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

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Abstract: 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. 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 a 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. 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.

Keywords: Life Cycle Assessment, The Green Shift Sustainable FM, Sustainable Buildings, Assessment, Zero Emission Buildings.

1. 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. 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 based on the policy document. It offers the term "friendly restructuring", referring to a combination of a governing policy introducing stricter buildings codes and regulatory city planning based for 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, and provides support to building developers, owners and managers for improving the sustainability of their building stock outside the existing building regulations (Enova, 2013).

A focus on the construction and building sectors has seen one of the more crucial focuses in this overall strategy. The move towards "the Green Shift', one of the most important measures is reducing emissions in the building and construction sector. In the case of Norway, this approach is already found in technical regulations and building codes for 2017 for low energy and passive houses (Lavenergiprogrammet, 2016). These types of measures combined with international sustainability initiatives for green accreditation and certification methods, like the Building Research Establishment Environmental Method (BREEAM), help in the creation of a more holistic approach to further development of the sustainable built environment.

In Norway real estate developers, corporate real estate and public institutions are already beginning to address sustainability and green solutions in their building development projects and in Facilities Management (FM). Whilst some are adopting the likes of BREEAM (Collins et al., 2016) for their own portfolios, a focus on the development of Sustainable Buildings (SB) with or without a certification and its associated FM are key methods for the 'greening' of state owned real estate and ride the wave of the Green Shift. This process has also been driven by the research and development of Zero Emission Buildings (ZEB) by the Research Centre headquartered at the Norwegian University of Science and Technology (NTNU). Positive results have been achieved by setting up consortia with many partners and close cooperation between research, education, industry and private and public partners in the real estate industry (Hestnes et al., 2017). The overall goal of substantially in reducing climate gas emissions from the built environment, set new requirements to link and integrate planning, design, construction and FM in a life cycle perspective. The long use phase of buildings makes Sustainable FM (SFM) with operation, maintenance and refurbishment more important in the assessment of climate gases over a lifetime from cradle to grave.

We see that despite many private real estate and public institutions aiming to tackle the green challenges for their buildings, there is still a disintegration in terms of how different disciplines and elements of operation and design consider how best to tackle this from a lifecycle perspective. Whilst a full lifecycle consideration can benefit buildings in the longer term (Zuo et al., 2017, p.358) from the perspectives of adaptability, operations and maintenance, the degree which this is achieved and successful is variable.

1.1 Problem Statement, Research Questions and Methodology

Referring to our overall objective in developing more sustainable buildings (SB) and developing better models for SFM, the aim of this paper is to investigate the gaps that we assume exists between SFM and SBs with respect to new and transformed buildings and for portfolio management at the strategic and operational levels. We will be looking at how the building process with the development of SB and SFM can be organised into a more integrated approach considering both technical and non-technical aspects of sustainability.

A basic assumption in our case studies is that there needs to be coordinated information and communication between different management levels; 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 & Klungseth (2017). With the aim of this paper being an explorative study, research questions were developed that would allow for the scope to produce indicative results given a small sample size. The broader scope for these questions along with the process behind procuring the sample can be found in the in the methodology later in this paper.

The paper will deal with these issues by addressing the following research questions:

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 were the gaps between integrated SFM and SB present in these projects, and what are possible measures for bridging the gaps?

The paper also deals with the development of a theoretical framework for exploring the gap between Sustainable FM and Sustainable Buildings. Our focus in this paper based on six exploratory case studies, led us to developing a multi-dimensional framework for analysing and bridging SFM and SB in development and construction projects as well as in asset management and FM. Students through semi-structured interviews accrued data collected for analysis with key personnel in these buildings such as Real Estate directors, Project Managers, Facilities Managers (FM's) and Operations Managers (OM), as well as technical information and other documentation supplied by the institutions. Core key performance indicators (KPI's) were collected during fieldwork and later analysed to reflect the mandate of the research questions. The data from the interviews and documentation are augmented using academic and practice literature for the most part from journals from 2000 to present.

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 consists of new and existing buildings including two refurbishments. Whilst scope and depth of research is considered significant by the authors, the small building sample size nonetheless affects the external validity of the results. This is also the case with regard to the fact that the paper features cases limited only to Norwegian buildings. This why this research should be considered 'exploratory' in nature and the results 'indicative' as opposed to definitive in nature.

After describing each case profile, the sustainable infrastructure from the perspective of SB's and SFM will presented. The paper will conclude by looking at the research questions through a discussion analysing the results from the perspective of the 'strategic',' 'tactical' and 'operational" along with looking at the degree which they bridge the gap between sustainable public buildings and FM.

2. LITERATURE AND THEORY

When considering the research questions and scope of the study, is in important to define certain terms and concepts as they are considered in the context of the paper more broadly.

2.1 Sustainable Development

When it comes to sustainable development, the most widely understood and used definition was given by the Brundtland report in 1987, 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). Although this platform provides a theoretical context to sustainability, it does not provide for specific indicators for sustainable development. In 1994 this was expanded upon by John Elkington who developed the now called 'Triple Bottom Line' for sustainable development (Elkington, 1994). This model addresses sustainability from three different perspectives, social sustainability, environmental sustainability and economic sustainability. In the Norwegian context, the Brundtland definition provides an overall 'mission statement' for a green perspective, with more key performance indicators (KPI) another appropriate metrics being developed by academic and practice institutions.

For analysing sustainability in construction projects and buildings, we can use their 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.

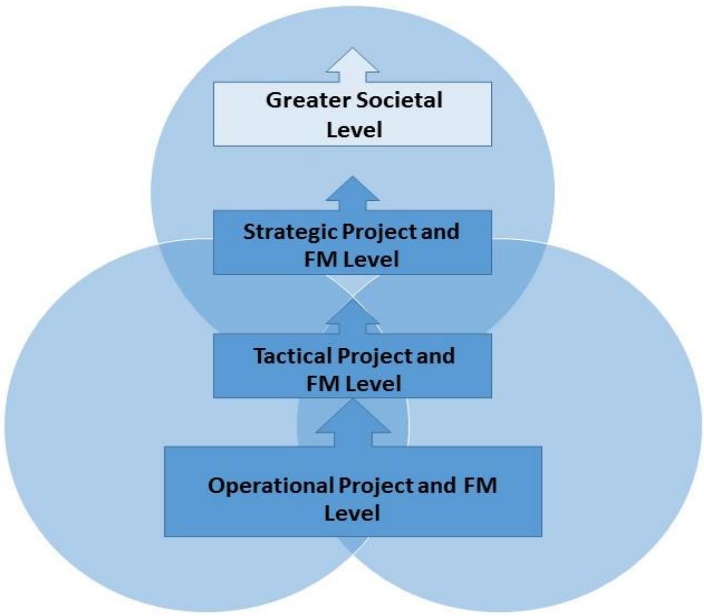

Figure 1. Assessment of projects must be based on all three pillars (the circles represents economy, environment and society) and at all levels (operational, tactical and strategical) normally used in construction projects and in facility management. (Illustration developed from Haavaldsen et al., 2014, p.10)

As illustrated in figure 1, 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 strategical). The three management levels used in development of projects corresponds with organisational and management models used in construction of SB's and in SFM. Analysing and bridging the gaps between SFM and SB should be done with a clear understanding of the different management levels (strategical, tactical and operational)

2.2 Sustainable Buildings

Whilst there is no commonly understood definition as to what constitutes a SB, there have been numerous attempts in both academia and practice to tackle as to what constitutes such a building. From an academic perspective, Berardi (2013) defined a SB as "*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.76). A discussion as to what constitutes an SB also leads to looking at definitions and interpretations of the term 'Zero Emission Building' (ZEB). A definition of a ZEB is relevant as a ZEB is often the end result of, or the intended goal of a the Green Shift in the context of buildings, and is a key consideration in the development of an SB itself. In this study, the definition of a ZEB building is that which has been defined by the Norwegian Zero Emission Building Centre.On a conceptual level they view a ZEB as one with 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, pp.16-17). The buildings evaluated in this study cannot be considered to be zero emissions by this definition, though an understanding as to the Norwegian definition of the term is contextually relevant.

2.3 Sustainable FM

When considering what constitutes a sustainable, low energy or zero emission building, it is also important to consider the context of FM. This is also relevant for the overall study due to the previously stated emphasis on the integration of SFM. Building assets provide the greatest opportunity for a positive sustainability impact that organisations either own or occupy (Nielsen et al., 2016, p.259). This can be achieved through effective management of these buildings as assets with the sustainable agenda as a core part of this strategy.

Whilst FM more generally was defined in the European Committee for Standardisations (CEN) EN15211-1 as "*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), this cannot be considered to also encompass the sustainable agenda for FM at present. In terms of how SFM differentiates, this can be in the context of FM including "*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 eco system*" (Nielsen et al., 2010, p.3). This could manifest in FM considering the likes of energy and waste management, sustainable procurement and logistics in the context of broader building sustainability objectives. The current challenge however 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.95).

Nielsen et al. (2016) sum up in their article regarding measuring and managing sustainability in FM and Corporative Real Estate Management (CREM) that one should be *"context specific in the formulation of 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) also underline the need for applying a life cycle perspective when planning FM or CREM activities. Nielsen et al. (2016) also points out that further studies in 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"* (Nielsen et al., 2016, p. 273).

Berker (2017) has looked into specific end-users perspectives when summing up experiences from ZEB pilot buildings with high energy ambitions (Berker, 2017, pp.152-153). There he addresses three main aspects that have characterised successful energy efficiency interventions for non-residential buildings. According to Throndsen et.al (2014) these aspects are of special interest for our focus on examining and bridging the gap between SFM and SB's *"they combined different methods and addressed both technical and non-technical aspects of energy use. The organisation's management had created a context which favors energy efficient behavior"*. The findings from Throndsen et.al (2014) review of existing literature, where confirmed by evaluations of ZEB's pilot buildings, exemplified by the three success factors in the refurbishment project Powerhouse Kjørbo (Throndsen et. al.,2015, p.153): A project is *"a mix of well-coordinated technical and non-technical approaches, a devoted management, and a common project creating a shared interest in succeeding."*

2.4 Life Cycle Assessment

With an integrated approach to SB design and infrastructure, it is also important to reflect on the building's life cycle context. When discussing buildings lifecycles in the context of sustainability, we often hear of it in the context of 'Life Cycle Assessments' (LCA). According to Bribián *et al.* (2009), these assessments were 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, complexity of components and the potential for multiple changes in their usage (Zabalza et al., 2009, p.2511). When looking at 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).

A consideration and understanding of the importance of emissions is also a key component of Life cycle discussions in SB's. Kristjansdottir (2017) for example points out that *"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 SB's and 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 standard EN15978:2011 "Sustainability of construction works" (CEN 2011), describes the life cycle of a building in four main stages; *Production, Construction, Use and End of Life*. An issue that is interesting for our study is the division into subcategories as illustrated in figure 2. What is also interesting from a SFM perspective is the detailed description of the Use stage into; Use, Maintenance, Repair, Replacement, Refurbishment, Operational energy use, Operational water use.

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.	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 2: Life cycle stages of a building according to EN 15978, CEN (2011) *Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.* CEN 2011. EN 15978 (Kristjansdottir, 2017, p.70).

In this study focusing on the gaps between SB and SFM, the main focus will be on 'B1-7: Use stage with Maintenance, Repair, Replacement, Refurbishment, Operational Energy use and Water use. Experiences and data from the use stages are important input 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 emissions from the production of the raw materials, transportation to manufacturing sites, and manufacturing emissions are all accounted for in this context. Jelle et.al. (2017) points out that selecting the right building materials and technical systems, are more important than ever (Jelle et al., 2017, p.93). In order to achieve SB's and a subsequent low environmental footprint, it is important to select materials with low embodied emissions, to reduce the materials used, to source local materials, to choose durable materials and technical solutions and to reuse and recycle materials.

From the Norwegian perspective however, Bygg21, an organisation consisting of public and private partners hoping to improve productivity and sustainability in the property industry, look at building lifecycles from more of a stakeholder perspective. They claim that mistakes, lower productivity and even accidents on projects are directly related to poor engagement with particular stakeholders at crucial stages of a buildings lifecycle (Bygg21, 2015a, p.2). They include stakeholders in their conceptual model from the owners, users, FM and even the public. For example, they advocate a role for users at the design stage in being involved with a 'needs analysis', but require a different role of these users later by involving them in room planning and even overall assessments during the life of the building life (Bygg21, 2015a, p.4).

2.5 A framework for exploring the gap between Sustainable FM and Sustainable Buildings

Based on the 'Green shift' ambition for a substantial climate and environmentally friendly restructuring of the building and real estate sector, we have in this paper given short overviews and examples of state of the art research, applied recommendations and development of SB's and SFM. This represents partly front end research and construction projects used to fullfil national strategies and goals to reduce the energy consumption in new and existing buildings. As described in the paper, there is not only a need for developing and managing energy efficient buildings and to lower the overall energy consumption, we also need to shift the focus to develop solutions that reduce the climate gas emissions from a life cycle perpective. A way to explore and analyse the gaps between SFM and SB's, is to study the total ecological footprint for the use of a building, for a larger neigbourhood or for a larger urban area.

Our focus in this paper based on a number of practical case-studies done by a group of master's students at NTNU, has led us to designing 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.

The multi-dimentional framework includes:

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

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

3. Life cycle assesments for new SB's and for sustainable refurbishment has to be based on analysing the ecological footprint and *emissions over planned life time 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, construction, handing over to the commissioning client, use and operation and maintenace with a focus on the different steps, processes and products that create the life cycle building process from "cradle to grave".

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.

3. THE SIX CASE STUDIES

The study takes the form of case study research with data collected from large public Norwegian buildings, with emphasis on higher education and research institutions. Master students researched these case studies in the autumn of 2016 as a part of their course module in SFM at NTNU. Six different case studies of the public buildings were selected according to the following criteria:

- Institutional buildings for higher education and research between 5.000-20.000 square meters
- 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
- A sample of buildings managed and operated by large Real Estate and FM organisations (four of the six cases) and a sample 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 is comparable to NTNU's existing building stock and future building projects while the criteria regarding sustainable strategies and operations should provide a state of the art approach for NTNU to emulate. Furthermore, these common denominators have revealed the different sustainability strategies and approaches employed, the criteria used to evaluate this, and how sustainability is implemented on the organisational levels of FM and the challenges and opportunities emerging in the projects.

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

3.1 Case Profiles

	Purpose	**Year of construction**	**Sq.m.**	**Total portfolio (sq.m)**	**Energy usage (kWh/sqm/year)**
Case A	Offices / Education	1910 (2016-)	17000	520000	183 (down from 217)
Case B	Offices / Education	2013	17000	520000	95 (1)
Case C	Offices / Private owner	2012	12000	12000	90,1
Case D	Library/ Study centre	1962 (2015-2016)	5500	582000	100
Case E	Hospital/ Education / Research	2013	17200	227000	127
Case F	Offices/Research /Laboratories	2013	7768	7768	70,7 (calculated)/ 140 (measured)

The total assets are calculated from 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 a Jugend 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 was finished in 2013, and achieved a class B energy mark. Interviews were conducted with both former and current FM, 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 sustainable profile. It's core construction mainly consists of prefabricated concrete elements. Photovoltaic (PV) panels have been integrated in 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 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 in terms of it being listed as an object fit for conservation. It's "Class 2 conservation" means that the overall architectural expression must be maintained, but that systems and objects that do not constitute as a major part of the architectural expression may be changed. The Project manager and the leader of project department in the organisation were interviewed.

Case E - This is a building owned by a regional hospital. Construction was 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 - This property is occupied by a national institution of research, and consists mainly of offices and laboratories. The building was built over the course of 2012/2013 to meet passive house standard. The building is constructed on a concrete fundament, designed to provide a similar look to a glacier in accordance with the profile of the organisation. The carrying infrastructure consists mainly of concrete and solid wood elements, and the building is a certified passive house. The manager of operations and operations engineer were the interview subjects.

4. RESULTS

The results from the case studies demonstrate differences in the approach used by the organisations with regards to how they tackle the issue of sustainability in their projects. Each of the cases had a high focus on energy efficiency within their frame of opportunity, although their approaches differed with regard to how they approached it from both an SFM and SB perspective

4.1 Sustainable Buildings

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

The first observation from the cases shows that every project unsurprisingly had a firm eye on the thermal 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.In terms of LCA of building materials, this was mentioned as an important point in 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 they financed the project themselves, the cost focus was higher than in the other cases, and their focus was on selecting materials with the best quality and value. Still, they managed to keep focus on keeping LCC low. Corte Steel was chosen due to low maintenance and architectural expression, and internal surfaces were chosen for their abilities of high resilience and low costs of operations.

As shown by these cases, a sustainable approach to these public buildings mostly placed a focus on energy efficiency, but placed less of a focus on, for example, LCA, embodied energy, waste disposal systems and a system to reduce spill water. While energy efficiency is a central factor in regards to sustainability, a holistic approach, as illustrated by the triple bottom line model, would also bring other factors into consideration.

Numerous incremental factors influence a buildings overall sustainability in a broader perspective, for example management of spill water, lighting and waste. These factors needed to be considered during early design stages. Only Case D had a sufficient system for repurposing spill water. The cases show that a sustainable system for a mixture of natural and produced lighting were prioritised, however in a few cases fluorescent lighting was installed, only to be switched out for 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 SB's 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. In this case it helped them in planning for ensuring sustainable solutions, processes and implementation, with positive results.

4.2 Sustainable Facilities Management

Regarding their systems for heating, cooling and ventilation, each of the cases had an integrated Building Management System (BMS). 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 OM to make quick alternations, which is good both from a social and economic perspective, as it improves user satisfaction and control for the OM. Some of the users from the cases were experiencing problems with air quality, as this could be the product of issues with either 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 Case E and F, the users could open external windows or doors to temperate rooms to gain a more comfortable working environment, which greatly improves their satisfaction. Case F has accomplished this successfully, as their temperate zones reduces high fluctuations in temperature in the office landscape.

The new buildings had variable qualities in terms of adaptability, which could result in the overall quality of the building deteriorating faster as new needs emerges from the tenants. It becomes apparent that adaptability in terms of flexibility is not a priority and the builder doesn't plan for further add-ons to the building mass. However, in several cases the internal flexibility and generality has been taken into consideration with a high number of building sections, which leaves room for adjusting the internal environment.

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

A recurring problem in several cases is that the simulated use of energy differs from the measured use of energy. In addition, at Case E and F, it was decided that they should be of passive house standards at a very late stage in the process. This put a lot of strain on the time consumed on re-drawing the technical systems. A few of the 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 this in the FM or user organisation.

5. DISCUSSION

When looking at the results from the cases in this study, it is important to reflect on the degree to which they touch on the three levels of organisational management in the context of both their building and associated FM.

In terms of approaches that focus primarily on the strategic level, these are found mostly in the context of the buildings themselves and less about the FM. With regard to Case B for example, the development of their buildings was done from a 'top down' perspective as they themselves both financed and spearheaded the project as a University. However, approaches similar to this, that focus on a project development or LCC perspective, also creep into the 'tactical', as the focus over the project moves into the procurement of high quality materials and sustainable technology in the context of maintenance planning. Some of the cases focus on the early development and operational considerations that targets the previously mentioned 'triple bottom line' factors, which due it's lack of KPI's could be considered to fit firmly in 'strategic' considerations on sustainable development. These focuses 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 also feature prominently in the cases, with considerations coming from both the SB's and SFM. As mentioned previously, some of the buildings maintained control over the materials that they used in the development of their buildings. This choice is in itself an extension of their overall sustainability policy for their buildings. The prioritisation of sourcing these types of materials are a crucial part of tactical sustainability in a SB due to their importance in terms of securing the thermal envelope, and even providing possibilities for easier maintenance for FM's. With regard to tactical SFM, this has focuses 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 change.

With regard to the overall model, the tactical level appears to offer the largest scope for sustainability and the most significant levels of overlap between SB's 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 negatively influences the technical potential of the buildings in this study. Many of the cases report poor technical optimisation at earlier stages of a buildings development, resulting in energy use hitting wide off their calculated target. This is also reflected in an LCA perspective, where some cases noted that cost / quality efficiency considerations had negatively impacted the operational efficiency of their building, as in Case B. Even though this is the situation for the selected cases for this study, this might not be transferable to cases with different criteria, and should only be used within the current scope. Factors like financing and insourced-/outsourced services might be a major influence on the SFM, and is worth a study in of itself.

6. CONCLUSION - BRIDGING THE GAP

The cases in this study have offered varying approaches as to how they have tackled their own commitments to the 'Green Shift', the extent to which they have 'bridged the gap' between SB's and SFM has also been variable. In some of the cases, a multi stakeholder 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 OM levels that such an approach would require. The difference between organisation size and how this made a difference to SFM's and SB's was also evident. The cases indicate a broader implementation of bridging both elements in larger organisations, primarily due to a more solidified OM infrastructure and greater experience in buildings development. This however does not mean that such approaches are entirely absent in smaller organisations, although they can be considered to be less prevalent.

In conclusion, this study demonstrates that in the context of the Norwegian cases featured in this paper, there is currently little consistency in the degree to which the bridging of the gap between SFM and SB is achieved or attempted. This also speaks to the existence of an integrated approach to these and degree to which this is becoming more common in the development of sustainable buildings as well as the process surrounding this development. The degree to which this impacts on the success of building projects is also unclear, which in itself presents an opportunity for further research. Despite this, the way in which the organisations featured tackle this does present evidence suggesting a more lifecycle and stakeholder focused approach. This is the case with new and existing sustainable building projects, which over time could become a standard practice.

In terms of further applications and opportunities for this topic, the authors make clear the exploratory nature of this survey and the degree to which this represents a larger survey 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 FM. The next step, both for this study and further research, is to open the sample to international study with building outside of Norway providing further external validity to the results and outcomes. This would ideally include one or two comprehensive case studies based on KPI's for sustainable FM and sustainable buildings. There are also opportunities further up the road to learn from other published and ongoing research in this field, which in turn may also impact how the authors own research develops.

7. REFERENCES

Berardi, U. (2013). Clarifying the new interpretations of the concept of sustainable building. Sustainable Cities and Society, 8, 72-78. doi:10.1016/j.scs.2013.01.008

BIFM. (2017). Facilities Management Introduction. Retrieved from http://www.bifm.org.uk/bifm/about/facilities

Brundtland, G. (1987). Our common future. Report of the World Commission on Sustainable Development. UN, Geneva, 208.

Bygg21. (2015a). Neste Steg - I Kort Trekk (English: 'The Next Step - The Short Version. In Bygg21 (Ed.), bygg21.no: Bygg21.

Bygg21. (2015b). Veileder for fasenormen «Neste Steg»» -Et felles rammeverk for norske byggeprosesser. Retrieved from http://www.bygg21.no/contentassets/ac0c77e4ec904c7a955525528b474b6c/veileder-for-fasenormen-neste-steg.pdf

CEN. (2011). Part 4: Taxonomy of Facilities Management - Classification and Standards.

CEN. (2012). Part 7: Guidelines for Performance Benchmarking.

Collins, D., Junghans, A., & Haugen, T. (2016). Green leasing in theory and practice: A study focusing on the drivers and barriers for owners and tenants of commercial offices. Paper presented at the CIB World Building Congress 2016, Tampere, Finland.

Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. California Management Review, 36(2), 90-100.

Elmualim, A., Czwakiel, A., Valle, R., Ludlow, G., & Shah, S. (2009). The Practice of Sustainable Facilities Management: Design Sentiments and the Knowledge Chasm. Architectural Engineering and Design Management, 5(1), 91-102. doi:10.3763/aedm.2009.0909

Enova. (2013). Formål. Retrieved from http://www.enova.no/om-enova/36/0/

Hestnes, A. G., & Gustavsen, A. (2017). Introduction. In A. G. Hestnes & N. Eik-Nes (Eds.), Zero Emission Buildings (pp. 15-22). Bergen: Fagbokforlaget.

Haugen, T. and Klungseth, N. J. (2017). "In-house or outsourcing FM services in the public sector: a review of 25 years research and development", Journal of Facilities Management , Vol. 15 Issue: 3, https://doi.org/10.1108/JFM-06-2016-0022).

Jelle, B. P., & Wiik, M. K. (2017). The Right Materials: More Important Than Ever. In A. G. Hestnes & N. Eik-Nes (Eds.), *Zero Emission Buildings* (pp. 81-93). Bergen: Fagbokforlaget.

Kristjansdottir, T. (2017). Low carbon Solutions: The Key Driver. In A. G. Hestnes & N. Eik-Nes (Eds.), Zero Emission Buildings (pp. 69-76). Bergen: Fagbokforlaget.

Lavenergiprogrammet. (2016, 19.02.16). Hva er et passivhus? Retrieved from http://www.lavenergiprogrammet.no/artikkel/hva-er-et-passivhus/

Nielsen, S. B., & Galamba, K. R. (2010). Facilities management–when sustainable development is core business. Paper presented at the 9th EuroFM Research Symposium, EFMC 2010.

Nielsen, S. B., Junghans, A., & Jones, K. (2016). Sustainability. In P. A. Jensen & T. J. Van der Voordt (Eds.), Facilities Management and Corporate Real Estate Management as Value Driver (1 ed., pp. 259-275). Oxon: Routledge.

Shah, S. (2012). Sustainable Refurbishment. Sussex: Wiley-Blackwell.

Throndsen, W., Berker, T., & Knoll, E. B. (2015). Powerhouse Kjørbo. Evaluation of Construction Process and Early Use Phase. Retrieved from Trondheim:

Zabalza Bribián, I., Aranda Usón, A., & Scarpellini, S. (2009). Life cycle assessment in buildings: State-of-the-art and simplified LCA methodology as a complement for building certification. Building and Environment, 44(12), 2510-2520. doi:10.1016/j.buildenv.2009.05.001

Zuo, J., Pullen, S., Rameezdeen, R., Bennetts, H., Wang, Y., Mao, G., . . . Duan, H. (2017). Green building evaluation from a life-cycle perspective in Australia: A critical review. Renewable and Sustainable Energy Reviews, 70, 358-368. doi:10.1016/j.rser.2016.11.251