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The legacy from construction projects to facilities management in Denmark: The good, the bad and the ugly

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ABSTRACT

Purpose: When construction projects are handed over to facilities managers who are in charge of operating the new facilities, things are not always as easy as could be expected. The scientific literature describes examples like discrepancy between the expected and the actual energy consumption, disappointing indoor climate and continuous troubleshooting after hand-over.

These issues are causing facility managers difficulties in new buildings. This is problematic as it has a negative impact on the costs, the people and the environment. Studies have been carried out on each of these important aspects. However, most studies have a specific focus on one issue.

The purpose of this study is to explore a broader range of FM difficulties in new buildings, with the aim of ranking which difficulties are most and least experienced by facility managers in new buildings in Denmark.

Methodology: Our study is based on a national web-based questionnaire survey among FM practitioners in new buildings in Denmark. The identified FM difficulties in new buildings are ranked by mean value to find the most and least experienced.

Key findings: The study shows that most frequent experienced difficulties are related to the quality of operation and maintenance material and drawings handed over from construction to operation. Unexpected high energy consumption due to lack of commissioning of the technical installations, and indoor climate difficulties are other often experienced issues. The least frequent experienced difficulties concern the layout and functionality of both FM space (as kitchen, cleaning room and technique rooms) and core business space (as offices, meeting rooms, and teaching rooms).

Intended impact of the study: The study informs building clients, design teams and facility managers about which difficulties they need to pay extra attention to in future building projects. To researchers, it suggests further research to find solution for the most experienced difficulties. Furthermore, our research suggest further research to investigate in the consequences of these frequently experienced difficulties and how they can be avoided in future construction projects.

Paper type: Research Paper

Keywords: FM, Facilities Management, FM difficulties, performance gaps, construction projects, building performance.

1 INTRODUCTION AND BACKGROUND

Construction of new buildings are heavily resource consuming, regarding both financial, human and natural resources. In Denmark more than 110 billion DKK (14.5 billion Euros) went into construction of new buildings in the year 2017 (Danmarks Statistik, 2018). Operating the new buildings are even more resource consuming, both financially (Hughes et al., 2004) and environmentally (Maslesa et al., 2018). New buildings offers a unique possibility to optimize the operation stage, by taking operation into consideration during design and construction (Boge, 2017). However, when a new building is handed over to facilities management (FM), responsible for the operational stage of the building, previous studies show, that operation is not always as unproblematic as could be expected. We will shortly introduce some of these challenges addressed by research. They include energy consumption, operation and maintenance (O&M) cost, impact on core business, end user satisfaction, and indoor climate.

A large pool of scientific literature describe a discrepancy between the expected and actual energy performance of new buildings, known as the energy performance gap (Gram-Hanssen & Georg, 2018; Mallory-Hill & Gorgolewski, 2018; Sunikka-Blank & Galvin, 2012) or the reliability gap (Mills, 2011; Ornetzeder et al., 2016).

Sustainability is the main focus of Building Performance Evaluation (BPE) which takes into account not only energy consumption but also other aspects such as water consumption and Indoor Environment Quality (IEQ) (Vischer, 2018). Also the concept Total Building Performance (TBP) (Loftness et al. 2018) goes beyond energy consumption by introducing six critical parameters in new buildings. They include IEQ, spatial quality, visual quality and building integrity.

Boge et al. (2017) adds further parameters to be considered in building projects. Referring to Bjørgberg, he mentions the risk of 'unnecessarily high operation and maintenance cost, increased replacement rate and negative impact on core businesses'. Borgstein et al. (2018) describe a number of performance failures in new Brazilian buildings. They include higher energy consumption, poor indoor environmental quality and lack of occupant satisfaction.

In a study of the hand-over process from construction to operation, Lindkvist (2018) finds that an overlap of the construction and operation phases is causing FM difficulties, as contractors continuously need to fix problems during operation. The finding, that there is a need for continuously 'fine tuning' after a building has been occupied, is supported by recent study by Mallory-Hill & Gorgolewski (2018).

Clearly, research has already identified a large number of challenges that FM face during operation of new buildings. As it seems that the term 'building performance gap' is considered to concern only energy performance, we use the term 'FM difficulty' as an overall term to address a broad range of challenges.

Although work has been undertaken on different types of FM difficulties in new buildings, no prior research is found gathering a broader range of FM difficulties in one study. Looking at different FM difficulties together offer an impression of which difficulties are least and most experienced in new buildings. With this knowledge, building clients, design teams and facility managers involved in building projects are given the opportunity to learn from the past and discuss how FM difficulties outlined in this study can be prevented in future projects.

To guide our research study, we formulated this research question: Which difficulties do facility managers in Denmark most frequently experience in new buildings in Denmark? And which difficulties are least experienced?

2 METHODOLOGY

In order to answer our research question, we applied the methodology outlined by Burns et al. (2008), suggesting the following steps.

Sampling

We applied a nonprobability sampling where individuals where selected because they met the sample criteria of being employed in a FM organization managing a newly built or rebuilt building. Since this population is not accessible as a unit, we distributed the questionnaire trough different channels reaching a broader population of facility managers (and potentially others). The size of the population (employees in a FM organization with a newly built or rebuilt building) is unknown to us, thus is the respondents rate unknown. Distributions channels were: 1) e-mails to the research team's professional network of FM practitioners, 2) newsletter (by e-mail) to the members of Danish Facilities Management Association, 3) newsletter (by e-mail) to members of the FM network of the Danish Association of Marine Engineers, 4) Linked-in posts.

Item development

To start the generation of items to include in the questionnaire we conducted a literature study. This resulted in 21 items spread on 6 categories. We consider an item 'a FM difficulty in new buildings', for example 'poor indoor climate – too cold'. We discussed the 21 items found in the literature with FM practitioners attending a FM course at the Danish Technological Institute. They were within the intended population and contributed with additional items based on their experience.

The final number of items were 35, spread on the initial 6 categories as shown in table 1. Since short questionnaires are more likely to have an increased number of respondents than longer ones (Burns, 2018), we only added 2 background question.

Table 1: Categories of FM difficulties in new built buildings.

No.	Category	Number of items
1	Indoor climate	5
2	O&M of technical systems	5
3	O&M of buildings	7
4	Sustainability	6
5	Functionality	5
6	Others	7

Response format

The questionnaire consisted of 4 parts: First a background question to verify if respondents were within the intended population, yes or no. Second, the 35 difficulties spread on 6 categories (one category on one page). We asked respondents to indicate their experience with each of the 35 difficulties on a four-point Likert scale: 1: Never experienced, 2: Experienced to a lesser degree, 3: Experienced to some degree, and 4: Experienced to a high degree. A fifth choice was "Do not know/not applicable (N/A)". Furthermore, we included a "free text" option at the end of each category, where respondents had the opportunity to describe other

experienced difficulties. In the third part, we asked respondents to describe in free text what they found most successful in their new building. Finally, we posed the second background question (figure 1) asking respondents to indicate by multiple choice which statement best described their work tasks.

We allowed respondents to move on to next question without having answered previous questions.

Questionnaire composition and testing

The software Qualtrics ® was used to publish and administer the web-based questionnaire. The questionnaire was pilot tested by the same group who had been part of identifying the 35 items (course participants). Another five persons with experience with FM in new buildings tested the questionnaire. The testing resulted mostly in correction of unclear language. Moreover, test persons were asked to record the time they spend on completing the questionnaire. Questionnaires completed as part of testing were not included in the results.

As introduction to the questionnaire, a brief text described the purpose of the study, the length of the questionnaire, and stated complete anonymity for respondents. The questionnaire was open for answers from October to December 2018. Both introduction text and questionnaire were in Danish.

Analysis

To answer our research question, we calculated the mean value of the respondents' indication on the likert scale of each of the 35 items. N/A answers were not included in the mean value. We then organized the items by their mean value (table 2). We interpret that items with the highest mean value (nearest '4: experienced to a high degree') are the most frequently experienced and thereby "the bad or the ugly", whilst items with the lowest mean value (nearest '1: Never experienced') are the least frequently experienced and thereby "the good".

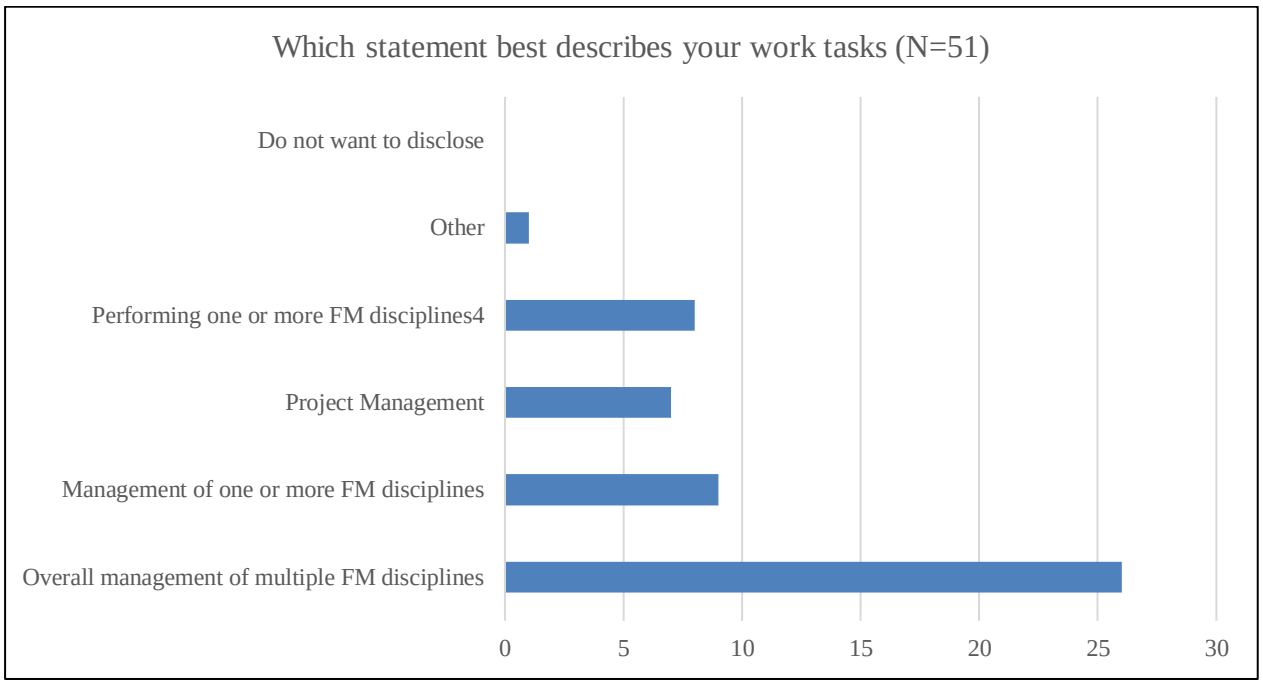
3 RESULTS

Respondents

Answers to the first background question showed that 76 FM practitioners in new buildings (or old buildings recently substantially rebuilt) filled in the questionnaire. Furthermore, 29 respondents (105 in total) outside the intended population completed the questionnaire. Due to the limited number of background questions, we do not know to what extend they are similar to the other 76 respondents (Burns, 2008) and we omitted their answers from the results.

The second background question, posed in the end of the questionnaire, shows that the majority of the respondents who answered this question (N=51) has FM responsibilities of one or more FM disciplines as shown in figure 1.

Figure 1: Respondents' work tasks



Ranking of the 35 difficulties

Table 2 shows the 35 difficulties ranked by mean value (see 3.5 Analysis). Number one (top of table 2) is the difficulty with the highest mean value whereas bottom row, number 35, is the least experienced difficulty. The number in the first column refers to the rank (by mean value), second column refers to the six categories (see table 1). Third column is the specific difficulty, translated to English. Fourth column is the number of respondents who ranked the specific difficulty, in parenthesis the number without N/A.

Table 2. The 35 difficulties ranked by mean value

Rank	Category /No.	Difficulty	N=	Mean value
1	6.3	Inadequate or poorly structured O&M material e.g. missing information in the O&M software/ lack of upload of information to the software	51(47)	3,36
2	4.6	Unexpected high energy consumption due to the lack of commissioning of the technical installations	52(51)	3,24
3	6.4	Inadequate or not updated blueprints to the FM-staff	51(49)	3,18
4	3.2	Unexpected costly og difficult cleaning of windows externally og internally due to lack of accessibility	52(48)	3,06
5	6.1	Unexpected operating investments due to the change of costs from Capex to Opex	51(49)	3,04
6	1.1	Poor indoor climate – too hot	58(56)	3,04

7	1.4	Lacking or difficult coordinated control of heating and cooling	59(57)	3,00
8	3.7	Damage to doors and windows forced open by the users using e.g. wedges	52(50)	2,98
9	1.2	Poor indoor climate – too cold	59(57)	2,86
10	2.2	Unexpected costly O&M of technical installations due to limited access or costly spare parts	54(52)	2,83
11	4.1	Higher energy consumption than expected	52(40)	2,83
12	3.1	Unexpected costly cleaning of surfaces due to choice of materials, e.g. on floors and walls	52(46)	2,80
13	2.4	Inappropriate or expensive options for changing light sources and servicing light fixtures	54(49)	2,78
14	3.6	Difficult or expensive change of building components – e.g. windows and façade panels	52(48)	2,75
15	2.3	Floors in wet rooms with incorrect or defective slope and / or drainage	54(52)	2,62
16	2.1	Limited possibility to use auxiliary tools such as lifts due to interior design or construction	54(48)	2,60
17	1.3	Poor indoor climate - draught	58(57)	2,60
18	1.5	Poor acoustic indoor climate - noise from people, machines, surroundings	59(57)	2,60
19	3.3	Unexpectedly rapid wear and tear of floors due to inappropriate material selection	52(48)	2,58
20	5.1	Inappropriate location and / or layout of kitchen, cleaning room, waste room	52(49)	2,43
21	5.2	Inappropriate location and or layout of rooms with technical installations	52(49)	2,41
22	5.5	Restricted adaptability of office spaces to changes e.g. during to organizational changes	52(45)	2,40
23	4.2	Too few energy og water meters	52(44)	2,40
24	5.4	Lack of opportunity to use rooms for multiple purposes during the day	52(47)	2,36
25	6.2	Lack of compliance on regulatory requirements, fire prevention demands, safety requirements etc.	51(50)	2,32
26	4.4	Difficult waste handling	52(45)	2,31
27	2.5	Poor physical working conditions for the FM-staff. E.g. reduced ceiling height og poor daylight conditions	54(53)	2,30
28	3.4	Unexpected or fast discoloration/ patina of *internal* building components	52(49)	2,27
29	4.3	The lack of bicycle parking, poor accessibility of the bicycle parking and/or lacking shower facilities for the bikers	52(45)	2,24
30	3.5	Unexpected or fast discoloration/ patina of *external* building components	51(47)	2,23
31	6.5	Unexpected need for double operation due to delay in the construction project	51(46)	2,22

32	4.5	Lack of automatic control of the light	52(51)	2,06
33	5.3	Inappropriate location or interior design of the core facilities of the enterprise e.g. class rooms, offices, meeting rooms and production facilities	52(49)	2,00
34	6.7	The architecture does not fulfill the function or mirrors the culture of the enterprise	50(47)	1,89
35	6.6	The architecture is not aligned with the brand of the enterprise	50(43)	1,72

The good

Starting from the bottom, the three least experienced difficulties concern architecture and layout design (table 2, rank 35, 34 and 33). This is supported by the free text answers to the question "What do you consider to be most successful in your new building?" where 6 out of the 17 statements, described successful architecture or layout. Examples are *"Creating a completely new unity"* and *"Super nice and functional building; new and fresh without being showy".*

"Lack of automatic control of the light" (table 2, rank 32) and "Unexpected or fast discoloration/ patina of both *internal* and *external* building components" (table 2, rank 30 and 28) are also little experienced. So is "Poor physical working conditions for FM staff: too low ceiling height, poor daylight conditions, etc." (Table 2, rank 27).

"Unexpected need for double operation due to delay in the construction project" (table 2, rank 31) is another little experienced difficulty.

Within the ten least experienced difficulties 3 are in category 4 (Sustainability), 3 are in category 6 (Others), 2 are in category 3 (O&M of buildings). Only one is in category 2 (O&M of technical installations) and in category 5 (Functionality). None of the least experienced difficulties concern category 1 (Indoor Climate).

The bad and the ugly

The first and third most experienced difficulties concern the quality of documentation and drawings from the construction project (table 2, rank 1 and 3).

"Unexpected high energy consumption due to the lack of commissioning of the technical installations" is the second most experienced difficulty (table 2, rank 2).

Another three of the most experienced difficulties concern indoor climate: too hot, too cold and lack of - or poorly coordinated control - of heating and cooling (table 2, rank 6, 9, 7).

Unexpected operating investments due to the change of costs from Capex to Opex is also high on the list (table 2, rank 5).

Within the ten most often experienced difficulties are 3 in category 1 (indoor climate), 3 are in category 6 (others), 2 are in category 3 (O&M of buildings). Only one is within categories 4 (Sustainability) and 2 (O&M of technical installations). None is in category 5 (Functionality).

Additional difficulties

Respondents were given the opportunity to add difficulties they had experienced, which were not already included in the 35 difficulties identified by us. 8 difficulties were added to the first category, Indoor Climate. They were spread on light, noise, smell, lack of individual control, dry air, and lack of fresh air.

Less difficulties were added to the other categories: 3 to category 2 (O&M of technical installations), 2 were added to category 3 (O&M of buildings). 2 difficulties were added to category 4 (Sustainability), nothing was added to category 5 (Function), and finally 2 difficulties were added to category 6 (Others).

4 DISCUSSION

Documentation from construction projects to FM

The quality of documentation from the construction project was ranked as number 1 and 3, showing that this is highly problematic. In our opinion, this is worrying, as documentation about the building and it's technical installations in many cases is a prerequisite to operate and maintain the new building legally and satisfying. A Norwegian standard has recently been published (Standard Norge, 2018), to aid Norwegian building owners, design teams and facility managers in preventing such difficulties. This could possibly serve as inspiration in other countries, including Denmark, too.

Successful architecture and layout

Due to the limited background questions, we do not know the educational background and experience of the respondents. However, we know from other studies (Kolarik et al., 2017), that facilities managers in Denmark on a managerial level with responsibility for one or more FM disciplines (as the majority of the respondents of our study), are likely to have a technical background. Consequently, there is a possibility, that the respondents having a technical background are more critical regarding technical issues than they are regarding architecture.

Indoor climate

The study shows, that indoor climate is causing FM difficulties. The large research focus on indoor climate further confirms indoor climate to be problematic. Building commissioning is a process, which focuses on the coordinated performance of the building and technical installation throughout a construction project (Mills, 2011). It is gaining momentum in Denmark (Ágústsson & Jensen, 2012), possibly as the result of the many experiences of poor indoor climate in new buildings in Denmark.

Start-up loss

We are surprised to find 'Unexpected high energy consumption due to the lack of commissioning of the technical installations' ranked as number two. The large pool of research concerning the energy performance or reliability gap supports this finding. However, previous research has limited focus on the peak of consumption in the first years of operation. In regard of energy efficient buildings, this frequent experienced 'start-up loss" is possibly overlooked.

5 CONCLUSION

In conclusion, our research demonstrates that facility managers of new buildings experience difficulties in operation due to the legacy from earlier phases of the building's lifecycle. The study was limited to a Danish context, but based on the literature, we have reason to believe, that this is also the case in other countries.

Most experienced difficulty is poor quality of documentation from the project to FM. Difficulties in controlling the indoor climate is another frequent experienced difficulty, resulting in poor indoor environment.

The scientific literature has a large focus on the energy performance gap. In this study, a high number of respondents experienced an unexpected high consumption due to lack of commissioning of technical installation. This poses a problem, as such 'start-up loss' have negative impact not only on the economy and occupants, but also on the planet. We recommend both researchers, the industry and policy makers to focus on this loss.

Limitations

We kept the questionnaire short with the aim of an increased number of respondents. However, a limited numbers of questions poses obvious limitations to the study. Omitting 29 completed questionnaires was a result of the lack of background questions. This lead to another limitation of the study, which is the limited number of respondents.

To follow up on some of the unanswered questions derived from this study and to validate the results presented here, we are supplementing the study with in-depth interviews during 2019.

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