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Success Factors and Barriers for Facility Management in Keeping Nearly-Zero-Energy Non-Residential Buildings Energy-Efficient over Time

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Abstract: Energy efficiency is a cornerstone of climate change mitigation. For buildings, facility management is an essential part of achieving efficient energy use while keeping tenants satisfied. This interview study explores success factors and barriers for facility management in maintaining energy efficiency over time in four approximately 10-year-old non-residential premises built as so-called nearly zero-energy buildings (nZEB) in Sweden. The study highlights the importance of functional digital tools, benchmarks, and building professionals' involvement in ensuring energy efficiency. It also emphasizes the need for involvement communication and strategies to engage facility management in energy efficiency efforts. The study suggests that in-house and public policies can play a crucial role in sustaining high ambitions for energy efficiency. Access to professional support that is self-evident to use is identified as a critical success factor. Additionally, the research presents an analytic model that can be used in future studies to assess facility management organizations' potential for maintaining energy performance in buildings over time.

Keywords: facility management; energy efficiency; nearly zero-energy buildings (nZEB); non-residential buildings; interview study; building energy management

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1. Introduction

Improved energy efficiency is a cornerstone for climate change mitigation and buildings remain a key area. This paper focus on facility management as an essential part in the non-residential building segment, in achieving energy-efficient buildings [1–4].

The Intergovernmental Panel on Climate Change (IPCC) predicts that unless significant cuts in CO_2 and other greenhouse gas emissions are made soon, the global temperature will rise by more than 1.5–2 °C this century [5]. Reducing greenhouse gas (GHG) emissions is crucial for combatting global warming. In 2022, the total CO_2 emissions from energy combustion and industrial processes were 36.8 Gt CO_2, of which buildings accounted for 2.97 Gt CO_2 [6]. In 2020, energy usage worldwide in the housing and service sector accounted for approximately 38% of the total 100 GWH energy usage [7]. For buildings, it is essential to reduce emissions, both during construction and in their operational phase. The energy use of a building during operation is influenced by many factors, such as its thermal characteristics, construction specifics, external climate, the behavior of its inhabitants, efficiency of HVAC system, and management [8].

The concept of nearly-zero-energy buildings aims to minimize energy usage in buildings and is used in areas worldwide. However, definitions and requirements differ according to climate and other local settings [9]. The starting point for stricter energy demands for buildings [10] in the EU that aim for nZEB status can be related to two main pieces of legislation: the Energy Performance of Buildings Directive (EPBD) [11] and the Energy Efficiency Directive (EED) [12]. These directives addressed the reduction in energy usage

and environmental impact generated by the building sector and challenged some actors to explore the limits for low energy usage even before national legislation was intensified. There are currently proposals from the European Commission to change from nearly-zero energy to zero-emission requirements for all new buildings as of 1 January 2030, and for all new buildings occupied or owned by public authorities as of 1 January 2027. The number of nZEB buildings in EU Member States and the United Kingdom is increasing [13]. For future success with implementation of even stricter requirements, it is important to examine the barriers, success factors, and driving forces for energy efficiency over time for existing nearly zero-energy buildings. This is also motivated by the known energy performance gap [14], where new buildings do not fulfill energy requirements at the start of operation and there are additional causes added during operation and usage of the building.

According to Tsemekidi Tzeiranaki [15], energy usage in the service part of the sector is growing in the EU and the UK. In Sweden, there are almost three million non-residential buildings, approximately 120,000 buildings for public service, and approximately 60,000 office buildings. In 2021, the largest proportions of heated space in Swedish non-residential premises consisted of schools (27%), offices (22%), and healthcare facilities (15%) [16]. Combined, these account for over half of the total area of heated non-residential buildings, which justifies gaining a deeper knowledge of how to keep energy efficiency in these types of buildings.

In both public and private non-residential premises, facility management (FM) plays an important role in maintaining the buildings and keeping users and tenants satisfied [1,2]. Together with energy management professionals (EMP), FM also has a significant role for energy efficiency in buildings [3,17], both by maintaining the energy performance of buildings, but also by initiating energy efficiency actions [18]. An FM organization can also be a link among users, the technology, and the prevailing authority as it can regulate the indoor climate and other functions in the building. In practice, however, there are challenges, such as through different views and prioritization of energy efficiency [19] within facility management.

The development of digital technology influences how management of buildings is performed [20]. Building energy management systems (BEMS), described as a combination of strategies and methods to improve performance in buildings, have been pointed out as important for energy efficiency [21]. Automatic control systems that replace continuous manual system operation by humans in everything from thermostatic valves to digital building automation systems (BAS) have been a part of the building industry for a long time. Support systems for facility management like computerized maintenance management systems (CMMS) are also a part of the everyday work in facility management organizations [19]. Digital technologies such as Building Information Modelling (BIM) [22,23], artificial intelligence (AI), and machine learning (ML) for building control are under development [24–27].

Aim and Scope

This study addresses gaps in knowledge regarding success factors and barriers for facility management in maintaining non-residential nZEBs' energy-efficient over time. It is during the operational phase that the building systems use energy, so the daily operation and maintenance has a major impact on the buildings' energy use over time. The FM organization, including operating technicians, is responsible for the operation and maintenance of buildings. As shown by Brackley [4], there is only a limited but growing number of bottom-up studies related to operating technicians' perspectives on energy use and energy efficiency in buildings. There is even less research about success factors and barriers for facility management in maintaining non-residential nZEBs' energy efficiency that have been in use for at least 10 years. Some studies have been conducted on nZEBs that have been in use for a shorter time; for example, a French retirement home built in 2011 that was investigated six months after occupancy [28] and two office buildings built in 2012–13 that were investigated in 2015 [1].

It is therefore important to study their perspectives more closely to understand how important energy use is in the contexts in which they work. Energy-efficient buildings, especially non-residential buildings, may have a lot of advanced technology that may require a high level of competence to operate within the organization. Accordingly, it is extra important to investigate possibilities and barriers for FM to manage energy efficiency during the operational phase of this type of buildings.

The aim in this paper is to explore how professionals in an informal or formalized facility management role in an organization manage the energy efficiency performance of non-residential nZEBs over time. The research questions are:

- What are the major drivers and success factors for facility management in maintaining non-residential buildings' energy efficiency over time?
- What are the major barriers for facility management in maintaining non-residential buildings' energy efficiency over time?
- The article is based on a qualitative interview study with professionals in formal and informal organized facility management linked to four different nZEBs. Each of the buildings were built around 2012 in different locations in Sweden, and were therefore approximately 10 years old at the time of the study. Two of the buildings, a preschool and a retirement home, are owned, managed, and used under municipal auspices. The other two buildings are privately owned offices where the tenants who have their business activities in the segment of energy-efficient buildings engage in the property operation and were also involved in designing the buildings.

This study is also unique because it contributes with an analytical model that could be applied to other research studies of facility management organizations to identify their potential to maintain buildings' energy efficiency over time. Sweden shares several energy features and types of buildings with other countries, which makes for good exemplary cases.

2. Theoretical and Central Concepts

This section describes central theories and concepts for the study, starting with the energy efficiency and energy performance gaps, the 3C theoretical framework, a description of roles in facility management, and finally policy and energy requirements in the Swedish context of the study.

2.1. Energy Efficiency and Energy Performance Gap

The fact that buildings use more energy than theoretical assumptions can be explained by various barriers to energy efficiency, which have given rise to an energy-efficiency gap where cost-effective investments and measures have not been undertaken [29–31] during the construction process or later on in the building's life cycle. It can also be explained by the fact that the energy performance targets for the building have not been met due to issues during the construction process or building operation. This energy performance gap [14] is defined as the difference between predicted and measured energy usage, which has been shown in studies conducted in Sweden and in other European countries [32,33]. Issues giving rise to the energy performance gap have been identified in all parts of the building process with all actors involved [34,35]. Therefore, in order to minimize the energy performance gap, the quality assurance method ByggaE was developed [36] to support all actors through all parts of the building process. The method involves all parties to identify, handle, and follow up against risks that could have an impact on requirements for energy usage in the building (see Figure 1).

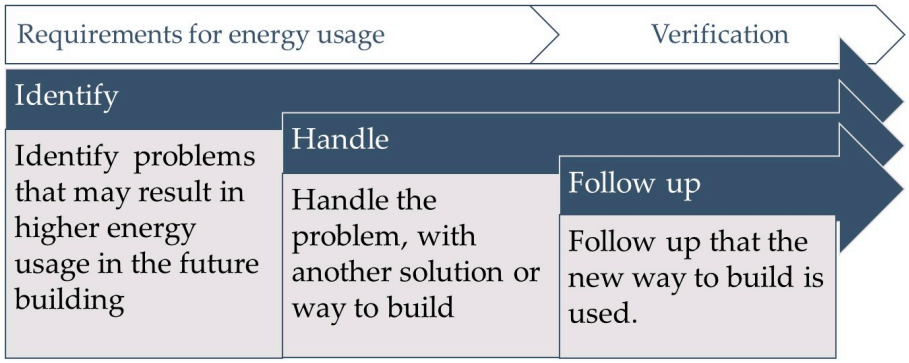


Figure 1. Processes in the method ByggaE.

During the operational phase, built-in defects, design of the building, and systems will affect the energy usage [37] if they cannot be effectively addressed. Occupants also have an impact on the actual energy usage [38,39] by their actions and social habits in the building [28]. Occupancy levels and hours of operation may also differ according to the set up in design. Users, facility management, and the interaction between them in non-residential premises all have an impact on reducing or increasing the energy performance gap [1]. As described above, facility management plays an important role in maintaining energy performance for the building.

2.2. The 3C Theoretical Framework

To explore barriers, success factors, and driving forces for low energy usage in buildings over time, the results in the study are discussed with a starting point in the 3C theoretical framework [40], which stands for concern, capacity, and conditions. Concern describes factors that shape attention to energy, such as legislation, internal policy in organizations, and individual values. Conditions describes factors that shape where energy actions occur, such as the technical conditions in buildings and digital support systems. Capacity describes factors that moderate abilities to take energy actions, like energy management structure, ability to use systems, and solve technical problems. The framework was initially formed to analyze how commercial and institutional organizations responded to energy supply problems in California in 2000 [41]. The framework was further developed [40], and in 2018 [42], the engagement gap was introduced.

In the present study, the individual perspective from the user of the building by Janda [40] is applied to professionals in an informal or formalized facility management role in an organization. A group that can also be included in the category of "middle actors" or intermediaries is described as those who have the position, knowledge, and concerns to influence others in all directions for energy efficiency in buildings. Building professionals [43] have been identified as possible middle actors that have the possibility to influence upstream, downstream, and sideways directions by enabling, mediating, and aggregating.

2.3. Roles in Facility Management

Facility management (FM) is a broad concept that is defined in the International ISO standard 41011:2017 [44] as "an organizational function that 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." According to this definition, providing these services in a sustainable and energy-efficient way is not obviously included in the concept initially, but is something that has become more important to achieve global goals. To achieve energy efficiency, energy management has been introduced into building operation.

There are many job titles for those working with building and energy-related FM since there is no protected professional title. What is included in the job varies greatly in

the Swedish context of this study, ranging from a person who takes care of everything to having several different specialist skills and support functions within or connected to the organization. *Real estate technicians* can have a role with general real estate competence, or there may be different real estate technicians for installations, construction, electricity, and factors related to the outdoor environment, etc. *Operations technicians* are normally more specialized in technology, such as heating, ventilation, and associated control systems. A property manager has a greater overall responsibility for the building such as finances and leases. The title energy management professional (EMP), defined as those who in practice have the responsibility of pursuing energy goals, can be found in the literature [17].

FM can be organized in many ways: it could be an external company or an inhouse organization. Split incentives [31] could occur if energy bills not are paid by the FM [4,45].

2.4. Policy and Energy Requirements

Requirements for new buildings' energy use in the specific setting of this study in Sweden are regulated in the Swedish National Board of Housing, Building and Planning Building regulations, BBR [46]. The level of these requirements has been elevated, while the definition has varied over time. Energy usage (excluding activity and household energy) in existing buildings is monitored by the National Board of Housing, Building and Planning through energy declarations every 10 years for non-residential premises and apartment buildings [47]. In the energy declaration, actions for energy efficiency can be proposed, but there is no requirement to implement these actions or to limit the building's energy use in other ways. There are also requirements for indoor temperature in homes and non-residential premises in Sweden determined by the Public Health Agency of Sweden [48].

3. Methodology

The qualitative research methodology in this paper aims to answer questions containing what, why, and how. According to Brinkmann [49], interviews are a suitable method for obtaining in-depth data from relatively few individuals. Examples of other qualitative interview studies in the field of energy-efficient buildings are [50–52], among others. The research design in this study is illustrated in Figure 2.

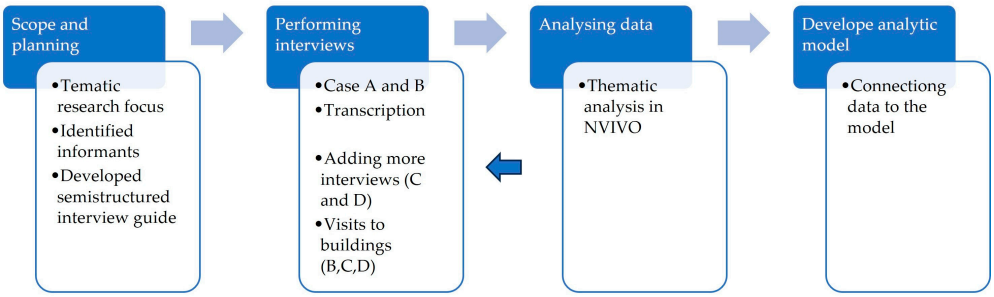


Figure 2. A flowchart of the research design in this paper.

The investigation was carried out as a case study inspired by Yin [53]. There are six different sources for evidence in a case study according to Yin where interviews are one important source. The cases, A–D, are defined as facility management connected to four different buildings that will be described in the next section. The starting point for this interview study is the professionals' everyday routines. This includes interaction with the energy system, digital support systems, and other people where norms, values, and guidelines are a part of their activities.

3.1. Case Description—The Buildings

The Swedish Energy Agency and the National Board of Housing, Building, and Planning [54] have implemented measurements in approximately 30 nZEBs, broken down

by the categories non-residential buildings, multifamily buildings, and single-family houses. In this study, four of these non-residential buildings (referred to as Buildings A–D) are included as case studies; see Table 1.

Table 1. Overview of the case study buildings in the study.

Building	A	B	C	D
Type of building	Preschool	Retirement home	Office	Office
Owner	Municipality A	Municipality B	Private	Private
Participating organization	Facility management A	Facility management B	Tenant C	Tenant D
Year built	2011	2012	2011	2012–2013
Approx. area (m^2)	800	7000	4100	3000
Size of tenant activities in the building	Four preschool departments, total 80 children and personnel. Commercial kitchen	100 apartments and common spaces with personnel round-the-clock for elderly care recipients. Offices and commercial kitchen in first floor.	One tenant Around 150 office spaces	150 office spaces Two or more tenants
EMPs daily visit to the building	0	0	1	2–5
Requirements for energy usage at start	Passive house 15 kWh/m^2, year for heating	45 kWh/m^2, year for heating	Green Building Gold, 75 kWh/m^2, year including all energy usage for the building	Green Building 41 kWh/m^2, year

3.2. Empirical Data—Interview Study

The empirical data presented in this paper are based on semi-structured interviews [55] with 14 professionals involved in facility management for Buildings A–D; see Table 2. A semi-structured interview guide was developed with the following themes: background, a normal working day, tasks, and specific tasks, when problems with the building occur, control and monitoring for the building, learning, priorities, engagement, and communication in the organization.

Table 2. An overview of the informants.

	Position	Comments	Area
A1	Manager, former	Involved in the building process	Overall/main mission
A2	Operations technicians		Close to the property
A3	Real estate technician		Close to the property
A4	Energy technician	Energy monitoring, etc.	Overall/support function
A5	Building automation expert	Involved in both construction projects and operations	Overall/support function
B1	Area operations technicians	Trained as an operations engineer	Close to the property
B2	Real estate technician		Close to the property
B3	Operational optimizer		Overall
B4	Energy strategist	Plans, overall goals	Overall/support function
B5	Operations coordinator	Part of the management team, communication, coordination, internal training, follow-up of abnormal energy use,	Overall/support function
B6	Energy controller	Manages the energy monitoring system, sets budget with follow-up for energy costs for all properties	Overall/support function
C1	Tenant operations manager		
D1	Tenant operations manager		
D2	Property managers		

Informants were recruited based on responsibilities related to daily facility management for the buildings or as EMPs and were identified with the help of the participating companies in the project. In the spring of 2021, interviews linked to Buildings A and B were conducted and recorded as online video meetings. They were conducted during the COVID-19 pandemic, which meant that in-person meetings had to be avoided. The audio files were transcribed.

Although some informants were found to be not directly related to Building A or B, they were important in describing how property management and operations are organized with respect to managing energy use in buildings within the organization. As an iterative process to add more understanding of the impact of different kinds of organization of facility management, interviews with informants for Buildings C and D were conducted in the spring of 2022 as online video meetings (D2) or as physical meetings (C1 and D1) with audio recording. These interviews were partly transcribed to complement notes. The organization for the real estate operation of these buildings is much smaller, which justifies why fewer interviews were conducted for these buildings. Buildings C and D were both visited during the interviews and the researcher was given a tour with an on-site inspection of the building and the energy systems. Building B was visited during 2022. Notes of conversations and observations outside the interviews were made after the visits and used in the analysis. The purpose of visiting the sites was to obtain knowledge about the building systems, identify measurement points, make observation, and gain a deeper understand for the context of the everyday work.

3.2.1. Thematic Analysis

Thematic analysis [56] is a method of identifying, analyzing, and reporting patterns within data. A theme is trying to catch something central according to the research questions and is usually not dependent on quantifiable measures. The interviews were read and reread and coded in the software NVivo. Both an inductive and deductive perspective guided by the previously described theoretical perspectives was used. The analysis resulted in some themes connected to general drivers, concerns, and conflicting objectives for energy efficiency. Furthermore, an analytic model based on the quality assurance method ByggaE (Figure 1) for the building process was developed based on the main activities. The model is illustrated by a circle in Figure 3**.** The analysis begins with "follow-up" or monitoring, energy usage according to requirements. Requirements refer to legal [46] or sharper demands for energy usage applied under construction. The next step is to "identify" or diagnosis reasons behind inefficient energy use. The final step in the circle is "handle" or resolution problems causing deviations in energy usage. The 3C theoretical framework (concerns, capacity, and conditions) has been used to elucidate different dimensions of these activities and other aspects in everyday work and practice, which also is illustrated in Figure 3.

3.2.2. Limitations and Prerequisites for the Study

The interview study is limited to the people who were employed in facility management and wanted to participate when the study was conducted. Some changes over time that are linked to staff changes could not be investigated. The interviewer was well versed in the subject and tried to shape a setting to avoid bias in the interview situation [49] that could occur.

4. Results

The empirical findings are divided into two main parts. In the first part, general drivers, concerns, and conflicting objectives for energy efficiency have been elucidated. The second part presents an analysis of everyday work and practice according to the follow-up, identify, and handle activities referred to in the analytical model in Figure 3.

4.1. General Drivers, Concerns, and Conflicting Objectives for Energy Efficiency

This section starts with findings on how energy efficiency is prioritized in the business concept or job mission of the company or organization. This is followed by how opinions of the professionals contribute to legitimacy of work with energy efficiency together with the influence of policy, goals, and requirements for energy usage.

4.1.1. Business Concept

Keeping non-residential premises for a company's energy efficiency could be motivated as part of a business concept and a possibility to develop services. The tenants in Buildings C and D work with energy efficiency in buildings as part of their business and are also involved in the operation of their own office buildings. Based on their business concept, Informant D1 talked about the importance of an energy-efficient office:

> **D1:** "*We can't sit in old, poorly functioning premises where the heat just spews out . . .. That is clearly important.*" (1)

Having a new energy-efficient office is important, as it makes the company a role model and gives confidence in their business. Energy efficiency and good indoor climate are core parts of their business concept, as Informant C1 described:

> **C1:** "*We mostly work with energy. That's a part of our business concept. That is always a very important question. At the intersection between indoor climate and energy use is where we work.*" (2)

Energy is always an important question and a part of the business concept since the tenants work in the intersection between energy usage and indoor climate. Indoor climate is also a part of the business concept of Companies C and D. Over time, indoor climate has been given higher priority than energy efficiency in the companies' own office buildings.

> **C1:** "*We have a hundred-some people working here, who have their experiences and opinions about the climate . . . It's the case that you can always have a sense that you can stay at a considerably lower room temperature than you do. You can't put up with that. You know that you're not constructing a nice building just so people will complain.*" (3)

Having satisfied colleagues who do not complain about indoor climate in a new office has been given higher priority over time than reaching high requirements for energy efficiency; this reflection also was mentioned at the visit in Building D. C1 also reflected on overly high ambitions and underestimation of indoor temperatures in the design of offices. The design of buildings is a way in which company C delivers energy efficiency to their customers. This self-reflection may help diminish this part of the energy performance gap [14] in future designs by using more realistic data in the design. In Building D, the companies also use their office in development of their services by testing new components and functions and then use it as a reference. This makes them active and alert in optimization of their office space.

4.1.2. Job Mission

Taking care of property could be a job mission, as explained by one informant who described their mission in facility management as:

> **A3:** "*Our mission, that is . . . to take care of the property, keep the tenant happy and our buildings in good condition.*" (4)

Keeping the tenant happy and take care of the property is a way that informants describe their job mission in line with the definition of facility management in the ISO Standard [45].

There is a priority order in the job mission, described by A4 as:

> **A4:** "*Yes, but it is of course that priority is. . . that it is good indoor environment that the business thrives well there and that we try to do it in the most cost-effective way possible and of course energy-efficient as well.*" (5)

Working with energy efficiency and keeping energy usage low in the buildings is a secondary condition and limitation for the job mission, together with cost efficiency, which has higher priority. Other tasks also appear to be even more important than energy efficiency.

> **B6:** "*So, for me, it could just as well move up on the priority list. Of course, I understand that the building shell is the absolutely most important thing, otherwise we have nothing to make more energy-efficient, so to speak.*" (6)

To keep the non-residential premises safe and secure for the users seems also to have higher priority than sustainability questions where energy efficiency could be included.

4.1.3. How Employees Motivate Themselves for Work with Energy Efficiency

The importance and concern about energy efficiency is also reflected in the employees' own opinions and values, in four different ways, the first of which is:

> **B1:** "*We humans . . . we've acted catastrophically with the earth. Yes. We injured our mother.*" (7)

Energy use seen as part of a global threat towards the earth motivates the informant (B1) to work with energy efficiency at work. The second interpretation and motivation to keep updated about energy efficiency is the possibility to contribute to a better society and be part of the solution, as A4 expressed:

> **A4:** "*It's extremely important. We must keep working to make sure that we get more capable and more educated in energy issues to be able to . . . contribute to a society that doesn't just increase its consumption . . .*" (8)

The third example emphasizes how work with energy efficiency could be important and motivated for technicians themselves from a win–win perspective as the only way because of all its positive aspects. It contributes both to sustainability and better economy.

> **B5:** "*It can really be win–win. You can add something that turns out to be better and then you save both money and energy so it will be positive for the environment . . . I don't think there is any alternative because there are so many positive aspects of working with this particular issue.*" (9)

The win–win perspective agrees with previous studies related to sustainable buildings [57–59].

Finally, the fourth example highlights that energy efficiency is important, and even fun, and that the technicians are good at it.

> **B3:** "*Extremely important and it's something I'm passionate about. I think it's an extremely fun task . . . it's also cool when you look at installations in pumps and that sort of thing and maybe you find something wrong and such.*" (10)

They legitimize their mission in the drive to be competent and that it is fun.

4.1.4. Policy, Requirements, and Goals for Energy Usage

Policy and policy management can support and create legitimacy for the work on energy efficiency of non-residential premises and concerns for energy usage in the buildings. Organization B, which is part of a municipal organization, described policies and governance outside the organization, such as EU-level sustainability targets and energy requirements for new building construction, as an engine and driver for its own ambitions in plans and goals at the level of politicians and officials. As informant B3 explained:

> **B3:** "*There is a unit . . . and they are the ones who order for us. And they've been working on developing a new energy plan for local administration and such. And based on that then we are a small part in how we will achieve this target with saving energy. For 2029 now a new target is coming here.*" (11)

Officials work as middle actors [43] by formulating the Energy and Climate Plan [60] with measurable goals anchored upwards to politicians. The goals are also dispersed in their own organization in order to be implemented. Municipalities have a statutory obligation [60] to draw up an energy plan that will both promote energy conservation and promote a secure and adequate supply of energy.

Private companies' global goals could also be a driver for energy efficiency. Informant D1 spoke of their company's environmental ambitions:

> **D1:** "*It's high up on the agenda. We have rather high climate targets, we want to be part of lowering the CO_2 content in the world.*" (12)

> **D1:** "*Our owners are also extremely focused on this, the ones who own all of Company D, they are working a lot with the UN climate targets and all of that piece of it.*" (13)

The company policy is influenced by the global goals and described as important at all levels in the company. Another way that policy is demonstrated is by environmental certification of the office Buildings C and D.

4.2. Everyday Work and Practice According to Follow up, Identify, and Handle

This section presents the results connected with the analytical model in Figure 3. It starts with the activity to follow up energy usage according to requirements, followed by identifying and finally handling reasons for deviations in energy usage.

4.2.1. Follow up Energy Usage According to Requirements

The exploration of the activity to follow up energy usage starts with technical conditions in digital measurement systems, followed by the importance of key indicators and reference values, and finally concerns, drivers and capacity in facility management to follow up energy usage.

Technical conditions with meters and digital measurement systems are the basis for the possibilities for EMPs and FM to follow up energy usage. The informant B4 describe problems with technical conditions to follow up energy usage.

> **B4:** "*When I try to find the value then that value is missing …. There are meters, sub-meters and everything, but it also has to be connected to Vitec, and it hasn't been fully connected, so we haven't received a complete history of the building and of the various energy parts.*" (14)

Deficiencies in the measurement system, such as the fact that they are not connected digitally even though there are physical meters, limit the possibilities to follow up energy usage, according to Informant B4. Other shortcomings may be that a digital measurement monitoring system has limited functions and is time-consuming to handle. Informant B6 described it as follows:

> **B6:** "*To make the follow-up aspect itself more efficient so there is as little manual adjustment as possible and then as little manual labor as possible … Because, as I perceive it, currently there is nothing on the market, an energy follow-up system that gives you exactly the parts you want. Someone should construct their own.*" (15)

Informant B6 expressed that there are great opportunities to improve the digital systems, and that the best option would be to build their own that would be adapted and to minimize manual work [4]. This is the situation in Building D, as Tenant D develops and installs digital systems for building operations. Informant D1 said that the idea is that it should be easy to use the system.

> **B7:** "*I think it's a very easy-to-use system. I've looked a little at other systems that we've tried. So every time we come back. Our VDC is still the best.*" (16)

Informant D1 felt that their company's ambitions to develop an easy-to-use system has succeeded compared to other systems and that they contribute good conditions.

There seem to be barriers for investments in functional digital systems, even in organizations with high concerns for energy efficiency. The informant C1 tells that they had a functional system for some years.

> **C1:** "*We had a system for many years, which unfortunately does not remain with us. It worked very well. We sold it to customers and some cooperation was interrupted. When they wanted to get paid for the system, it fizzled out.*" (17)

Even if the system contributed good conditions to follow up energy usage and saved time, the company did not want to pay for it. There were barriers for investment when it was not within their own business. Barriers for investments in digital tools was also found by Fialho et. al. [22].

Key indicators and reference values for perceived energy usage are important data as a basis to follow-up energy usage for the buildings; otherwise, a deviation cannot be recognized. These data, among other building data, are perceived as important by energy management professionals such as the operations controller (B5), who looked overall at energy usage in many buildings and, by real estate technician (B2) who visited different specific buildings:

> **B5:** "*Yes, my God if you could dream. . . I would like to have reference values on our properties. Yes, but also surface areas. . . . clearly what heating systems, year, construction year . . . to be able to follow outside temperatures and such . . .*" (18)

> **B6:** "*I can't see statistics if I drive out to a property. I don't know if it uses a little or a lot of energy . . . Like this one. . . This property was built in . . . It's about the same size but one uses a lot more. . . What I mean is, so that you have something to go on. Comparison . . .*" (19)

Building specifications such as age, type of heating system, and reference values have been identified as important key indicators and as highly desirable information, both in overall online systems with energy measurements and available in the building. This would assist both EMPs and facility management technicians in their actions to follow up on energy usage. Available key indicators and reference values are indicated to contribute better conditions for work and increase their capacity according to energy efficiency. This claim is confirmed by the operations technician (A2), who has access and knowledge of how to use the system for energy measurements in Municipality A.

> **A2:** "*I've gone in myself and looked . . . because we do have monthly readings, and there we're going to see month by month what it looks like. And for being as big as it is then it uses a little. It uses approximately like . . . the single-department preschool that we have here . . . I can simply compare like that. Make simple references compared with other buildings so to speak . . . it's probably mostly out of curiosity . . .*" (20)

The availability of data and curiosity makes it possible for the informant to compare buildings and make their own key indicators to find out that Building A is much more energy-efficient than other preschool buildings built with older technologies.

This example with available data in combination with curiosity leads to the next focus in this section, which is concerns and drivers to follow up energy usage. The other drivers, concerns (or lack thereof) to follow up energy usage found in the interviews that will be explored are (1) lack of communication; (2) reporting to politicians; (3) interest and high concern to reach requirements; (4) to keep a building certification; and (5) control of costs.

Lack of communication within the organization about energy usage can be perceived as a lack of concerns. Informant A2 was curious to follow up on energy usage in the nZEB Building A, based on available data. Informant A2 perceived that this concern was not shared by those responsible in Municipality A.

> **A2:** "*They had an idea that they would do a follow-up. That's what Municipality A is not very good at. I don't think I've seen any follow-up of the whole thing.*" (21)

Informant A2 is aware of concerns in the municipality to follow up energy usage in their buildings, but when there is no communication about it, A2 perceived a lack of concern in the municipality to follow up energy usage in their new buildings to draw on experiences for future choices between different construction techniques.

The former manager, Informant A1 in municipality A, described reporting to politicians as a driver to follow up energy usage:

> **A1:** "*Yes. Then yes, maybe there can be many other things to think about now, but we also report every year about the energy savings we make and what the operation looks like purely in energy terms every year up to the politicians.*" (22)

Staff in Organization A use yearly follow-up of energy usage presented to politicians as a driver for the energy efficiency work among other tasks. Even if it is a busy organization, the politicians still ask for energy reductions and energy usage in the buildings. This routine of reporting motivates the facility management to follow up and document the energy usage in the buildings. The report is communicated upwards to the politicians, but not sideways and downstream within the organization. This could be perceived as lack of follow-up among workers in the organization, as Informant A2 mentioned above.

The privately owned office Building C is Green-Building-certified, and the report that is required in order to maintain the certificate is an external driving force to follow up the building's energy use, over time.

High concerns to reach requirements were the ambition for the newly built Building C. Informant C1 discussed these ambitions:

> **C1:** "*We spent a lot of time on this in the beginning. Completely disproportional, you might think, there aren't that many who do this, but it was also the case that we have very great interest that now this will be good. We will try to reach these targets, which were set pretty high when we built this. So there was an interest in that.*" (22)

The informant described that their high concern to reach requirements resulted in many hours spent following up energy usage in the building. Now, 10 years later, these ambitions are lower. Concerns to follow up energy usage have been reduced over time, which has also reduced the capacity used for following up energy usage. There are big differences in capacity between the facility management for the buildings in the study. The final concern is control of cost, which the energy controller (B6) who works with budget for energy usage in 800 buildings uses:

> **B6:** "*I set a maximum amount. So presumably I would have reacted, as it will go over the maximum amount, because then it comes to me so that I have to look at it, otherwise it's like it slinks through the system, so to speak. Then it's paid.*" (23)

Using warning limits for energy costs is one way of detecting high deviations in energy usage. The informant supposes that she would have noticed if the energy usage in Building B had increased greatly, but it has not happened. In this kind of warning, cost has higher priority than the actual use of energy and if there are price variations per kilowatt hour energy, some deviations may not be caught by the system.

4.2.2. Identify Reasons for Deviations in Energy Usage

The next step is to identify reasons for deviations in energy usage. The section starts with (1) general routines for operation and maintenance; and then continues with (2) how these could be used to involve technicians to find reasons for specific deviations in energy usage; (3) another way found to involve technicians was to create a group or individual involvement; and finally, (4) ongoing controls performed by professionals in the building are explored.

Routines for operation and maintenance generally mean taking care of urgent problems [4]. Planned maintenance work is basic in facility management and shapes general conditions for work with energy issues. Using different digital tools could be a starting

point for the daily routine in the facility management operation mentioned by informants. Informant B1 described it as follows:

> **B1:** "*It's the day-to-day operation that we have; first and foremost, we check all our alarms, installations . . . And other things, which are planned, for example I plan my installations, or for example I choose which installation, for example I will check energy consumption. Generally, ventilation and heat, and I check if I have deviation, I look for defects, what kind of defect it is, if, for example, that has gone up.*" (24)

Checking alarms is prioritized before planned maintenance where Informant B1 described one task as identifying reasons for deviations in energy usage. How deep the daily control of the buildings could be is a question of capacity in the organization according to how many buildings they handle. Informant A3, who handles approximately 30–50 non-residential buildings together with 10 colleagues, described a regular check of the ventilation and heating system after checking urgent alarms. Organization B handles even more buildings, and there are no resources to check functions in systems that do not alarm daily in every building. The operations technician (B1) handles operation systems and functions in 68 buildings alone and the real estate technician (B2) handles 40–45 non-residential buildings together with one colleague.

> **B1:** "*I don't check every property every day; for example, Building B. But no, that's not the case. If I have an alarm. I check. Because I have many other places, I don't have time . . . And I have many different control systems . . . I have to check in the morning.*" (25)

With many buildings, the highly prioritized routine to take care of alarms is time-consuming and deeper controls are not within the capacity in the organization. There is a routine to do an annual round of all buildings in Organization B with deeper controls. This is one way to compensate for the lack of capacity in daily ongoing controls and a part of the planned maintenance.

One way to involve technicians to find reasons for deviations in energy usage found by an energy management professional is to use these established routines and systems. This is the ambition in Organization B, which has approximately 800 buildings.

> **B3:** "*And then the idea is probably that if there's something that goes wrong, a deviating energy use order will come. But it's a little unclear who should send that out. Or it changes a little. Right now, it's our responsibility to check it, because EII has been understaffed. Not on me, but on my unit. But that's not something I do, make those kinds of work orders.*" (26)

Informant B3 talked about how they should use the system of work orders to find deviations in energy usage, but there is now a problem with a lack of resources and capacity to make those work orders, so it is unclear who has the responsibility to make the orders.

Another way that is used in Organization A is to form a group with focus on energy usage. Informant A2 talked about their meetings:

> **A2:** "*Yes. We always get insight into what it looks like, and I mean, we have a guy who compiles it all, so it's probably mostly to get the rest of the personnel to get a little interested in keeping the energy use in the buildings down . . . It's like with everything else, some think maybe it's a little interesting to look at, others think it's less interesting.*" (27)

Informant A2 said that the meetings give information about and insight into energy usage, and that the energy technician (A4), who has focus on following up energy usage, tries to make the staff interested, but there is a variation in concern among the staff. Informant A3 also joins these meetings and said that individual technicians create specific tasks to search for reasons for increased energy use.

> **A3:** "*Then the individual property technician who has responsibility for those building starts checking, but why does it use more energy? Do we have any times? Have we*

changed temperatures? Has the operation or the school done anything to explain why it uses more energy?" (28)

The energy technician (A4) tries to use involvement strategy [61–63] on the group level to activate the competence among the technicians to identify reasons for deviations in energy usage. The result is both active and conditional engagement [64] among the staff.

Obtaining information about energy usage in specific buildings is something that the technician and Informant B2 in Municipality B have requested.

B2: "*Yes, but perhaps more, for example, if operations technicians say that this is a building that uses a little too much energy . . . to me, so maybe I can try to find solutions or find the energy villains.*" (29)

The real estate technician (B2) perceived active and involved communication [63] about energy usage in the buildings as important to be able to contribute energy efficiency actions. This is an example of the potential to move passive engagement to active [53] among interested technicians such as B2, which also strengthens all three Cs in the organization.

In Buildings C and D, some people working in the building also have responsibility for operation of the building and access to the system controls. In Building C, the ventilation system has variable air flow, a so-called VAV system. The air flow is controlled by several sensors in the device such as temperature, carbon dioxide, as well as a presence sensor.

C1: "*I guess it was me anyway, because I have a certain ongoing task to review and check that it works. So I discovered it at last, that what the heck how strange this looks.*" (30)

By ongoing controls, the informant C1 finally noticed that there was something strange with the presence sensors in the ventilation devices, as they indicated presence all the time on the visualized drawings in the digital control system. A condition that makes it difficult to detect this type of error is that the indication appears instantaneously. Logging of data requires memory space and collected data may be useful for other sensitive purposes. Now they have another system, where the conditions to notice the problem would be even harder, since it does not include drawings, just a list of the devices.

C1: "*As operations personnel you have to be fairly interested in discovering certain defects, such as machinery running all the time. This is a common problem that operations organizations wrestle with. Not that we haven't had that too.*" (31)

Informant C1 said that there is a need for interest and concern among facility management to keep functions going in modern complex systems. The conditions to find some errors are a problem even for those who have competence, concerns, and capacity such as time to spend, and it is hard to make alarms for all the complicated errors that can occur.

4.2.3. Handle Reasons for Deviations in Energy Usage

Once a problem has been detected, the next step is to handle it. This section treats external network and agreements as a support or a barrier to handle technical problems in combination with internal concerns to solve them.

To manage and fix problems in buildings, conditions and capacity are needed within the operating organization or in its network. In the facility management company that manages Building D, it is a normal routine to hire extra skills when needed.

D2: "*If our operating technician goes there and can't manage it, then we always get help.*" (32)

It is a matter of self-care to hire external help when your own organization is not able to solve problems directly. As a private company, Company D is free to hire whoever they want, and they also see it as important to have good contacts in the industry. However, the existence of service agreements does not always mean that the problems are solved. In Municipality A, Informant A2 described that there were repeated problems with the freezers in the commercial kitchen in Building A. Even though there was an external agreement for service, the problem was not solved; instead, the agreement became a barrier.

The high concerns of Informant A2 to solve the problem and overcome the barrier were supported by the kitchen personnel who had to accept the consequences and throw away food every week, and by the boss by supporting a change of contractor. This problem was visible in that the food was spoiled. Other errors can affect energy use, but not be so visible and irritating. Using another firm could be more complicated in a public organization where the Public Procurement Act [64,65] must be followed.

Informant B5 talks about a lot of problems with VAV ventilation in many buildings in Municipality B:

> **B5:** "*There were of course the VAV problems we had, and which went on for such a long time were very tiresome and just that they were changed over to CAV, preschools primarily.*" (33)

In Municipality B, problems with VAV were not solved, which ended in their functions not being used. An unused investment that ended up in no energy savings. Municipality B changed strategy for new buildings. The reason for giving up solving the function is not clear: it may have been the lack of capacity to handle complicated technology in many buildings and lack of supporting network.

The problems in Building C with sensors in VAV described in this section were handled by the supplier since it was an unusual problem. Regarding whether Building C, as HVAC consultants, were handled differently than other customers since they proposed installations of these kind of systems for their customers, C1 indicated that this probably was the case.

Finally, to follow up handled deviations in energy usage close the circle in Figure 3. Informant B2 asked for results after energy efficiency actions:

> **B2:** "*So, it would have been nice if I got . . . Now I'm talking about myself . . . so, for example, let's say that I'm replacing a pump, a newer one. Then I'm certainly saving energy. That is, that you get some type of statistics. Got feedback. After, say, a couple of months, or after a year in any case, so . . . yes, so it will also be fun to work, it feels like you're making a difference.*" (34)

Informant B2 emphasized that feedback about the result of energy efficiency actions was motivational and something that makes work fun and meaningful. This is a driver to find even more reasons for high energy usage and concerns to handle it. This is an example of involvement strategy as a mutual process where participants create meaning through interaction and a shared understanding [53].

5. Discussion

Four nZEB non-residential buildings located in different places in Sweden where various technologies have been used to achieve energy efficiency were the starting point for the interview study in this paper. Concerns, conditions, and capacity [40] for energy-efficient operation and maintenance of these buildings varies according to ownership structure, organization of facility management, and type of tenant activity in the buildings. These aspects have been explored according to energy efficiency in the buildings over time in Section 4 and the findings according to the analysis model (Figure 3) are summarized in Table 3. Policy and general drivers are summarized in Figure 4.

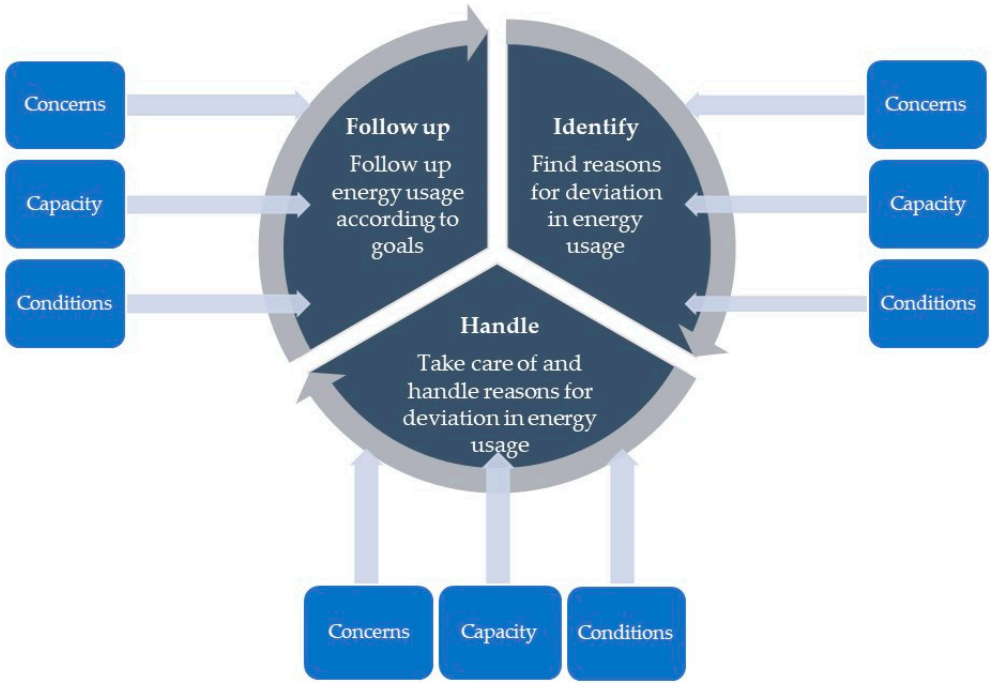


Figure 3. Illustration of main activities in the model used for analysis, based on the quality assurance method for the building process, ByggaE, and the analyzing perspective of 3C.

Table 3. Summary of drivers, success factors, and barriers for energy efficiency over time according to the aspects in the analytic model in Figure 3. The numbers in parentheses refer to quotes from the interviews in Section 4.

	Concern	Capacity	Conditions
Follow up	Drivers: Cost control (23) External reports (22) Curiosity and great interest (20,22)	Success factor: Few buildings per energy manager (Building C, D)	Success factors: Easy access to energy data (16,17) Key indicators and defined requirements for energy usage (18,19) Visualization
	Barriers: Shift of priorities over time (3)	Barriers: Many buildings per FM and energy manager (25)	Barriers: Lack of functional meters and digital tools with key indicators and visualization (14,15,18,19)
Identify	Drivers: Increased by involvement communication (27) Motivated technicians in FM (30,31) Support from management (29) It is fun (10,34)	Success factors: Increased capacity by involvement communication in FM (27,29) Daily or ongoing controls (24,30)	Success factors: Established routines for fault detection (26) Group meetings with energy focus Supporting digital tools (28)
	Barriers: Other priorities Lack of interest among staff (27)	Barriers: Lack of capacity in FM for trouble shooting (25,26)	Barriers: Complex technology according to available competence Hidden problems ex sensor problems
Handle	Drivers: Self-evident to use external support when needed (32)	Success factors: Available internal and external resources to solve problems	Success factors: Functional external support (32)
	Barriers: Other priorities	Barriers: Lack of internal and external resources (33)	Barriers: Dysfunctional external support (33)

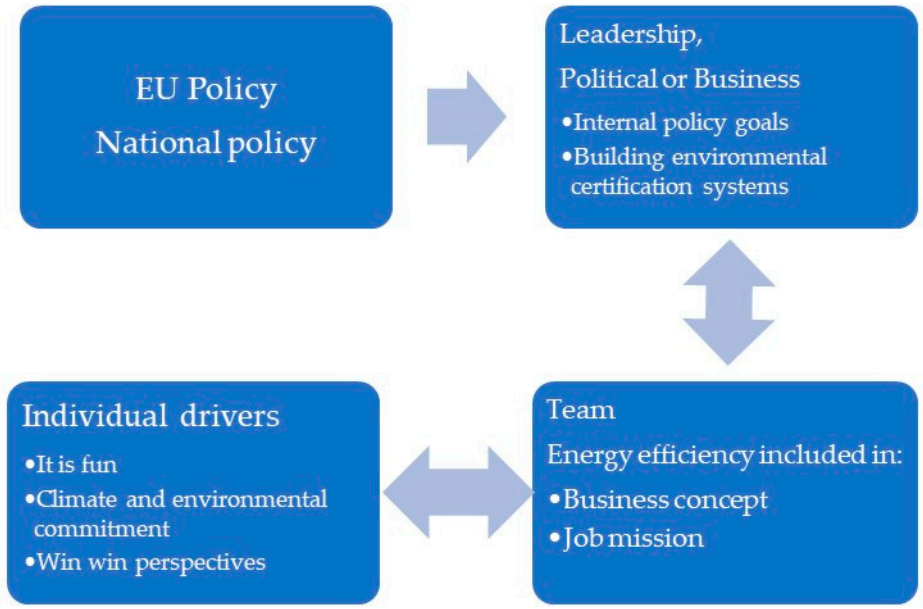


Figure 4. The figure shows the schematic interaction between public policy, inhouse policy, and other drivers for energy efficiency over time on different organization and individual levels that were found in the case studies.

Public policy, for example, through policy at EU or national level, is driving change and leads to adoption of in-house policies to be implemented in organizations, which was exemplified in Section 4.1.4. Here, in-house policy was found as a factor that acted as a driving force and shaped the work with energy efficiency in buildings such as municipalities or companies and was further channeled down in the organizations. This has previously also been shown to be important within the manufacturing industry [66]. There are examples in this study (Section 4.1.4, quote 11) where persons in the organization have acted as an intermediary [43] by shaping and influencing internal goals and approaches for work with energy efficiency upwards in accordance to in-house policy goals. This is illustrated in Figure 4, which also shows drivers on an individual level (described in Section 4.1.3) that could contribute to the team and interact with the energy efficiency in-house policy included in job mission (Section 4.1.2) and business concepts (Section 4.1.1). This study therefore suggests that in-house and public policies can play a crucial role in sustaining high ambitions for energy efficiency. Previous research also lifts the importance of support from leadership for energy efficiency [67,68] and lack of energy management and policy as a barrier.

The illustrated policy drivers in Figure 4 support concerns in all steps in the analytic model in Figure 3 and the column "Concern" in Table 3.

Ambitions for energy efficiency may fade out over time, especially for nZEBs with very high ambitions from start. This was exemplified by informant C1 (quote 22) for building C in Section 4, where the ambitions have been reduced from very high to a level where the report for building certification still is remaining. These repeated activities, such as external energy reports to private owners, politicians for buildings in the public sector, or for building an environmental certificate [69,70], have been found as success factors and drivers.

A shift of priority over time could be related to the priority of thermal comfort. A barrier for energy efficiency found in this study is the use of lower indoor temperature in building design than users want in practice. This results in an energy performance gap [14], and often creates higher energy use over time as there are no margins from start [28]. In the case study buildings, where operators are on site and share the indoor environment (building C and D), the temperature is gradually increased (citation 3). In other buildings where there is a strong policy regarding indoor temperature, and less presence of operating

personnel, it is more kept at the same level. However, it should be noted that the level of satisfied users, which is also important, was not examined [71].

There is an overall barrier and challenge to keep concerns for energy efficiency prioritized over time. When prioritizing fails according to monitoring and follow up energy usage, the following step in the model in Figure 3 will naturally fail also, as any deviations in energy usage are not detected and thereby not possible to diagnosis and solve. There could be lack of concerns and prioritizing of energy efficiency over time in leadership, within job mission for the team and on an individual level as not all employees are committed to energy issues (quote 27). Here, routines in facility management with activities that support energy efficiency could be a success factor as things are conducted without being seen as energy efficiency and need for concern for energy efficiency becomes less important. This was found as a way to handle conditional or non-engagement according to the model by Isaksson et al. [53]. It was also found to be of importance to use involvement communication [63] and strategies, which means that there is a two-way communication and discussion to develop a shared understanding, which not necessarily mean that all participants support or that they come to an agreement about what to do. The involvement strategy could activate more parts of facility management to diagnosis and identify reasons for deviation in energy usage. An example in the study was to create a group with energy focus (quote 27,28). Using established systems for work orders were found to be success factors in the study for diagnosis, which was exemplified in Section 4.2.2. (quote 26), if there is capacity in the organization.

Lack of benchmarks for energy usage was found as a barrier for energy efficiency over time (quote 18,19). Benchmarking using appropriately defined energy KPIs is a prerequisite to know whether there is a deviation or not in energy usage. The requirements could refer to nZEB or legal requirements used under construction. These requirements must be implemented in digital systems and measurements also must be related to them for easy follow up which was also mentioned in the study by Pettersen et al. [1] and Brackley et al. [4]. Digital systems could on the one hand support work with energy efficiency over time as they provide possibilities to obtain information about energy usage and possibilities to understand systems and act remotely in building automation systems, which is exemplified in the Norwegian study from 2009 [2]. Urgent alarms, error reports from users, and work orders for maintenance are also delivered in different digital systems, such as BEMS, BAS, and CMMS (quote 24,25). On the other hand, these digital systems also were found to be important barriers to energy efficiency, e.g., if many such systems exist [4], some of which are deficient and complicated to use and understand, this does not contribute good conditions for providing enhanced understanding of current operation of buildings and how it affects energy efficiency. When the understanding of data from the digital systems is limited to a few persons in an organization, the capacity [40] in relation to energy efficiency goes down. This in turn results in little action in the form of identified errors and thus little opportunity to solve problems and maintain buildings' energy efficiency performance [14] over time. Therefore, both development of and investments in functional digital systems that contribute enhanced understanding of energy use for those who work with the buildings are important for energy efficiency in non-residential buildings in common, not only nZEBs (quote 16,17,18,19). Furthermore, the study does not point out digital system as a replacement for the physical presence of building professionals in non-residential buildings. Rather, the study demonstrates the strength of the combination of functional digital tools and concerned building professionals that regularly visit or work in the buildings.

Capacity in the organization is also found as crucial. Within the study, there is a wide range in capacity according to how many buildings one professional must handle, which is an important factor for follow up and identification of deviations in energy usage. It also affects how advanced technology can work both from the start and in the long run. Adapting technology choices to the resources available within the operations organization is therefore a success factor.

According to the present study, access to professional support is important for the possibility to solve and handle identified defects in buildings. It has been found as a success factor to have a competent network with contacts and agreements with parties that have knowledge in the specific technology of the buildings. Examples in the study are VAV systems for ventilation (quote 30,33) and refrigeration systems. Moreover, it is important that these resources are easy, self-evident, and obvious for the organization to use (quote 32). To have a non-functioning network such as framework agreements with companies that do not solve problems (Section 4.2.3) has been identified as a barrier for long-term energy efficiency that requires high concerns in the facility management and support from management to overcome and solve problems.

When the result, however, is summarized in Section 4, the findings were, to a very little extent, specific for non-residential nZEB buildings. Rather, the results show common challenges that FM faces when it comes to maintaining non-residential buildings' energy efficiency over time. This makes this study even more important, as long-term fading energy efficiency results in higher energy usage, and thereby, impact on sustainability and possibilities to reach goals for climate mitigation.

Some challenges are related to advanced technology, such as ventilation systems with VAV that were used in three of the buildings. But these technologies are also used in other modern buildings, even without nZEB standard. As the informant D2 reflect over the advanced and energy efficient office building D:

> "*The thing about this building D is that it has very low operating costs. That's what's revolutionary. It is technically advanced, but there are many other technologically advanced properties without such low operating costs.*"

As informant D2 tells, advanced technology is not equal with nZEB standard, but nZEBs often have advanced technology [72]. This is a reason why the challenge with advanced technology also is applicable for other modern non-residential buildings.

Research Limitations

This interview study was conducted with Swedish conditions and limited to four specific non-residential nZEB cases. However, the concept of nZEB is used in the building sector worldwide [72]. Non-residential buildings are a wide concept with many different kinds of buildings according to function and use, but pre-schools, elderly homes, and offices are common types of buildings, both in Sweden and elsewhere. Also, the technologies used in the buildings are common in different kinds of new, modern buildings. The ownership structure and organization of FM is limited in some ways in the study, as the studied organizations for FM benefit from energy savings. All buildings were built for sharper energy requirements than necessary. This indicates ambitions and concerns for energy usage from the start and the buildings are still within or used by the initiator's organizations. These concerns are probably not common for building owners and FM in general. Future studies on other ownership structures, outsourced FM, and organizations with fewer concerns about energy efficiency would offer more knowledge in the area.

6. Conclusions

The starting point for this study was facility management connected to four energy-efficient non-residential nZEBs, but the findings turned out to be more general for non-residential buildings. The major drivers and success factors for facility management in maintaining non-residential buildings energy-efficient over time found in this study are:

- In-house and public policies can play a crucial role in sustaining high ambitions for energy efficiency;
- Regular external reporting;
- Functional digital tools with benchmarks in combination with presence of FM or EMP in the building;
- Involvement communication in FM;

- Routines in FM that include energy efficiency actions;
- Functional support for the specific technologies and self-evident to use the support.

The major barriers for facility management in maintaining non-residential buildings energy-efficient over time found in this study are:

- Lack of concerns and policy drivers for energy efficiency;
- Lack of benchmarks and dysfunctional digital tools;
- Low capacity in FM according to the number of buildings to handle;
- Lack of or dysfunctional support for the specific technologies in the buildings.

This study is important because it contributes to the knowledge gap regarding the role of facility management in maintaining nearly zero-energy non-residential buildings energy-efficient over time. But the results show common challenges that FM faces when it comes to maintaining non-residential buildings energy efficient over time. This makes the study even more important as long-term fading energy efficiency results in higher energy usage and, thereby, the impact on sustainability and possibilities to reach goals for climate mitigation.

Another contribution is the importance of focus on the users in FM in development of digital tools and support systems for buildings. The study also shows barriers to investment in functioning digital tools, which can be examined further. Developing and investing in functional digital systems that contribute an enhanced understanding of energy use for those who work with the buildings were found to be important for energy efficiency in non-residential buildings. Furthermore, the study does not point out digital systems as a replacement for the physical presence of building professionals in non-residential buildings. Rather, the study demonstrates the strength of the combination of functional digital tools and concerned building professionals that regularly visit or work in the buildings.

Finally, this paper contributes with an analytic model that is useful for other studies to explore potential in facility management organizations according to keep energy performance in buildings over time.

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