirements and the facilities schedule. The key outcome is maximising the value and satisfaction of the facility owner and end-users. Generally speaking, the primary controls (or limitations) relate to quality (performance), productivity, and monetary restraints. Initially, the model can be broken down into five stages based on high-level functions: formulation of FM strategies, analysis of requirements, creation of solutions, implementation of solutions, and monitoring services. Figure 3 depicts the five critical stages of performing Facilities Management according to Alexander (2008).

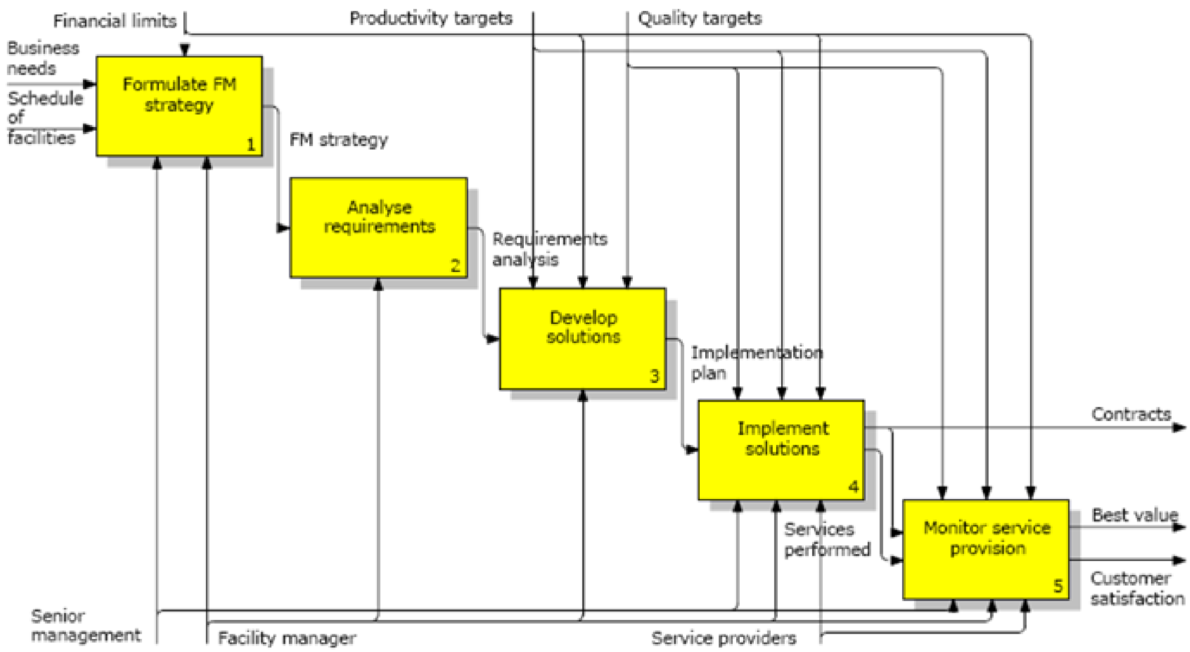


Fig. 3: Modelling the five critical stages of performing FM with the aid of IDEF0 (Alexander, 2008).

The five stages are interconnected and necessary for successfully implementing facilities management services. The creation of FM strategies establishes the framework

for the following four stages by identifying the organization's aims and objectives. The analysis of requirements helps ensure that the services provided are tailored to the organisation's specific needs. Creating solutions helps identify the best course of action, while implementing those solutions ensures that the services are delivered as intended. Finally, monitoring services help ensure the services meet the organisation's needs.

Using the top-down approach, it becomes clear that the first step in the FM process is formulating a strategy. This strategy relies heavily on the need of the core business. After this, the requirements must be analysed to develop a viable solution. Then, the solution has to be implemented and monitored.

In order to establish an FM strategy, it is paramount to distinguish between essential and non-essential services. Essentially, the owner must determine which operations and services may be outsourced and which services have to be sourced internally. Market price and availability of support (non-core) services are essential factors for the owner to consider. The strategy is a shining example of forethought and opportunity alignment. A second task that can be deduced from the same model is assessing the requirements of the owner organisation.

As a result, robust decisions can be made regarding outsourcing, retaining in-house staff, or a mix of both (Atkin & Brooks, 2005). As indicated in Figure 4 below, services are executed in a sequence of activities. It begins by mobilising the workforce and continues through conducting adequate performance, the review process, report creation, and rework. After these activities have been done, the needed solutions are established, which may be based on outsourcing, which entails some sort of bid competition for the delivery of services and always necessitates the compilation of paperwork. It may be possible to provide in-house services, which require specifications and SLAs just like outsourced services.

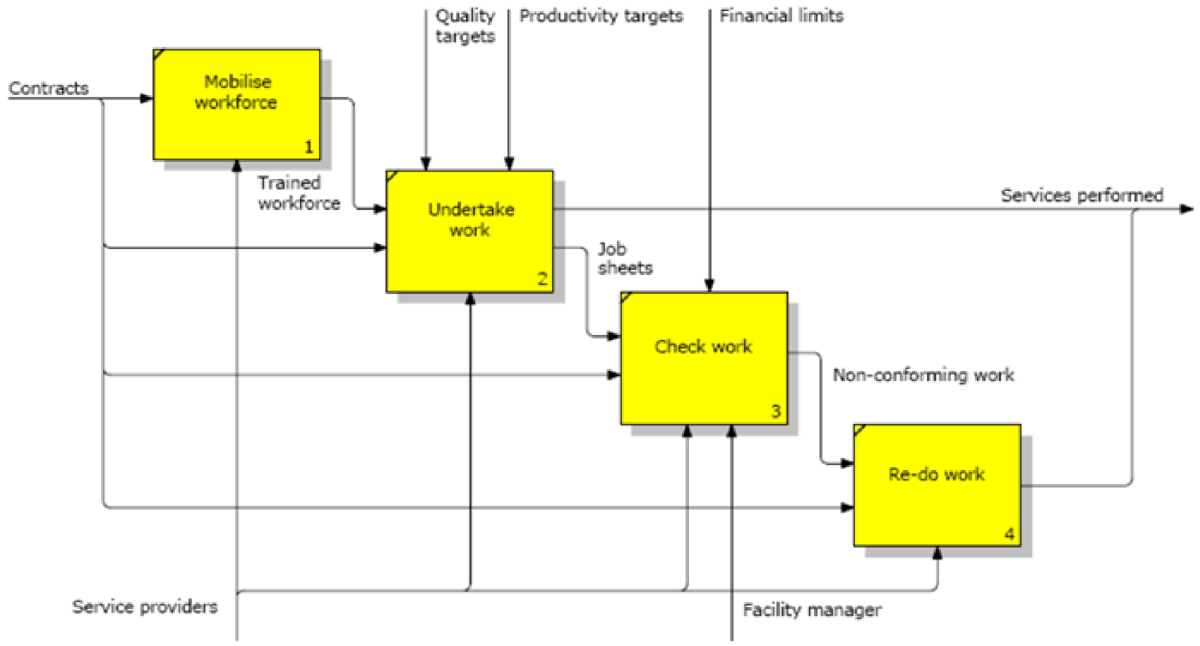


Fig. 4: Modelling the five critical stages of performing FM with the aid of IDEF0 (Alexander, 2008).

This sequence of tasks ensures that the in-house services are performed to the same standards as outsourced services (Alexander, 2008). The mobilisation stage ensures that the right personnel are in place and the necessary resources are available. The due performance stage ensures that the work is carried out in the prescribed manner. The review stage ensures that the work meets the specified standards, and the report stage ensures the outcomes are documented. Finally, the reworking stage ensures that issues are addressed before the services are completed.

The model provides the necessary structure for stating services and SLAs within the context of the individual services to be performed. This model's top-down approach must be set in a broad framework for decisions and effects to coincide with the owner's top-level objectives. Goals-driven practices and procedures allow the owner to incorporate fit-for-purpose practices and processes. When owners fail to appreciate the broader context, they risk being misled by only superficially appealing procedures.

2.1.2 Process Performance

In 2005, IFMA Switzerland initiated a project to build a Process and Service Model for Facility Management in order to include new trends (ProLeMo). ProLeMo developed

fundamental principles in a Swiss context to promote FM processes, performance and cost standardisation for owners, operators, and users. ProLeMo is based on the Integrated Facility Management (IFM) approach, which is an internation

ally accepted standard for the professionalisation of FM services. ProLeMo has been successfully implemented in many organisations and is now being adopted in other countries. It has become a benchmark for FM professionals.

Creating constant understanding regarding definitions, processes, accomplishments, and costs is a goal of Facility Management. ProLeMo's objectives include: establishing a foundation to increase the transparency of Facility management accomplishments and costs for owners, operators, and users; developing a standardised and acknowledged framework for Facility management accomplishments; and establishing standard processes and best practices to fill the process landscape. Measuring performance, identifying improvement potentials, and benchmarking are critical components of ProLeMo. It also helps standardise stakeholder communication and clearly define roles and responsibilities.

Different participants with different interests meet through real estate services management and use. Each of these participants has defined authority and responsibilities as well as various starting points and definitions. As defined by the project operator authority (BFE, 2005), owners, tenants, users, and managers form a 'triangle'. Within the FM system, GEFMA guideline 100-1 (GEFMA 2004, 100-1) advocates for the provision of transparent services. A client-customer relationship forms the basis of the DIN EN 15221:2011 standard developed by the CEN and adopted by DIN. In order to determine whether Facility Management is successful, the customer must evaluate its products and services. Independent of whether the participants are different individuals or the same legal entity, each has a different relationship with the other. Every participant aims for optimal and long-term success in the free market. DIN EN 15221:2011 outlines the following connections between the participants. Clients (such as owners) specify FM needs and contract for facilities services. An FM agreement specifies the conditions under which the customer (e.g. tenant) can order and receive facility services (FS). Service providers (e.g. operators) deliver defined operational results according to their FM agreements. An employee (e.g. co-worker) requires FS continuously or occasionally. Participants in the role models fall into two groups: clients and one-act contractors.

There are three levels of performance contribution: strategy, planning control, and operations. There is a clear differentiation of roles depending on the enterprise and the size of the real estate operation. At the outset, the process/performance model fulfils a set of requirements. The first step is to represent the roles in their various aspects. A standardized operational sequence and achievement represent processes through the model. A structure of utilisation costs was added, allowing the assignment of performance and defining exemplary products. Figure 5 illustrates a model that begins with the process/performance model considering the roles equally. A defined power spectrum describes what is to be done.

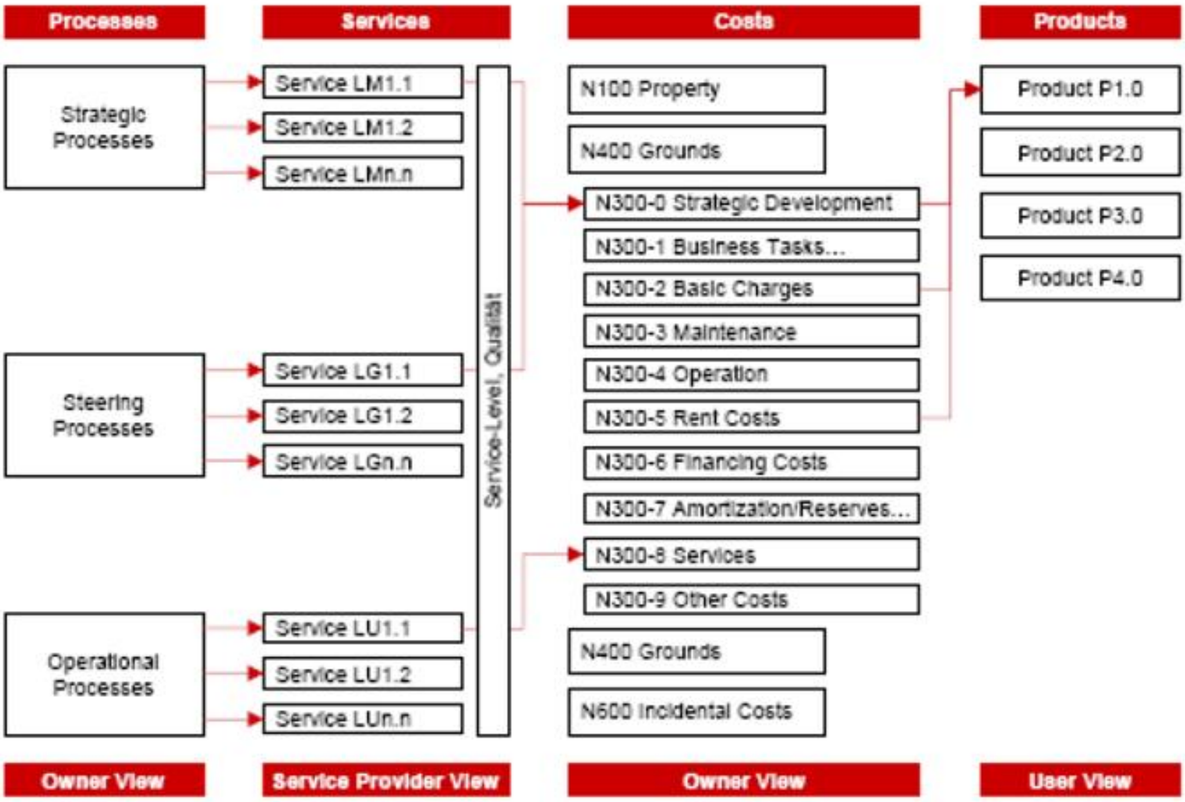


Fig. 5: General model beginning for Process Performance (IFMA, 2005).

Products are defined as power spectrums or enhanced processes that correspond to those who order (for example, renters) and obtain performance (e.g. end-users, occupants). Since the specified products are plainly depicted, this process framework is commonly used to calculate and allocate costs. For example, a company may use this model to track the costs of each project, measure progress, and adjust resources accordingly. This can be highly beneficial in helping the company optimise costs and

increase efficiency. Utilisation expenses are distributed to groups (and an object structure) by characterising the performance contribution's quality and technique (service level). Customer achievements are embodied holistically by the introduction of product catalogues in FM.

2.1.3 Process Mapping

The notion of business process mapping encompasses actions that accurately define what a firm does, who is accountable, how a process should be completed, and how its performance may be assessed (Alexander, 2008). By depicting the links between inputs, outputs, and activities, a process map may be utilised to visualise work processes. According to Cousins (2003), the process mapping method encompasses a graphical depiction of the transformation process. The process map permits complete macro and micro perspectives of activities. Figure 6 illustrates how a map can be utilised from a macro to a micro perspective.

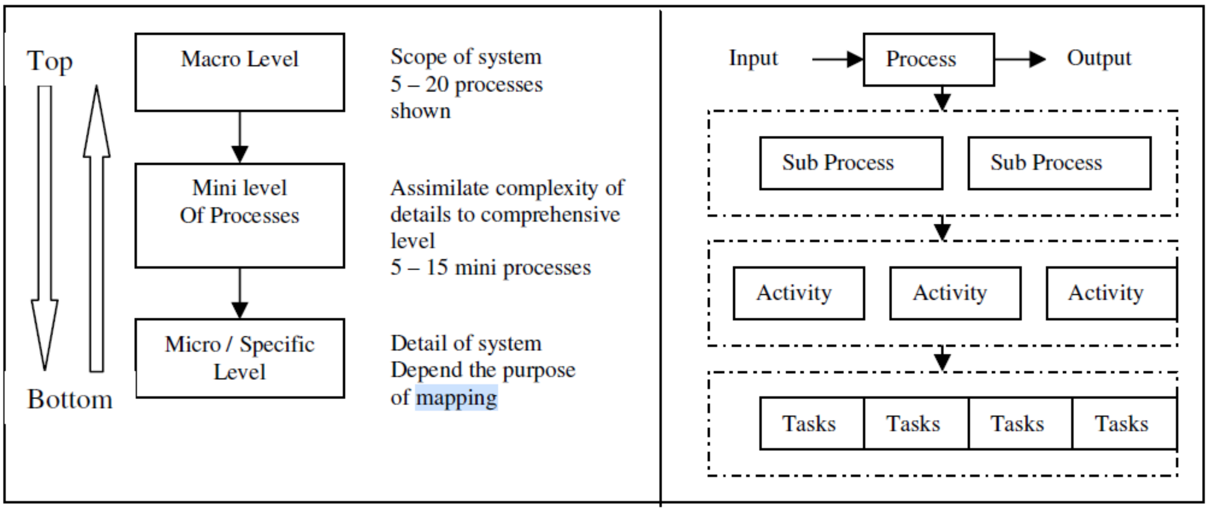


Fig. 6: Level of Detail of Process Maps (Alexander, 2008).

Process maps can display varying degrees of detail regarding the modelled process. This enhanced visibility enhances communication and comprehension and offers a common reference point for everybody participating in the work process (Pojasek 2005). The broad top-level (or phase) outlines the entire procedure by defining the principal phases and activities (Chapman and Austin 2002). This method centres attention on the data flow inside an enterprise and between distinct players.

The University of Salford developed a protocol known as the Generic Design and Construction Process Protocol (GDCPP), which serves as a framework for design and construction processes. This high-level process map presents an improved design and construction process. In Europe's market, FM processes are crucial in delivering innovative services of the highest standards. The British Standards Institute (BSI) and CEN have collaborated to establish a process-based definition of FM, which involves the integration of processes within an enterprise to uphold and enhance services that reinforce and improve primary actions' effectiveness.

The GDCPP, adapted and expanded by the FM Process Protocol, enables collaboration among multi-organisational teams in construction projects by providing standard definitions, documents, and procedures. This coordinated protocol facilitates the identification, collection, and assimilation of knowledge, promoting transparency in the process. The protocol encompasses all project steps, starting from the client's recognition of the need for operations and maintenance.

Using matrix networks, the design and construction process is modelled. Along the y-axis, activities are classified into eight activity zones, while the lifecycle parts are organised into four stages with 10 phases along the x-axis. The phase separations are referred to as stage gates. They provide a consistent approach to planning and assessment throughout the process, guaranteeing that the project is continually coordinated and monitored by means of phase reviews. The necessary tasks may be determined by identifying the zone of each activity, also referenced as phase, of the project's life cycle inside each matrix cell.

The project management process represents a set of processes to guide and support a multifunctional approach to achieving a common objective. Upon defining the elements of each cell, it is evident that a network of executable items is formed. In this way, the entire project process is modelled. Optimised activity zones are multifunctional and comprise all disciplines needed to complete a particular project task, allowing the goal to drive the process while optimising themselves to be highly effective across phases. By organising project participants into core tasks (also called activities), the process protocol's activity zones attempt to encourage multidisciplinary cooperation and eliminate obstacles associated with segmenting project teams.

As part of the GDCPP, FM processes are developed and structured in a robust framework. A non-technical representation of processes and sub-processes is possible using this open-source framework without having to use commercial software. The adaptation of the process protocol to an FM-focused one included activity zones, stages and phases intrinsic to the GDCPP. The first step in the modification was identifying the organisation's primary FM-related operations.

Alexander (2008) undertook a data-gathering effort to determine the scope and primary functions of Facility Management. The collected data was analysed to identify activities undertaken during the Facility Management lifecycle, as shown in the following Figure 7.

- Asset management
- Benefits realisation mgt
- Business definition mgt
- Business planning and dvpt
- Change management
- CSR management
- Environment Management
- Financial management
- HR Resource management
- ICT management
- Innovation management
- Health & safety management
- Knowledge management
- Legal management
- Lifecycle management
- Maintenance management
- Media management
- Performance management
- Primary and secondary process alignment management
- Process management
- Procurement and logistics management
- Programme management
- Project management
- Quality management
- Regulatory management
- Resource management
- Risk management
- Service delivery management
- Stakeholder management
- Standards and terminology management
- Strategic, tactical and operational management
- Value management

Fig. 7: Identified high level activities (Alexander, 2008).

The objective of business definition management is to define the organisation's key processes and activities and to improve organisational comprehension by supporting these processes, external variables, and internal capabilities. These activities are usually outlined in a framework that outlines the execution process. Consequently, activities might be continuous throughout a process or can change based on the phase in which they are involved.

Primary and secondary process alignment management is responsible for aligning the support infrastructure with primary business operations. The objective of asset management is to identify and manage the assets of the client's organisation according to their requirements. Through Service Delivery Management, client organisations are assured that the physical and soft services they procure meet their requirements.

On the basis of strategic, tactical, and operational considerations, high-level activities were first divided into six stages, reflecting business cycles; these six stages comprise the FM process protocol. The first stage consists of identifying the core business requirements. It is intended to guide understanding of the client organisation. It involves analysing primary processes and activities within the organisation and factors affecting it internally and externally.

Then, an FM policy and strategy are devised. In this stage, FM policy and strategy should have been determined by at least some degree of organisational understanding. This requires FM professionals to understand the organisation's objectives, resources, goals and capabilities and to use this knowledge to create a policy and strategy to optimise the use of the organisation's resources.

The next stage involves developing an alignment mechanism that seamlessly links the organisation’s requirements and the policies established by FM. Support has several objectives, including minimising costs, optimising space, responding to corporate social responsibility challenges, managing portfolios and business continuity, managing benefits, and helping improve performance.

Following the process protocol, the next step involves developing and integrating business support. This initiative's principal objective is establishing support capabilities based on the organisation's core operations. In this way, a dynamic, seamless support system should be integrated into the business infrastructure at the appropriate time. This gives the business a comprehensive view of its operations, allowing it to anticipate and address potential issues and risks. It also allows them to create a unified approach to managing their resources, ensuring they are used as efficiently and effectively as possible.

The subsequent phase focuses on deploying the infrastructure that supports and monitors the following frameworks: project management, communication, performance

management, stakeholder management, change management, customer relationship management, and risk management.

Finally, a dedicated task to maintain and administer the support infrastructure was established. This activity evaluates support requirements and capabilities to ensure the support infrastructure is continuously aligned with the core business operations. It should monitor performance and evaluates services that are being provided. This activity is critical for the organisation's success because it helps ensure that the support infrastructure provides the services necessary to support the primary business activities. It also helps to identify areas of improvement that may need additional resources.

A hierarchy of three levels was then used to fill in the details for each stage. A ten-phase process incorporating the six stages principle and providing detailed information regarding the FM Process Protocol's enactment sequence was then developed (see Table 1). The FM Process Protocol's x-axis displays stages and phases.

Phase 0, Organisational Preparedness	Changes in the external environment, new regulations, shifts in customer preferences, and leadership changes should be considered, and their impact on the organisation should be analysed.
Phase 1, Organisational Understanding	A phase designed to guarantee that all aspects of the organisation are known.
Phase 2, Organisational Definition	The policies and strategies of an organisation are defined or revised.
Phase 3, FM Definition	FM policy and strategy are specified or reformulated.
Phase 4, FM strategy development	Alignment of the strategy with the main business requirements.
Phase 5, Define Support Infrastructure	Determine the skills and capacity of the infrastructure support.
Phase 6, Develop Support Infrastructure	Establishing a supportive environment to facilitate the creation of business opportunities for the organisation.
Phase 7, Integrating Business Support	An integrated support capability that provides seamless dynamic support to the business infrastructure.
Phase 8, Implement Support capability	Implementation on a tactical level.
Phase 9, Maintain and Operate Support Infrastructure	It is necessary to check the alignment of support processes with main activities. The triggers of organisational change should be observed and kept in mind.

Tab. 1: Phases for FM processes developed by Alexander (2008).

FM process protocol has ten stages or phases. After the stages were developed, the streams of the activities within which the processes would dwell were created. As described by Kagioglou (1998), these activity zones are based on the type of function rather than being based on roles and tend to intersect and interact. The following Table (2) displays the identified series of zones.

Stakeholder (Relationships) Management	The indicated activity zone focuses on satisfying the concerns of stakeholders and assuring FM. It involves several activities, including identifying and categorising stakeholders and managing relationships with them. The stakeholders involved in this zone include the community, customers, clients, users, and human resources.
Programme Management	This activity zone oversees program management activities and correctly implements program and project tools. It involves various activities such as quality management, value management, risk management, performance management, media management, ICT management, knowledge management, and project management.
Resource Management	This activity zone handles resource requirements for FM programs. It manages financial resources, asset management, maintenance management, procurement, and logistics management.
Business Planning and Development	This activity zone ensures FM alignment with the supported business by focusing on business planning, development, change management, and strategy. It aims to integrate FM practices seamlessly into the overall business framework to enhance effectiveness and efficiency.
Implementation	This activity zone oversees the execution of FM programmes. The emphasis is on Service Delivery Management.
Lifecycle Management	This activity zone is crucial in considering lifecycle issues to prevent short-term decisions from adversely affecting long-term outcomes. In addition to strategic, tactical, and operational management, innovation management, and benefits realisation, it supports the transition from planning to implementation.
Health, Safety, Statutory, Legal and Environmental Management	This zone focuses on maintaining compliance with legal regulations and taking social and environmental considerations into account throughout the FM process. It tackles health and safety management, legal and regulatory compliance, standards and terminology management, and corporate social responsibility (CSR) management, including governance, liability, accountability, and environmental issues.
Process Management	This activity zone focuses on ensuring the process is executed correctly and efficiently, with the right individuals and in the correct sequence. Its primary responsibility is the management and execution of the process, encompassing

	activities related to process development, supervision, and implementation. This is to meet the required standards.

Tab. 2: Activity zones for FM processes developed by Alexander (2008).

Zones of activity are shown on the y-axis of the FM process protocol. The activity zone analysis grouped the determined FM activities into four main groups, which are based on the stakeholders' relationships; the management of FM tasks like quality compliance and risk management, the management of resources; matters related to planning, development and execution; matters related to the lifecycle of the assets; matters related to compliance with statues as well as corporate social responsibility; and finally, matters related to the management of processes. Figure 8 shows that the generic process protocol map can be adapted and implemented to develop and structure FM processes.

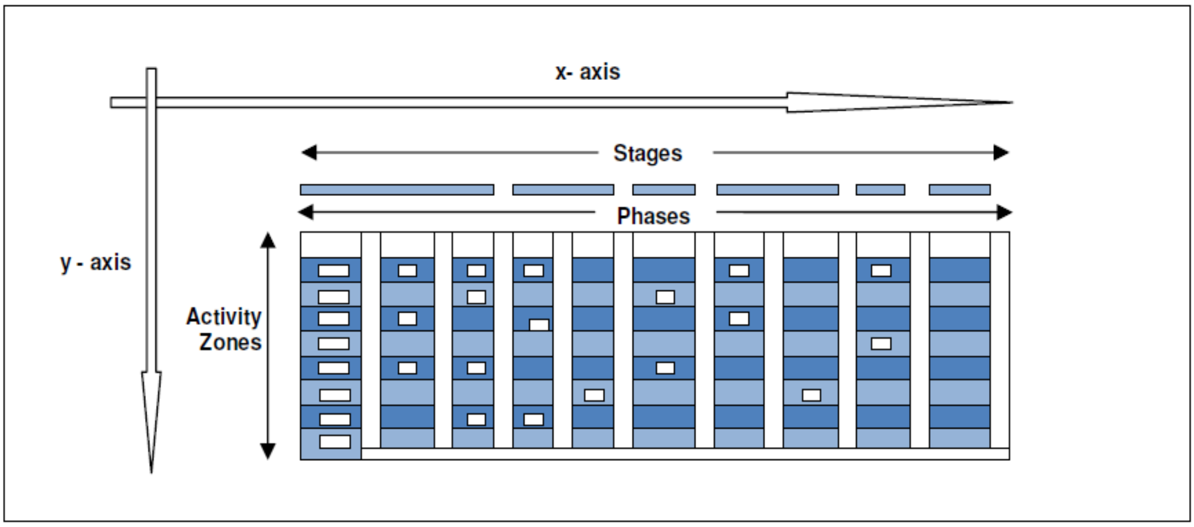


Fig. 8: Generic Process Protocol (Alexander, 2008).

The FM Process Protocol, established based on a process mapping technique, is a valuable tool for organisations to improve their FM competence in line with industry standards. As mentioned, the x-axis shows the different stages and phases. Zones of activity are indicated on the y-axis. The network formed is also referred to as a process matrix.

Alexander's (2008) perspective on FM is the most pertinent to how FM fits into the entire business agenda since he has said that understanding the factors that affect

business environment change and designing facilities to support it is essential to the FM role.

The DIN EN 15221-5 (2011) standard provides a framework and recommendations for facility management processes, which can assist businesses in enhancing their operational procedures. This chapter has discussed the strategic importance of facilities management, the need to better comprehend the need to improve processes, and a framework that provides the tools for adequate analysis, organisation, and decision-making. In addition, the chapter introduced the concept of business process mapping, which entails identifying what a firm entity accomplishes, who is liable, to what standard a process should be executed, and how the effectiveness of a business process may be monitored.

2.2 Standards on FM

FM is viewed as a relatively young, rapidly expanding discipline formed as the economic functioning of the built environment assumed greater significance (Shohet and Lavy, 2004). EuroFM (2023) and the Institute for Workplace and Facilities Management (IWFM, 2023) have adopted ISO 41011:2017 definition of FM as an " organizational function which integrates people, place and process within the Built Environment with the purpose of improving the quality of life of people and the productivity of the core business”. Its approach focuses on developing professional standards and training to guarantee high-quality service delivery and adequate facilities management team development. The International Facility Management Association (IFMA, 2023) has also recently adopted the definition of ISO. Figure 9 illustrates the proposed model.

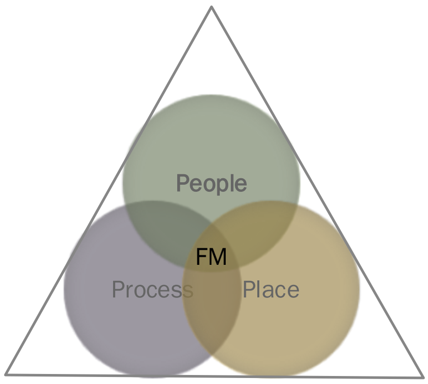


Fig. 9: FM concept adopted from IFMA (Patanapiradej, 2006).

The IFMA strategy stresses the significance of data analytics and technology in increasing facility management efficiency and defining international standards and best practices. As shown in the figure, the agreed definition encompasses three components that conform to a triangle signifying the relationship between them and FM.

In contrast, the German Facility Management Association (GEFMA) defines FM as the consideration, analysis, and optimisation of all cost-relevant processes surrounding a building, another structural object, or a (service) provided by the organisation that is not its core business (GEFMA– Definition Guidelines 100, Bonn 1996). GEFMA's approach to facility management is comprehensive, encompassing both hard and soft services and highlighting the significance of sustainability, EE, and life-cycle cost management.

Consequently, FM may be characterized as a multidisciplinary approach encompassing a vast array of processes, services, activities, and facilities to ensure the built environment's functionality by integrating people, places, processes, and technology. The establishment of a European norm for facility management helped to bridge the gap between these different approaches and establish a common language and set of standards that can be applied across the continent.

The DIN EN 15221:2011 is a set of norms that provides a framework for FM processes, encompassing all aspects of managing buildings and their services. The standard emphasises the importance of adopting a strategic approach to FM that aligns with the organisation's objectives and is continuously monitored and improved.

The standard is divided into six chapters, covering the scope, terms and definitions, requirements for the management systems, process model, performance measurement, and an implementation guide. The standard is designed to help organisations develop and maintain a comprehensive and cost-effective facility management system. It also guides how to identify, prioritise and manage facility-related risks. Finally, the standard provides tools and strategies to measure and improve the performance of facility-related activities.

The International Organisation for Standardisation (ISO) has also adopted the EN 15221:2011 norm as ISO 41001:2018. The adoption of EN 15221 by ISO demonstrates international recognition and acceptance of these norms as essential guidelines for effective facility management. ISO 41001 retains much of the same structure and

content as EN 15221, with only minor modifications to align it with ISO's management system standard format. This standardised approach to facility management enables organisations of all sizes and across all sectors to benefit from best practices. This contributes to facility performance optimisation.

The DIN EN 15221:2011 standards provide guidance on effectively managing facilities, including managing resources, processes, and people. It also outlines best practices to ensure efficient operations and improved service quality. Additionally, it provides a framework for assessing the performance of facility management operations. The informative Facility Management model described in DIN EN 15221-3 (DIN EN, 2011) is depicted in Figure 10.

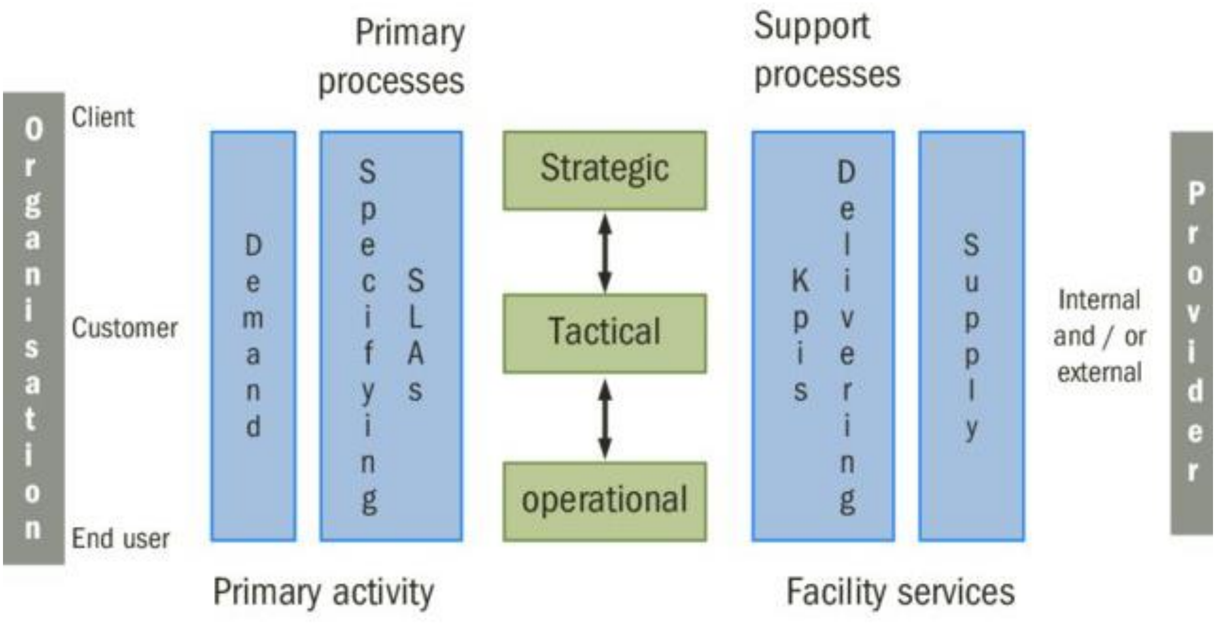


Fig. 10: FM Model (CEN, 2011).

The model stresses the FM support for the primary activities and addresses the demand-supply relationship. In order to meet the organisation's demands, the model developed a set of levels of interaction comprised of a strategic level, followed by a tactical one and then an operational level. It also describes the many levels of interaction amongst FM: strategic, tactical, and operational, in order to meet the demands. The model suggests that FM should be an integral part of the organisation and not just a support system. It emphasises FM's importance in cost reduction and value creation

for the organisation. Finally, it emphasises the importance of a continuous improvement process for FM.

Numerous activities, such as precise formulation of policy, directives for space, activities, processes, and services, promotion of risk assessment, and definition of relationships with the authorities, user and owner, strategic partners, and associations, contribute to the long-term achievement of strategic goals. Developing Service Level Agreements (SLA) as well as identifying the key performance indicators (KPIs) related to them effectively achieve these goals. SLAs and KPIs allow organisations to measure progress towards their strategic goals and provide feedback for corrective actions when needed. This helps ensure the organisation remains on track to achieve its long-term objectives.

An SLA is a contract between the party that provides a specific service, also named service provider (SP) and the party that requires the service, also known as the service recipient (SR). It describes the services both parties need (Goo, J. 2010). Hiles (1993) is often cited as one of the sources defining the SLA as the minimum provision of services granted by the SP and agreed upon by the SR. Based on the development of the SLA practice, a characterisation was developed that defines the services to be supplied (Beaumont, N. et al., 2004). Additionally, SLAs are established to ensure that performance and quality standards are managed regularly with performance-based agreements (Zammori, F. et al. 2009). SRs and SPs have specific responsibilities in agreement-making, procedures, incentives, penalties and rewards, according to the SLA described by Goo (2010).

The tactical level enables the implementation of strategic objectives over the medium term through preparing business plans and budgets, managing FM staff, and observing existing rules and regulations, among other particular choices. The tactical level mainly focuses on achieving short-term objectives, such as optimising resources, reducing costs, and identifying new opportunities. It also requires the evaluation of the performance of FM staff and adjusting plans and budgets when necessary. Finally, it is responsible for ensuring the organisation's compliance with applicable regulations.

Finally, the operational level concretises the primary objectives through, for example, dialogue with service providers and performance evaluations requested from end users. These evaluations help the organisation identify areas of improvement to meet the

desired objectives. The feedback from end users can also provide valuable insights for improving service delivery and customer satisfaction.

2.2.1 The FM Strategical Level

The strategic level is primarily characterised by the long-term planning process attempting to maximise the organisation's physical resources and assets. As per Johnson and Scholes (2002), management strategy involves coping with the intricacies of ambiguous, non-routine circumstances that might impact the organisation's future course. Strategic choices necessitate an integrated strategy since the entire organisation must progress in the same direction.

According to DIN EN (2011), the FM strategy must be tailored to the specific needs and challenges of the organisation. It should also be regularly reviewed and adjusted in response to organisational goals or objectives changes. This level also includes creating guidelines and policies for spaces, assets, processes, and services. These guidelines should ensure that the FM strategy is implemented effectively and efficiently while ensuring the safety and comfort of the staff and visitors to the organisation's spaces. Regular maintenance and monitoring should also ensure that the strategy remains effective.

The strategic level requires constant communication with the organisation's management department and should actively provide suggestions and answers. This helps ensure that the strategy remains aligned with the organisation's objectives and goals. Regular strategy reviews should be conducted to ensure it is up-to-date and relevant. Adjustments should be made when necessary to ensure the strategy remains effective.

This management level should include risk management, mitigation plans, define performance management guidelines and expenditure plans. The risk management and mitigation plans should outline the steps to reduce risk and protect the organisation from unexpected events. The performance management guidelines should include criteria for measuring success and any necessary steps to reach the desired outcomes. Including a budget for the resources needed to provide the organisation with the required service level as part of the expenditure is essential.

The Strategic level of FM needs to thoroughly analyse the facility's impact on the main activities, the environment and society. This includes examining how the facility affects

production processes, the surrounding environment and the community. It also involves considering how the facility can be improved to meet the needs of all users better.

Maintaining relationships with authorities and other stakeholders is crucial. This allows the facility to stay up-to-date with regulations and remain compliant. It also allows the facility to build relationships, which can be beneficial when it comes to gaining support from the community and engaging with customers. Additionally, having a strategic agenda that includes the approval of business plans helps ensure the business can stay on track with its goals and objectives.

Provision of advisory services to the demand organisation, defining replacement criteria, and making procurement decisions are also activities to perform strategically. These activities help to ensure the organisation is making the best decision possible when it comes to procuring goods and services. By defining replacement criteria, the organisation can identify the best value for their money and ensure they get the most out of their procurement budget. Advisory services can also help ensure the organisation makes the most informed decision possible.

Increasingly, organisations are taking a strategic view of FM outsourcing as they gain experience. Theoretically, strategic sourcing is related to the classic management principle of buying or making, which is correlated with organisation and market coordination (Williamson, 2008). It can be seen as an economic question of finding the cheapest solution, but it can also be viewed as a strategic one considering long-term benefits and risks. The procedures organised at this level contribute to the decision-making process at the top management level, enable holistic management of the FM organisation, and fulfil the requirements for the sustainable use of resources (DIN EN, 2011). Table 3 describes each of these processes according to DIN EN 15221-5:2011.

Strategical Processes	Description
Alignment with the organisation's strategy and changes	The alignment procedure guarantees that the FM organisation is aligned with the business plan.
Development of internal FM standards	Based on the FM strategy produced throughout the alignment process, internal business FM standards establish the operating parameters for the FM organisation.

Investments and strategic projects	As a result of the business plan analysis phase and after validating the current space and infrastructure resources, it may become necessary to expand the available space. In this instance, the "investments and strategic projects" procedure begins.
Reporting to the top management	The purpose of the reporting procedure is to demonstrate to senior management the efficacy and efficiency of the FM organisation. The findings of the FM processes are reported in a comprehensive report for this purpose.
Strategical planning	Strategic planning enables the FM organisation to provide room for essential activities as needed. Given that space has the most considerable impact on an organisation's running costs and that investments in space consume a significant portion of an organisation's financial resources, it is evident that sustainable selections are necessary.
Identifying the need for facilities and FS	As current and prospective changes influence long-term developments, planning for future facility and service requirements is necessary.
Consultation with the top management	To ensure that facility management requirements are incorporated into the choices of senior management, the FM organisation must provide strategic guidance to its members. The objective is to establish viable and sustainable decision-making that incorporates FM-relevant factors.
Management and control of the FM organisation	All facility management organisations require strong regulation/governance, leadership, and review to be effective.
Communication and change management	Due to the growth in change and the complexity of interdependencies, the FM community must also be able to communicate effectively and efficiently. Change management actions produce the required sustainability by resolving issues that develop during the implementation of changes.
Risk analysis and relationship with external providers	All hazards related to the management of facilities and the supply of FS must be analysed, and their effects must be evaluated.
Relationship with external contacts	Facility managers should collaborate with service providers, suppliers, and other external stakeholders and actively participate in professional events and networks to learn about industry trends and practical solutions.

Tab. 3: Strategic FM Processes (DIN EN, 2011).

These processes involve several key elements, including developing internal FM standards, identifying the need for facilities and services, consultation with top management, and managing and controlling the FM organisation. Risk analysis, communication, and change management also play a crucial role in ensuring the organisation is prepared to react to changing conditions and adapt to new business demands. Finally, reporting to top management, investment in strategic projects, and engagement with external providers are essential features that allow FM professionals to optimise their resources and deliver value to the organisation. These strategic processes form

the foundation for effective facility management that supports the organisation's goals and adapts to changing conditions.

The table below (4) depicts a total alignment between the facility management process, the organisation's strategy, and the development of internal FM standards to ensure consistency and efficiency throughout the facilities.

Alignment with the organisation's strategy **Activities**	**Inputs**
Analysis of the organisational strategy -Relevant strategies can be sustainability, expansion, growth, preservation of shareholder value, corporate social responsibility, cost leadership, quality leadership, and branding (company visibility).	-Change requests from business units -Investment project list -Business plans from business units
Deriving the FM strategy -Performance strategy (availability of space and functions) -Strategic space plan (acquisition of additional space) -Long-term project strategy (investments required to adjust demand and supply, buildings, equipment, assets, etc.) -Operation and maintenance strategy -Health, Safety, Security & Environment (HSSE) Strategy -Energy strategy -Contingency strategy (rules of procedure, emergency preparedness	**Outputs** -Actual FM strategy -Action plans to adapt to changes Information on FM organisations -Investment project plans
Process of FM strategy development Description of the Plans	**Trigger** -FM standard process Budgeting, investments Strategic changes in the organisation (mergers. growth etc.)

Tab. 4: Alignment with the organisation's strategy and changes (DIN EN, 2011).

The table above demonstrates the alignment with the organisation's strategy and change process. It outlines how important it is for the FM organisation to align with the overall business plan to achieve long-term success.

Development of internal FM standards **Activities**	**Inputs**
-To create a harmonised understanding of FM responsibilities and framework, FM standards are required	-Organisational strategy -Relevant corporate standards
Standards should be introduced for the following areas:	**Outputs**

-Operating and maintenance standards -Space (function, equipment media energy, size, dimen-sions) -Cleaning (performance levels, specification, etc.) -Safety (performance levels, risks, equipment, etc.) -Cost key, operating cost levels, target costs -Interface with main processes -Assessment (buildings, equipment, assets) -Quality audit (service audit, documentation audit) -Procedures for assessing facilities and buildings -Procedures for auditing performance levels against SLAs and KPIs -Adoption of existing standards and procedures depending on changes	-Intra-company FM standards -Intra-company FM procedures -Communication on the implementation of standards and procedures **Trigger** -Changes in organisational strategy -Changes in asset values, Facilities and needs of clients and users

Tab. 5: Development of internal FM standards (DIN EN, 2011).

The table above outlines the step-by-step method of developing the internal FM standards process, which highlights how these standards are informed by the FM strategy produced during the alignment stage, serving to establish the operational framework for the FM organisation.

2.2.2 The FM Tactical Level

The tactical level strives to accomplish the strategic objectives of the organisation over the medium term by establishing administration, reporting (setting up and executing), documenting (status and occurrences), and introducing and monitoring policies (DIN EN 2011). The tactical level is responsible for dealing with the practicalities of implementing the strategic goals. This includes ensuring that the resources are available to meet the goals, setting up systems to track progress, and monitoring the progress to ensure that the goals are achieved.

Tactics are action plans consisting of routine, targeted, and short-term preventative or administrative actions (Johnson & Scholes, 2002). These activities, which should be maintained as straightforwardly as possible, concentrate on everyday acts, such as implementing preventative safety measures and the proper use and upkeep of maintenance resources. The activities carried out at this level contribute to responsible workplace conduct and the non-stop optimal provision of working conditions in the facility.

DIN EN (2011) also specifies the development of financial plans as well as elaborating operational budgets as the main activities at this level. The tactical level accounts for translating the FM aims into operational demands by defining service level agreements (SLAs) based on strategic requirements and setting up the appropriate KPIs for tracking those objectives. Aside from managing projects, processes, and agreements, others include managing both FM teams and services teams, as well as communicating with internal and external service providers.

The FM procedures at the tactical level are intimately related to the FM organisation's strategic and operational levels. The binding nature of the tactical-level procedures ensures the flow of information from top to bottom and bottom to top. These processes' inputs and triggers consist of outputs from strategic and operational-level activities. In addition to the interconnectedness of the processes at the tactical level, the requirements of the principals are simplified to the needed form. The Table below (6) illustrates the tactical processes outlined by the DIN EN 15221:2011 standards.

Tactical Processes	Description and Activities
FM planning, implementation and monitoring of standards	Analysis of Service Provider's contracts, active participation in FM-related events, presentations on examples of best practices and other valuable content.
Valuation of Facilities	Application of a methodology for assessing the condition of the facilities and analysis of the assessment results concerning economic and ecological requirements. Plan necessary actions based on future requirements and ongoing projects to create sustainable facilities. Design, planning and realisation of action plans. Appropriate updating of the facility inventory.
Assessment of the performance of the FM organisation	Apply a methodology for measuring performance (performance levels and KPI). Analyse the results of the assessment in terms of achieving the agreed level. Planning of necessary actions based on the agreed requirements to achieve the objectives. Approval of action plans by strategic management. Design, plan, and implement action plans—appropriately updating the performance report.
Land use planning and assessment	Application of the methodology for space assessment. Assess current occupancy and use of space (users, extent, unused space). Analyse the results of the assessment in terms of needs. Planning of necessary actions based on agreed requirements to achieve objectives. Approval of action plans by strategic management. Design, planning and implementation of action plans. Appropriate updating of the performance report.
Procurement of facilities and FS	Application of the FM strategy and FM standards. Consideration of the results of the assessment process. Specifying the required quality. Collection of the required quantities. Communication of decisions. Implementation of FS. Start of performance measurement.

Contract management	Manage existing contracts. Assess contract duration, and analyse future changes. Taking into account the results of the performance evaluation. Taking into account the customer satisfaction survey. Update contract content (specifications, quantities, performance levels, etc.). Identify developments in FS and facility markets (benchmarking.) Approve costs against prices and quality (invoice approval). Meet with service providers to assess contracts. Communicate changes in FM strategy and standards—assessment of target achievement. Audit the service provider to check compliance with the contract.
Audit of health, occupational safety, security and environmental protection	Apply audit procedures and assess existing health, safety, security and environmental aspects. Create measures to meet the requirements derived from legal and insurance regulations. Control the measures through regular audits. Update the HSSE list of requirements. Train FM team members on health, safety, security and environmental aspects.
Change management and business unit coordination	Communicate with business units (tactical level) regarding changes in FM organisation. Identify changes in business unit needs. Clarify the needs of facilities, space and infrastructure. Estimate the costs of adapting to the changed requirements. Approval of the solution by top FM management. Approval of cost financing by business unit. Design, plan and implement the project. Notification of changes to service providers, business units, and other interfaces. Update facility and area directories, budget and contract directories. Report on project results.
Service provider control	Implement new service providers and debrief with outgoing service providers (space access, systems, procedures, health and safety regulations, FM strategy, behaviour in contact with the user/business unit, etc.). Management of existing service providers. Informing service providers about changes (FM strategy, internal FM standards). Communicate the results of the performance and status assessment (KPI, Facilities). Set targets for the upcoming period (adjustment of KPIs, targets, etc.). Manage changes from the service provider (contacts, staff, subcontractors) and grant or deny approval. Assessing the planning of services and granting or refusing approval. Control the actions of the service providers. Update the development and ranking of service providers.
Leading the facility management team	Set the objectives of the FM team. Assess the competencies of the team members. Assign necessary in-house competencies. Derive the competence development plan for the team members. Informing the team about strategic changes in the organisation. Organising the team according to the projects.
Management of facilities and resources	Create the Facilities Inventory. Assess the use of resources. Review the efficiency and effectiveness of the use of facilities and resources.
Communication Management	Establish communication forms for immediate and regular information of the FM team. Determine the FM company's communication channels and content per the decrees. Establish and provide means of communication in case of emergency. Establish communication principles (top-down, bottom-up). Train the FM team in communication. Inform the FM organisation of changes. Develop a change in management procedures. Establish tools to archive the changes for later investigation.

Tab. 6: FM processes at the Tactical Level (DIN EN, 2011).

The tactical level connects the strategic level to the operational level. At this step, processes transform the service levels and plans supplied at the strategic level into operationally executable plans. These plans are then executed at the operational level, with

the results feeding back to the tactical and strategic levels. The tactical level bridges the broad-brush policy decisions stipulated by the FM department at the strategical level and the detailed specifications for the daily facility function at the operational level.

2.2.3 The Operational FM Level

In order to deliver services accurately, the operational level is paramount. At the operational level, the goal is to create the necessary daily environment for the adequate performance of users. This level is responsible for guaranteeing that services are carried out in compliance with the SLA while also monitoring and reviewing service performance and ensuring that any changes in service delivery are documented and communicated to the user (DIN EN, 2011). Additionally, this level is responsible for ensuring the necessary environment is updated daily.

In order to ensure that the environment is updated and that service requests are attended to promptly, the staff at this level must monitor the system and be prepared to respond to any issues that may arise. They must also be able to troubleshoot problems and offer solutions that meet the customer's needs.

DIN EN 15221:2011 identifies data collection, feedback, and user requirements as critical responsibilities within the operational level. Data collection is essential to understanding customer behaviour and preferences, while feedback helps identify improvement areas. User requirements help ensure the product or service is tailored to meet customer needs. Troubleshooting and offering solutions are crucial to resolving customer issues and providing the best possible customer experience. The previous information is documented and reported back to the tactical level for further analysis. This data can be used to make informed decisions and optimize customer experience. Additionally, it can be used to identify areas for improvement and drive innovation.

Communicating with internal as well as external providers is of the utmost importance. This communication informs decisions, ensures process accuracy, and allows for the delivery of high-quality results. It also allows for developing trust and a better understanding of the customer's needs. Finally, it facilitates the implementation of strategies based on data-driven insights.

The DIN EN 15221:2011 strongly emphasises the distinction between operational FM procedures and FS linked to service delivery. Operational FM procedures relate to the

activities of monitoring, assessing the performance of the FS, collecting relevant data, creating reports on the FS and coordinating the FS. In contrast, FS relate to the services offered by the facility management team either through the internal department or through an outsourced service provider to facilitate the operation of the facilities, such as operation and maintenance, property management, cleaning, security, and catering. DIN EN 15221:2011 acknowledges that operational FM procedures and FS are essential to efficiently managing facilities but need specific skills, resources, and methods. By separating the two, this standard guarantees that facilities are successfully and efficiently managed. When FM procedures are distinguished from facility service delivery processes, it is simpler to identify areas of responsibility. Table 7 presents the operational processes with their related activities.

Operational Processes	Description
Monitoring and assessing the performance of FS	Audit the service delivery process. Consideration of the facility assessment report and customer satisfaction surveys. Measuring service outcomes against the SLA and KPIs. Negotiate adjustments in service delivery. Communicate findings up the hierarchy as necessary. Assessing service provider proposals for efficiencies and improvements. Agree on proposals. Adapt specifications to proposals. Communicate results to service provider management.
Data collection and management	Manage the facility directory. Manage the space data—update changes. Clarify additional data requests—Archive existing directories. Contribute to reporting.
Reporting on facilities and FS	Analysis of the results of the assessment processes. Inclusion of the results in the draft reports. Reports can cover the following: Operational and maintenance data (completed activities, status or condition data, condition data, emergencies and failures, corrective actions, etc.). Service requests from users. User change requests Complaints (cleaning, defects, etc.) Security issues Relocations Costs/budgets Measures (KPl, etc.).Projects.
Service coordination	Assess the planning of FS. Agree on possible timeframes for service delivery with users. Validate the needs for service provision, and determine the effective sequence. Communicate the results of the clarification with the users to the service providers. Inform service providers and users about changes.

Tab. 7: FM processes at the Operational Level (DIN EN, 2011).

Several rules and principles govern the delivery of services that can be outsourced. A service provider's management capability becomes increasingly important as the outsourcing project becomes more diversified (many FS in one contract). Facility service providers must support specific FM processes (coordination of services, reporting, and data management) to deliver effective and efficient FS. Nevertheless, an FM

organisation cannot outsource its intelligence client competence (DIN EN, 2011). It is easier to identify areas of responsibility when FM processes are differentiated from facility service delivery processes (FS).

DIN EN 15221:2011-5 provides guidelines for facility management processes at the operational level. These processes are divided into two types, which are area and infrastructure and people and organisation. The first type of process involves managing the physical aspects of the facility, such as the building's infrastructure and maintenance. This includes managing the electrical, plumbing, and HVAC systems and cleaning, landscaping, and pest control services. The second process involves managing the personnel and resources necessary to support the facility, such as staffing, communication, and safety management. Both types of processes respond to a series of requirements to ensure the proper functioning of the facility. These requirements are translated into actual processes and are used to provide the necessary FS. Figure 10 presents the mapping of the processes at the operational level, distinguishing between FM processes and FS.

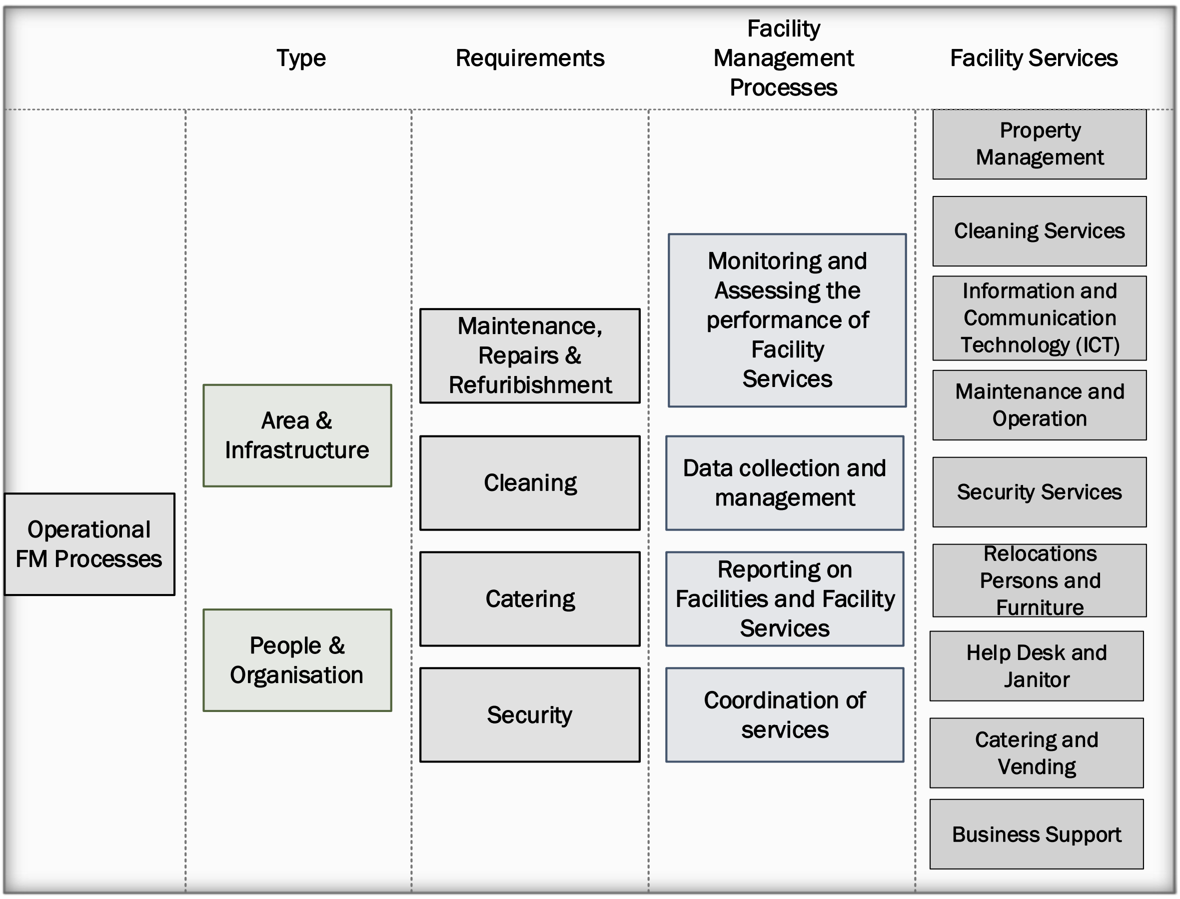


Fig. 11: FM Processes at the operational level and FS (CEN, 2011).

The tasks at this level have a very limited scope and entail straightforward, particular activities, such as cleaning, replacing, repairing, redecorating, and groundskeeping (housekeeping). Securing provisions for these basic operations and services provide the foundation of excellent FM practice (Nutt, 2002).

The facilities management concept described by DIN EN 15221:2011 is generally recognised and acknowledged. This model separates the FM organisation into three levels: strategic, tactical, and operational. An emphasis on developing a plan to accomplish the organisation's long-term goals by conducting adequate decision-making is paramount at the strategic level. The tactical level is concerned with turning strategic objectives into practical and operational operations, whereas the operational level is concerned with the day-to-day functioning of facilities.

To handle internal and outsourced supply, strategic and operational issues are connected and have to be established simultaneously (Nutt, 2002). Strategy is the compass that guides the operation of suitable facilities. Tactics and operations are the way through which an organisation achieves its objectives. The functions are reliant on one another. A harmonious, secure, and stable work environment is facilitated by a positive connection, allowing the organisation to advance toward its goals.

This FM approach is helpful due to several factors. It provides a clear structure for managing facilities, with distinct roles and duties at each level. This clarity of roles and duties enhances communication, coordination, and collaboration across all levels, resulting in enhanced decision-making, increased productivity, and cost-effectiveness. Second, it allows facilities management to link with an organisation's business strategy, ensuring that FM operations contribute to its broader business objectives. Lastly, this paradigm enables adaptability and scalability, with facilities management techniques tailored to the shifting business demands and nature of facilities management. Overall, the FM model described by DIN EN 15221:2011 offers a systematic approach to FM that can result in enhanced performance, higher efficiency, and improved results.

2.3 Energy Management

In light of the fact that energy costs have become a significant factor in the performance of the organisation, managing energy resources becomes an important task. Rathore (2011) argues that effective management of energy involves reducing or eliminating waste and maximizing efficiency so that available resources can be used more effectively. According to Doty and Turner (2004), energy management involves the thoughtful utilisation of energy in order to achieve particular objectives. Typically, the goals of private organisations are to increase revenues and improve competitive advantage. In most organisations, energy does not produce revenue; since it does not, they focus on identifying what areas are most advantageous instead of focusing on EE. With rising energy costs in recent years, government and private organisations have become increasingly concerned with reducing operational expenses within their organisations.

The realisation that energy usage can be one of their core activities has only begun to emerge in recent years. The reason is that if managed well, the organisation can save money and improve its financials. In other words, organisations can lower their operating costs and increase their profits by reducing and managing their energy usage more efficiently. It is suggested by Rathore (2011), who argues that energy costs contribute significantly to overall energy costs, especially in industry and commerce. In this regard, it refers to the management of energy or the management of resources. This chapter aims to provide an overarching approach to energy management, starting from a broad perspective and moving towards the critical role of energy management within buildings. One must first understand its strategic viewpoint to comprehend energy management's value. In this regard, the chapter elaborates on energy management's significance in meeting an organisation's objectives and goals, including financial, environmental, and social factors. By providing a strategic outlook, the chapter demonstrates how a far-reaching energy management method can bolster the organisation in the long term. One approach that provides a framework for continuous process enhancement in an organisation is the Plan-Do-Check-Act (PDCA) cycle.

Among the best EMSs (EMS) practices are the energy management fundamentals provided by the Association of German Engineers (VDI). ISO also developed an EMS in its 50001 guideline, which provides a framework for organisations seeking to achieve EE and improve their energy-related performance. The ISO 50001 system guides

organisations in integrating energy management within their business model by establishing a PDCA. This cycle involves assessing energy usage, implementing an EMS, monitoring and reviewing energy performance, and then undertaking corrective actions as necessary, all in a continuous cycle.

It's imperative to have a clear understanding of two terms related to energy management: energy conservation and EE. Energy conservation refers to reducing energy consumption through practices such as eliminating waste. EE measures the relationship between energy input and performance output. This was explained by González et al. in 2011.

2.3.1 PDSA Cycle

The PDCA cycle is a well-known concept for process improvement on an ongoing basis (Tague, 2004). It teaches organisations how to plan an activity, execute it, verify that it corresponds to the plan, and apply the lessons learned (ASQ and the Holmes Corp., 1999). The Shewhart and the Deming cycles are two other synonyms for PDCA, although each possesses a set of features that differentiates it from the others.

The PDCA cycle consists of four phases for change or improvement. The plan entails identifying an opportunity and organising a change. The modification is evaluated in the subsequent step. Checking involves examining the test, analysing the findings, and identifying improvement areas. The third stage, the act phase, involves putting what was learnt in the previous step into practice. If the improvement was effective, incorporate the test's findings into more considerable modifications. If not, repeat the cycle with a different strategy.

The PDCA cycle was first outlined by Walter A. Shewhart in his 1939 book Statistical Method From the Perspective of Quality Control. The form of the cycle, according to Shewhart, derives from the belief that regular examination of management practises and management's readiness to adopt and reject unproven ideas are essential to the creation of a productive organisation.

In addition to his mentor and instructor at Bell Laboratories in New York, W. Edwards Deming was responsible for coining the term "Shewhart cycle" for PDCA. Deming advocated PDCA as the most important method for attaining continuous process improvement. In the 1950s, Deming is credited with influencing the Japanese to embrace

PDCA. To honour Deming's ideas, the Japanese refer to the PDCA cycle as the Deming cycle(see Figure 12). The Japanese eagerly accepted PDCA and other quality principles.

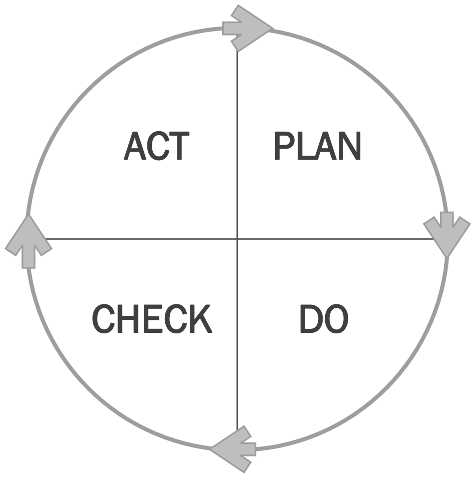


Fig. 12: Deming Cycle (Moen and Norman, 2006).

With a modified version of the Deming cycle, Moen and Nolan (1987) offered a comprehensive technique for process improvement. The planning phase of the improvement cycle necessitated the application of prediction and related theories. As a basis for learning, the third stage involved comparing the observed data to the forecast.

The Langley, Nolan, and Nolan (1994) PDSA Cycle is a revised version of the improvement cycle. The use of the word "study" in the third phase of the cycle emphasises that the purpose of this phase is to learn new knowledge based on the collected data. It is not sufficient to determine that a modification led to an improvement on a particular test. It is necessary to be able to estimate whether a modification results in an improvement under the many scenarios you may encounter in the future as you increase your knowledge. Additionally, they added three essential questions to the PDSA cycle:

- What are we attempting to achieve?
- How will it be determined if a change represents an improvement?
- What modifications will result in enhancements?

Langley, Moen, Nolan, Nolan, Norman, and Provost (1996, 2009) included these three inquiries as well as the new PDSA cycle into an improvement model. The three inquiries define the objective, measurements, and potential modifications. The concept applies to enhancing any organisation's operations, products, and services, as well as

one's pursuits. The approach seeks to strike a balance between the desire and benefits of taking action and the wisdom of conducting thorough research before taking action. Figure 13 provides, on one side, the enhanced PDSA cycle; on the other, it introduces the framework developed, including the essential questions.

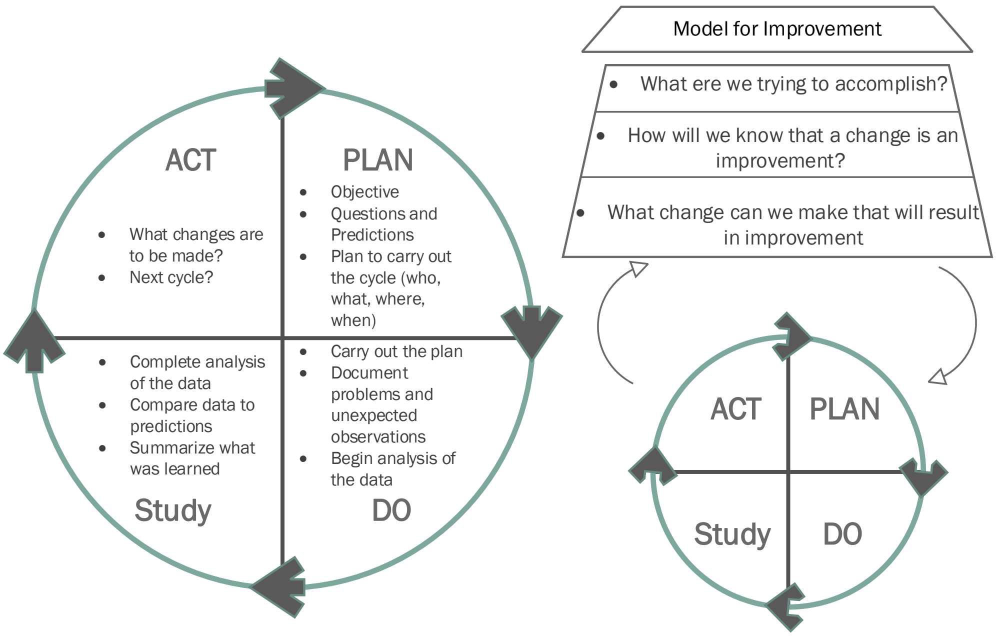


Fig. 13: PDSA Cycle and Model for Improvement adapted from Moen and Norman (2006).

The PDSA cycle is a tool used to improve quality management continuously. The cycle has four sequential stages for improvement: Plan, Do, Study, and Act. The Plan stage involves identifying a problem, setting up an improvement plan, and formulating questions and predictions. In the Do stage, the plan is executed, and the changes are implemented, while problems and unexpected observations are identified. The Study stage involves analysing the results of the changes and comparing them to the predicted outcomes. Finally, in the Act stage, the team determines if the changes were successful and whether further improvements need to be made. The PDSA cycle provides a structured approach to quality improvement, emphasising that small, incremental changes can lead to significant improvements over time. Organisations can consistently improve processes and achieve their goals by utilising the cycle.

The PDSA cycle is an improvement on the PDCA cycle. The shift from check to study was proposed by Deming (1986) since "check" means "hold back" in English, but "study" is a more understandable name for the actions underpinned during the third stage of the framework.

By introducing the PDSA cycle, an organisation can continuously improve its EMS, reducing its environmental impact and saving money on energy costs. The cycle creates a culture of continuous improvement in which employees are encouraged to discover and execute energy-saving methods, and the progress toward EE targets is constantly examined and assessed.

2.3.2 Energy Management

According to VDI (2018), energy management ensures that energy is acquired, converted, stored, distributed and used in a manner that meets ecological and economic goals. Implementing an energy management strategy is one of the most effective methods for reducing the EE gap in an organisation. A recognised EMS (EMS) is an advantageous tool for establishing energy management practices within an organization.

The EMS must take into account the existing organisational structures and application procedures. Therefore, successful energy management is contingent on adopting an organisation's strategy, objectives, and planning. Only by a thorough evaluation of the impacts of measures and documentation of continual improvement can a lasting influence be established (controlling). The Figure below (14) provides hindsight on implementing energy management in organisations.

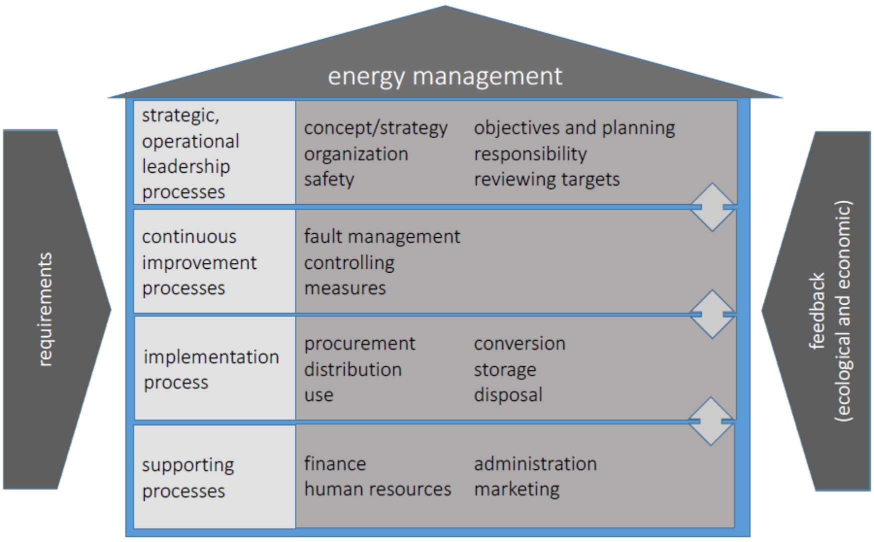


Fig. 14: Energy Management in an Organisation (VDI, 2018).

Leadership channels are developed and implemented from the strategy for achieving the defined objectives and considering the organisation's rules. These are reviewed

and adjusted as necessary using a controlling system to explain the responsibilities for accomplishing the objectives.

Continuous learning (e.g., from one's mistakes or external knowledge) derives measures from designing new implementation methods for attaining objectives and correcting existing measures.

The impact of the measures adopted within the context of the given objectives is routinely evaluated. Simultaneously, the application procedures deriving from the requirements for use are continually questioned in light of changing economic, ecological, and legal contexts and changes to the requirements for use. This permits modifications to be made regarding acquisition, utilisation, or disposal as appropriate.

As an EMS function, technological and commercial energy acquisition and storage require predetermined objectives. These may be qualitative as a starting step. Quantification is possible, however, once an assessment of the degree to which objectives have been met is known.

The EMS is a closed-loop control circuit in which the measures taken to increase efficiency and save energy are examined and evaluated based on the targets set. An EMS comprises the organisational and informational structures required to implement energy management and the necessary technical aids (energy data management and information channels) (VDI, 2018).

Depending on the region of application (e.g., local government or an industrial firm) and the use case (organisations with a large or small energy input), the organisation assigns EMSs varying statuses (staffing, funding, decision-making influence). From thorough research, Schulze et al. (2016) identified what an energy management plan should contain. These requirements are shown in the following table (8).

Minimum requirements
1.- Develop and execute a strategy over a more extended period that incorporates an energy policy as well as an energy conservation objectives.
2.- Organise energy-related activities by assigning responsibilities and duties
3.- Establish an interdepartmental management team with an energy coordinator as the leader (an energy manager) that directly reports to top management.
4.- Develop pertinent policies and processes, such as those pertaining to energy procurement, energy consumption, energy-efficient purchasing, etc.
5.- Conduct a (first) energy audit to discover opportunities for energy savings.

6.- Plan and execute particular energy conservation programmes (known also as EE measures or EEM)
7.- Detect company-specific key performance indicators that are periodically monitored to gauge success.
8.- Regularly measure and monitor crucial process's energy utilisation.
9.- Periodically apprise management of the progress.
10.-Ensure support from upper management for energy management efforts.
11.- By informing, inspiring, and educating staff, seek to engage them in energy management.

Tab. 8: Minimum requirement for an energy management plan (Schulze et al., 2016).

Noting that the International Organisation for Standardisation (ISO) 50001 (2018) provides a more in-depth and comprehensive approach to energy management than the minimum standards listed in the table above is necessary. DIN EN ISO 50001 (2018), which is the adoption of the ISO standard by DIN, offers enterprises a framework for developing, implementing, maintaining, and continuously improving their EMS. The standard includes a wide range of methods to assist businesses in monitoring and managing their energy consumption, such as creating energy targets and objectives, conducting energy reviews and audits, establishing energy performance indicators, and implementing energy-saving measures. In addition, DIN EN ISO 50001 (2018) standard defines a mechanism for ensuring that the EMS is effective, practical, and improving over time.

2.3.3 Energy Management Systems, Norms and Best Practices

Following the accumulation of information about electrical energy as well as the overall interest of industries in managing this resource in an intelligent manner, the ISO developed its 50001 (DIN EN ISO, 2018) standards in accordance with the management system model applicable to global enterprises. The standard can contribute to businesses of all types in the short-term as well as long-term efforts to develop energy technology. The requirements for EMS for companies are outlined in this standard. Energy management is thus incorporated into the organisation's overall quality and environmental management improvement efforts. It is essential for organisations worldwide because it enables them to meet stakeholder demands, prevent risks, and achieve strategic approaches for value creation, EE, and sustainable development by

utilising good management practices in manufacturing, business, and service institutions.

The implementation of the EMS begins with the decision of management to implement a system to enhance the EE processes of the enterprise. Once this occurs, a group responsible for enforcing the plan is designated within the organisation. The team must constantly communicate with the management department as cross-functional teams promote EE throughout an organisation (Parrish and Whelton, 2013).

The first task of this team is to determine the as-is state of the enterprise in terms of energy. A first energy assessment or evaluation should be carried out to accomplish this. The term energy audit can be related to this step. The objective is to pinpoint the company's primary energy procedures and consumers, gauge energy usage, and explore approaches to enhance EE, as suggested by Abdelaziz et al. (2011) and Gordić et al. (2010).

Following the initial energy assessment, the energy management group must develop an energy guideline or plan that encompasses both short- and long-term energy goals. These documents must be tightly aligned with the broader business plan, as energy management must contribute to the organisation's mission. It is crucial to integrate energy-related goals specific to the company into the planning process at various levels, including business groups, functional areas, and facilities, if relevant (Rietbergen and Blok, 2010).

During this phase, it is fundamental to identify the proper metrics, called energy performance indicators (EnPIs), to evaluate the implementation of the framework. EnPIs should be selected based on the specific objectives of the organisation. They should be measurable, achievable, relevant, and time-bound. They should also track the progress of energy conservation initiatives and accurately reflect the organisation's energy performance.

Energy management implementation involves executing measures and activities based on technological, organisational, and management-based plans developed during the planning phase (Caffal, 1995; Fleiter et al., 2012; McKane et al., 2007). The measures are trained, implemented, and measured for their effectiveness in areas identified as significant during the energy assessment.

According to Abdelaziz et al.'s 2011 suggestion, management can receive regular updates on energy usage and costs to establish a feedback loop for performance evaluation. An energy information system requires a controlling element to ensure that energy-associated data is consistently gathered and to monitor a company's energy consumption and associated costs. Studies by Bunse et al. (2011), Drumm et al. (2013), and Kannan and Boie (2003) have emphasized this. Moreover, it analyses and appraises the outcome effects of the implemented measures through the observation of the designated EnPIs. By establishing measurement standards for both internal and external entities, this process can identify areas requiring corrective action (Bunse et al., 2011; McKane et al., 2007; Sivill et al., 2013). A management review is fundamental within this method. The review consists of a thorough evaluation of the initial plan to evaluate if the steps and implementation were successful. The evaluation permits improvements to be made to the EMS to ensure success with a broader scope. Figure 15 presents a graphical representation of the system.

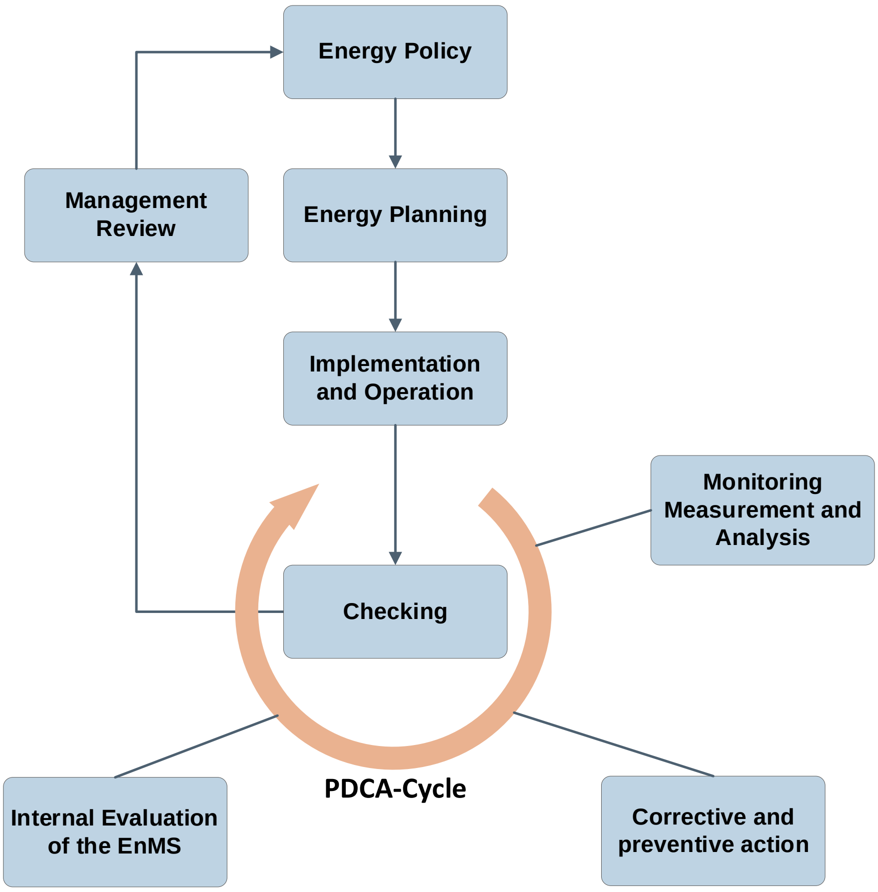


Fig. 15: Model of an EMS used for the Standard; adopted from (DIN EN ISO, 2018)

ISO's EMS is a tool that may aid in creating EE improvements within an organisation's operations. The purpose of the standard is to prevent the inefficient use of energy and

to offer explicit instructions for developing more efficient and cost-effective operations and organisational procedures. The proposed management model is PDCA-continual Improvement, focusing on the most significant sources of energy consumption within an organisation and how their management keeps energy performance growing continuously.

Parrish and Whelton (2013) identified two critical factors for the success of an EMS implementation. Multiple case studies reinforce the necessity for management commitment and show the effectiveness of their EMS, not only in delivering energy savings but also in creating cultural change, when management regards energy performance as essential to the organisation's strategy. In addition, the literature indicates that successful businesses have a direct correlation between energy expenditures and their bottom line.

Schulze et al. (2016) created an alternative, integrative paradigm for corporate energy management based on their findings. Strategic energy risk management (SERM) is a crucial element that must be taken into consideration. It involves analyzing and regulating a company's exposure to various risks associated with its energy consumption while keeping in mind the firm's economic goals and threat tolerance levels, according to Vasudevan and Higgins (2004).

EMS has an organizational component that can be divided into two parts: the governance structure within the company and the procedures and policies. The governance structure serves to create clear lines of authority and accountability, while policies and procedures are implemented to manage various aspects of the company’s energy value chain, including energy purchase, conversion, distribution, and consumption. This approach has been thoroughly researched by experts such as Abdelaziz et al. (2011), Christoffersen et al. (2006), Ates and Durakbasa (2012), Jelić et al. (2010), and McKane et al. (2007).

A company's senior management plays a crucial role in establishing and promoting an energy-conscious culture both within and outside the organisation. This involves their active participation in making energy-related decisions (Blass et al., 2014), incentivizing individuals and teams through rewards and compensation (Stawicki et al., 2010), and providing education and training on energy matters (Bowonder, 1984; Lesourd and

Ruiz, 1984). Such efforts can help create a sustainable and responsible business environment. Figure 16 shows the developed framework model.

The integrative energy management model was developed by Schulze et al. (2016)

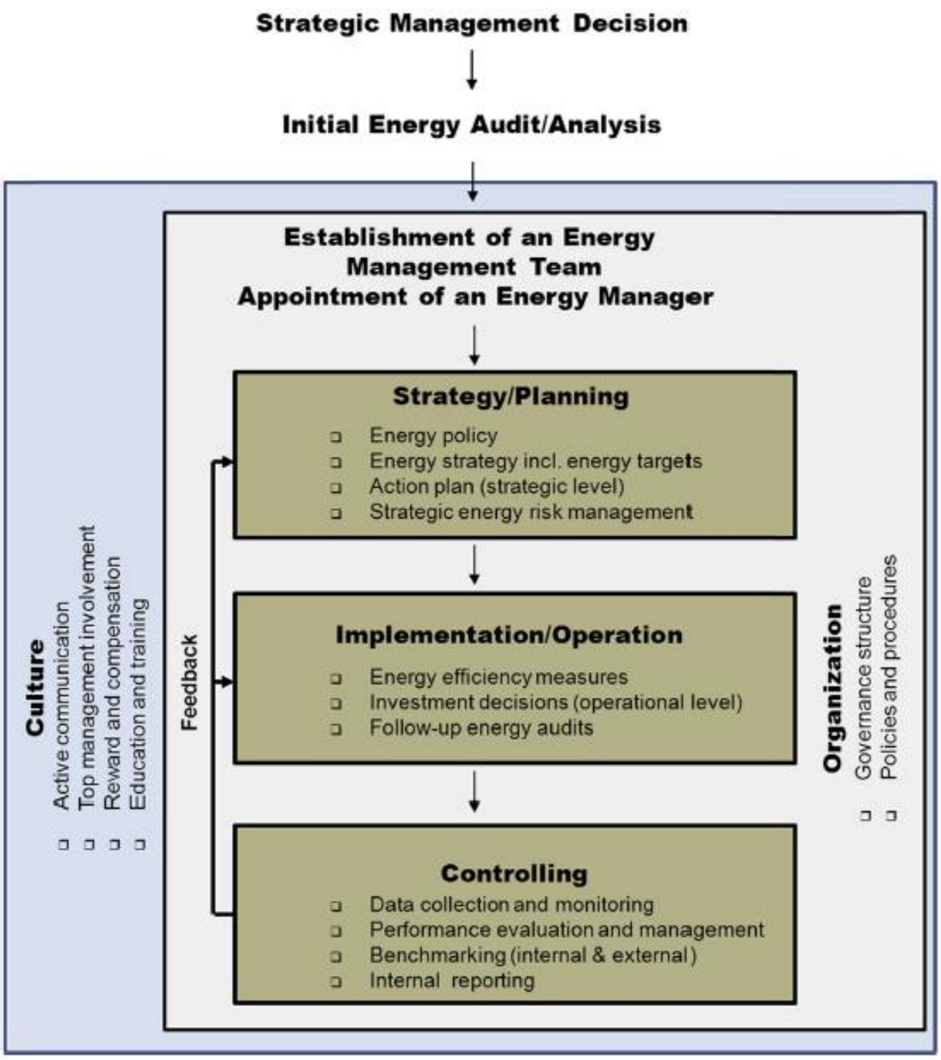


Fig. 16: Integrative framework for managing energy in companies (Schulze et al., 2016).

as a way to provide a comprehensive approach to energy management, considering three main subprocesses in a top-down approach starting with a strategy or planning phase where an energy policy is conceived, moving to the implementation phase where the measures are implemented and getting finally to the controlling subprocess which contributes to improving the overall performance.

2.4 Energy and Operation Services of Buildings

Buildings and their related infrastructure consume energy for heating, cooling, ventilation, lighting, and other operations. Real estate professionals are increasingly turning to EEMs, such as improved building insulation, energy-efficient lighting and appliances, and more efficient HVAC systems to reduce energy consumption in the built environment. Furthermore, they are currently investigating the potential of utilising renewable energy options, such as solar and wind power, as well as pursuing green building certifications to promote sustainable construction practices.

After the Covid-19 restrictions were lifted in 2020, there was a significant rebound in both energy consumption and emissions, bringing them back to 2019 levels. In the year 2021, it was observed that buildings accounted for 30% of the world's final energy consumption, along with 27% of the total energy sector emissions. Furthermore, 8% of direct emissions in buildings and 19% of indirect emissions from electricity and heat production were responsible for this ("Buildings – Analysis," n.d.). Figure 17 shows the energy consumption according to construction-, and industry type.

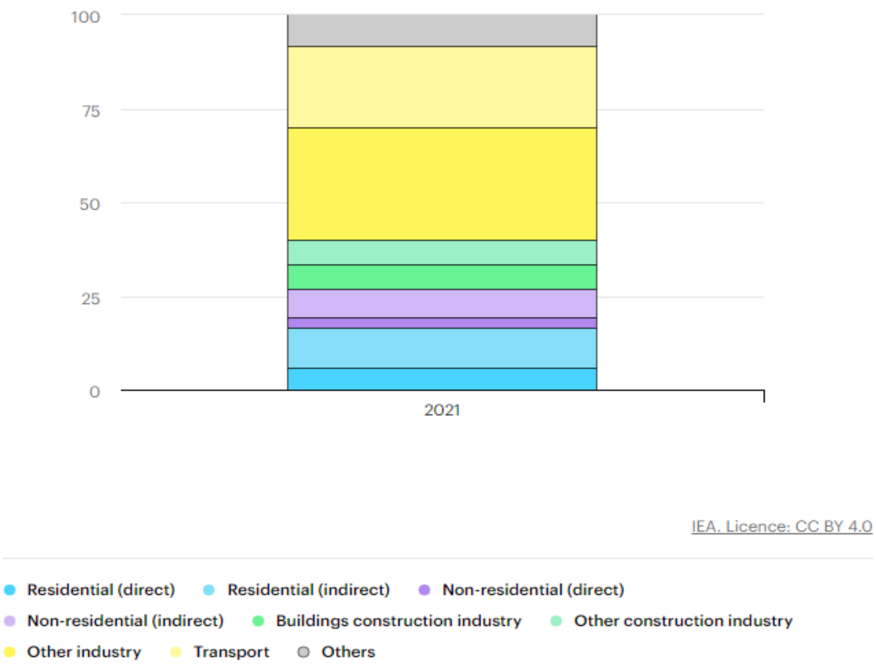


Fig. 17: Energy consumption according to type of construction and industry in the year 2021 Buildings (IEA, 2021)

There is an increase in both the scope and severity of minimal performance standards and building energy codes. Moreover, buildings use more efficient and renewable

energy technology while the power sector decarbonises. Nevertheless, the buildings sector must rapidly change to meet the Net Zero Emissions by 2050 Scenario.

The International Energy Agency's (IEA) Net Zero Scenario presents a comprehensive strategy to aid nations in reaching net zero emissions by 2050. The plan includes various measures such as the decarbonization of energy systems, enhancements in EE, and the adoption of novel clean energy sources to achieve this objective. According to the IEA, attaining this objective is crucial in restraining global warming to 1.5°C above pre-industrial levels and preventing the most adverse consequences of climate change.

The objective is to swiftly overhaul the global energy system by prioritizing the reduction of carbon emissions in electricity generation, boosting EE, and promoting the widespread utilization of renewable energy sources. Furthermore, the plan aims to gradually eliminate the consumption of coal and oil while implementing carbon pricing mechanisms and other policies to expedite the shift towards a future with zero net emissions.

The buildings sector has a significant carbon footprint due to direct and indirect emissions. In 2021, fossil fuel consumption in buildings contributed to around 8% of global CO2 emissions related to energy and processes, while generating electricity and heat for buildings accounted for 19%, and cement, steel, and aluminium used in construction contributed 6%. The buildings sector is responsible for roughly one-third of global CO2 emissions. To lower CO2 emissions, limiting construction and building activities throughout the value chain of buildings and construction is crucial.

2.4.1 Operational Energy and Energy Systems

As a result of the operations of buildings, direct and indirect emissions have risen about 2% from 2019 to about 10Gt in 2021 and about 5% from 2020 to 2021. The growth of direct emissions was observed in both advanced and emerging economies, with the primary factor being the increasing demand for natural gas in emerging economies.

In order to achieve the Net Zero Scenario, there is a need to cut down on carbon emissions from building operations by more than half by 2030. This can be achieved by reducing energy consumption through the use of clean and efficient technologies in all areas while also encouraging behavioural changes such as lowering thermostat settings.

The building’s energy consumption is profoundly influenced by its life cycle and, in turn, affects it. From the time of construction to operation, maintenance, and demolition, energy is utilized throughout the building's life cycle. Embodied energy, which includes material expenditure, equipment consumption, and labour consumption, is used during construction.

An energy-intensive process occurs during building operation, such as heating, cooling, and lighting. The energy consumed by these and all other building services is referred to as operational energy (OE) (Praseeda et al., 2016). OE in buildings represents the primary source of energy consumption throughout their lifetime (Stephan and Stephan, 2016), reaching between 80% and 90% of the total life cycle (LC) energy (Churcher, 2013). Finally, deconstruction consumes energy from the demolition process and during the disposition of its contents.

According to Rasmussen et al. (2018), operational energy pertains to the energy utilised in keeping a building's interior comfortable, covering heating, ventilation, air conditioning, water supply, and lighting. Meanwhile, Giordano et al. (2015) describe Primary Energy Demand (PED) as the OE, which includes heating, ventilation, cooling, hot water production, and lighting.

Regarding operational energy consumption, air conditioning and illumination are the most significant consumers (Praseeda et al., 2016). Buildings in developed nations use 50% of their energy for air conditioning (Pérez-Lombard et al., 2008).

In a building, HVAC systems can consume a significant amount of energy. These systems are responsible for heating, cooling, humidity regulation, air filtration, pressure control, and overall comfort of the occupants. With minimal intervention required from the building occupants, well-planned, installed, and maintained HVAC systems can efficiently conserve energy, promote occupant comfort, and prevent mould and fungus growth.

Buildings necessitate well-designed, energy-efficient HVAC systems, which boost staff productivity. The system typically comprises various components, including boilers, air distribution systems, chillers, absorption cooling systems, desiccant dehumidification, and ground-source heat pumps. Chillers, for instance, are used to cool air by passing it through coils containing a coolant, such as water or a refrigerant. Up to 35 per cent

of a facility's electrical energy consumption can be attributed to the machinery needed to manufacture chilled water for HVAC systems (Wilson, 2001).

Continuously working air distribution fans require more electric power annually than intermittently operating boilers or chillers. High-efficiency air distribution systems can drastically lower the energy consumption of HVAC fans (Wilson, 2001). A highly efficient design method is supplying a large quantity of air at a low velocity as fan power grows exponentially with airspeed. This is superior to forcing air through small ducts at a high velocity. Additionally, using variable-air-volume systems to provide only the necessary amount of air for conditioning or ventilation is more efficient than constantly supplying a fixed air volume.

According to Mastrucci and Rao (2017), heating consumes 25-36% of energy in countries with cold climates. Many facilities of different sizes and types rely on boilers to generate hot water or steam for various purposes, including space heating, food preparation, and industrial processes. It is crucial for operators to manage several factors, such as boiler staging, water chemistry, pumping and boiler controls, insulation for boilers and pipes, fuel-air mixes, burn-to-load ratio, and stack temperatures, to ensure optimal boiler efficiency. Regular maintenance and testing of these components are required for the boiler system to operate reliably and effectively. To prevent accidents and maintain effective operation, boiler operators must be well-trained and familiar with boiler safety laws.

The provision of hot water is an additional heating-related system. In buildings, hot water is utilised for handwashing, showering, cleaning, cooking, dishwashing, and laundering. It accounts for 4 to 10% of the overall energy consumption (Pérez-Lombard et al., 2008). Frequently, facilities have significant hot water needs in one or more locations and several lesser needs distributed throughout the building. The complexity and construction of hot water systems differ. Depending on the facility's needs, hot water can be provided by electric, gas, or solar-powered systems. Hot water systems must be adequately maintained to ensure the safety and efficiency of the facility.

Artificial lighting consumes a considerable portion of the world's electrical energy. Lighting accounts for 20 to 45 per cent of total energy use in office buildings (Dubois and Blomsterberg, 2011). The high energy consumption is due to the fact that office buildings are typically illuminated for long periods of time, thus increasing the amount

of electricity needed for lighting. Additionally, conventional lighting technologies, such as fluorescent and halogen lighting, are known to be particularly energy-intensive.

All other systems and equipment that do not fall into these categories are known as Miscellaneous Electric Loads (MELs). McKenney et al. (2008) define MELs as electric loads, except those associated with central heating, cooling, and ventilation systems. MELs are sometimes called electricity-consuming loads that do not qualify as typical end uses, such as lighting, HVAC, and refrigeration (Roth et al., 2008). Recent information indicates that MELs contribute considerably to the building's energy load, with consumer electronics among the most prominent contributors.

More than 20% of the primary energy consumed in commercial buildings comes from MELs, and this proportion is expected to climb by 40% over the next two decades (Renewable Energy Data Book, 2011). The expansion is attributable to the prevalence of PCs and other office devices in office buildings, which has resulted in a substantial installed base of computer equipment. Plug loads linked with Information and Communications Technology (ICT), such as PCs, monitors, printers, etc., which comprise a substantial portion of office equipment, are a crucial component of MELs. Table 9 summarises the described energy systems, the related equipment or components, and the energy they account for in terms of overall usage percentage.

Energy System	Equipment/Components	Energy Consumption in Buildings (%)	Sources
HVAC	Boilers	35%< for cooling systems 25%-36% for heating systems	Building Green, Inc., 2001 Mastrucci and Rao, 2017
	Air Distribution Systems		
	Chillers		
	Absorption cooling Systems		
	Desiccant dehumidification		
	Ground-source heat pumps		
Hot Water	Fixtures	4%-10%	Pérez-Lombard et al., 2008
	Appliances (dishwashers and laundry)		
Lighting	Lighting Fixtures	20%-45%	Dubois and Blomsterberg, 2011
MELs	PCs	20%<	Renewable Energy Data Book, 2011
	Monitors		
	Printers		
	Other office devices and equipment		

Tab. 9: Energy systems and energy consumption (by author).

According to Perez-Lombard et al. (2008), occupancy duration and facility improvement contribute to the escalation in building OE. Moreover, operational energy is significantly affected by comfort level, climate conditions, and operating schedules (Ramesh et al., 2010). Based on similar weather conditions, the energy consumption of a building can rise by 42-68% by increasing energy use by 20% plus increasing hours of air conditioning usage to maximise comfort (Mastrucci and Rao, 2017).

Heating and cooling of buildings are two areas in which it is possible to increase EE and decrease CO2 emissions, both of which are important in reducing energy consumption. There are, however, other building services besides these, and to have a holistic view, other building energy services (e.g., lighting) should also be considered in order to achieve a comprehensive view of the building services.

2.4.2 Operation Services

Essentially, building services are those systems and features integrated into a building to make it more comfortable, efficient, functional, and safe. Building services often comprise building control, energy distribution, and energy supply systems. Building services are classified based on this traditional description, including building management systems, energy generation and protection, HVAC, ICT networks, lighting, lighting protection, refrigeration, alarms, and security and ventilation systems.

According to another definition, building services are responsible for creating a safe and comfortable indoor environment while minimising the impact of a building on the environment ("Independent building test, research, instruments and information - BSRIA," n.d.). In addition, economic factors, as well as climate change mitigation, environmental quality, as well as thermal comfort, and acoustic comfort become increasingly essential factors as well. As an alternative, one could include terms such as shelter, cooking, materials, embodied energy and embodied carbon, and CO2 emissions, as well as Greenhouse Gas emissions and pollution, resulting from a more holistic approach.

In order to include all building services, as seen in Figure 18, they can be categorised as safety-related, comfort-related, efficiency-related, and eco-related services that deal with climate change.

Fig. 18: Identified building services by Vérez and Cabeza (2021).

Vérez and Cabeza (2021) developed a comprehensive method for cataloguing building services based on the effect of each service on safety-, comfort-, efficiency-, and climate change-related services.

On the other hand, DIN EN 15221-5 (2011), as previously shown, refers to Facility Services as the provision of services by an internal or external service provider to support an organisation's main activities. These services derive from the analysis of the needs of the core enterprise translated to a set of requirements to be undertaken by the service provider. The complete description of the client's requirements is known as Service Level Agreement (SLA). This agreement is a written or verbal contract between a client or customer and a service provider regarding the performance, metrics, and terms of the loaned services. Tracking the performance of the services is done by monitoring an established KPI that directly correlates to the SLA description.

Property management deals with the management of real estate and is carried out either through the internal FM or it can also be outsourced. It is often also referred to as property management or rental management. The various tasks include selecting and supporting tenants, formulating and concluding tenancy agreements, preparing

service charge statements, and commissioning and reviewing measures that serve the property's repair, maintenance and modernisation. It is also available to tenants and authorities as a contact. Income and expenses are regularly analysed, and suggestions for increasing efficiency in lettings and sales are developed. The awarding of work contracts required for maintenance and modernisation are also assigned by this management, always acting within an agreed financial budget framework (MOM, 2015).

Cleaning services for buildings are integral to maintaining a healthy and hygienic environment for the occupants. These services are usually carried out at night or very early in the morning to minimize disruption to the occupants' daily activities. During these times, the cleaning crew has unrestricted access to all areas of the building, enabling them to perform their duties efficiently and effectively. The cleaning process involves various tasks, such as vacuuming, dusting, mopping, and sanitizing surfaces. The crew uses specialized equipment and cleaning products to ensure that every surface is thoroughly cleaned and disinfected. Cleaning services for buildings are essential for maintaining a clean and healthy environment, preventing the spread of infections, and promoting the overall well-being of building occupants.

Cleaning services typically account for almost 25 per cent of weekly lighting use, which is equivalent to about 7 per cent of total building energy use (“The Benefits of Day Cleaning,” 2008). This is due to the use of lights during the cleaning operations, as well as the energy used by cleaning equipment.

The integration of ICT services into buildings has significantly increased over recent years. These services include communication networks, servers, and data centres, which provide internet access, email hosting, and cloud computing services. The service comprises the provision of desktops, monitors, printers, servers, etc., which account for more than 70% of MELs, being 50% of the overall building load during peak hours and reaching almost 80% during off-peak hours (Kamilaris et al., 2014).

The operations and maintenance (O&M) FS is crucial for the smooth running and upkeep of any building. Its main feature is regularly inspecting and maintaining the building's systems, such as HVAC, electrical, plumbing, and structural elements. The service ensures that these systems function efficiently and effectively, reducing the likelihood of costly breakdowns.

A security service for buildings is an operation service that aims to ensure the safety of the building, its occupants, and its contents. It provides vital security measures such as access control, surveillance, and emergency response to prevent unauthorized access and protect against potential threats (“A Simple Guide to Ensuring Building Security,” n.d.). At the same time, the security service requires energy to operate. This includes energy for the lighting, surveillance equipment, and alarm systems. Security systems also consume energy to keep occupant comfort levels in check.

Relocation of people and furniture is an essential facility service that plays a crucial role in workplace management. It involves moving employees, equipment, and office furniture to another location for various reasons, such as expansion, cost reduction, or organisational restructuring. This service requires careful planning, efficient communication, and proper coordination to ensure a smooth transition without disrupting the business's everyday operations.

Energy consumption in office buildings has risen considerably in recent years due to the increase in building utilization and office floor space expansion. This has resulted in higher heating and lighting demands. Additionally, the prolonged occupancy hours, growth of information technology, and frequent use of air conditioning, often without occupant control, have contributed to this increase. (Wade et al., 2003; Energy, 2003).

Even though EE has improved significantly (Energy, 2003), evidence suggests that small power equipment and ICT technology equipment, as well as lighting (Menezes et al., 2014; Wang and Ding, 2015), are significant contributors to energy end-use ("Climate Action Plans & Business Sustainability | The Carbon Trust," n.d.).

Although the space is not being used, lights often remain on in many offices, especially open-plan ones (Energy, 2003). Several office buildings were monitored by Masoso et al. (2010). According to the study, commercial buildings waste a significant amount of energy during non-occupied hours due to occupants leaving lights and equipment on at the end of the day. Surprisingly, more energy is being used after hours (56%) than during working hours. Wade et al. (2003) cite space cooling as another significant energy user in offices intimately connected to the floor space.

The help desk and housekeeping building operation service are essential in any commercial or residential building. It is responsible for the maintenance and upkeep of the building, ensuring that it is clean, safe, and functional. The help desk assists with

answering questions and resolving issues related to building operations, such as climate control, electrical wiring, plumbing, and security. Housekeeping is a maintenance activity commonly conducted by the internal FM team and is strongly related to the O&M services. Operating and maintaining the help desk and housekeeping building operation service requires energy. For instance, the help desk may have computers, printers, phones, and other office equipment that consume energy, while the housekeeping team may use cleaning machines, vacuum cleaners, and other appliances.

The catering/cafeteria building service is crucial to any business or institution. However, its impact on energy consumption may not be immediately noticeable. Based on a European study, preparing a single meal consumes between 350 and 2000 Wh (INKISUP 2002). There is a significant difference in the amount of energy used by cooking appliances in food-service facilities: 25%, according to the U.S. According to the Energy Information Administration (U.S. Energy Information Administration 2003) and the California Energy Commission (2006), 54 % of energy is used by cooking appliances in food-service facilities.

Hot water is also used as heat, primarily for sanitary purposes and dishwashing. The energy required to heat water varies between 150 and 1300 Wh/meal (INKISUP 2002), of which 80 % is used for dishwashing (Argulander & Aulik 2009).

The use of refrigeration keeps food in hygienic condition and keeps some products cold at the appropriate temperature. It is observed that energy consumption varies from facility to facility depending on the kind of food and the cooking organisation. The average energy consumed by food refrigeration in a food-service establishment is approximately 50 to 90 Wh per meal (U.S. Energy Information Administration 2003).

In warm regions or in summer, air conditioning is necessary for the thermal comfort of customers. A kitchen fan can also be necessary if the temperature is too high, typically over 28°C (Paillat, 2011), due to heat generated by appliances such as cooking appliances, dishwashers, and refrigerators.

Approximately 10% of the energy used by food-service facilities is spent on lighting (U.S. Energy Information Administration 2003). Around 5% is attributed to ventilation, for example. High lighting intensity is usually required to provide good working conditions for kitchen workers (Sullivan, 1998). Electric motors are also used for ventilation systems, air conditioning units, dishwashers, food processors and conveyors.

Operational energy, energy systems, and building operation services are closely interconnected factors significantly affecting EE. While operational energy is the energy consumed during the day-to-day operations of a building, energy systems refer to the various equipment and devices utilized in running the building. Building operation services encompass a range of activities and services that ensure the smooth operations of a building. All these factors must work together harmoniously to achieve optimal EE, reducing energy consumption and costs while minimizing environmental impacts. However, such efficiency can only be accomplished through an adequate energy management framework that effectively measures, analyses, and controls energy use.

3 The Framework

This study aims to develop a strategic FM framework that can assist organisations in identifying, analysing, and enhancing services and business processes that influence their OE management. In order to accomplish this, a comprehensive analysis of existing best practices in strategic facility management and facility management procedures was undertaken. Through this, it became evident that norms and standards such as the DIN EN 15221-5 (2011), the ProLeMo initiative carried out by IFMA Switzerland, as well as the analysis developed by EuroFM, specifically by Alexander (2008), provide an exhaustive assessment regarding FM processes and best practices. Also crucial is the fact that there are several ways for developing and analysing FM processes, and depending on the strategy and scope, one may be more appropriate than the others.

Process modelling is the practice of creating graphical representations or descriptions of a specific sequence of activities or events that comprise a specific process. This method enables organisations to comprehend the workflow of a specific process, identify bottlenecks, and simplify complex processes, thereby transforming them into more manageable and streamlined workflows. Process models illustrate quantitatively and objectively corporate processes. The models are rich in workflow data, including information on events, a record of who initiates or owns them, the pathways of the workflow, deadlines for each step, and success rates ("Process Mining vs Process Modeling vs Process Mapping," 2023).

In contrast, business process mapping involves accurately outlining the tasks carried out by a business, identifying the responsible parties, determining the level of performance expected, and establishing methods to evaluate the effectiveness of the process. In order to map a process, a subjective and qualitative approach has to be taken. A major advantage of process mapping is that it depicts operations in a more human-centric manner. Instead of recording objective data, process maps primarily depict the many individuals, areas or teams engaged in a specific business process. Specifically, the FM process protocol established by Alexander (2008), which is derived from the GDCPP and is map-based, helps identify the activities, stages, phases, and zones of a process in order to improve it. Furthermore, the protocol also includes the different levels established for FM and the different responsibilities and stakeholders of each level.

IFMA Switzerland's ProLeMo project has some shortcomings in terms of facility process identification and improvement. As it is meant primarily for determining costs related to each facility product, it is helpful for major enterprises and organisations. Consequently, the effort may not assist smaller firms. As a uniform procedure, the project may not be able to fit the specific demands of each facility. Therefore, it is possible that the program may fail to address the unique concerns and obstacles experienced by various institutions. Thirdly, the ProLeMo effort may take substantial time and financial resources to accomplish. This may provide difficulty for smaller institutions or those with limited resources. Lastly, the effort does not provide a complete answer for facility process development, and it should be utilised in concert with other tools and techniques for maximum outcomes. In conclusion, although the ProLeMo program provides a beneficial foundation for developing facility processes, it is not without limits.

Due to the features mentioned above, it was decided that the best method to adopt for identifying, analyzing and enhancing the process and services that impact OE management is the process mapping approach developed by Alexander (2008). If followed thoroughly, this mapping system can provide a layout that allows for a comprehensive OE management approach. It is a process-oriented approach emphasising the importance of using a structured process to ensure that all relevant aspects, in this case, related to OE management, are considered within a process. However, to fully comply with the proposed framework, it also needs to be determined whether organisational processes can be enhanced to impact the operation services energy management.

The DIN EN ISO 50001 (2018) established a methodology intended to assist companies in systematically optimising their OE use. It considers the role of management in supporting energy initiatives, integrating energy into organisational policy, monitoring OE use, and controls improvements. The standard recommends the PDCA cycle, which is also used for quality management. As per the previous chapter, the suitable term for the cycle is PDSA. This cycle is valuable for determining which operating services can affect the EMS. It enables managers to discover possibilities for improvement in the EMS, plan and perform the required activities, and evaluate their efficacy. The deployment of such a cycle may aid in identifying energy-intensive operational services and optimizing their operations to increase their EE. The missing piece that allows bridging process mapping and an EMS can be provided by introducing the FM concept developed on DIN EN 15221-5 (2011).

The framework developed through the abovementioned concepts is only the starting point in establishing a robust OE management plan for any organisation. The real-world application of this framework is what ultimately drives successful outcomes for a business. Therefore, a collection of thoroughly selected case studies is imperative in order to refine and augment the framework to ensure maximum effectiveness. These case studies allow for the mapping and referencing of business processes and activities that are related to the OE management of an organisation. A thorough and well-rounded understanding of different methods and approaches facilitates developing a comprehensive OE management plan encompassing various energy sectors. With this approach, organisations can be better equipped to identify and address energy inefficiencies and, ultimately, improve their bottom line.

The next critical step in the framework is putting it to the test through a practical case. In this case, the validation process focuses on the OE management practices of a local FM department at a renowned research institute in Berlin, Germany. This case study helped to assess the feasibility and effectiveness of the developed concept and evaluate the potential impact it can have in addressing the challenges faced by the department. By analyzing the OE management practices of this department, the feasibility and effectiveness of the developed concept can be tested, leading to possible further refinement and improvements. Ultimately, this practical case provided valuable insights and enabled the evaluation of the concept's effectiveness in the real world, which is critical for its wider adoption.

3.1 Identifying Building Operation Services with Impact on Energy

The first stage in the suggested technique for optimising a building's EMS is to identify building operating services that may affect OE usage. As seen in the previous chapter, building services are essentially the systems and features built into a building to make it more pleasant, efficient, functional, and secure. DIN EN 15221-5 (2011) catalogues the services into FS, which rely on FM processes at the operational level to function. An internal or external source might perform the FS and must adhere to a quality standard outlined in an SLA.

A significant portion of FS needs systems and equipment to operate at the quality standard defined by the organisation and enforced by the FM provider. In turn, the

functionality of these systems relies on OE. HVAC, lighting systems, equipment, domestic hot water, refrigerators, and ICT systems account for building OE consumption.

A process flowchart is a powerful tool for identifying the operation services that impact a facility's energy systems. The flowchart includes a thorough strategy that requires assessing the existing services and determining whether an energy system is involved. This step necessitates a thorough comprehension of the building's layout, energy systems, and the operation services that occur within them.

The next stage is to document the data and record any observations and suggestions that could benefit EE and sustainability. In addition, it is crucial to recognise that some operation services' impact on OE might not be a direct one but rather an indirect influence. For example, property management services can aid in building OE management by discovering cost-effective energy providers and implementing energy-saving measures through innovation and technology. Understanding these service components and their role in the building's energy systems, as depicted in the process flowchart, is crucial for any organisation seeking to reduce its carbon footprint and operate sustainably. The insights gleaned from the flowchart can be utilised to develop actions that improve EE and limit any negative impact on the operation services of the facility.

The flowchart to determine if a building operation service impacts an energy system can serve as a critical first step in developing a suitable OE management system for an enterprise (see Figure 19). By identifying the potential impacts of building operation services on the energy system, companies can begin to prioritize key areas for OE management and efficiency improvements. This flowchart can provide the foundation for a more comprehensive OE management framework, which can help companies identify areas where EE improvements can significantly impact the bottom line while reducing the organisation's environmental impact.

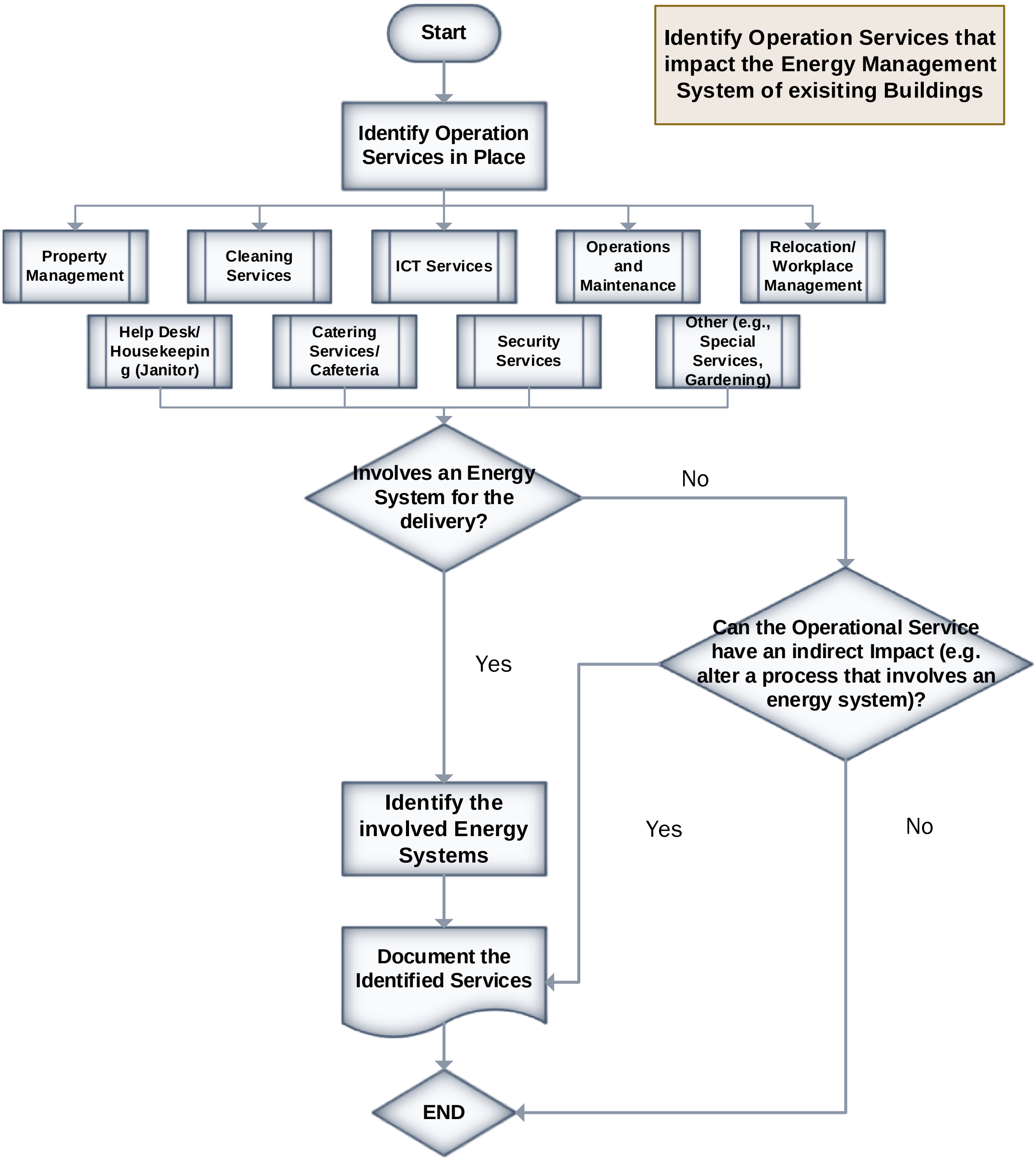


Fig. 19: Proposed Process Flowchart for Identifying Possible Building Operation Services that might have an effect on OE management (by Author).

This technique may be categorised as a sub-process inside a framework or used as a tool to find potential opportunity areas. Some established businesses and FM groups may have previously mapped and accounted for each of their services. This phase applies to all FM organisations tasked with maintaining an existing facility.

Flowcharts are one of the three forms of mapping tools for processes. Detailing a single process or activity illustrates the sequence of steps required to get a desired outcome. Process flowcharts visually depict a process's steps, facilitating comprehension and analysis. They aid in identifying process bottlenecks, inefficiencies, and potential changes. Additionally, they may be used to track and monitor the progress of a procedure.

In this instance, the flowchart assists by mapping the process necessary to identify operational services and doing a first assessment of its potential influence on EE. First, the various services are evaluated according to their link to an energy system. Other services not depicted on the chart may be discovered, but the most crucial aspect is determining their relationship to an energy system. Some services may have indirect effects, but the same concept applies nonetheless. The flowchart closes upon documentation of the FS.

3.2 Initial Framework

The GDCPP developed by Salford University provides a holistic approach, including general definitions, documentation, and procedures, to ensure that all stakeholders involved in a construction project identify the required activities, optimise procedures, and avoid defects or delays by collaborating in harmony. The top-level approach, which is based upon, allowed for replicability in related sectors, one being FM.

Alexander utilized the process mapping technique to create an FM process overview. This approach involves breaking down the different stages of a process and visualizing them in an easily understandable way. The highly interconnected network formed can also be referenced as a process matrix. It is a valuable tool used to organise and map out the steps involved in a process. This technique helps highlight areas that can be streamlined or optimised, resulting in better performance and increased productivity.

The procedure utilised to map the FM process is a highly effective and efficient method that can be seamlessly replicated for mapping every other process in an organisation. This technique involves breaking down the process into discrete steps and utilizing process mapping tools to visualise the flow of activities. These activities are assigned to zones which organise many activities along a single axis. On the other axis, the activities are organised into several stages based on the mapped process's scope and

characteristics. This strategy is highly beneficial since it helps the business thoroughly understand each process, including its strengths, shortcomings, and optimisation potential. In addition, this strategy helps firms to develop transparent contact with stakeholders and boosts productivity. In addition, this strategy may be utilised to build process improvement projects tailored to each process's specific requirements, resulting in higher productivity, cost savings, and customer satisfaction.

In particular, the stated approach of process mapping can help analyse and enhance the implementation of an organization's EMS. Identifying and visualising each phase of the EMS deployment process is one of the primary advantages of this technology. This can assist in uncovering process bottlenecks and inefficiencies and give a foundation for improvement.

The process mapping method can be used to map out the entire EMS implementation process. Following the requirements for implementing an EMS according to DIN EN ISO 50001 (2018), the first activity needed is to get top management committed to implementing EMS within the organisation. In order to ensure this, a common practice is to define and sign an energy policy, which is then integrated into the company’s general policy. However, following the FM approach, getting written or verbal approval to begin the incursion in the EMS can be sufficient to trigger the next steps.

A strategy or implementation plan envisioned for the long term is then developed. It includes the defined objectives that the EMS should cover in a broader sense. Having designated an energy team or energy manager, at least, can contribute to shaping the strategy and following the plan. In this stage, the key is identifying the stakeholders involved in the plan and addressing their requirements.

Once the goals are identified, it is relevant to assess the current as-is state of the organisation. To do this adequately, the FM tactical team should be involved to help translate the broader goals into an initial implementation plan. It is paramount to be able to determine the current status quo regarding OE consumption of the building. Usually, an energy audit, which an external provider carries out, aids in this step. A common practice also is to benchmark the consumption of the building to determine the level of EE that can be reached.

As previously noted, OE consumed in a building is due to the collection of different equipment or energy systems that provide the minimum requirements for optimal

operations. Hence, a principal activity for an EMS is identifying the energy uses. A tool that can be used is the one addressed in the previous chapter. Once the system has been identified, its related EnPI is established for future monitoring. The next phase is to identify potential EEMs that may be deployed to support the plan.

Once the EEM to be executed has been determined by analysing the energy audit results, the next step is to carry out the execution plan. The building's operation team, which is in charge of running and maintaining the building on a daily basis, typically performs this. They execute the plan through the operation services already in place in the building. The team may work with contractors or manufacturers to ensure the equipment is installed and maintained correctly. The execution plan may also involve training for staff and building occupants to ensure that they understand the changes being made and how they can contribute to the success of the EEMs.

Data collection concerning EEMs is essential for monitoring and analyzing their effectiveness. Without proper monitoring and analysis, it is difficult to identify any flaws or corrective measures that need to be taken. Creating a report on the key findings resulting from implementing the EEM is also necessary. This report can then be used to make informed decisions about future EEMs. By analyzing the data gathered, potential weaknesses in the system can be identified and addressed, resulting in more efficient OE use in the future. Ultimately, gathering data is crucial to ensure that all EE measures successfully reduce OE usage.

Once the operations team has created a report on the EEMs, revising and analysing it is the next crucial step. The tactical team analyses the report in detail to understand the measures undertaken by the operations team and the relation to the initial plan and evaluate the effects of the measures in the medium-term plans of the organisation. At this point, examining the feasibility of these measures from a practical standpoint is vital.

After assessing the operational plan for implementing the EEM, the next crucial step is to conduct a thorough review of the findings concerning the overall strategy of the OE management system. This review aims to provide the management team with comprehensive insights into the effectiveness of the implemented measures and their impact on the organisation's OE consumption patterns. After analyzing the report data, the tactical team can assess the impact of the implemented measures and identify areas

for improvement. They can also execute additional EE measures based on the data. It's essential to evaluate other strategies, such as allocating more resources towards optimized OE solutions, implementing training programs for staff, assessing other possible EEMs, or investing in alternative OE sources. This review is essential in ensuring that the OE management system operates efficiently and effectively, resulting in cost savings through increased efficiency and optimal usage of OE resources.

At this stage, any significant changes involving resources and organization should be shared with top management, along with the current status of the EMS and its primary outcomes. The strategic team then conducts a review, evaluating the overall implementation of EMS and considering the alternative options proposed by the tactical team. It's important to carefully assess each option and its potential impact on the organization's long-term plans and requirements before deciding on the feasibility of implementation measures.

The final steps of any process are crucial in determining whether or not the goals set are achieved. In the case of business operations, the top management takes charge of these final steps. They recognize the achievements made during the entire project or task, evaluate the further actions to be taken and determine the next course of action. If a corrective measure is identified during the evaluation process, the top management can change the initial strategy and start the process again. The relevant activities derived from this process are summarized in Table 10.

Get Top Management committed	Identify Energy-using Equipment/Systems	Procure and Design	Execute EEMs	Recognise Achievements
Engage in Energy Management/Energy policy drafting	Benchmark Energy Consumption/Identify Energy Consumption	Engage Employees in EnMS	Monitor and Analyse EnPIs	
Define the energy efficiency objectives	Establish EnPIs	Document and Record Results	Gather Data	
Designate Energy Team/Energy Manager	Develop Training Strategies	Training	Identify Corrective Measures and Scope	
Identify Stakeholders	Decide which investment is required	Determine possible EEMs and Execution Plan	Management Reviews and Further Actions	
Assess the Energy Status Quo and develop Initial Plan	Review and Analyse energy sources in the Building	Report Performance of EEMs	Review Efffectiveness of the Measures	

Tab. 10: Identified activities in an EMS (by author).

Reviewing the identified activities for implementing an EMS plan, it becomes evident that the FM department plays a vital role in the plan's success. The facility management model developed by CEN in DIN EN 15221-3 (2011) standard provides a comprehensive framework for managing facilities and ensuring their optimal performance. As has been discussed, the model divides the FM into three levels, each with predetermined processes and activities that contribute to the function of the enterprise within a building. The activities correlate to the responsibilities of each level and therefore allow for a seamless integration of both.

In order to successfully implement an EMS, allocating the necessary activities across various levels of facility management is essential. This is due to the nature of the system and its correlation with other aspects of facility management. A process matrix is often used to complete the process mapping, which is essential for the successful implementation of the system. The phases of this process are given by the PDCA cycle. However, recent research suggests that this cycle should be renamed the PDSA cycle, with the S standing for study. This highlights the importance of continually evaluating and adjusting the system to ensure its effectiveness. Organisations can successfully implement an EMS and achieve significant OE savings by allocating activities across facility management's strategic, tactical, and operational levels and utilizing the PDSA cycle in the process mapping.

The framework which links the FM practice with an executable EMS is essential in today's world, where OE consumption is a significant concern. The implementation of this framework emphasises the importance of standardization, monitoring, and continuous improvement in the FM industry. By applying a process mapping technique, relevant activities of the EMS are identified and allocated in the FM area. This ensures that the activities are carried out standardized, facilitating precise monitoring and allowing for the processes involved to be enhanced incessantly. This helps reduce OE consumption and ensures that the FM practice is carried out efficiently and effectively. This framework contributes to the organisation's sustainability and reduces unnecessary waste and excessive costs. Therefore, the emphasis on the importance of this framework cannot be overstated, as it serves as the backbone for the successful implementation of EMSs in FM practices. The following Figure (20) illustrates the overall result of the abovementioned approach.

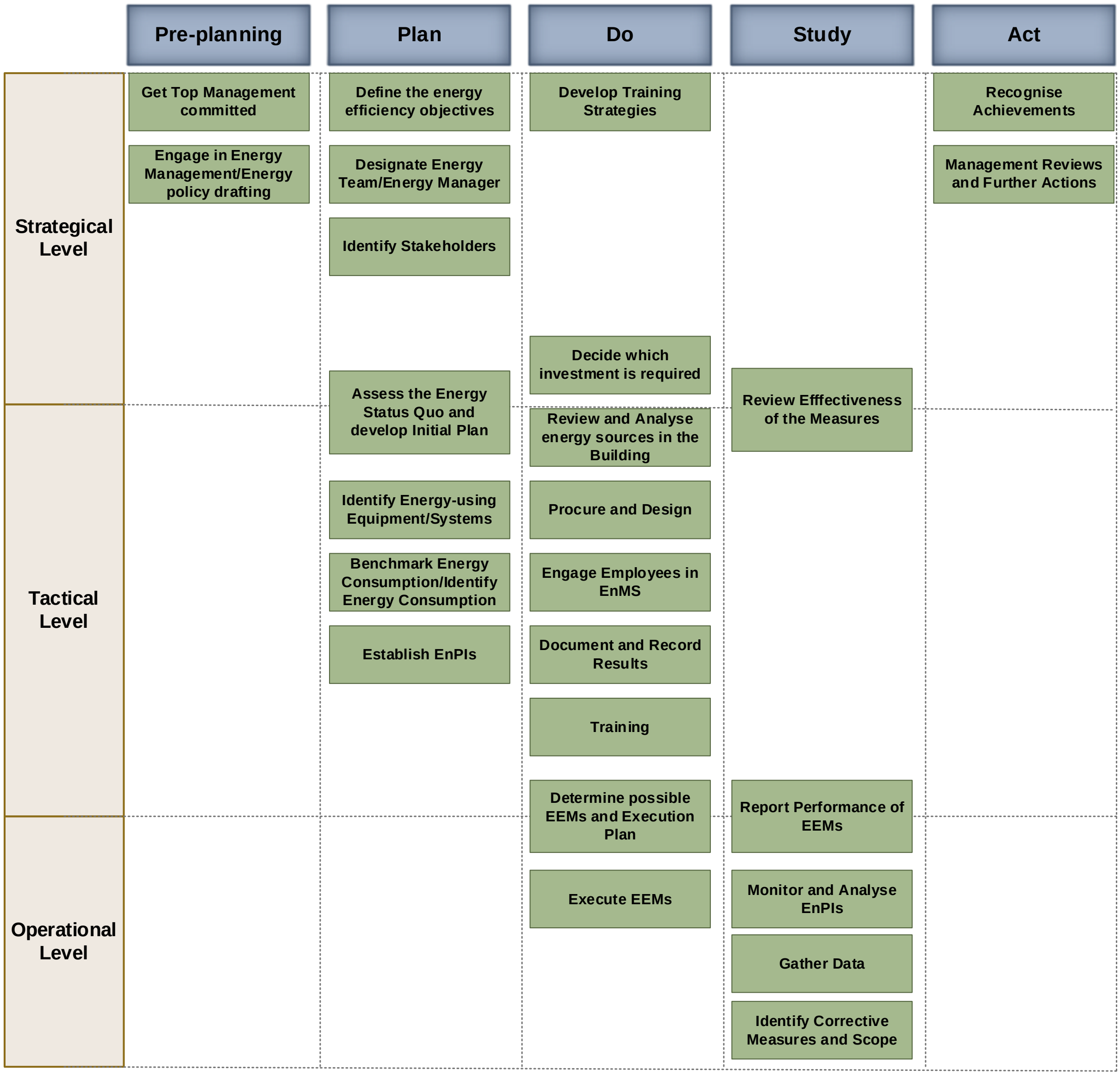


Fig. 20: Framework for an EMS (by author).

Alexander's (2008) top-level framework for mapping FM processes permits the smooth incorporation of EMS activities generated from DIN EN ISO 50001 (2018) into the FM model. Note that the activities placed between two levels connect the two and are carried out between them. The GDCPP established by the University of Salford for the construction industry utilised a similar method to connect diverse areas or stakeholders.

The proposed framework clarifies the activities to implement an EMS within an enterprise successfully. However, it is crucial to refine it by complementing it through a series of best practices gathered from research to ensure that it is effective and efficient.

This helps enhance the framework and makes it more relevant and applicable in real-world situations. Through this process, the model can be adapted and customized to the specific needs of organisations and businesses, leading to improved outcomes and greater success in achieving their respective goals. Therefore, the next step of the study is to gather more best practices and refine the proposed framework to make it even more effective and impactful.

3.3 Refinement of the Framework

Actual case studies can provide valuable insights into the practical implementation of an EMS and thereby improve the proposed framework. By analyzing real-world examples of various facilities, we can identify the potential challenges and opportunities different organizations face in their OE management practices. This can help us to refine and optimize the framework better to suit the needs of different users and situations. For example, case studies can help us identify the most effective strategies for monitoring and controlling OE consumption in different types of buildings or better understand the role of employee engagement and behaviour change in achieving EE goals. By dividing case studies into key activities and facility management levels, we can also gain a more granular understanding of how different framework aspects can be applied in different contexts. Ultimately, actual case studies can help in developing a more evidence-based and practical EMS framework and improve the chances of successful implementation by highlighting best practices and critical success factors.

3.3.1 Strategical Refinement

In their study, Schulze et al. (2016) highlight a strategic management decision as paramount for implementing an EMS. The strategic component comprises the commitment of the whole organisation to a long-term plan. Implementing a written energy policy or strategy can achieve this type of commitment. The adoption of such policies by various sectors has been reluctant. Jalo et al. (2021) carried out a questionnaire to assess the level of implementation of EMS in small and medium enterprises (SMEs) in Sweden. They found that more than half of their respondents did not have a written energy policy and identified this as a barrier to OE management.

A study conducted by Ate and Durakbasa (2012) in Turkey highlighted the significance of creating a formal (written) energy policy/strategy for effective OE management methods in energy-intensive industrial sectors. However, the study revealed that only 40% of the surveyed Turkish companies had a formal energy policy in place. The majority of other companies communicate energy-related principles and goals verbally. Further research by Rudberg et al. (2013) shows that OE is not treated strategically, even in companies that consume a significant amount of the resource. Per their case study, several obstacles hinder a Swedish chemical company's strategic OE handling. They have identified some hindrances, such as inadequate integration of OE management within the organization and a perception that OE costs are not essential to the business, given their relatively small portion of total costs.

The review demonstrates that a well-defined and documented OE management strategy significantly impacts the long-term success of the EMS. Although a verbal or informal commitment to OE management may commence, having a tangible policy increases EMS's chances of success. It gives a structure for the company to plan, establish targets, and measure progress methodically. Star (2012) provides, within its guideline for OE management, examples of viable policies which can be utilised to develop a policy that ensures the feasibility of the EMS in the long run.

According to Rudberg et al. (2013), having a dedicated energy manager with the responsibility of managing a company's energy system is the first step towards adopting a strategic approach. This energy manager should possess the skills to integrate energy planning and initiate energy-saving activities across the company. It is essential to assign an energy manager or team early in the strategy development process to ensure maximum energy savings.

Studies conducted by Cohen and Levinthal (1990), Damanpour (1991), and Lenox and King (2004) have shown that energy managers play a crucial role in enhancing an organization's absorptive capacity. By facilitating communication and promoting information flow, energy managers can help develop internal research and development, such as implementing an EMS. Professional energy managers can also improve communication between external knowledge sources and internal operations, as well as engage in extra organizational and professional activities to interpret technical knowledge for internal stakeholders. Additionally, energy managers can enhance boundary-spanning activities, as Tushman (1977) notes.

Furthermore, Olsthoorn et al. (2017) conducted an empirical analysis based on a large sample of organisations that are typical of the German trade, commerce, and services sector to assess the adoption of EEMs in non-residential buildings and found that having an energy manager in the organisation promoted the adoption of EEMs even if an EMS has not been implemented, whereas having implemented an EMS does not necessarily contribute to the adoption of EEMs.

In order to successfully implement energy-efficient practices, the energy manager must have access to top management and a solid cross-functional base. This ensures that the energy manager's necessary resources and support are available to effectively execute their job responsibilities, typically identifying areas for improvement, evaluating energy-saving strategies, and implementing energy-efficient practices. However, for SMEs, appointing an energy manager might not be feasible due to limited resources. Despite the potential OE savings that could be achieved, the costs associated with hiring an energy manager may not be justifiable for SMEs, making it difficult for them to adopt energy-efficient practices (Kannan and Boie, 2003).

Ates and Durakbasa (2012) have emphasized the importance of an OE management action plan for effective OE utilisation. This plan should focus on identifying financing sources, developing a well-functioning organizational structure, establishing and implementing EE measures, preparing internal communication, and assessing the program's effectiveness. These tasks are crucial for the energy manager to develop a sustainable OE management program that can bring significant cost savings and environmental benefits to the organisation.

The top management in an organisation must receive adequate training in OE management. As Bowonder (1984) claimed, senior executives need to understand the scope and benefits of OE management to endorse its practice and encourage it among their employees fully. Implementing OE management without their conviction and support may not gain traction in industries. Therefore, training programs that equip top management with the necessary knowledge and skills to steer their organisation towards EE may yield tangible results. A more substantial commitment towards OE management from the top may lead to a ripple-down effect where employees also take responsibility for conserving OE, ultimately reducing their carbon footprint and contributing to long-term sustainability.

The recognition of achievements is a crucial aspect of any successful OE management program. Stawicki et al. (2010) suggest that rewards for operational and technical staff can help to sustain momentum and increase overall support for the program. Recognizing the efforts of those involved in the program's success creates a positive and motivating work environment where staff feel valued and appreciated for their contributions. This boosts morale and increases the likelihood of continued success in achieving EE goals. Providing rewards can take many forms, from monetary incentives to recognition through awards and certificates, aiming to stimulate healthy competition and drive energy-saving behaviours. In conclusion, recognizing achievements by providing appropriate rewards is an effective strategy that can help to foster a culture of EE, leading to long-term benefits for the organisation and the environment.

Vasudevan and Higgins (2004) suggest strategic energy risk management (SERM) as a final strategy for OE management. SERM entails analytically evaluating how a company's energy use affects its exposure to various risk components and managing them in accordance with predetermined financial targets and risk tolerances (Vasudevan and Higgins, 2004).

Rietbergen and Blok (2010) present one method for defining goals for reducing industrial OE use or greenhouse gas emissions and offer a taxonomy of suitable targets. In their view, setting specific, measurable, appropriate, realistic, and timed (SMART) targets is crucial for effective OE planning. This enables stakeholders to track progress towards their environmental goals and make course corrections as needed.

When making financial decisions, it is essential to consider the long-term returns, not simply the short-term ones. This is because short-term gains may not accurately reflect the overall performance of an investment. It's fussing to find that according to Gruber and Brand's (1991) study, less than half of the SMEs in Germany conducted a systematic calculation to determine the return on investment. This highlights the issue of not considering the long-term return on investment in decision-making. Additionally, Thollander and Ottoson's (2010) analysis of payback periods found that many surveyed companies applied a pay-off criterion of only three years, which might be too short and restrict the implementation of substantial measures. Therefore, companies must carefully consider their investment decisions and evaluate their long-term potential.

In recent years, there has been a growing interest in using financial tools and techniques to evaluate the financial feasibility of EEMs. While traditional financial metrics such as Return on Investment (ROI) and Net Present Value (NPV) are widely used, nowadays, other financial tools could be implemented to assess the financial feasibility of EEMs. One of these tools is the Value-at-Risk (VaR). VaR is a statistical method that measures the potential losses of a portfolio of assets or liabilities over a particular time horizon and at a given confidence level. Jackson (2010) describes VaR and how it can enable EE capital determinations.

3.3.2 Tactical Refinement

The tactical activities begin by assessing the current status of the building in terms of OE. Energy audits are a form of carrying out this activity. They entail an extensive process of examining and evaluating an organisation's OE use, identifying areas of OE wastage, and suggesting practical solutions that can lead to significant OE savings. An energy audit goes beyond just assessing a company's OE consumption status quo; it's a proactive mechanism that helps businesses realize their energy-saving potential and identify opportunities to operate more efficiently while reducing their carbon footprint. Hence, an energy audit is integral to any successful OE management program, providing valuable insights that can contribute to the OE management strategy.

A study conducted by Abdelaziz et al. (2011) identifies three kinds of energy audits: a preliminary audit, a general audit and a detailed one. The preliminary audit, also known as a simple or walk-through audit, is the quickest and most straightforward type of audit. It involves brief interviews with site operators, a quick review of utility bills and other operating information, and a walkthrough of the facility. During a general audit, energy-consuming machines or systems are measured to gather more information about the facility's operations than what was obtained during the preliminary audit. Lastly, a detailed audit includes a dynamic representation of energy-use traits of the existing building to identify short- and long-term fluctuations in load profile profiles, extending the general audit.

Furthermore, Olsthoorn et al. (2017) determined that the execution of energy audits is significantly and positively related to adopting EEMs related to lighting systems and heating systems and operations. However, they also noted that a significant barrier to

conducting such procedures within enterprises is not an investment priority and the cost implication of carrying out a general or detailed audit by an external party.

The introduction of the term "significant energy users (SEUs)" within energy audit activities is a significant step towards identifying and addressing the OE consumption in buildings. SEUs refer to specific systems or equipment within a building that consumes significant energy. These systems, such as HVAC, lighting, and water heaters, are responsible for most OE consumption and therefore require special attention during energy audits. By identifying SEUs, building owners and energy auditors can develop targeted strategies. This new term is a valuable tool for EE professionals and underscores the importance of focusing on the substantial OE consumers in a building to achieve meaningful OE savings.

SEUs were determined to carry out an EMS through the Lean Six Sigma approach by Mkhaimer et al. (2017). They used a Pareto analysis to identify the significant SEUs within a manufacturing facility. Pareto analysis is a valuable method to distinguish the crucial from the trivial tasks, allowing businesses to focus their efforts on conserving OE more efficiently. This method follows the Pareto Principle or the 80/20 rule, which states that around 80% of the outcomes result from 20% of the causes.

In the study, Mkhaimer et al. (2017) analyzed the energy consumption data from a manufacturing facility. They determined that a few processes, equipment, and systems consumed most of the OE. These SEUs were identified using a Pareto chart (Figure 21), a graphical representation of the data showing the frequency and distribution of each cause of energy consumption.

The researchers could target their energy-saving efforts by identifying significant energy users more effectively. The analysis findings helped the company develop a plan for reducing OE consumption, including upgrading equipment or processes, adjusting operational schedules, or improving maintenance practices. Overall, Pareto analysis proved to be a beneficial technique for identifying the facility's energy-intensive activities, which enabled the creation of focused energy-saving measures.

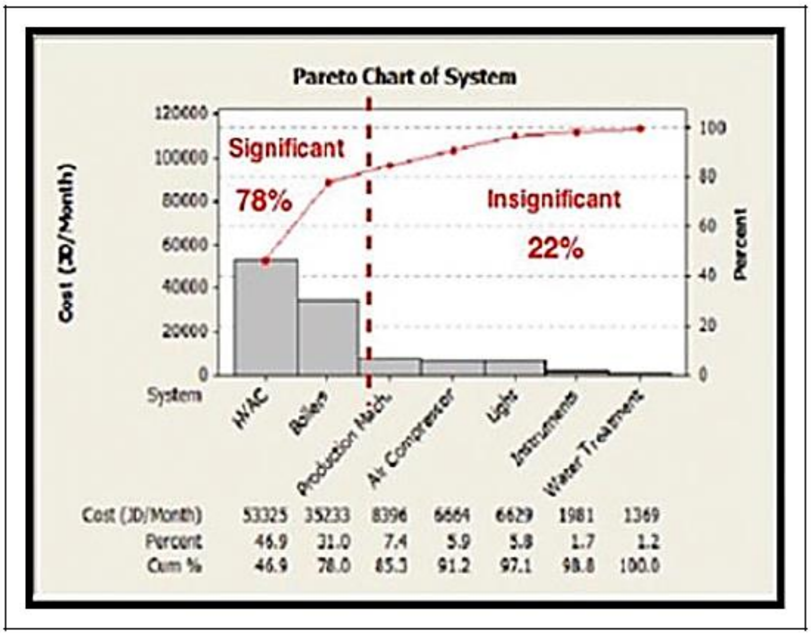


Fig. 21: Pareto analysis to determine the SEU (Mkhaimer et al., 2017).

A Pareto analysis is a realistic method for identifying the most relevant energy systems regarding a building's energy use. The energy systems are graphed according to their contribution to the building's total OE consumption in terms of cost and weighted proportion. By carrying out this analysis, Mkhaimer et al. (2017) concluded that the pertinent EEMs to be undertaken were the ones that involved the HVAC and Boilers systems. By using a gap analysis, the performance of SEUs was compared to the nameplate (nominal) and best-in-class performance as a further step in this procedure.

Benchmarking is a valuable activity at the tactical level that can help organisations identify areas for improvement in their EE performance. Peterson and Belt (2009) classify benchmarking into three different types, namely industry benchmark, historical benchmark, and company-wide benchmark. Industry benchmarking involves comparing an organization's OE performance with that of its competitors in the same industry. This type of benchmarking helps companies gauge how well they are performing compared to others in the same field and identify best practices that can be adopted to improve their EE.

On the other hand, historical benchmarking involves comparing an organisation's current energy performance with its past performance. This type of benchmarking allows companies to track improvements in their EE over time and identify areas for further improvement. Finally, company-wide benchmarking involves comparing the OE performance of different departments within an organisation. This type of benchmarking

helps companies identify which departments are performing well and which areas need improvement.

One significant outcome of any audit is the establishment of energy-efficiency indexes or EnPIs. An EnPI is a metric used in EMSs to quantify performance. It is a formal definition used to identify the progress of OE management initiatives and the amount of OE consumption in a specific facility or building. EnPI allows building managers and energy professionals to track EE and identify potential energy-saving opportunities (Fichera et al., 2020).

By measuring the baseline consumption and the energy-saving measures taken, the EnPI indicates the energy saved over time. EnPIs are crucial in establishing and maintaining an effective energy management program in a building or facility. The most common EnPIs used to track energy performance in a building include kWh/sqm, energy intensity index, total OE consumption, and energy cost reduction. These indicators help facility managers make informed decisions regarding EE initiatives and identify underperforming areas that require attention. Incorporating EnPIs into the EMS of a building can result in significant cost savings and increased efficiency.

Fichera et al. (2020) researched EnPIs and the importance of establishing proper boundaries. They found that boundaries are crucial in determining the physical perimeter of a department, process, or system that an organisation wants to control. Following the DIN EN ISO 50001 (2018) standards, defining boundaries that can be easily isolated is essential. Additionally, the process of identifying boundaries should not only consider the physical viewpoint but also allocate clear responsibilities and OE usage. Their case study defined the boundary as a building, which helped them accurately measure the building's OE performance metrics. Their findings emphasize the significance of setting appropriate boundaries to obtain reliable and actionable EnPIs.

Communication is vital when it comes to implementing an EMS. Peterson and Belt (2009) stress the importance of taking into account the individual corporate culture when selecting communication tools. They utilised a variety of methods, including reports presented at monthly business meetings, monthly letters outlining particular outcomes, internal websites, and directed memoranda. Christoffersen et al. (2006) recommend actively involving employees by using "passive" information, such as notice boards.

By providing monthly group-level feedback, spreading information, and encouraging colleagues to reduce OE use, a 4% to 7% of OE consumption decrease in terms of MELs, can be achieved (Carrico et al., 2011). This kind of feedback helps to create a culture of OE conservation by increasing awareness and giving employees a sense of ownership. It also helps to motivate individuals to take action and encourages them to stay engaged in the process.

Lesourd and Ruiz conducted a study in France in 1984 that highlighted the need to develop specific human resource and energy management strategies in organisations. Their research identified a clear link between the skills and competencies of employees and the overall success of energy management programs in organisations.

One of the key findings of their study was that energy managers require continuous training and development programs within their organizations. This is because effective OE management requires a thorough understanding of energy usage patterns, technology, and energy-saving techniques that are constantly evolving. The need for constantly upgrading skills and knowledge is essential to keep up with changing trends and technologies in the energy sector. Their study emphasized the importance of providing consistent training opportunities for employees to ensure that the organisation remains effective in its OE management efforts.

The study conducted by Liu et al. (2012) in China is noteworthy as it highlights the importance of training in the context of OE management. The finding that internal training on energy saving has a significant favourable influence on a company's involvement level in energy saving activities ESAs is particularly significant. This implies that employees provided with the necessary training are more likely to be more motivated and committed to implementing energy-saving measures in the workplace. The study further suggests that energy-saving practices can be viewed as a competitive advantage for companies, as they can lead to cost savings and improved environmental performance.

Similarly, the study by Suk et al. (2013) in Korea reinforces the importance of internal training for OE management. The finding that internal training is one of the critical determinants of a company's practice level of ESAs underscores the need for companies to invest in training programs that focus on energy-saving practices. Moreover, the study highlights the role of top management in supporting energy-saving initiatives

within the organization, which can be seen as a critical factor for fostering a workplace EE culture.

Acquisition and design are essential to the proper management of energy usage. In this regard, Parrish et al. (2012) give valuable insights into the significance of procurement. The research highlights the need to consider OE performance as a criterion for selecting materials, labour, and equipment within procurement procedures. Thus, enterprises may connect their procurement activities with their energy conservation objectives, resulting in energy conservation.

Another way that procurement can contribute to sustainable practices is by reducing energy consumption attributed to MELs. This can be achieved by adopting mandatory EE standards and voluntary ENERGY STAR specifications when acquiring equipment and machinery. Significant reductions in OE consumption and associated costs can be achieved by choosing products with high EE ratings, such as computers, televisions, distribution transformers, and microwave ovens with ENERGY STAR specifications ("Analysis and Representation of Miscellaneous Electric Loads in NEMS - Energy Information Administration," n.d.).

Proper documentation of all the steps and processes involved in the implementation of an EMS is crucial to ensure its success. It helps identify flaws and improvement areas, making it easier to refine the process and achieve better results in the future. In their study, Parrish and Welton (2013) found that keeping records of all EE measures contributed significantly to the continuous improvement process. This is because it enables organisations to identify initially deemed irrelevant measures and replace them with more feasible options in the long term. Besides, documentation also provides a record of past achievements, which can be used to motivate employees and inspire more outstanding commitment to achieving energy management objectives.

The tactical team should be the one responsible for the elaboration of the required reports based on the collected information and analysis of the operational OE aspects of an EMS.

3.3.3 Operational Refinement

Every EMS implementation plan translates to executable actions or EEMs. In the simplest sense, EE measures refer to any action or tool that helps reduce OE consumption while maintaining or improving service levels. They can range from simple software updates to complex retrofits and system overhauls ("5 Energy Efficiency Measures for Buildings - ClevAir Blog," 2021). Still, the goal is always the same: to reduce energy use and costs without negatively affecting productivity or output. Figure 22 shows the different categories of EEMs.

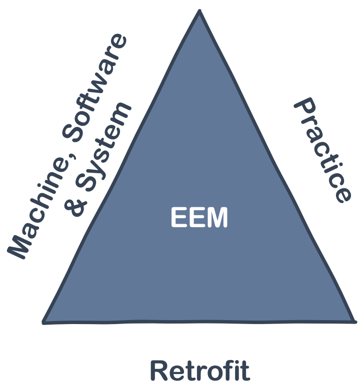


Fig. 22: Definition of EEM adopted from ("5 Energy Efficiency Measures for Buildings - ClevAir Blog," 2021).

One of the most important things to understand about EE measures is that they are the action-intensive part of any EMS. While monitoring and tracking OE use is crucial, the efficiency measures themselves perform the heavy lifting in terms of lowering consumption.

EEMs are often grouped into four functional categories: motors, cooling, lighting, and HVAC (Trianni et al., 2014). Each of these categories encompasses a range of technologies and practices designed to help reduce energy consumption in specific areas. It is clear that EEMs are undertaken by altering the buildings' energy systems. This means that in order to enhance EE, the energy systems of buildings must be modified and optimized. As the previous chapter shows, the energy systems include HVAC, hot water, lighting and MELs.

The decision to invest capital in EE measures has a strong linkage with a company's strategic objectives. Depending on the level of capital involved, the scope of EE measures can be divided into routine, practice or behavioural aspects, system upgrades and replacements, and energy retrofits (Parrish and Whelton, 2013). Routine measures involve simple changes in operation and maintenance practices, whereas system upgrades and replacements focus on replacing old equipment with more energy-efficient ones. Energy retrofits, on the other hand, require a more extensive plan and involve a significant investment of capital. Retrocommissioning involves improving the integration of building systems and equipment rather than simply focusing on their individual parts (Min et al., 2016). Due to this, the top management level is more involved in these decisions. Therefore, the investment decision taken at the strategic level of the company is crucial in determining the scope of EEMs that can be implemented, and it also determines the involvement of the top management level in these measures (See Figure 23).

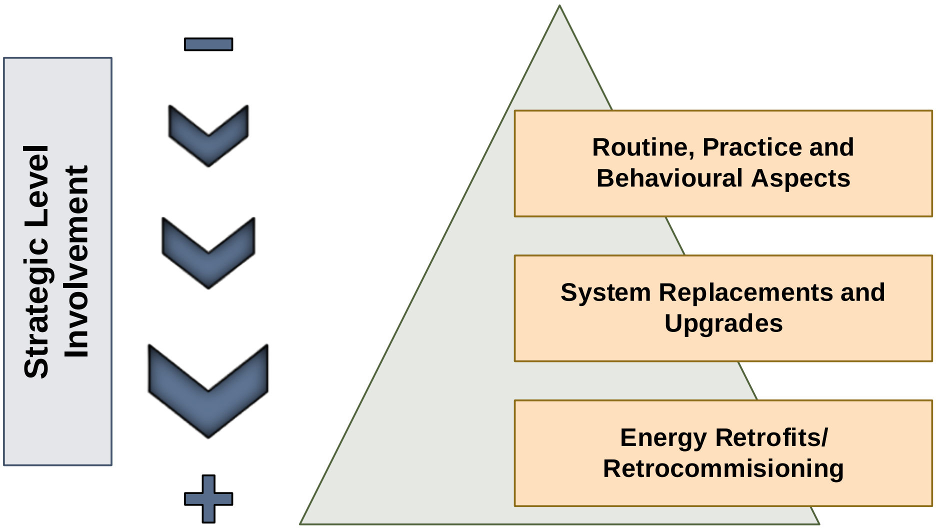


Fig. 23: Pyramid of EEMs adopted from Parrish and Whelton (2013).

Implementing EEMs within a building cannot be accomplished solely by installing energy-efficient technologies or equipment. Building operation services play a significant role in ensuring these measures are executed successfully. The O&M service is responsible for the regular maintenance and repairs of building equipment to ensure high functionality and EE and also contributes to the identification of energy usage of equipment and SEUs. The housekeeping service, carried out by also conducting periodic reviews of the building and its components, as in some cases is undertaken, can

contribute to identifying opportunity areas in terms of EE. The cleaning service, although it might not be evident at first sight, can also impact energy consumption. The catering services can also support the implementation of energy-efficiency measures. Lastly, the relocation or workplace management system contributes to EE by strategically identifying the use of workspace within buildings.

The optimal OE performance of a building is directly related to the quality of its operation and maintenance service. According to the IFMA, a staggering 70% of the existing building stock consumes more energy than necessary due to poorly managed and maintained systems (Putnam et al., n.d.). The Carbon Trust (2011) identified several issues responsible for this, such as inadequate commissioning, poor measuring and management of building systems performances, and inefficient O&M practices. Therefore, Bordass and Leaman (2015) propose that comprehensive building performance evaluations, with a greater emphasis on O&M, can be beneficial for enhancing energy performance.

Due to the well-positioned nature of O&M services as a result of their deep knowledge of building systems and equipment, a proactive arrangement of O&M services may be vital when implementing EEMs.They play a critical role in ensuring that buildings operate optimally and energy efficiently over the long term. Furthermore, they deeply understand the financial and operational implications of EE measures and can provide invaluable insights into the feasibility and payback period of proposed upgrades. Their expertise in equipment maintenance and repairs can also spot and address inefficiencies and malfunctions as part of their day-to-day work, leading to further energy savings.

The longitudinal case study conducted by Min et al. (2016) aimed to assess the impact of proactive O&M practices on energy performance in a higher education (HE) campus in Singapore. Over the course of 15 years, the O&M team executed a series of Energy EEMs focusing on specific energy systems.

One of the O&M team's primary focuses was to address and implement EEMs related to the cooling systems. One of the first measures adopted was to switch the air volume of air handling units (AHU) from constant to variable air volumes (VAV). This step is essential because VAV systems are more energy-efficient than constant air volume (CAV) systems. A constant airflow in CAV systems is delivered into a space, regardless

of the actual demand. In contrast, VAV systems adjust the airflow based on the cooling load of a building or a designated zone. Therefore, VAV systems are more efficient as they maintain the desired airflow with minimal energy consumption. Implementing VAV systems is an example of how O&M teams can use proactive practices to reduce OE consumption and operational costs.

In addition to implementing various energy-saving practices, the O&M team also raised the set-point temperatures of different areas and the chiller and its components as part of their OE conservation program. Fraij's scientific research from 2020 has convincingly shown that changing the temperature setpoint on heating and cooling equipment via a thermostat has a dramatic impact on energy usage, with changes as small as 1 degree Celsius resulting in energy savings of up to 8%. While this adjustment may have made the indoor environment slightly warmer, it was done in a way that did not compromise the comfort or safety of the occupants. This simple energy-saving practice exemplifies how slight adjustments can lead to substantial energy consumption and sustainability improvements.

Another retrofit option that was introduced in the HE campus was to retrofit the chilled water system to variable primary flow. This was done in a similar way to the AHUs previously. By implementing this technology, the chilled water system was then able to adapt to changing load requirements by adjusting the flow, resulting in a reduction in energy consumption.

In addition, two other EEMs were carried out to improve the cooling system's efficiency. One EEM involved the adjustment of the operating hours of the AHUs. It involved shifting the start and stop times of the AHUs to begin after peak electricity periods and stop earlier in the day. By doing this, off-peak energy consumption could be reduced.

Another EEM involved installing variable speed drives (VSD) to the chiller pumps and reducing the minimum frequency limit of the VSD for lower flow rates. This helped reduce the chiller pumps' energy consumption during low-demand periods.

The O&M team also carried out a lighting retrofit, changing the T8 lights to T5 lights, which played an essential role in contributing to energy savings. The T5 lights consume less energy and are more efficient than the T8 lights. They also provide better light quality and have a longer lifespan, reducing the need for replacements. Additionally, motion sensors were installed to control the lighting in unoccupied areas, leading to

significant energy savings. Another lighting EEM that was undertaken involved replacing induction lights with energy-efficient plug-in cluster fluorescent lamps (PLC). PLC lamps are energy-efficient fluorescent lamps optimised for commercial and industrial settings, with a compact design that makes them easy to install and helps maximize space utilization.

When it comes to reducing OE consumption in buildings, temperature setting adjustments can significantly impact them. Research shows that, just like with the cooling systems, lowering the set-up temperatures can contribute to approximately an 8% reduction per degree (Fraij, 2020).

Olsthoorn et al. (2017) introduce three additional operational enhancements for heating systems. The first enhancement discussed is a hydraulic adjustment. This option maintains a constant temperature by implementing various adjustments to the heating system's hydraulic layout, which includes pipes, pumps, and valves. These adjustments adapt to changing heating demands, thereby maintaining a consistent indoor temperature while minimizing OE consumption. The second enhancement Olsthoorn et al. (2017) mention is nighttime turndown. This feature is designed to reduce unnecessary energy consumption by heat systems during the nighttime hours when fewer people are in the building. Lastly, Olsthoorn et al. (2017) mention dynamic control. This enhancement takes into account real-time indoor and outdoor temperatures to regulate heating output and adjust it as necessary. Dynamic control systems can respond to environmental changes and automatically adapt the heating system to maintain a comfortable indoor temperature while minimizing energy usage.

The success of the referred EEMs in a building largely depends on the availability of relevant data. Data collection is a crucial part of these measures as it helps building managers and owners identify areas where OE consumption can be cut down. However, many buildings lack proper data collection systems, which results in inefficient energy use. Therefore, the enhancement of data collection can be considered a significant EE measure on its own. Through gathering and analysing energy data from the HE campus, as demonstrated in the case study researched by Min et al. (2016), the O&M team facilitated a process for continuous improvement of the energy systems.

Building automation systems (BAS) have become essential for managing facilities and optimising building performance. Apart from being used to control the technical

features of buildings, BAS also contribute significantly to data collection and management. These systems provide reliable and accurate data critical for effective decision-making, planning, and resource allocation. In addition to supporting troubleshooting, specific BAS provide helpdesk functions, enhancing stakeholder communication and collaboration. Preventive maintenance is a feature that can also be supported by building automation systems (Redlein and Stopajnik, 2020). In their study, Min et al. (2016) identified integrating a computer-aided facility management system (CAFM) that supported booking specific areas with the BAS as a crucial component in the energy strategy. CAFM is a potent application software that facilitates the automation and digitalisation of facility procedures throughout the lifespan of a building (GEFMA, 2021). The integration allowed controlling air-conditioning and lighting to be turned off or on depending on the occupancy of the areas.

The rise of the Internet of Things (IoT) and ICT products has significantly advanced how data is collected in the building sector, focusing on achieving EE (Hong et al. 2017). The IoT has rendered it possible to gather real-time data on energy usage, equipment performance, and environmental factors like temperature and humidity. In recent years, a significant rise in data availability has been noted in the areas of occupancy (motion sensors), interactions with the building envelope (such as windows, blinds, and shades), and the use of control systems (such as HVAC, lighting systems, and plug-loads) (D'Oca et al., 2018). This data can be harnessed to analyse trends, identify areas of inefficiency, and make informed decisions about energy-saving solutions.

The study conducted by Cholewa et al. (2023) explores a new approach to controlling the heating systems in buildings via the use of a newly developed forecast method called forHEAT. This method is designed to be installed in district heating network controllers of buildings and can be connected to the existing weather for real-time data collection. The forHEAT module is equipped with IoT capabilities, which enables it to access local weather data through a mobile web application called meteor API (application programming interface) from nearby weather stations.

The capacity of the forecasting module to anticipate the weather is an intriguing part of the study since it enables precise modifications to the temperature settings of building heating systems. The technology can minimise building energy usage and substantially reduce energy costs. According to the report, the introduction of forHEAT led

to a 10.7% decrease in energy use in public buildings. The results indicate that the forHEAT module is an efficient method for controlling building heating systems.

Bunse et al. (2011) emphasize that incorporating EE monitoring and continuous analysis of energy utilisation is crucial for effective OE management. By doing so, decision-makers can pinpoint opportunities for improvement and track the impact of their decisions on OE consumption. Additionally, monitoring energy use can determine if anticipated energy savings are achievable (Kannan and Boie, 2003). According to Bunse et al. (2011), ICT is essential for ensuring EE as they enable effective management and assessment of energy savings.

Regular monitoring of equipment performance helps technicians identify any potential faults or issues affecting the system's functionality. Moreover, it helps in recording energy consumption, which is a critical factor in maintaining efficient operations. In a study conducted by Knowles and Baglee (2012) on cooling systems, they found maintenance to have a crucial role in ensuring maximum efficiency. The study further emphasized the need for detailed energy monitoring to improve maintenance procedures. Therefore, proper monitoring is a significant aspect of maintenance practices that cannot be ignored.

According to Knowles and Baglee (2012), monitoring the condition of individual main components is crucial for achieving optimal performance. Several factors, including investment cost and ease of use, support the implementation of monitoring technology. This implies that investments in monitoring technology may require a significant capital outlay, but the resulting benefits in terms of improved asset performance make it a valuable investment. Additionally, the simplicity of the use of monitoring technology has enabled maintenance and engineering teams to quickly identify any problematic areas, enabling timely interventions and repairs to minimise disruptions to processes.

Organisations have a range of maintenance practices at their disposal to enhance their EE. These practices can be grouped into several categories, such as housekeeping, predictive maintenance (PdM), preventive maintenance, advanced condition monitoring and condition-based maintenance (CBM). The cost-effective housekeeping and maintenance practices can keep the equipment in good condition, promoting EE (Zohir, 2010).

With the help of advanced technology, PdM can identify possible machine defects before they cause any harm or malfunction. The most significant advantage of PdM is its real-time monitoring capability, which utilizes sensors to collect data on factors such as temperature and vibrations. Instead of waiting for equipment to break down and then repairing it, preventive maintenance involves scheduling routine maintenance tasks like equipment inspections, cleaning, and replacing worn parts. The goal is to minimise downtime and lower repair costs.

Advanced condition monitoring goes beyond just PdM by utilizing advanced monitoring tools to analyze various machine components such as motors, gears, and bearings. This method is able to identify even the slightest deviations in machine performance. CBM is a type of PdM that specifically targets lower-level machine degradation that may not require immediate replacement or repair. CBM uses a diagnostic and fault analysis system to determine the most appropriate course of action, be it repair, replacement, or another solution. As shown by Firdaus et al. (2019), these enhanced maintenance practices, if implemented, are also considered as EEMs.

The BETTER BRICKS organisation strongly recommends that all organisations implement night walks as part of their housekeeping practices. This simple yet effective visit after hours of the facility can reveal many operational issues that may be affecting EE, building performance, tenant comfort, and consuming valuable resources such as money and time. Night walks allow housekeepers or technicians to identify problems that may go unnoticed during regular business hours. Through immediate addressing of these issues, organisations can improve their EE, reduce costs, improve tenant comfort, and achieve building performance improvements (“Hidden Building Energy Wasters | Building Operation,” n.d.). In one instance, an engineer determined that two AHUs were not shutting down at night, causing them to operate longer than necessary. By controlling the run times of this equipment, the property saved an estimated 15,000 USD per year.

Using IoT to monitor real-time energy consumption, as well as a tool that facilitates visualization of the consumption pattern and profile, one might be able to spot abnormal behaviour in increased OE consumption. An increase in OE consumption profiles may indicate the equipment malfunctioning (Vikhorev et al., 2013). Data analysis and decision analysis can be used to take immediate and appropriate maintenance action. Energy consumption monitoring is also helpful in detecting the source of a failure

(which machine, where, and what type of failure). By using this method, advanced condition-based maintenance is achieved.

While many organisations focus on energy-efficient lighting systems, HVAC systems or equipment, one operation service that may be overlooked regarding energy usage is the catering/cafeteria service. It's been noted that the catering service in some businesses is a significant driver of OE consumption and that the efficiency potential of this service remains untapped. In-depth research conducted by Paillat in 2011 discovered numerous measures that could be implemented to optimise the OE consumption of the catering/cafeteria service.

In his study on EE in kitchens, Paillat (2011) suggests that a few simple practices can go a long way in reducing energy consumption. These measures include delaying the turning on of equipment, installing energy-efficient appliances, and making adjustments to the menu size and operating hours. By doing so, not only are costs for energy reduced, but the impact on the environment is also lessened. According to the European research INKISUP (2002), employing these operational methods might result in up to 10 or 15% savings with minimum or no expenditure. Another measure that can be undertaken is enhancing the insulation in the kitchen, given that heat loss accounts for the majority of energy loss.

Similar untapped potential can be found in building cleaning services, as this also involves other factors worth exploring, such as the timing of cleaning services. It may seem irrelevant initially, but choosing to conduct day cleaning instead of overnight cleaning can lead to significant energy savings. In fact, the Building Energy Efficiency Programme (BEEP) has found that this simple switch can result in OE savings of anywhere from 0.6 to 8% per year. Not only does this benefit the environment and the building's bottom line, but it also improves job satisfaction for the cleaning personnel who are able to work more regular hours (“The Benefits of Day Cleaning,” 2008). Therefore, the unrealized energy savings potential of cleaning services can be realized if day cleaning's potential is leveraged.

Figure 24 presented below indeed provides a clear and concise summary of all the EEMs that can be executed at the operational level. However, it's essential to understand that the implementation of these EEMs is triggered by the prior activities that are demonstrated in the proposed framework. It's worth noting that there are certain EEMs

that demand a higher involvement of other FM levels, not just the operational one. Hence, while this diagram aids in comprehending EE measures, one must be mindful of the other factors that determine the implementation of these measures.

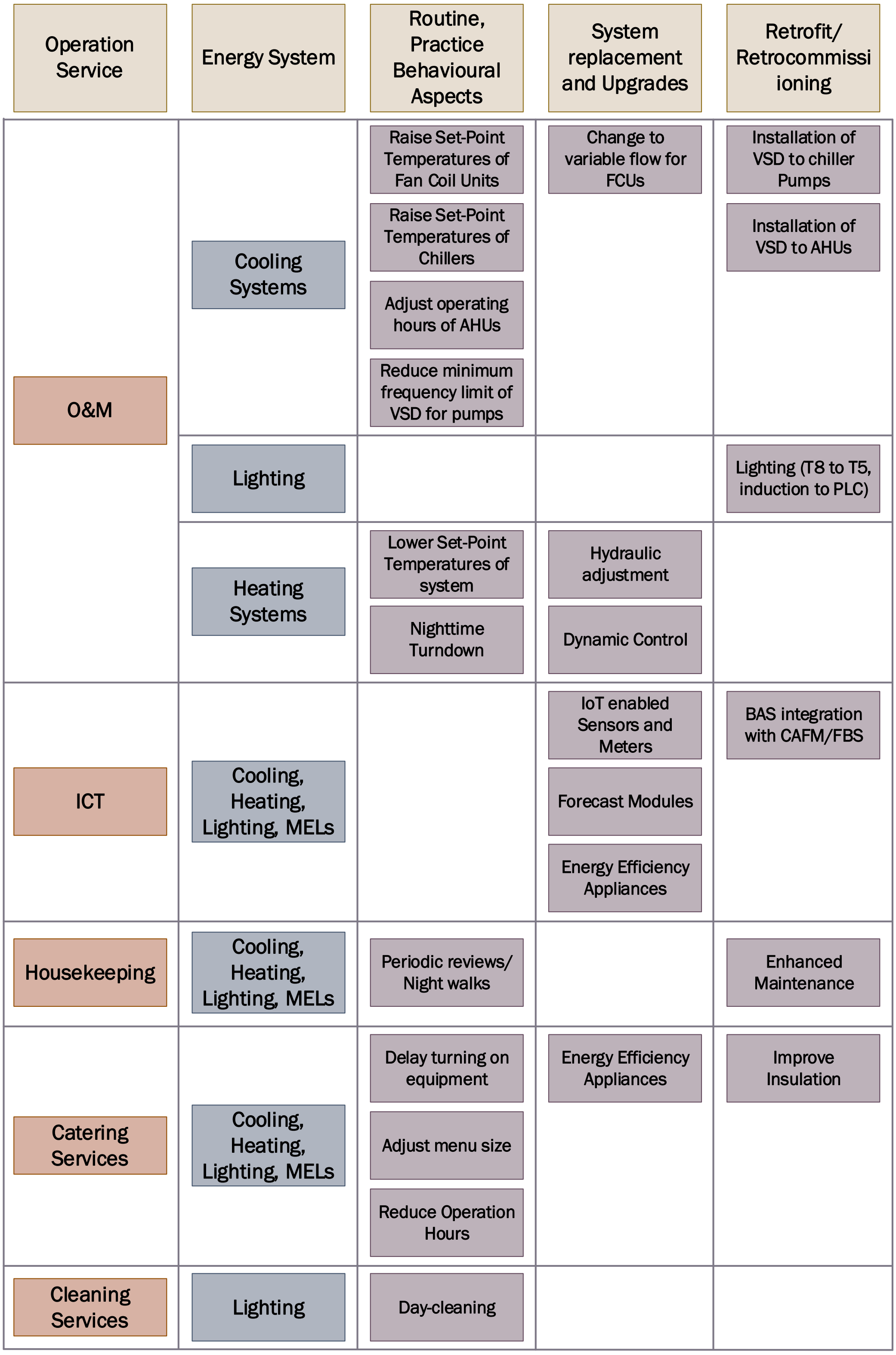


Fig. 24: EEMs identified through the operational refinement (by Author).

4 Validation of the Framework

A validation of the developed framework was the next crucial step of the study. In doing so, the researcher took into account the most significant findings extracted from the surveyed literature. As shown in the previous chapters, the case studies analysed provided hindsight into a plethora of different activities and approaches that have been conducted to implement an EMS for different organisations and building types. Based on these best practices, the proposed framework, which integrates FM processes and operations along with an EMS, and the identified activities were included or rearranged to enhance the replicability of the framework for actual organisations and real-life scenarios. The enhanced EMS framework is displayed in Figure 25 below.

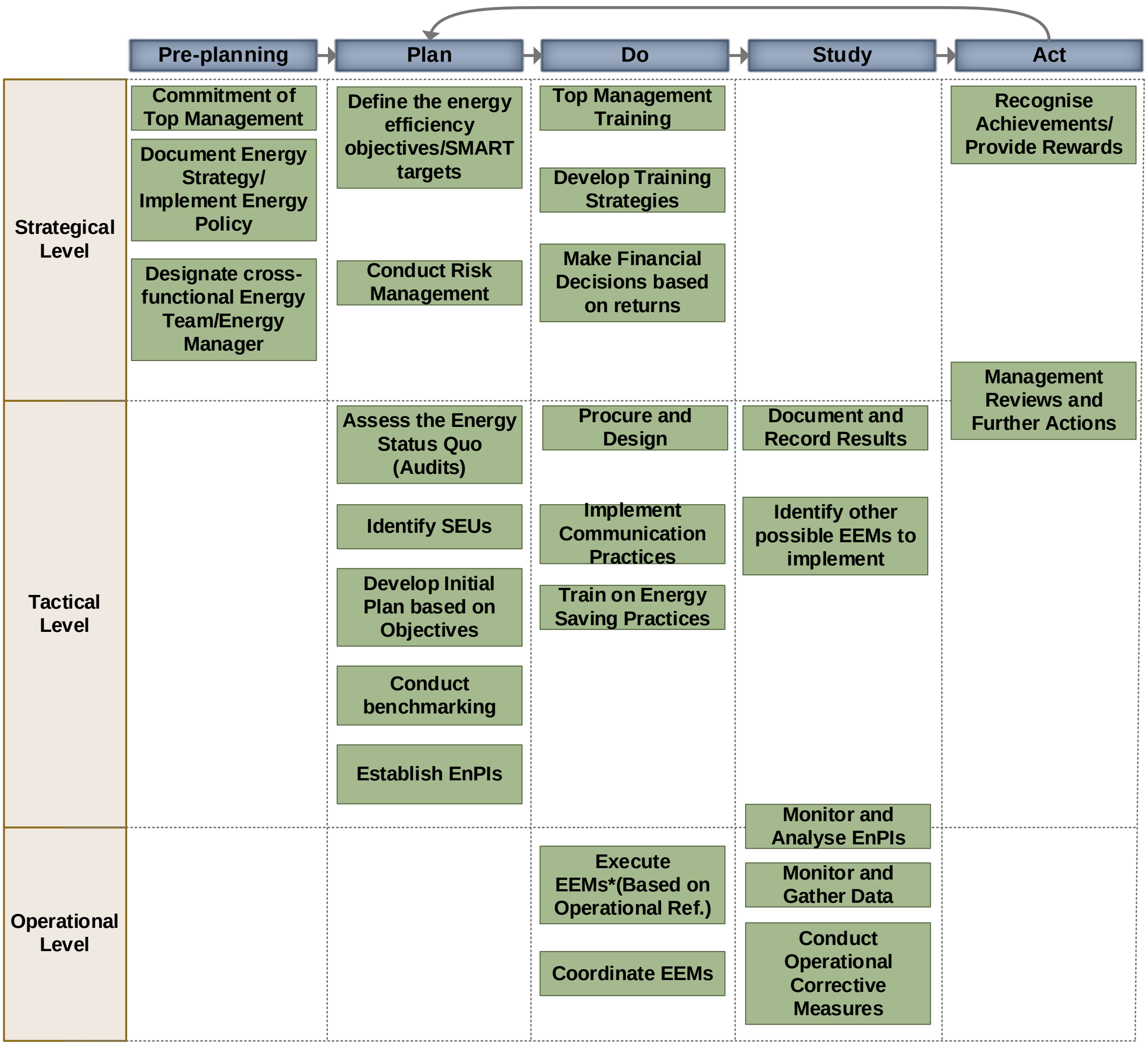


Fig. 25: Refined proposed EMS framework (by Author).

The refinement chapter provided valuable insights into how en EMS has been implemented in different scopes and industries, enabling an enrichment while also clarifying the exact level and scope of different activities. It is worth noting that the execution of the EEMs at the operational level follows the refinement described in the previous section and complements the proposed framework. Since a vital feature of the PDSA is continuous improvement, the links between the phases have also been added.

In order to conduct the validation process, field research was conducted in a local FM department that ensures the optimal operation of a research institute located in Berlin, Germany. The field research was realised by performing assistance activities for the actual FM team during a period of two months. The practical study provides another invaluable aspect of the study by analysing the operation of the team and its EMS practices.

4.1 Field Research: Local FM Department

The *Max-Planck-Gesellschaft* (MPG) is one of Germany's most prestigious research institutions. Founded in 1948, the MPG has played a vital role in advancing scientific research in Germany, particularly in the fields of physics, chemistry, biology, and technology. There are currently 85 institutes spread around Germany, employing around 23,950 people, with the administrative headquarters of all institutes located in Munich. In 2021, the Max Planck Society received a total financing of around 1.97 billion euros, mostly from public funds provided by the federal government and the federal states (“Facts and Figures,” n.d.).

The prominent Max-Planck-Institute for Human Development (abbreviated MPIB in German) is based in Berlin. The institute is focused on advancing knowledge in the realm of human development through research and exploration of four key areas - adaptive rationality, developmental psychology, the history of emotions, and man and machine. With a team of 360 employees dedicated to improving our understanding of human behaviour and capabilities, the Institute continues to push the boundaries of knowledge and innovation in its field (“Facts and Figures,” n.d.). The institute is located in the city's southwest area, on Lentzeallee Street.

The Max Planck Institute for Human Development began operations in 1963 thanks to the visionary initiative of Hellmut Becker. Located in Berlin, Germany, the building was designed to facilitate ground-breaking research in a wide range of fields. The main building (Lentzeallee) has 29,400 m² divided into 625 rooms with different purposes. Recently, the Institute acquired a new property, which is next to the facility.

The technical services (*Technische Dienste, TD*) department is entrusted with ensuring that the operation of MPIB runs smoothly, carrying out some FM processes required to achieve this optimally. TD falls under the jurisdiction of the administration department, which provides oversight for all cooperative functions. The department assists the four research areas' daily operations by providing technical support and resources. Meanwhile, there is also a building department under the control of the MPG headquarters in Munich. It is responsible for all major construction activities and renovations at the institute and also accounts for the guidelines and standards for all technical services departments affiliated with all 85 institutes. Together, these departments ensure that the facilities and systems function efficiently and contribute to the institute's functions. Figure 26 depicts how MPIB is structured concerning the TD.

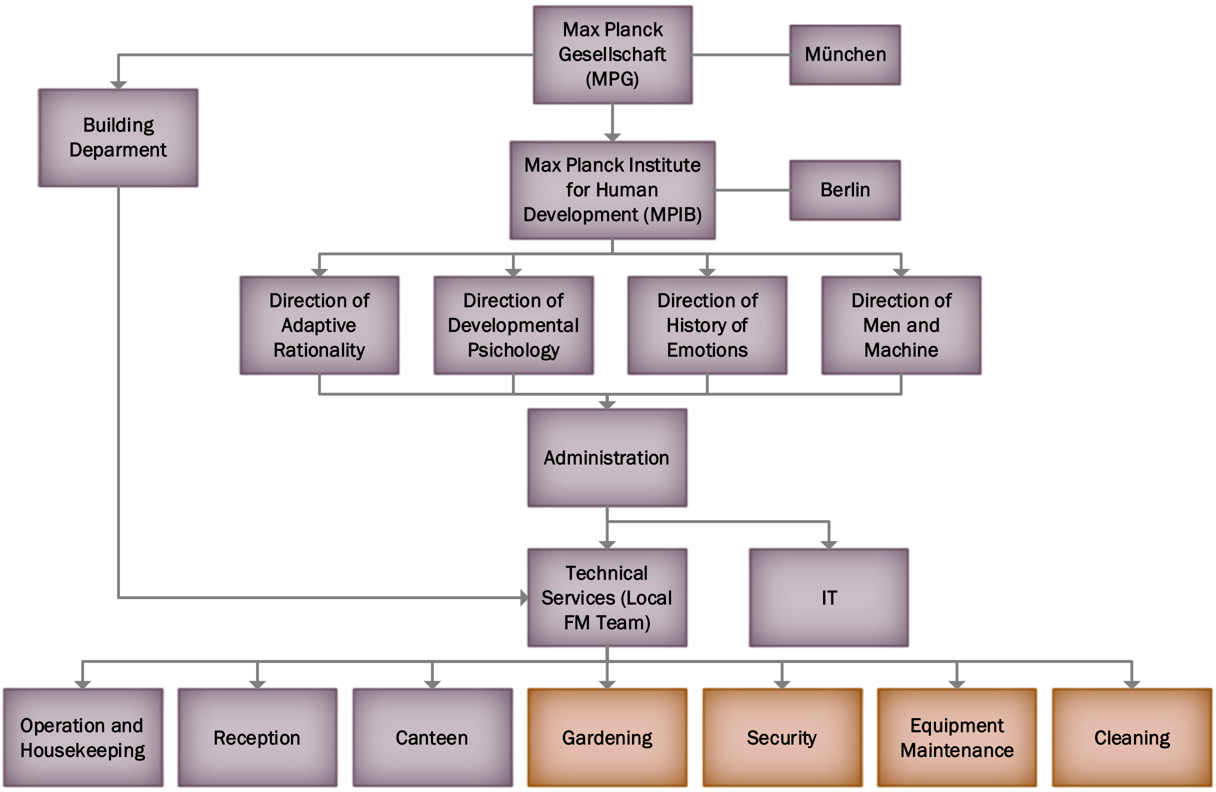


Fig. 26: MPIB organisation concerning the technical services (by Author).

One of the critical responsibilities of the TD is the management of reception and canteen services. These services are sourced internally. The department is also responsible for outsourcing cleaning, gardening, security, and equipment maintenance services. This involves selecting the right vendors, negotiating contracts, and ensuring service quality meets the required standards. The operation and housekeeping chores are activities conducted by the local FM department. The TD department comprises a head of the department and two technicians. The field research conducted was carried out in the form of assistance to the TD team while also contributing to improving energy management practices in the building.

The cooling system of the Lentzeallee building is composed of a single circuit that includes two chillers, one buffer tank, and a pumping system, along with two AHUs.They supply air conditioning and ventilation to the server room as well as the main auditorium. The pumping system ensures that the chilled water is distributed efficiently throughout the building, providing comfort during hot weather. Besides, the system has four air handling units that provide adequate ventilation to required areas. On the other hand, the heating system is facilitated through district heating. The institute’s new building holds a variety of laboratories, a magnetic resonance imaging (MRI) machine with the necessary equipment and setup, as well as more office spaces. The MRI is cooled via a third chiller with its own AHU located at the top of the new building. In addition, there are plans to renovate a substantial amount of this facility to accommodate additional research laboratories and testing rooms.

When it comes to long-term planning, the MPG serves as the central authority responsible for setting guidelines and policies for all institutes. They work in conjunction with the directors of the research areas to ensure that all departments align with the vision and objectives of MPG. Concerning OE savings practises, things are not as clear. The TD team reported a lack of commitment to energy management from the building department and the directors in the MPIB. This is reflected in the fact that no written energy policy is in place, either from MPG or the local institute. It was analysed if implementing such a policy was feasible, and it was determined that due to the fact that a sizeable rethinking process within the top management areas was necessary, this implementation is difficult to achieve. Currently, there is also no clear and defined long-term EMS plan in place that outlines specific and measurable objectives.

Notwithstanding, the TD team has received verbal approval to carry out different OE management activities, and it also considers that having an energy management plan is helpful in displaying MPIB’s energy engagement to the public. There is also an EEM implementation plan in progress. This plan aims to identify the areas of the building where EE measures could be implemented. However, it would be more effective if the superordinate building department carried out this plan.

At MPIB, there is currently neither an energy team nor an energy manager in place to oversee energy consumption and identify opportunities to improve EE. One significant factor is that the team does not think having a full-time energy manager in the institute can deliver higher OE savings in relation to the costs incurred to employ such a manager. However, during the field research conducted by the researcher, one of the key activities was identifying and analysing possible EE measures that could be implemented within the institute.

At MPIB, the implementation of EMS has faced several challenges due to the absence of a cross-functional energy management team. Additionally, the directors' and top management's low commitment has further added to the issue. According to the TD team, there is no use of communication tools to promote OE conservation practices, and there are no training practices to enhance personnel's awareness of EE. Moreover, the organization lacks a policy to incentivize staff to introduce energy-saving methods. Consequently, the employees' engagement in energy conservation initiatives has remained low.

In light of the high costs of hiring an external consultant to carry out a detailed energy audit, MPIB has not yet conducted such an audit. However, as part of the regular housekeeping activities, periodic reviews have been carried out to assess the different systems in the facility and empirically determine which systems account for the most consumption. As a result, TD identified the heating and cooling systems, along with the canteen services, as the SEUs. Even though this did not provide comprehensive insight into the overall energy consumption patterns, it provided a reasonable starting point to focus the EE efforts.

It is important to note that the TD team responsible for managing the OE consumption of the building is only aware of the overall energy consumption. There are no benchmarking practices implemented to compare the consumption of previous years or with

similar buildings. Another obstacle that TD faces is the lack of a metering system that can collect data on the energy consumption of specific equipment. Without this data, it is difficult to determine which areas or equipment of the building consume the most energy and where EE improvements could be made.

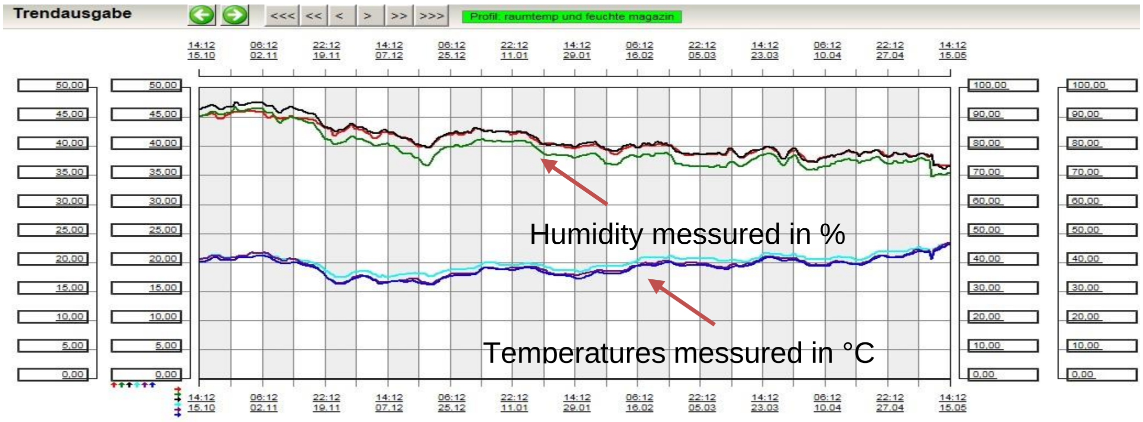
After conducting a preliminary audit, a tentative strategy was developed to assess which EEMs may be deployed in the various systems. The audit discovered that the systems lacked energy metres, making it difficult to estimate the energy use of these systems precisely. Consequently, the EnPI for these systems was established to be temperature, a parameter that can be straightforwardly obtained from the equipment.

Due to the lack of engagement of the directors and the limited participation from MPG HQ, the emphasis on conducting EEMs shifted to adopt routine, practical, and behavioural solutions that are more cost-effective in the short run. Due to their operational components, these EEMs may be readily integrated into the daily tasks of the TD team, allowing for effective implementation and continued monitoring.

The TD team implemented their first EEM by shutting off one of the four AHUs during winter and spring, which was responsible for keeping a magazine room in the library cool and dry. The team was aware of the significant energy consumption caused by this particular AHU. After shutting off the equipment, the team used the BAS to track the temperature and humidity levels for a few weeks. The results showed that the parameters were within the acceptable range. As a result, this measure was executed for an extended period of time, which saved a considerable amount of OE (See Figure 27). The success of this EEM demonstrated the team's commitment to EE and conservation and their ability to make informed decisions to reduce OE consumption.

The team then performed a second EEM, which consisted of increasing the water temperature set point for the cooling system of the Lentzeallee building from 7 to 12 degrees Celsius. As it has been shown, modifying the set point temperature for cooling and heating systems can help reduce the load on equipment and, therefore, lead to lower energy consumption. Monitoring this measure was slightly complicated since the parameters of the cooling systems delivering the air conditioning are not tracked through the BAS. This means the impacted areas' temperatures had to be constantly checked to monitor the temperatures. To comply with the required comfort, the measure must be thoroughly tracked during the summer, when cooling system demand is

high. Image 28 shows the cooling cycle showing the nominal temperatures from the equipment and the actual temperature delivered.



Max	Min	Wert	Einheit	Trendtext	DP-Text	Nutzeradresse
51,470	36,120	---------	[%rF]	ANE ANE 38: Raumfeuchte 3	ANE 38: Raumfeuchte 3	0303ING01RL11LAFF23RA
47,150	0,000	---------	[%rF]	ANE ANE 36: Raumfeuchte 2	ANE 36: Raumfeuchte 2	0303ING01RL11LAFF21RA
49,710	35,740	---------	[%rF]	ANE ANE 48: Raumfeuchte 1	ANE 48: Raumfeuchte 1	0303ING01RL11LAFF25RA
23,480	0,000	---------	[°C]	Raumtemperatur 2	ANE 37: Raumtemperatur 2	0303ING01RL11LATF22RA
23,760	0,000	---------	[°C]	Raumtemperatur 3	ANE 39: Raumtemperatur 3	0303ING01RL11LATF24RA
23,260	0,000	---------	[°C]	Raumtemperatur 1	ANE 49: Raumtemperatur 1	0303ING01RL11LATF26RA

Fig. 27: Humidity and temperature measurements extracted from the BAS.

For the first EEM, the temperature and humidity were monitored with the aid of the BAS. The parameters were then compared to the target temperatures in case corrective measures were needed. However, both the humidity and the temperature remained under permissible values based on the established requirements.

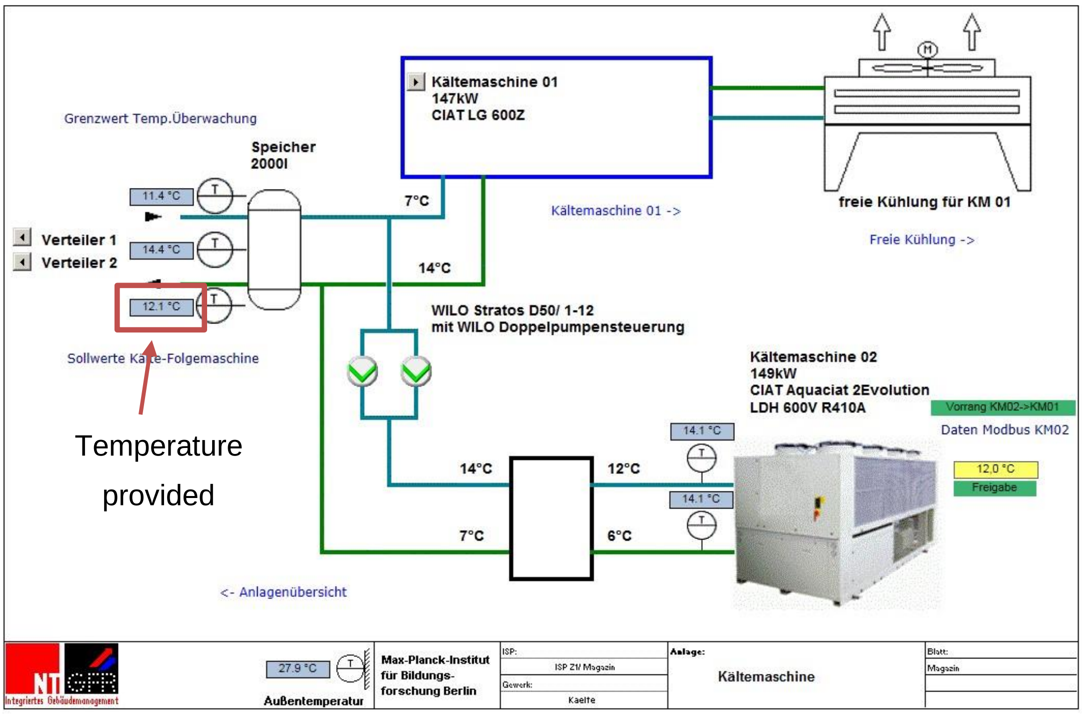


Fig. 28: Cooling cycle of the building displaying the changed set-point temperature from BAS.

Similar to the previous EEM, the cooled areas had to be physically monitored to determine the conditions between acceptable ranges. Increasing the set-point temperature for the cooling cycle by just 5 degrees can result in significant energy conservation, making it a highly efficient and cost-effective EEM.

It was confirmed by the maintenance provider that the AHUs and the cooling system pumps are equipped with VSD. This technology allows for the speed of the AHUs and pumps to be adjusted based on the cooling demands of the building, resulting in more energy-efficient operation. Furthermore, the pumping system has been programmed to run at the minimum frequency to achieve additional OE savings. Using VSDs and a well-regulated pumping system, this cooling system may deliver comfort to the building's occupants while also using energy in a more efficient manner. It was also noted that the fan coil units (FCUs) could be potential targets for further EEMs, partly by raising the set-point temperatures and also if retrofitted. This is due to the fact that this equipment is the only one missing VSDs.

One of the most essential retrofitting activities that is carried out thoroughly in the institute is the lighting system. With the constantly evolving technology, the lighting system is continuously updated with the latest technology during operation. The retrofitting process is conducted gradually, where the lights are changed per segment, ensuring a smooth transition and minimizing disruption.

When it comes to the heating system of the building, there is a great deal of room for improvement in terms of EE. While the shutting down of the heating at night is already being carried out, it is one step in a broader process. Consideration is being given to lowering the set-point temperatures of vacant workplaces, which would minimise the amount of OE needed to maintain a suitable temperature in these facilities. However, this is just one of many measures that need to be evaluated and implemented, particularly in the era of remote work, where many offices are unoccupied for extended periods of time. By installing individual controlling equipment and managing occupancy more effectively, it is possible to achieve significant EE gains while maintaining a comfortable and productive work environment.

After conducting a thorough analysis, the TD team came to the conclusion that implementing a hydraulic adjustment and dynamic control of the pumps in the heating system would not be feasible. The potential savings do not outweigh the significant

investment costs associated with these measures. Similarly, a forecast module such as forHEAT meant to regulate heating in the building is also seen as not viable due to similar factors.

In terms of ICT, the presence of BAS is vital in ensuring that significant equipment in the building is monitored closely. The GLT (Gebäudeleittechnik) system used at the institute played a crucial role in managing the first two EEMs, as has been noted. Despite this, the BAS has its limitations, and, in this case, it lies in the absence of energy consumption metering systems. The absence of these systems significantly limits the potential of the BAS, hindering its ability to identify possible EEMs and adequately monitor and control the ones already implemented. While monitoring significant equipment is a big step in ensuring EE, the lack of comprehensive energy measurement and tracking systems poses a challenge for EMS.

In that regard, the field research, in collaboration with the TD team, has brought about an initiative aimed at improving the building's energy systems monitoring and control process. This initiative involves implementing energy meters to monitor energy consumption and ensure optimal usage. To achieve this, an inventory of all equipment in place was undertaken, and technical specifications have been determined to identify the optimal location for installing the energy meters. Determining if the metering systems can be synched with the BAS is paramount for the success of this initiative.

Another tool with massive potential for developing and executing a condition-based maintenance plan that can contribute to EE practises for the building is the Integrated Workplace Management System (IWMS) Archibus, which is available within the Institute. This tool has been designed to help organisations manage their real estate and facility assets more efficiently, including maintenance, repair, and replacement activities. If used to its full potential, Archibus encompasses a comprehensive catalogue of the equipment along with its technical data while also including a report/control function consisting of assigning responsibilities to the team to undertake periodic revisions to assess the condition of the equipment and the operability of the systems. Both of these actions are encompassed within CBM maintenance practices. By doing so, faults can be detected before or at the moment they occur, reducing non-operational times and enabling energy conservation measures. However, its potential is largely untapped, and the Institute has yet to integrate it into its maintenance strategy fully.

As previously mentioned, one effective method of identifying and utilizing facility EE opportunities is conducting regular night walks. The TD team recognized the potential benefits of this measure and agreed to conduct these reviews. During the first night walk, several energy-saving opportunities were identified, such as exterior lighting that had been left on unnecessarily. Promptly switching off this lighting helped to reduce energy usage and save costs. Furthermore, the night walk included visits to machinery rooms, and it was observed that no equipment that should have been turned off was left operating. This measure has been assimilated and is planned to be carried out periodically.

At the institute, the canteen is a primary service that consumes a significant amount of operational energy. The kitchen has six cooling units, four refrigerators, an AHU for fresh air, an electric stove with four heating plates, three baking ovens for bread, and a large dishwashing machine.

When assessing possible energy efficiency measures, it was determined that the team, composed of one chef and three assistants, was already implementing different measures to reduce its energy consumption. Although the canteen employees start their day early, at 5:30, they only turn the oven on half an hour before using it. This happens once for breakfast and lunch. Moreover, out of the 4 available heating plates, only 2 are regularly utilised, limiting consumption. The baking ovens are not pre-heated and are only switched on right before they are used.

The team has reported that they aim to optimise the space in the refrigerators, enabling one of the four to be shut down during the weekends. A relevant EEM is the reduction of operation time of the AHU, which is regularly turned off 3 before closing. Cooling units, on the other hand, operate for more extended periods. A reduction in operation times would be advantageous. The menu size has only two main courses per day, along with a soup and salad bar. Unfortunately, serving only cold dishes is not an option, so there is no further room for menu size improvement.

The chef suggested upgrading the equipment, like replacing the electric oven with an induction type, to improve energy efficiency. The dishwashing machine could also be upgraded to a more energy-efficient model. The below-displayed figure (29) shows the summary of all EEMs differentiating from the ones currently implemented, the ones partially implemented and those not in place.

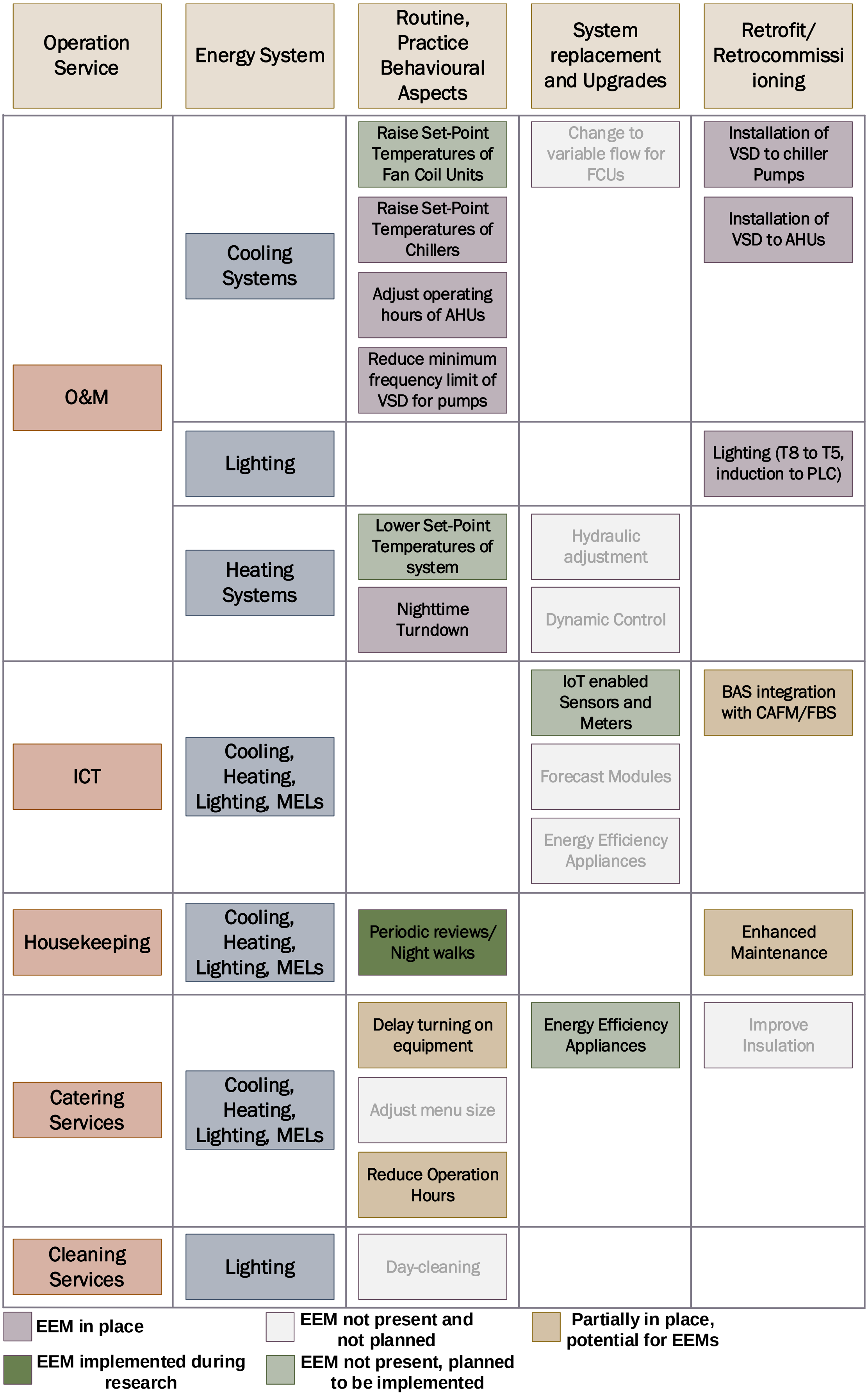


Fig. 29: Developed Operational EEMs framework applied to MPIB (by Author).

Regarding implementing day-cleaning as an EEM, the TD team concluded it would not result in substantial energy conservation. This is because the main advantages of day-time cleaning are linked to lighting. The energy usage attributed to lighting is comparatively low compared to other energy systems in the building.

As the image above depicts, the institute has implemented various EEMs at the operational level, with plans in place for additional measures. Currently, the cooling systems have more EEMs compared to other systems. However, there are plans to introduce new EEMs for the heating systems, one of which is to lower the temperature in unoccupied areas. Another plan is to install energy metering devices to enhance system monitoring and control, allowing for better tracking of EnPIs.

The institute's monitoring practice is essential in identifying areas for EE measures that can reduce energy consumption. Unfortunately, this practice is only partially implemented, leading to inadequate documentation. As a result, there is a lack of additional energy-saving measures, and a holistic management review of the EMS has not been conducted.

Figure 30 presents the outcome of the evaluation of the energy management system initiative, highlighting the established framework. The identified and executed activities related to an EMS at MPIB have been outlined. Still, it's important to note that not all activities are carried out, and some are only partially implemented.

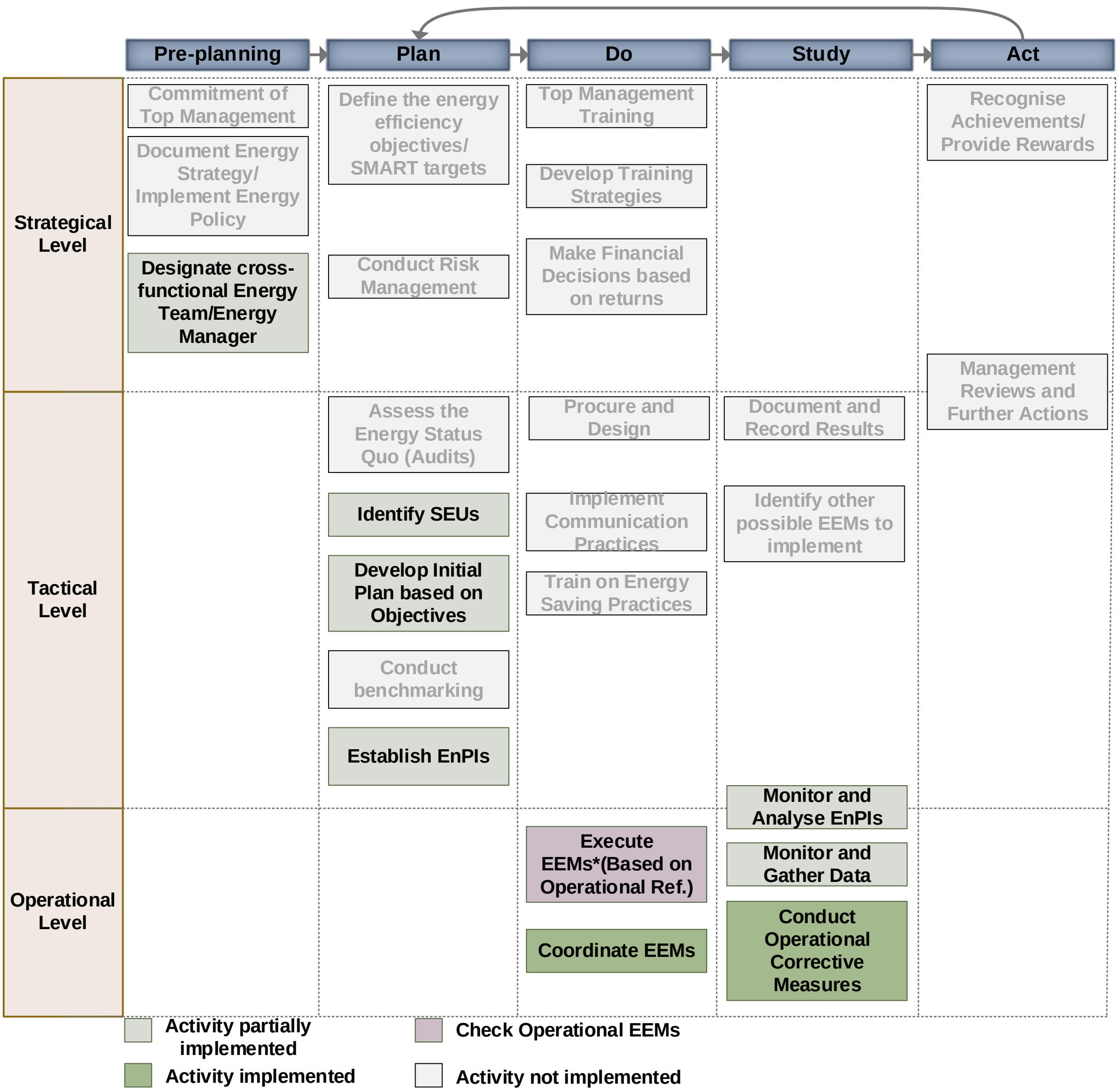


Fig. 30: Developed framework applied to MPIB EMS practices (by Author).

The image provided clearly illustrates that most EMS activities carried out at the Institute are operational. However, some activities have been partially implemented at the tactical level, mainly during the planning phase. Unfortunately, OE management activities are almost nonexistent at the strategic level, indicating a lack of long-term planning and vision regarding energy consumption management at the Institute. Additionally, the PDSA cycle, which provides a systematic approach to managing continuous improvement in energy management, is not fully completed, suggesting the Institute may not be utilizing opportunities to improve its energy management practices through continuous learning and enhancement.

4.2 Discussion

During the study of energy management practices at the institute, it was observed that the TD team has dedicated themselves to improving energy conservation and efficiency. They have implemented proactive EEMs in some energy systems, which is a positive step towards environmental sustainability. It shows that at its operational level, the building management area values this issue's significance and is trying to address it.

Despite the various measures being implemented, there is still plenty of room for improvement in energy management practices. Unfortunately, the lack of solid commitment and support from top-level management and the board of directors makes it difficult to establish effective long-term strategies. Implementing and maintaining adequate energy practices becomes increasingly challenging without their buy-in. However, as demonstrated in the refinement chapter, having an energy policy and a commitment towards energy management pays off for implementing an EMS in the long run. Additionally, even though the researcher acted as an energy manager during the field research, more effort and creating a cross-functional team are necessary to carry out energy management best practices. Unfortunately, the lack of an energy management strategy, EE objectives, and proper risk management practices are currently missing.

According to the TD team, the building department's oversight of all TD teams from the institutes is a major hindrance to progress in EMS practices. Instead of concentrating on the day-to-day operations of the TD teams, the building department places more emphasis on the construction of new facilities and renovation projects. Consequently, crucial energy management approaches, such as monitoring energy consumption, identifying energy-efficient solutions, and implementing energy-saving measures, are frequently disregarded at the strategic level.

In enterprises, the absence of firm commitment from top management can have far-reaching consequences. This is especially evident in setting EE goals. Establishing a comprehensive energy management plan is challenging without a strong focus on EE. Additionally, the lack of commitment can also impact financial decision-making. For instance, energy audits have been undervalued due to a misconception regarding their cost-benefit ratio. However, research shows that energy audits can yield numerous

benefits. Olsthoorn et al. (2017) discovered a correlation between heating systems EEMs and energy audits, which can be translated into practical application. In the particular case of MPIB, a comprehensive audit has not yet been performed; hence the heating system lacks EEM implementations.

As previously mentioned, the TD team is exploring the EEM of lowering set-point temperatures in unoccupied office spaces. They also recognise that the heating system has high-efficiency potential, but minimal effort is being made in this area. The team is considering installing "smart" radiator thermostats that can be remotely controlled through an application or Bluetooth.

The TD team believed that utilizing communication tools would facilitate the implementation of EMS strategies. These tools effectively create awareness and educate stakeholders about energy-saving practices while encouraging energy conservation among personnel. However, introducing these communication practices is not a straightforward process. Per Institute policies, public relations should handle this responsibility, but it requires a directive from top management.

The institute is currently analysing and scrutinising the potential implementation of a highly effective and sustainable retrofit strategy. The TD team inquires about installing a state-of-the-art photovoltaic (PV) panel system. This cutting-edge technology can contribute to reducing the carbon footprint of the building while also contributing to the EMS efforts.

The TD team has made some strides in short-term planning by incorporating activities from an EMS. While their approach has been based on practical experience, they have effectively identified some SEUs. However, without being able to measure the consumption, the savings potential is hindered. As discussed in the previous chapter, TD began implementing measures to enhance EE in certain operational services and systems. However, the full potential of the EMS has yet to be realized, as only some of the EnPIs are being monitored. This is also attributed to the unavailability of energy meters at the institute.

Introducing Archibus by the building department to the institutes can prove to be a brilliant decision. Thanks to Archibus, the TD team now has an efficient way of listing all the equipment and their relevant data, which makes it easy to keep track of any updates or repairs that need to be done. Furthermore, Archibus enables the scheduling

of periodic revisions and checkups to the different systems using checklists to monitor them and prevent failures. This not only helps with equipment maintenance but also supports energy conservation efforts. So far, this tool utilisation at MPIB is minimal.

As the TD team has remarked, one hindrance to the adequate inclusion of Archibus in daily operations is the availability of time the staff can allocate to learn and correctly implement the tools provided without neglecting the other functions necessary to maintain the institute's operation in optimal conditions.

The canteen personnel proved to be partially engaged in energy efficiency measures, with operational and routine aspects already implemented for the kitchen operation. There are additional steps that can be taken to enhance the EE of this service. Potential areas for improvement are acquiring energy-efficient equipment and reducing the operation of cooling units and other appliances.

Effective energy management practices have taken a sizable step forward with the implementation of night walks. However, there is still room for improvement in the ICT department. By introducing energy meters and synchronizing them with the BAS already in place, the monitoring process can be significantly enhanced. This measure is currently underway, and its success is yet to be determined.

The proposed framework allowed for a thorough examination of the OE management practices of the institute. It covered all EE tasks recommended by best practices and thorough research and determined whether they were being implemented within the building and organisation. This level of detail can be applied to other enterprises facing similar conditions, as the activities have been derived from an international standard such as ISO 50001 and the processes and operational services are set in a general manner. Furthermore, the framework emphasises the crucial role of Facility Management in addressing the energy needs of the company.

Moreover, although the activities are specific to energy management, they are general enough for other organisations and companies to assess their energy practices through the framework. The study becomes even more relevant in relation to the formulation of more stringent international norms and standards that seek to accelerate the implementation of energy efficiency measures within the built environment. The proposed framework, together with the PDSA component, allows any organisation, regardless of the level of implementation of energy practices, to apply this assessment

method in order to either move into these practices or to improve the measures already implemented.

4.3 Answering the Research Questions

The research questions have been thoroughly addressed through diligent efforts in developing and implementing the proposed framework. The comprehensive framework was formulated with a clear understanding of the research objectives and executed meticulously, yielding conclusive results. The framework was put to a real-world scenario through on-site research, confirming its viability.

At what level do enterprises manage their service process concerning their energy management strategy?

As mentioned, energy management encompasses a collection of different activities which, if carried out adequately, conform to an EMS. DIN EN 15221-3 (2011) establishes an FM model composed of three different functional levels (strategic, tactical and operational), each with a set of tasks and processes that must be carried out to meet the organisation's or enterprise's demands. A linkage between the tasks and energy management activities was identified, which allowed for the distribution of these activities into one of the three levels (in particular cases, some activities were determined as a link between the levels). The different activities were also placed according to different phases set by the PDSA cycle used in the DIN EN ISO 50001 (2018) norm. This formed the proposed framework, which was then validated through a practical scenario. Having conducted this validation, it became clear that different enterprises can manage their energy management strategies at different levels. In the case of the conducted field research, the institute carried out most of its energy management practices at the operational level. There was also a tactical component since the tactic level is responsible for the execution of short-term plans. From the refinement chapter, it can be deduced that some enterprises have an energy management plan for the long term and, therefore, have a higher strategic commitment. It can also be inferred that the term “services” relates to the operational level. If the operational level is engaged with energy management practices, at least one of the operation services is being impacted.

How do facility management processes from strategic and tactical levels influence the energy management strategy?

In order to achieve long-term success, an organization's strategic processes must prioritize the maximisation of resources and assets. This involves developing policies, managing stakeholders, and ensuring EE practices are implemented throughout the organization. Research has shown that a lack of engagement at the strategic level, including the absence of an energy policy, can hinder the success of EMS practices. Assigning an energy manager and cross-functional energy team is also a responsibility at the strategic level, as their absence can create barriers to implementing an effective EMS.

Based on the literature survey and the conducted field research, it appears that tactical-level processes are focused on short-term goals. These processes translate strategic guidelines into executable functions that ensure optimal service delivery at the operational level. It is at this level that the EEMs are translated from plan to execution. However, without the involvement of the strategic level, the measures they can implement are limited to routine, practical, and behavioural aspects. By proactively identifying the energy systems with the highest consumption rates, establishing tracking of related EnPIs, and modifying operational services accordingly, the tactical team can execute a series of OE management activities with the aid of the operational level.

What is the implementation degree of strategic and tactical specifications at the operational level?

At the operational level, a set of FM procedures are in place to ensure smooth coordination of both internal and outsourced operation (FS) services. The implementation of EMS relies on the deployed EEMs in various services, which are closely tied to the established plan at the tactical and strategic levels. If OE management practices are enforced at the strategic level, a more comprehensive range of activities and EEMs can be carried out, and a continuous improvement PDSA cycle can be put in place. However, suppose the strategic level is not involved. In that case, the responsibility of the energy management initiative falls on the tactical level, which can only execute EMS activities and EEMs on a limited scale with limited resources. It is important to emphasize that the executable EEMs are directly linked to the operation services (FS). When the strategic and tactical levels share a common objective and have a

comprehensive plan in place, the implementation success chances at the operational level and operation services significantly improve.

How can operational services be organised/set up for them to impact the Building Energy systems?

Operational Services, or FS, can directly or indirectly impact the different energy systems in place at a building, as shown in Chapter 3. Implementing energy management procedures or an extensive EMS permits the further modification of the delivery of the specific services. A series of EEMs which can be conducted at the operational level have been identified and validated via field research. The EEMs can be of different scopes depending on the engagement level by the strategic or top-level group from the organisation. Routine, practice and behavioural modifications related to the different energy systems can be deployed to impact them in a way that promotes energy conservation or EE. System replacement and upgrades can also be implemented with the aid of the FM levels at the organisation. Energy retrofits or recommissioning practices can also be undertaken to improve the efficiency of the different energy systems.

5 Conclusion

The optimization of building operational setups, particularly the improvement of FS and energy systems, presents a significant opportunity for OE savings, EE and conservation promotion. Notwithstanding, this potential remains largely untapped.

This research has shown that an EMS provides an extensive amount of benefits to enhance building operation services. An EMS based on state-of-the-art practices such as DIN EN ISO 50001 (2018) guidelines encompasses a set of activities that, when implemented by an organisation, contribute to energy conservation and efficiency measures throughout the whole organisation. It has been found that these activities correlate to the different established FM processes as per DIN EN 15221-5 (2011). The FM model notably allowed for the allocation of the activities according to the three FM levels (strategic, tactical and operational), clarifying the tasks every level requires in order to execute an EMS successfully.

The framework, established with the aid of FM process mapping and a PDSA cycle for continuous improvement introduced in DIN EN ISO 50001 (2018), depicts how FM can bridge the gap between energy management and effectively impact EE through building operations. By validating the framework through a practical scenario, it became palpable that enterprises currently exploring ways to improve their energy management have different levels of commitment and implementation, which can hinder the optimal execution of an EMS.

Enterprises have the opportunity to enhance their energy management practices by implementing EEMs by building operation services that are directly linked to the energy systems in the facility. These EEMs can cover a wide range of scopes, including routine, operational, and practical aspects, as well as system replacements or retrofits.

In light of the recent occurrences, the relevance of this study has gained momentum. As the Federal Ministry of Finance (Bundesfinanzministerium) has remarked, Germany has pledged to become carbon neutral by 2045 (admin, n.d.), furthering the already bold commitment to reduce carbon emissions by 65% in 2030 compared to 1990. By establishing EMS in buildings as proposed in the framework, energy conservation and efficiency support these goals in the built environment.

Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 6th of July

Location, Date

Signature of the student

List of Literature

5 Energy Efficiency Measures for Buildings - ClevAir Blog [WWW Document], 2021. URL https://clevair.io/en/blog/5-profitable-energy-efficiency-measures-buildings (accessed 6.6.23).

A Simple Guide to Ensuring Building Security [WWW Document], n.d. . SafetyCulture. URL https://safetyculture.com/topics/building-security/ (accessed 6.11.23).

Abdelaziz, E.A., Saidur, R., Mekhilef, S., 2011. A review on energy saving strategies in industrial sector. Renewable and sustainable energy reviews 15, 150–168.

admin, n.d. Climate Action Programme 2030: frequently asked questions - Federal Ministry of Finance - Resources [WWW Document]. Bundesministerium der Finanzen. URL https://www.bundesfinanzministerium.de/Content/EN/FAQ/climate-protection-faq.html (accessed 6.25.23).

Alexander, K., 2008. Facilities Management Processes. https://doi.org/10.13140/2.1.5108.0328

Analysis and Representation of Miscellaneous Electric Loads in NEMS - Energy Information Administration [WWW Document], n.d. URL https://www.eia.gov/analysis/studies/demand/miscelectric/ (accessed 6.16.23).

ASQ and the Holmes Corp., 1999. ASQ's Foundations in Quality Self-Directed Learning Program (Milwaukee: ASQ Quality Press, 1999).

Ates, S.A., Durakbasa, N.M., 2012. Evaluation of corporate energy management practices of energy intensive industries in Turkey. Energy 45, 81–91.

Atkin, B.L. & Brooks, A. (2005). Total Facilities Management, 2nd edition. Oxford:

Blackwell Publishing.

Beaumont, N., Sohal, A., 2004. Outsourcing in australia. International Journal of Operations & Production Management 24, 688–700.

BFE Bundesamt für Energie, IEA Internationale Energie Agentur (2005). IEA Annex 40 -Betreiberkompetenz. Bern: Bundesamt für Energie.

Blass, V., Corbett, C.J., Delmas, M.A., Muthulingam, S., 2014. Top management and the adoption of energy efficiency practices: Evidence from small and medium-sized manufacturing firms in the US. Energy 65, 560–571.

Bordass, B., Leaman, A. (2015). Building performance assessment and evaluation. In: Paper presented at PART 1. 2, Building Performance Sessions, 12 May 2015, Centre for Alternative Technology (CAT), Machynlleth. <www.usablebuildings.co.uk> (accessed 2 June 2023).

Bowonder, B., 1984. Energy management awareness programme for senior executives. The Environmentalist 4, 125–129.

Brady, L., Abdellatif, M., 2017. Assessment of energy consumption in existing buildings. Energy and Buildings 149, 142–150.

Buildings – Analysis [WWW Document], n.d. . IEA. URL https://www.iea.org/reports/buildings (accessed 6.28.23).

Bunse, K., Vodicka, M., Schönsleben, P., Brülhart, M., Ernst, F.O., 2011. Integrating energy efficiency performance in production management–gap analysis between industrial needs and scientific literature. Journal of Cleaner Production 19, 667–679.

Caffal, C., 1995. Energy management in industry. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET). Analysis Series 17, 1–95.

Carrico, A.R., Riemer, M., 2011. Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education. Journal of environmental psychology 31, 1–13.

Chapman, D., Austin, A., 2002. Higher Education in the Developing World: Changing Contexts and İnstitutional Responses.(Eds.) Westport.

Cholewa, T., Siuta-Olcha, A., Smolarz, A., Muryjas, P., Wolszczak, P., Guz, Ł., Bocian, M., Sadowska, G., Łokczewska, W., Balaras, C.A., 2023. On the forecast control of heating system as an easily applicable measure to increase energy efficiency in existing buildings: Long term field evaluation. Energy and Buildings 292, 113174.

https://doi.org/10.1016/j.enbuild.2023.113174

Churcher, D. 2013 Life Cycle Assessment : an introduction, Bracknell, BSRIA.

Christoffersen, L.B., Larsen, A., Togeby, M., 2006. Empirical analysis of energy management in Danish industry. Journal of Cleaner Production 14, 516–526.

Climate Action Plans & Business Sustainability | The Carbon Trust [WWW Document], n.d. URL https://www.carbontrust.com/ (accessed 5.30.23).

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative science quarterly 128–152.

Commission, C.E., current-date. 2006 California Commercial End-Use Survey (CEUS) [WWW Document]. California Energy Commission. URL https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2006-california-commercial-end-use-survey (accessed 6.28.23).

Cousins, M. (2003). "Follow the Map." Six Sigma Today Launch Issue (October 2003).

Damanpour, F., 1991. Organizational innovation: A meta-analysis of effects of determinants and moderators. Academy of management journal 34, 555–590.

Deming, E., 1986. Out of the crisis. MIT Press, Cambridge. USA MA, Page 88

DIN EN 15221-3 (2011), Facility Management - Part 3: Guidance on quality in Facility Management; German version EN 15221-3:2011.

DIN EN 15221-5 (2011), Facility Management - Part 5: Guidance on Facility Management processes; German version EN 15221-5:2011.

DIN EN ISO 50001 (2018), Energy management systems - Requirements with guidance for use (ISO 50001:2018); German version EN ISO 50001:2018.

DIN EN ISO 9000 (2015), Quality management systems - Fundamentals and vocabulary (ISO 9000:2015); German and English version EN ISO 9000:2015.

Doty, S., Turner, W.C., 2004. Energy management handbook. Crc Press.

D’Oca, S., Hong, T., Langevin, J., 2018. The human dimensions of energy use in buildings: A review. Renewable and Sustainable Energy Reviews 81, 731–742. https://doi.org/10.1016/j.rser.2017.08.019

Drumm, C., Busch, J., Dietrich, W., Eickmans, J., Jupke, A., 2013. STRUCTese®– Energy efficiency management for the process industry. Chemical Engineering and Processing: Process Intensification 67, 99–110.

Dubois, M.-C., Blomsterberg, Å., 2011. Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: A literature review. Energy and Buildings 43, 2572–2582. https://doi.org/10.1016/j.enbuild.2011.07.001

Energy, A., 2003. Energy consumption guide 19: energy use in offices. Energy 348389.

Star, E., 2012. Energy Star guidelines for energy management. Washington, DC, US Environmental Protection Agency, nd http://www. energystar. gov/buildings/tools-and-resources/energystar-guidelines-energy-management. https://www.energystar.gov/buildings/tools-and-resources/energy-star-guidelines-energy-management (accessed 5.17.23).

FM Standards • EuroFM, n.d. . EuroFM. URL https://eurofm.org/about-fm/fm-standards/ (accessed 6.27.23).

European Commission, 2006. Action plan for energy efficiency: realising the potential. COM (2006) 545.

Facts and Figures [WWW Document], n.d. URL https://www.mpg.de/facts-and-figures (accessed 6.19.23).

Fichera, A., Volpe, R., Cutore, E., 2020. Energy performance measurement, monitoring and control for buildings of public organizations: Standardized practises compliant with the ISO 50001 and ISO 50006. Developments in the Built Environment 4, 100024. https://doi.org/10.1016/j.dibe.2020.100024

Firdaus, N., Samat, H.A., Mohamad, N., 2019. Maintenance for Energy efficiency: A Review. IOP Conf. Ser.: Mater. Sci. Eng. 530, 012047. https://doi.org/10.1088/1757-899X/530/1/012047

Fleiter, T., Hirzel, S., Worrell, E., 2012. The characteristics of energy-efficiency measures–a neglected dimension. Energy policy 51, 502–513.

Fleiter, T., Schleich, J., Ravivanpong, P., 2012. Adoption of energy-efficiency measures in SMEs—An empirical analysis based on energy audit data from Germany. Energy Policy 51, 863–875. https://doi.org/10.1016/j.enpol.2012.09.041

Fraij, A., 2020. How Much Can You Save Energy by Adjusting Your Thermostat by 1°C? | appliedenergysaving. URL https://appliedenergysaving.com.au/how-much-can-you-save-energy-by-adjusting-your-thermostat-by-1c/ (accessed 6.16.23).

GEFMA 100: Facility Management. Begriffe, Strukturen, Inhalte. Deutscher Verband für Facility Management.Vorentwurf. Bonn 1996

GEFMA Richtlinie 400: Computer Aided Facility Management CAFM—Begriffsbestimmungen Leistungsmerkmale, März 2021, 19 p

GEFMA Deutscher Verband für Facility Management e.V. (2004). GEFMA 100-1 Facility

Management – Grundlagen. Nürnberg.

Giordano, R., Giovanardi, M., Guglielmo, G., Micono, C., 2017. Embodied energy and operational energy evaluation in tall buildings according to different typologies of façade. Energy Procedia 134, 224–233.

Goo, J., 2010. Structure of service level agreements (SLA) in IT outsourcing: The construct and its measurement. Information Systems Frontiers 12, 185–205.

González, A.B.R., Díaz, J.J.V., Caamano, A.J., Wilby, M.R., 2011. Towards a universal energy efficiency index for buildings. Energy and buildings 43, 980–987.

Gordić, D., Babić, M., Jovičić, N., Šušteršič, V., Končalović, D., Jelić, D., 2010. Development of energy management system–Case study of Serbian car manufacturer. Energy Conversion and Management 51, 2783–2790.

Gruber, E., Brand, M., 1991. Promoting energy conservation in small and medium-sized companies. Energy Policy 19, 279–287.

He, Y., Liao, N., Bi, J., Guo, L., 2019. Investment decision-making optimization of energy efficiency retrofit measures in multiple buildings under financing budgetary restraint. Journal of cleaner production 215, 1078–1094.

Hidden Building Energy Wasters | Building Operation [WWW Document], n.d. . BetterBricks. URL https://betterbricks.com/resources/building-night-walk-video-series (accessed 5.16.23).

Hiles, A., 1993. Service level agreements: measuring cost and quality in service relationships. (No Title).

Hong, T., Yan, D., D’Oca, S., Chen, C., 2017. Ten questions concerning occupant behavior in buildings: The big picture. Building and Environment 114, 518–530.

Huovila, P., Ala-Juusela, M., Melchert, L., Pouffary, S., Cheng, C.-C., Ürge-Vorsatz, D., Koeppel, S., Svenningsen, N., Graham, P., 2009. Buildings and climate change: Summary for decision-makers.

Independent building test, research, instruments and information - BSRIA [WWW Document], n.d. URL https://www.bsria.com/uk/?geoh=www.bsria.com&geoc=de (accessed 5.30.23).

INKISUP, (2002), Energy Concept Adviser. Deliverable of the European SAVE contract "INKISUP" n°4.1031/Z/02-101/2002.

IPCC (2018). Summary for policymakers. In V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, et al. (Eds.), Global warming of 1.5_C. an IPCC special report on the impacts of global warming of 1.5_C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (p. 32). Geneva, Switzerland: World Meteorological Organization.

Jackson, J., 2010. Promoting energy efficiency investments with risk management decision tools. Energy Policy 38 (8), 3865e3873.

Jalo, N., Johansson, I., Andrei, M., Nehler, T., Thollander, P., 2021. Barriers to and Drivers of Energy Management in Swedish SMEs. Energies 14, 6925. https://doi.org/10.3390/en14216925

Jelić, D.N., Gordić, D.R., Babić, M.J., Končalović, D.N., Šušteršič, V.M., 2010. Review of existing energy management standards and possibilities for its introduction in Serbia. Thermal Science 14, 613–623.

Scholes, K., Johnson, G., Whittington, R., 2002. Exploring corporate strategy. Financial Times Prentice Hall Hoboken, NJ, USA.

Kamilaris, A., Kalluri, B., Kondepudi, S., Tham, K., 2014. A literature survey on measuring energy usage for miscellaneous electric loads in offices and commercial buildings. Renewable and Sustainable Energy Reviews 34, 536–550. https://doi.org/10.1016/j.rser.2014.03.037

Kagioglou, M., Cooper, R., Aouad, G., Hinks, J., Sexton, M., Sheath, D., 1998. Generic design and construction process protocol: final report. The University of Salford.

Kannan, R., Boie, W., 2003. Energy management practices in SME––case study of a bakery in Germany. Energy conversion and management 44, 945–959.

Kerr, N., Gouldson, A., Barrett, J., 2017. The rationale for energy efficiency policy: Assessing the recognition of the multiple benefits of energy efficiency retrofit policy. Energy Policy 106, 212–221.

Knowles, M., Baglee, D., 2012. The role of maintenance in energy saving in commercial refrigeration. Journal of Quality in Maintenance Engineering 18, 282–294.

Langley, G., Nolan, K, and Nolan, T. 1994. The Foundation of Improvement, Quality Progress, June 1994, page 81

Langley, G. Nolan, K., Nolan, T., Norman, C., Provost, L. 1996. The Improvement Guide.Jossey-Bass, San Francisco, page 10.

Langley, G. Moen, R., Nolan, K., Nolan, T., Norman, C., Provost, L. 2009. The Improvement Guide, 2nd Edition. Jossey-Bass, San Francisco, page 24.

Lenox, M., King, A., 2004. Prospects for developing absorptive capacity through internal information provision. Strategic management journal 25, 331–345.

Lesourd, J.-B., Ruiz, J.-M., 1984. Human resources for energy management: The case of French industry. Engineering Management International 2, 195–198.

Liu, X., Niu, D., Bao, C., Suk, S., Shishime, T., 2012. A survey study of energy saving activities of industrial companies in Taicang, China. Journal of Cleaner Production 26, 79–89.

Masoso, O.T., Grobler, L.J., 2010. The dark side of occupants' behaviour on building energy use. Energy and Buildings 42, 173–177. https://doi.org/10.1016/j.enbuild.2009.08.009

Mastrucci, A., Rao, N.D., 2017. Decent housing in the developing world: Reducing life-cycle energy requirements. Energy and buildings 152, 629–642.

McKane, A., Williams, R., Perry, W., Li, T., 2007. Setting the standard for industrial energy efficiency. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States).

McKenney, K., Guernsey, M., Ponoum, R., Rosenfeld, J., n.d. Commercial Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential in 2008 by Building Type.

Menezes, A.C., Cripps, A., Buswell, R.A., Wright, J., Bouchlaghem, D., 2014. Estimating the energy consumption and power demand of small power equipment in office buildings. Energy and Buildings 75, 199–209. https://doi.org/10.1016/j.enbuild.2014.02.011

Min, Z., Morgenstern, P., Marjanovic-Halburd, L., 2016. Facilities management added value in closing the energy performance gap. International Journal of Sustainable Built Environment 5, 197–209. https://doi.org/10.1016/j.ijsbe.2016.06.004

Mkhaimer, L., Arafah, M., Sakhrieh, A., 2017. Effective implementation of ISO 50001 energy management system: Applying Lean Six Sigma approach. International Journal of Engineering Business Management 9, 184797901769871. https://doi.org/10.1177/1847979017698712

Moen, R. and Nolan, T. 1987. Process Improvement, Quality Progress, Sept. 1987, page 65

Moen, R., Norman, C., 2006. Evolution of the PDCA cycle.

MOM, 2015. Property Management vs. Facility Management - Gebäudereinigung, Gebäudeservice, Hausmeisterservice. MOM Märkisches Objektmanagement. URL https://www.mom-online.de/aktuelles/property-management-vs-facility-management/ (accessed 6.11.23).

NEEA, 2014. Northwest Commercial Buildings Deep Energy Retrofit Twenty Year Market Base Assessment <https://neea.org/docs/defaultsource/ reports/northwest-commercial-buildings-deep-energy-retrofitmarket- characterization-and-twenty-year-market-baseline.pdf?sfvrsn=5> (accessed 26 May 2023).

Nutt, B., 2002. The essence and value of facility management.

Olsthoorn, M., Schleich, J., Hirzel, S., 2017. Adoption of Energy Efficiency Measures for Non-residential Buildings: Technological and Organizational Heterogeneity in the Trade, Commerce and Services Sector. Ecological Economics 136, 240–254. https://doi.org/10.1016/j.ecolecon.2017.02.022

Paillat, E., n.d. ENERGY EFFICIENCY IN FOOD-SERVICE FACILITIES: THE CASE OF LÅNGBRO VÄRDSHUS.

Parrish, K., Ledewitz, J., and Leonard, E. (2012). "Building an Energy Management System for MIT: Lessons Learned from Implementing ISO 50001." In T. Hong and J. Loper (Eds.) Proc. ACEEE Summer Study on Energy Efficiency in Buildings 12-17 Aug, Asilomar, CA

Parrish, K., Whelton, M., 2013. Lean operations: An energy management perspective. 21st Annual Conference of the International Group for Lean Construction 2013, IGLC 2013 825–834.

Patanapiradej, W., 2006. THE SCOPE OF FACILITY MANAGEMENT. Nakhara : Journal of Environmental Design and Planning 1, 75–90.

Pérez-Lombard, L., Ortiz, J., Pout, C., 2008. A review on buildings energy consumption information. Energy and buildings 40, 394–398.

Peterson, R.D., Belt, C.K., 2009. Elements of an energy management program. Jom 61, 19–24.

Pojasek, R. B. (2003). "Selecting Your Own Approach to P2." Environment Quality Management, Summer(2003): 85-94.

Praseeda, K., Reddy, B.V., Mani, M., 2016. Embodied and operational energy of urban residential buildings in India. Energy and buildings 110, 211–219.

Process Mining vs. Process Modeling vs. Process Mapping: What's the Difference? [WWW Document], 2023. URL https://www.ibm.com/cloud/blog/process-mining-vs-process-modeling-vs-process-mapping (accessed 6.1.23).

Putnam, C., Danuser, M.L., Clark, L.M., Cooper, S.R., n.d. Sustainability How-To Guide Series.

Rasmussen, F.N., Malmqvist, T., Moncaster, A., Wiberg, A.H., Birgisdóttir, H., 2018. Analysing methodological choices in calculations of embodied energy and GHG emissions from buildings. Energy and buildings 158, 1487–1498.

Rathore, U., 2011. Energy management. SK Kataria & Sons.

Redlein, A., Stopajnik, E., 2020. IT Support, in: Redlein, A. (Ed.), Modern Facility and Workplace Management: Processes, Implementation and Digitalisation, Classroom

Companion: Business. Springer International Publishing, Cham, pp. 67–114. https://doi.org/10.1007/978-3-030-35314-8_3

Renewable Energy Data Book [WWW Document], n.d. . Energy.gov. URL https://www.energy.gov/eere/analysis/articles/renewable-energy-data-book (accessed 6.11.23).

Rietbergen, M.G., Blok, K., 2010. Setting SMART targets for industrial energy use and industrial energy efficiency. Energy Policy 38 (8), 4339e4354.

Roth, K., Mckenney, K., Paetsch, C., Ponoum, R., 2008. U.S. Residential Miscellaneous Electric Loads Electricity Consumption.

Rudberg, M., Waldemarsson, M., Lidestam, H., 2013. Strategic perspectives on energy management: A case study in the process industry. Applied Energy 104, 487–496.

Schulze, M., Nehler, H., Ottosson, M., Thollander, P., 2016. Energy management in industry – a systematic review of previous findings and an integrative conceptual framework. Journal of Cleaner Production 112, 3692–3708. https://doi.org/10.1016/j.jclepro.2015.06.060

Shohet, I.M., Lavy, S., 2004. Healthcare facilities management: state of the art review. Facilities.

Siregar, M., Nur, T., Purbantoro, F., Panjaitan, L., 2019. Optimization of the Energy Management Concept in High Rise Office Building (Case Study in SSS Building Jakarta), in: 2019 International Conference on Technologies and Policies in Electric Power & Energy. Presented at the 2019 International Conference on Technologies and Policies in Electric Power & Energy, pp. 1–6. https://doi.org/10.1109/IEEECONF48524.2019.9102552

Sivill, L., Manninen, J., Hippinen, I., Ahtila, P., 2013. Success factors of energy management in energy-intensive industries: Development priority of energy performance measurement. International journal of energy research 37, 936–951.

Standardization, E., 2008. Energy performance of buildings–Overall energy use and definition of energy ratings. Primary energy factors; Carbon dioxide emissions 62.

Stawicki, B., Lozo, B., Lajic, B., 2010. Energy management guidelines in pulp and paper production. Cellulose Chemistry & Technology 44, 521.

Stephan, A., Stephan, L., 2016. Life cycle energy and cost analysis of embodied, operational and user-transport energy reduction measures for residential buildings. Applied Energy 161, 445–464.

Suk, S., Liu, X., Sudo, K., 2013. A survey study of energy saving activities of industrial companies in the Republic of Korea. Journal of Cleaner Production 41, 301–311.

Sullivan, C.F., 1998. Health care food service systems management. Jones & Bartlett Learning.

Tague, N., 2004. The quality toolbox. Quality Press.

The Benefits of Day Cleaning [WWW Document], 2008. . Buildings. URL https://www.buildings.com/associations/article/10192511/the-benefits-of-day-cleaning (accessed 5.16.23).

Thollander, P., Ottosson, M., 2010. Energy management practices in Swedish energy-intensive industries. Journal of Cleaner Production 18, 1125–1133.

Trianni, A., Cagno, E., De Donatis, A., 2014. A framework to characterize energy efficiency measures. Applied Energy 118, 207–220.

Tushman, M.L., 1977. Special boundary roles in the innovation process. Administrative science quarterly 587–605.

Trust, C., 2011. Closing the Gap—Lessons Learned on Realising the Potential of Low Carbon Building Design. Carbon Trust London: London, UK.

Urge-Vorsatz, D., Petrichenko, K., Antal, M., Staniec, M., Ozden, E., & Labzina, E. (2012). Best practice policies for low Carbon & Energy

U.S. Energy Information Administration, (2003a), Table E1. Major fuel consumption by end use for non-mall buildings. 2003 Commercial buildings energy consumption survey.

Buildings Based on scenario analysis. Paris: Global Buildings Performance Network.Vérez, D., Cabeza, L.F., 2021. Which Building Services Are Considered to Have Impact on Climate Change? Energies 14, 3917. https://doi.org/10.3390/en14133917

Vasudevan, S., Higgins, B., 2004. Strategic energy risk management for end users. Journal of Structured Finance 10, 74.

VDI 4602 Blatt 1 2018, Energy management – Fundamentals

Vikhorev, K., Greenough, R., Brown, N., 2013. An advanced energy management framework to promote energy awareness. Journal of Cleaner Production 43, 103–112.

Wade, J., Pett, J., Ramsay, L., House, W., 2003. Energy efficiency in offices: assessing the situation. London: Association for the Conservation of Energy.

Wang, Z., Ding, Y., 2015. An occupant-based energy consumption prediction model for office equipment. Energy and Buildings 109, 12–22. https://doi.org/10.1016/j.enbuild.2015.10.002

What is Facility Management? [WWW Document], n.d. URL https://www.ifma.org/about/what-is-fm/ (accessed 6.27.23).

What is workplace and facilities management? [WWW Document], n.d. URL https://www.iwfm.org.uk/about/what-is-workplace-and-facilities-management.html (ac-cessed 6.27.23).

Williamson, O.E., 2008. Outsourcing: Transaction cost economics and supply chain management.

Journal of supply chain management 44, 5–16.

Wilson, A., 2001. Greening Federal Facilities: An Energy, Environmental, and Eco-nomic Resource Guide for Federal Facility Managers and Designers. National Renew-able Energy Lab.(NREL), Golden, CO (United States).

F. Zammori, M. Braglia, and M. Frosolini. 2009. A Standard Agreement For Vendor Managed Inventory. Strateg. Outsourcing An Int. J. 2(2): 165–186.

Zohir, A., 2010. Energy efficiency improvement by housekeeping measures. Presented at the 2010 3rd International Conference on Thermal Issues in Emerging Technologies Theory and Applications, IEEE, pp. 245–255.