BRIDGING THE GAP BETWEEN SUSTAINABLE FM AND SUSTAINABLE BUILDINGS
An exploratory study of six public buildings in Norway

Dave Collins, Tore Haugen, Carmel Lindkvist and Christian Aamodt

Department of Architecture and Planning,

Norges teknisk-naturvitenskapelige universitet

Trondheim, Norway

Purpose

The purpose of this paper is to explore how sustainable facilities management (SFM) and sustainable buildings (SB) can be designed and managed, bridging these gaps with a more integrated process. The need to bridge the traditional gap between design, construction and FM demands more effective solutions based on life cycle assessments. This also requires a coordinated approach with emerging environmental and sustainable initiatives in new and refurbished buildings. The solutions to these issues and aspects of the ‘Green Shift’ need to be co-ordinated at the strategic and tactical levels of an organisation with an aim of further implementation at the operational level.

Design/ Methodology/ Approach

This paper takes the form of an exploratory approach based on six different case studies. The data has been sourced from cases studies involving interviews and documentation from large public institutions on how they manage and operate their existing buildings and how FM strategies are coordinated at all levels. A particular focus has been placed on buildings for higher education and research institutions.

We have used a theoretical multidimensional framework for analysing the gaps based on models for sustainable development, life cycle assessments of buildings and recognised models for efficient FM. The case studies have been supported by literature research as well as documentation from a number of applied projects.

Findings

In conclusion, this study demonstrates that in the context of the Norwegian cases, there is currently little consistency in the degree to which the bridging of the gap between Sustainable FM and Sustainable Buildings is achieved or attempted.

Originality/ Value

This paper offers a contribution to the study of how public buildings approach the development of the building stock, whilst also dealing with the challenges associated with bridging the gap between the buildings and the facilities management that supports the

building. The introduction and use of a multidimensional theoretical framework for analyzing sustainability in buildings and FM create a new platform for further research, development and implementation in practice.

Keywords

Life cycle assessment, the green shift, FM, sustainable building assessment, multidimensional theoretical framework, green buildings

INTRODUCTION

With Norway being one of the 195 countries to adopt the Paris Agreement in 2015, there has been a notable increase in focus on environmental issues worldwide. In Norway, this went further with the publication of the governmental policy document "*The Green Shift – climate and environmentally friendly restructuring*". The Green Shift is not isolated to this document but creates a platform for both regulatory approaches and market incentives. It offers the term "friendly restructuring", referring to a combination of a governing policy introducing stricter buildings codes and regulatory city planning based on reducing climate gas emissions. An example of such a combined regulatory and market incentive approach would be Enova. Enova is owned by the Norwegian Ministry of Petroleum and Energy, providing support to building developers, owners and managers for improving the sustainability of their building stock outside the existing building regulations (Enova, 2013).

The overall goal of substantially reducing climate gas emissions from the built environment sets new requirements to link and integrate planning, design, construction and facilities management (FM) from a life cycle perspective. However, the primary focus of many studies is on the design phase, as the design of a building and its associated energy solutions influence the potential of its sustainability (Alwaer et al., 2010, p.800). However, in Norway, buildings constructed before 1931 have a lower energy use than those built in 1997 (Ryghaug et al., 2008, p.7), primarily due to changes since then in heating and the indoor temperature in buildings and the level of energy this requires along with other improvements. The key word here is 'usage' as buildings are not always used as designed. This is why we focus on sustainable buildings at the 'use' stage. Indeed, the long use phase of buildings makes Sustainable FM (SFM) with the operation, maintenance and refurbishment more important in the assessment of climate gases over a lifetime from cradle to grave. The implementation of a sustainable building has positive benefits for the use phase in terms of reducing operating cost and creating healthier workplaces, which can lead to increased productivity where the whole life cost of the building can be less (Alwaer et al., 2010, p.799).

In Norway, real estate developers, corporate real estate and public institutions have for the last ten years focused on sustainability and green solutions in building development projects and in FM. Building owners and building developers are readily adopting certification schemes such as the Building Research Establishment Environmental Method (BREEAM) (Collins et al., 2016, p.419) for their own portfolios. A focus on the building of Sustainable Buildings (SB) with or without a certification and its association with FM is a key principle for the 'greening' of state-owned real estate and riding the wave of the Green Shift.

Many private real estate and public institutions are addressing green challenges in their buildings. Despite this, we see that there is still a disintegration of how different disciplines, particularly within operation and design, consider how to tackle these challenges in a lifecycle perspective. There has been some work in linking design to building in terms of information transfer at the point of building handover (Whyte et al., 2016, p.3; Zerjav et al., 2018, p.446) and it has been shown that a full life-cycle consideration can benefit buildings in the longer term (Zuo et al., 2017). However, this life-cycle perspective has had various degrees of success and achievement from the perspectives of adaptability, operations and maintenance. The building owner often inherits defects undiscovered in the project phase which later need to be corrected during initial operation of a building (Whyte et al., 2013, p.4; Forcada et al., 2015, p.16). Therefore, the one-way direction of the life-cycle perspective in terms of design, construction, operation and demolition needs underpinning by feedback loops from the use stage back into design. In this paper, we bridge the gap of the process of Sustainable Building by focusing on the building in use and how Sustainable Facilities Management, within this stage, can sustain sustainable buildings.

PROBLEM STATEMENT, RESEARCH QUESTIONS AND APPROACH

Problem statement

Referring to our overall objective in developing more sustainable buildings (SB) and developing frameworks for SFM, the aim of this paper is to investigate the gaps that exist between SFM and the building of SBs. We focus on commercial buildings which are both new and transformed buildings and on portfolio management at the strategic and operational levels. We will be examining the gap between the building process of SB and SFM through a literature review and six case studies, using data accrued from Master student group research projects. There are three research questions related to the case studies:

1) What were sustainable goals for SB and SFM of the cases studied?
2) How were performance goals set and implemented at the strategic, tactical and operational levels of the case, and what criteria did the cases use to evaluate their sustainable approach?
3) What gaps between integrated SFM and SB were present in these projects, and what are possible measures for bridging the gaps?

Within the FM discipline, there are three levels of management which are core in decision-making for a facility: strategic, tactical and operational (Atkin et al., 2015, p.46). A basic assumption in our case studies is that there needs to be coordinated information and communication between the different management levels of strategic, tactical and operational, in developing SBs and for efficient and effective SFM in a life cycle perspective. For more background information regarding this assumption, see previous studies by Haugen and Klungseth (2017).

Approach

The paper deals with the development of a theoretical framework for exploring the gap between Sustainable FM and Sustainable Buildings. This led us to develop a multidimensional framework for analysing the bridging of SB and SFB, supported by using academic and practice literature for the most part from journals from 2000 to the present.

Through semi-structured interviews, students collected data for analysis from key personnel in these buildings such as real estate directors, project managers, facilities managers and operations managers, as well as retrieving technical information and other documentation supplied by the institutions.

As with any study of this context, it is not without its limitations. The study in this paper features six separate building studies selected from initially 12 buildings from a combination of higher education institutions and research buildings in Norway. The study also comprises new and existing buildings including two refurbishments. The small size of the sample of buildings nonetheless affects the external validity of the results. This is also the case with regard to the fact that the cases are limited to Norwegian buildings. The value of examining a small amount of data set in detail allows for a deeper understanding of the problems we are examining, which is not possible when there are many cases included.

No standardised interview guide was employed. This was due to the intention that the student groups should focus on finding how best to answer the research questions themselves as independent researchers. For their assignment, the student groups were asked to address what made the studied buildings and its energy management unique and significant. They were also asked to examine the similarities and differences of comparable building types and energy management internationally. They ended their projects by looking at what were the benefits and risks and considering how energy-efficient buildings should look like and be managed in future. The interviewees for each case study were facilities management teams or those in each case who were responsible for energy management. Thus the position in the investigation presented here focuses on the standpoint of facilities managers and their perspective on energy management as a topic in the context of the 'bridging the sustainability gap'.

After describing each case profile, the sustainable infrastructure from the perspective of SBs and SFM will be presented. The paper concludes with a discussion of the research questions analysing the results from the perspective of the strategic, tactical and operational levels while identifying how they bridge the gap between sustainable public buildings and FM.

LITERATURE AND THEORY

Sustainable Building in the context of Sustainable Development

Decidedly, in terms of sustainable development, the most widely understood and used definition is in the Brundtland 1987 report, which states that sustainable development is "development that meets the needs of today without compromising the ability for future generations to meet their own needs" (Brundtland, 1987, p.15). This definition was expanded to the Triple Bottom Line for sustainable development in a model addressing social sustainability, environmental sustainability and economic sustainability (Elkington, 1994, p.99). Although this platform provides a theoretical context to sustainability, it does not provide for specific indicators for sustainable development. In the Norwegian context, the Brundtland definition provides an overall 'mission statement' for a green perspective. Indeed the concept of 'green' is core to Norwegian policy for the built environment under the 'Green Shift'. The move towards the Green Shift in Norway is one of the important measures in reducing emissions in the building and construction sector. Technical regulations and building codes for low energy and passive houses (Lavenergiprogrammet, 2016) embed the goals of the green shift to push the building industry to increase focus on sustainable building.

Zero Emission Building (ZEB) is often seen as the result or the intended goal of the Green Shift in the building process and is a main consideration in the development of a SB itself. A ZEB building is defined by the Norwegian Zero Emission Building Centre as a "greatly reduced energy demand, such that this energy demand can be balanced by an equivalent definition of electricity (or other energy carriers) from renewable resources" (Hestnes et al., 2017, p.16). Within the Norwegian context, sustainable building and energy reduction is central to being green. However, this does not mean that sustainable buildings in Norway are just about energy savings as the certification process leads to the broader field of sustainability.

Norway has its own BREEAM certification process, which helps in the creation of a holistic approach to sustainability of the built environment. BREEAM sets a clear goal for projects to build sustainable buildings. BREEAM Communities assesses social, environmental and economic sustainability for large-scale developments and promotes cooperation among stakeholders through a common framework (BREEAM, 2013). Such an approach falls in line with the more social/ecological perspective of sustainable buildings: "a healthy facility designed and built in a cradle-to-grave resource-efficient manner, using ecological principles, social equity, and life-cycle quality value, and which promotes a sense of sustainable community" (Berardi, 2013, p.74). Concepts of green and sustainable have no absolutes but are useful when thought of as a mindset or goal (Alwaer et al., 2010, p. 799). At the same time, not having a definitive measurement of what is green and what is sustainable as a reference point for the building sector leads to a broad interpretation of SB, which then has the flexibility to include or exclude the use stage.

Sustainable FM

Alwaer and Clements-Croome (2010) view sustainable intelligent buildings as a complex interrelated system of three basic issues – People (owners; occupants, users, etc.), Products (materials; fabric; structure; facilities; equipment; automation and controls; services) and Processes (maintenance; performance evaluation; facilities management). However, both these aspects are not prominent in the building of a sustainable building – namely people and process. The IFMA definition of FM incorporates the integration of people, place, process and technology (IFMA, 2004). In addition, the European Committee for Standardisations (CEN) EN15211-1 defined FM as the "the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities" (CEN 2006 cited in BIFM, 2017). In this way, the discipline of FM is in line with sustainable buildings as defined by Alwaer and Clements-Croome (2010).

However, the focus on the design stage in setting up solutions for sustainable buildings neglects the complexity of the interrelated system of people, products and processes which is a core part of the facilities management discipline. In addition, facilities managers are the main custodians of completed buildings. Building assets provide the greatest opportunity for a positive sustainability impact (Nielsen et al., 2016, p.6) when they are effectively managed. However, SFM differentiates itself from FM through its "consideration not only of core business and support functions, but also relations within the local and global society as well as the climate and the ecosystem" (Nielsen et al., 2010, p.2). This manifests in FM when considering energy and waste management, sustainable procurement and logistics in the context of broader building sustainability objectives. The current challenge is to develop SFM further by applying sustainable development, building management criteria along with design and construction and sustainable integrated processes (Elmualim et al., 2009, p.97). One need for this link in relation to a sustainable building is that there is a gap between estimated and actual building energy performance (Pettersen et al., 2017, p.112). There have been steps to engage facilities management thinking through the handover process (Whyte et al., 2016), but more could be done in developing sustainable building by identifying in the use stage measures of sustainability that could be fed back to the design stage.

Nielsen et al (2016) set an agenda for SFM. They argue for a context-specific measurement and management of sustainability in FM and Corporative Real Estate Management (CREM). They link this to organisational strategic goals and KPIs "as sustainability challenges as well as implementation possibilities and barriers vary between locations, buildings, businesses and organisations" (Nielsen et al.,2016, p.273). The SFM perspective is moving towards a need for measurement of sustainability, which departs from the broad definitions of "green" and "sustainable". However, SFM implies a reactive rather than a proactive approach to managing facilities as Nielsen et al. (2016) underline when discussing the application of a life cycle perspective for planning FM or CREM activities. With the idea of SFM not just being local but also global, they think that FM "should investigate whether and how the FM and CREM sector is developing into potential change agents for sustainable development on a societal scale to qualify policies and regulations in the field".

Technical and non-technical bridges between SFM and SB

The end-user perspective is often neglected in SB projects. According to Throndsen et al. (2014), both technical and non-technical aspects need to be considered for SBs, supporting favourable energy efficient behaviour. Berker (2017) examined end-users perspectives when summing up experiences from ZEB pilot buildings with high energy ambitions. There he addresses three main interventions that have characterised successful energy efficiency interventions for non-residential buildings from a refurbishment project called Powerhouse Kjørbo. These three interventions are:

1. a mix of well-coordinated technical and non-technical approaches
2. a devoted management
3. a common project creating a shared interest in success.

While this project was context-specific, it does introduce a starting point for what to include in KPIs to bridge the gap between SB and SFM. In support of involving users in the design stage is the Norwegian organisation of Bygg21, which is made up of public and private partners hoping to improve productivity and sustainability in the property industry and examine building lifecycles from a stakeholder perspective. Bygg21 claims that mistakes, lower productivity and even accidents on projects are directly related to poor engagement with particular stakeholders at crucial stages of a building's lifecycle (Bygg21, 2015a). In their conceptual model, they include stakeholders from the owners, users, FM and the public. For example, they advocate at the design stage a role for users in being involved with a needs analysis, but require a different role of these users later by involving them in space planning and even overall assessments concerning the life of the building.

There are established tools to bridge SB to SFM but these are of a technical nature. The tool often cited is the Life Cycle Assessment (LCA). According to Zabalza Bribián et al. (2009), LCA was designed for the development of environmentally friendly materials, products and infrastructure used when considering the whole lifespan of a building. Such assessments are particularly important for buildings due to their long life, the complexity of components and the potential for multiple changes in their usage (Zabalza Bribián et al., 2009, p. 2520). When examining sustainable retrofits more specifically, Shah (2012) notes that life cycle considerations should be considered from the perspective of the embodied energy expended throughout the lifecycle of the building (Shah, 2012, p.188). However, Kristjansdottir (2017) points out that a much broader picture of emissions in the life-cycle needs consideration regarding SBs, stating “the low emission focus needs to become a natural part of every building and renovation project” and “if we look only at energy use and energy balances, while dismissing emissions, we get an incomplete picture of the environmental impacts”. Both for managing sustainability in FM and for developing new SBs, as well as for sustainable refurbishment, we have to base our analysis on life cycle thinking and LCAs for the recommended and applied technical solutions and management issues.

The use-stage in the building life-cycle

The EN15978:2011 standard “Sustainability of construction works” (CEN 2011), describes the life cycle of a building in four main stages: Production, Construction, Use and End of Life and 17 subcategories as illustrated in Figure 1. The Use stage divides into Use, Maintenance, Repair, Replacement, Refurbishment, Operational energy use, Operational water use. This stage is the most interesting in an SFM perspective as it indicates different areas for potential optimization within a sustainability view.

A1-3 Product Stage			A4-5 Construction Process Stage		B1-7 Use Stage							C1-4 End of Life				D Benefits and loads beyond the system boundary
A1: Raw Material Supply	A2: Transport to Manufacturer	A3: Manufacturing	A4: Transport to building site	A5: Installation into building	B1: Use	B2: Maintenance (incl. transport)	B3: Repair (incl. transport)	B4: Replacement (incl. transport)	B5: Refurbishment (incl. transport)	B6: Operational energy use	B7: Operational water use	C1: Deconstruction / demolition	C2: Transport to end of life	C3: Waste Processing	C4: Disposal	D: Reuse, recovery, recycling

Figure 1. Life cycle stages of a building according to EN 15978, CEN (2011) Sustainability of construction works. Assessment of the environmental performance of buildings. Calculation method (Kristjansdottir, 2017, p70).

The gaps between SB and SFM can be bridged if the experiences and data from the use stage are used as important inputs to the planning and design of new buildings and for the assessment of the total environmental performance. In the production stage of a building, all the production of the raw materials, transportation to manufacturing sites, and manufacturing emissions are included. Selecting the right building materials and technical systems is more important than ever to reduce emissions (Jelle et al., 2017, p. 93). The achievement of SBs and a subsequent low environmental footprint is reliant on a selection of materials with low embodied emissions, reduction of materials usage, sourcing of local materials, choosing durable materials and technical solutions, as well as reusable and recyclable materials.

In our studies, we relate our findings to the Norwegian “Next step” framework (Bygg 21 - 2015), comparable to the UK RIBA Plan of Work 2013 which is the definitive UK model for the building design and construction process.

THE SIX CASE STUDIES

Data collected from large public Norwegian buildings emphasised buildings of higher education and research institutions. Master students helped in researching these cases in the autumn of 2016 as a part of their SFM course module at the Norwegian University of Science and Technology (NTNU). Six case studies of public buildings were selected according to the following criteria:

- Institutional buildings for higher education and research between 5,000-20,000 square metres
- New or refurbished buildings, up to five years since handing over the new or refurbished buildings
- Defined ambitious sustainable goals on a strategic and tactical level for the new or refurbished buildings
- Buildings managed and operated by large Real Estate and FM organisations (four of the six cases) as well as buildings managed and operated by smaller Real Estate and FM organisations (two cases)

These common criteria were chosen to give useful input for NTNU’s campus redevelopment, as the technical criteria mirrors NTNU’s existing building stock and future building projects while the criterion regarding sustainable strategies and operations should provide a state of the art approach for NTNU to emulate.

The participants of the study were selected for their key roles in construction or in implementing sustainable strategies. The participants were contacted either directly by students or through the network of the Centre for Real Estate and Facilities Management at NTNU.

Table 1. Case profiles

Case	Purpose	Year of construction	Sqm	Total portfolio (sqm)	Energy usage (kWh/sqm/year)
A	Offices / Education	1910 (2016-)	17000	520000	183 (down from 217)
B	Offices / Education	2013	17000	520000	95 (1)
C	Offices / Private owner	2012	12000	12000	90.1
D	Library/ Study centre	1962 (2015-2016)	5500	582000	100

E	Hospital/ Education / Research	2013	17200	227000	127
F	Offices/Research /Laboratories	2013	7768	7768	70.7 (calculated)/ 140 (measured)

Data concerning the total portfolios in Table 3.1 have been calculated for both owned and leased real estate for owners and tenants in the cases. For cases C and F, the total asset area is for a single building.

Case A - This building is an art nouveau style stone and masonry construction from early in the 20th century. This property serves as the main building of a large higher education and research institution and is an important symbolic building in the Norwegian university sector. The building is undergoing refurbishment, but due to it being listed for conservation reasons, challenges emerged for improving its sustainability. Interviews have been conducted with the strategic real estate manager, two operations managers and a building engineer.

Case B - University building constructed and owned by a public real estate organisation, and leased for the purpose of higher education. This building also has a grocery store on the ground floor, which further increases the demand for technical infrastructure. Construction finished in 2013 and achieved a class B energy mark in accordance with the Norwegian Energy labelling system. Interviews were conducted with both former and current facilities manager's, in addition to the operations manager.

Case C - This building was constructed in 2012 as an energy efficient office building by a private company with a sustainability profile. Its core construction mainly consists of prefabricated concrete elements. Photovoltaic panels have been integrated into the façade, producing an extra 15,000 kWh/year. The building is also certified with a class A energy mark. Interviews were conducted with a representative from the main long-term leaseholder and operations manager.

Case D - This building is a part of an institution for higher education and primarily consists of auditoriums, workspaces for students, a library and common spaces. The building was refurbished in 2015/2016 with ambitions of achieving the classification of BREEAM 'Excellent'. This building has restrictions as it is listed as an object fit for conservation. Its "Class 2 conservation" (according to the Norwegian Environment Agency) means that the overall architectural expression must be maintained, but that systems and objects that do not constitute major parts of the architectural expression may be changed. The project manager and the leader of the project department in the organisation were interviewed.

Case E - This is a building owned by a regional hospital. Construction completed in 2013, and it serves as a hub for developing and sharing knowledge of health services. It has also been certified as a passive house. Interviews were conducted with two operations managers in the FM section at the hospital.

Case F - A national institution of research occupies this property, and houses primarily offices and laboratories. The building was built during 2012/2013 to meet a passive house standard. The building is constructed on a concrete fundament, designed to look like a glacier in accordance with the profile of the organisation. The load-carrying structure consists mainly of concrete and solid wood elements, and the building is a certified passive house. The manager of operations and the operations engineer were the interview subjects.

RESULTS

The results from the case studies demonstrate that the cases had a high focus on energy efficiency within their frame of opportunity, although the organisations differed with regard to how they approached sustainability from both an SFM and an SB perspective. Subsections 'Sustainable Buildings and Sustainable Facilities Management' directly respond to the research question:

1) What were sustainable goals for SB and SFM of the cases studied?

These subsections are followed by the presentation of a Framework in the context of our findings, which directly responds to the questions:

2) How were performance goals set and implemented at the strategic, tactical and operational levels of the case, and what criteria did the cases use to evaluate their sustainable approach?
3) What gaps between integrated SFM and SB were present in these projects, and what are possible measures for bridging the gaps?

Sustainable Buildings

Applying Berardi's (2013) definition of what constitutes a SB, a mapping of the technical aspects of the building is needed, regarding the structure of the building, use of materials and technical equipment in the building.

The first observation from the cases is that every project, unsurprisingly, had a firm eye on the quality of their thermal envelope, as this was regulated through national building legislation. Furthermore, each case has an advanced ventilation system, containing systems for heating and cooling. As to LCA of building materials, this was mentioned as an important point for two of the new buildings, in addition to the refurbishment cases, especially regarding the external cladding and substructure. Case B is an interesting case in this respect. As the firm financed the project, the cost focus was higher than in the other cases with their intention to select materials with the best quality and best value. At the same time, the life cycle costing (LCC) was low and was considered when choosing materials. For example, Corten steel (weathered steel without the need for painting) was chosen due to low maintenance cost and architectural expression, and internal surfaces were chosen for high resilience and low costs of operations.

As shown by these cases, a sustainable approach to these public buildings mostly placed an emphasis on energy efficiency but placed less emphasis on LCA, embodied energy, waste disposal systems and a system to reduce wastewater. Numerous incremental factors influence a building's overall sustainability in a broader perspective and need to be considered during early design stages. Only Case D had a sufficient system for repurposing wastewater. The cases show that a sustainable system for a mixture of natural and produced lighting was prioritised, however in a few cases fluorescent lighting was installed, only to be replaced by LED lighting a year later. Furthermore, many of the cases experienced that waste management was insufficient and had to be adjusted after a short period of operations.

The case which had the most thorough approach to sustainability is Case D (a refurbishment project), as they included most factors related to SBs into the construction, and further on into FM. Although the case had some negative experiences in handling the process and documentation, this shows the potential for using such tools as LCC and LCA's. In this case, it helped them in planning for ensuring sustainable solutions, processes and implementation, with positive results.

Sustainable Facilities Management

Each case had an integrated Building Management System (BMS) for heating, cooling and ventilation. This reduces excess energy as balanced ventilation recycles excess heat and can be used as a tool for temperature adjustments. It also makes it simpler for the operations manager to make quick alterations, which is good from both a social and an economic perspective, as it improves user satisfaction and control for the operations manager. Some of the users from the cases were experiencing problems with air quality, which could be the product of issues with heating, cooling or the grade of air exchange. For example in Case C, where users experienced high temperatures which were not a product of low cooling, but of a low exchange of air in the building. In buildings with opportunities for more user influence, for example in Cases E and F, the users could open external windows or doors to gain a more comfortable working environment, which greatly improves their satisfaction. Case F has accomplished this successfully, as their temperate zones reduce high fluctuations in temperature in the office landscape.

The new buildings had various qualities in terms of adaptability, which could result in the overall quality of the building deteriorating faster as new needs emerge from the tenants. It becomes apparent that adaptability based on flexibility is not a priority and there have been no plans for future extensions. However, in several cases, the internal flexibility and generality have been taken into consideration with a high number of building sections, which allows adjusting the internal environment.

Both Cases E and F had ambitions of utilising spill products for other uses in the building, but this has not yet been implemented. An effective use of spill in multipurpose buildings such as Cases B and F may severely reduce the amount of energy that has to be delivered.

A recurring problem in several cases is that the simulated use of energy differs from the measured use of energy. Furthermore, in Cases E and F, the firm decided at a very late stage in the process to meet passive house standards. This put a lot of strain on the time consumed on re-designing the technical systems. A few cases mentioned specific plans for implementing SFM on a tactical and operational level. Sustainable policies in these cases seem to be decided on a strategic level without any action plan for implementing them in the FM or user organisation.

A FRAMEWORK FOR EXPLORING THE GAP BETWEEN SUSTAINABLE FM AND SUSTAINABLE BUILDINGS

There is not only a need for developing and managing energy-efficient buildings and to lower the overall energy consumption, but we also need to shift the focus to develop solutions that reduce the climate gas emissions from a life cycle perspective. A way to explore and analyse the gaps between SFM and SBs is to study the total ecological footprint for the use of a building, for a larger neighbourhood or for a larger urban area.

Our focus in this investigation, including the practical case studies, has led us to design a framework for exploring and analysing the gap based on a set of known models, pilot studies and knowledge from theory and practice regarding sustainability and sustainable development. This multi-dimensional framework includes:

1. *Assessment of buildings and projects* must be based on the three sustainability pillars with a holistic view on environmental, social and economic sustainability (Brundtland, 1987).

2. *Analysing and bridging the gaps* between SFM and SBs should be done with a clear understanding of the different management levels (strategical, tactical and operational) in building projects and FM CEN (2011), CEN (2012).

3. *Life cycle assessments*_for new SBs and for sustainable refurbishment_has to be based on analysing the ecological footprint and emissions over planned lifetime periods in addition to energy use and energy balances for the recommended and applied technical solutions and management issues.

4. *A commonly accepted whole life building process model* and a framework for planning, programming, designing, constructing, handing over to the commissioning client, use and operation and maintenance with a focus on the different steps, processes and products that create the life cycle building process from “cradle to grave”.

For analysing sustainability in construction projects and buildings, we can use these three levels for analysis (as an example): Sustainable (or not) at an operational level, Sustainable (or not) at a tactical level, Sustainable (or not) at a strategic level.

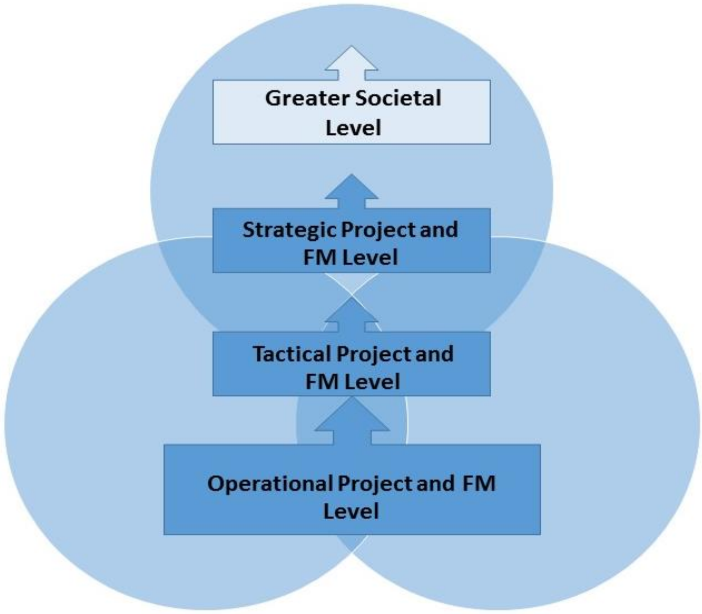

Figure 2. Assessment of projects, based on all three pillars (the circles represent economy, environment and society) and at all levels (operational, tactical and strategic) normally used in construction and facility management (Illustration developed from Haavaldsen et al., 2014, p.10).

As illustrated in Figure 2, the assessment of projects must be based on all three sustainability pillars (the circles represent the economy, environment and society) and at all three management levels (operational, tactical and strategic). The three management levels used in the development of projects correspond to organisational and management models used in the construction of SBs and in SFM. Analysing and bridging the gaps between SFM and SB should be done with a clear understanding of the three management levels.

When looking at the cases in this study, they indicate that approaches that focus primarily on the strategic level are found mostly in the context of the buildings themselves and less in FM. With regard to Case B for example, the development of their buildings was done from a 'top-down' perspective as the university both financed and spearheaded the project. However, similar approaches that focus on a project development or an LCC perspective also include the 'tactical', as the project focus moves into the procurement of high-quality materials and sustainable technology in a perspective of maintenance planning. Some of the cases focus on the early development and operational considerations that target the 'triple bottom line' factors, but given the lack of KPIs, these ambitions appear to belong to 'strategic' considerations of sustainable development. These ambitions can sometimes be a part of the branding and corporate policies of organisations, which also impact the development of their buildings, such as in Case F.

Tactical approaches to both SB and SFM also feature prominently in the cases. As mentioned previously, some of the organisations exercised control over the materials that they used in the development of their buildings. Sourcing materials consciously is important for securing the thermal envelope of SBs and also for facilitating maintenance. With regard to tactical SFM, this has otherwise a focus on usability and adaptability in the studied cases. In this context the focus is on how adaptability and usability cannot just improve the user experience, but also the long term usability of the building as needs and maintenance practices change.

With regard to the overall model, the tactical level appears to offer the largest scope for sustainability and the important area of overlap between SBs and SFM. Whilst building owners commission the policies and buildings that govern their practices, the maintenance and commissioning of these buildings require a sustainably orientated FM approach. It is a lack of consideration of FM teams that also have influenced negatively the technical potential of the buildings in this study. Many of the cases report poor technical optimisation at earlier stages of building design, resulting in actual energy use exceeding the calculated target. This is also reflected in a life cycle perspective, where some interviewees noted that short-sighted cost and quality considerations had negatively impacted the operational efficiency of their building, as in Case B. In addition, factors such as financing, insourcing and outsourcing of services might exert influences on SFM, and would be worth further study.

CONCLUSION - BRIDGING THE GAP

The cases in this study have offered varying approaches as to how they have tackled their commitments to the 'Green Shift'; the extent to which they have 'bridged the gap' between sustainable buildings (SB) and sustainable facilities management (SFM) has also varied. In some cases, a multi-dimensional approach (often involving sustainability demands from users) resulted in a much clearer bridging of the gap between the building and its FM, mostly due to the impact on the operational level that such an approach requires. How organisational size made a difference to practices for SBs and SFM is also evident. The cases indicate a broader implementation of bridging both elements in larger organisations, primarily due to a more solid operational management infrastructure and greater experience in building design. Such approaches can also be seen in smaller organisations, although they seem less prevalent.

In conclusion, this study demonstrates there is currently little consistency amongst the six Norwegian firms in their approach to achieve or attempt to achieve a bridge of the gap between SFM and SB. While the Green Shift is setting a mandate, firms must set their own path to meet that mandate. How this impacts the positive outcome of SB projects is unclear, which in itself presents an opportunity for further research. The ways in which the organisations featured here dealt with the gap between SFM and SB suggests a lifecycle-focused approach is required. This is the case with both new and existing SB projects, which over time could become a standard practice for bridging the gap.

In terms of further applications and opportunities for this topic, the authors wish to make clear the exploratory nature of this study and the degree to which this represents an early stage of a much larger project that is currently under development. The intention in the longer term is to further develop the framework to offer opportunities for analysis as well as provide scope to offer solutions to bridge the gap between SB and SFM. The next step after this study is to widen the sample to an international study with building projects outside Norway providing further external validity to the results and new insights. This would include at least one or two comprehensive case studies based on KPIs for SFM and SBs.

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