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Aysar Selman, Trine Saaby and Birgitte Munch

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Aysar Selman[1], Trine Saaby[2], Birgitte Munch[3]

[1]University College of Northern Denmark, Architectural Technology and Construction Management, Aalborg, Denmark

[2]University College of Northern Denmark, Energy Technology, Aalborg, Denmark

[3]Development Fyn, Odense, Denmark

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Abstract

DGNB (Danish Green Building Certification) is a certification which is adapted to Danish legislation and norms from a German certification for sustainable construction. Today there is an increasing number of partners involved in this certification, and many discussions evolves around the effects of producing a DGNB certification of a building. To achieve the chosen certification level (silver, gold or platinum), extensive documentation of tests, calculations and processes is required. Traditionally, production of documentation is integrated into or sidelines the (physical) construction process, but a DGNB certification will require implementation of new tasks, processes, and procedures. The introduction of new practical tasks, as well as through a development of visibility and responsibility for production and handling of documentation, a DGNB certification will by producing a common database for all DGNB documentation, transform the involved organizations and open for changes in construction practices and building design. Our research is aimed to help qualify and improve a DGNB certification, by making the involved parties, including builders, consultants, and contractors, able to gain an insight into the various challenges. This will help to draw up a plan for work tasks involved, and create efficient modes of work, to achieve the respective grades and criteria of a DGNB certified building. A qualitative method has been used in the form of literacy assessment and semi-structured interviews conducted with a DGNB auditor and an architect involved in DGNB certification processes, along with a questionnaire that allows researchers to investigate the challenges of organizations to fulfill the demands for documentation. The interviews are analyzed to detect and unfold challenging issues of the organizations. The discussion presents experiences and issues that were challenged within a DGNB certification process, pointing out some key factors in improving workflows and improving the effectiveness of the documentation, e.g. increasing the interdisciplinary interaction between involved actors early in the design phase.

Introduction

The first Danish certification system for sustainable buildings, was launched by the Green Building Council Denmark (DK-GBC) in 2012. DK-GBC adapted the German system DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) due to its emphasis on climate, holistic approach and promotion of innovation as a strategy for 'green buildings'. The DGNB's definition of sustainable buildings is originated from discussions started by 'Our Common Future Report, 1987' (the Brundtland Report) (DK-GBC, 2012), which stresses the three dimensions: environmental, social and economic as basic qualities (Brundtland, 1987). They inscribe a multiplicity of single factors to be included in the processes of planning and deciding qualities and performance of sustainable buildings (Ahn et al., 2013).

The certification process: Change and challenges

DGNB certification is a system of norms, procedures and points that corresponds with the Danish Building Regulation, it is designed to assist and motivate parties to engage in developing sustainable buildings. As the concept of "sustainable buildings" is still relatively new in terms of understanding

how a variety of sustainability qualities are produced by a multitude of interrelated decisions, hence systematic evaluations of experiences from certification processes are few (Worm, Amdi Schjødt et al., 2014). Our research is undertaken to produce information and knowledge about the challenges and benefit of engaging and motivating stakeholders in DGNB certification processes. Many parties in the building industry seem to have limited motivation to engage in DGNB certification, and equivalates certifications processes with problems and challenges that do not pay off. According to Denmark Statistics in 2015, over 5.5 million m^2 were constructed in Denmark while only 45 buildings were certificated by Dk-GBC ('DK-GBC Certificated projects', 2018). The building industry is lacking competences in certification, general knowledge of DGNB system, availability of proper (digital) tools or resources to generate the required data are sparse (Møller et al., 2018). The digitalization in this industry is intertwined with the benefits of certification which is raised many times by all parties. We have paid a specific interest towards this problem: the intertwined of digitalization and certification. Generally, new technologies (especially information technologies) are often implemented with inertness as radical process changes in organization and work are required to gain the benefits, hence digital technologies represent often unforeseen risks and costs. Barriers to certification are described by the parties as lack of management mechanisms, economics, lack of demand and competence of customers, stress on organization and processes (procurement and supply, timing, collaboration and networking), and lack of supporting knowledge (knowledge and common language, availability of methods and tools, innovation) (Møller et al., 2018), (Häkkinen and Belloni, 2011).

As the industry is picking up on producing and procuring information about DGNB certification, it seems that the main barrier for engagement is the extensive bulk of documents and documentation procedures required to get a certificate. Silver, gold or platinum level certificates require extensive documentation of tests, calculations, simulations and decision processes. Traditionally, production of documentation is undertaken in relation to the physical construction process, but a DGNB certification will rely only upon assessment of documents and buildings performance. It introduces new challenges and demands upon organizations, understanding of fulfillment of tasks, on professional competences and collaborative skills (Worm, Amdi Schjødt et al., 2014). Successful certification requires transitions of and within the organization, and innovation in work methods and processes. Currant working regimes must be adapted to the new tasks and demands of DGNB certification by introducing new tasks (tests, simulations and calculations) the division of labor, decisions and responsibilities.

The paper analyses some factors in the certification process; i.e. where the DGNB system challenges organizations by demanding changes in documentation and work practices. By presenting experiences from involved actors, we can gain an insight into some of the core challenges and consequences that a DGNB certification can lead to. We hope that this can help to create appropriate, efficient, and systematic modes of work, to achieve the respective DGNB scores.

The research main question: *What is the impact of Danish Green Building Certification (DGNB) on organizations work processes and documentation work?*

Literature Review

A study conducted by Herazo & Lizarralde, 2015 reveals that the processes within Sustainable/Green Buildings Certification (GBC) are shaped by at least four tensions that can either enhance or hinder the collaboration and innovation: strategic-tactical, collaborative-competitive, participative-effective and individual-collective. They highlight the importance of understanding GBC as a process

and not only as a final outcome, and thus, to better manage these tensions so they contribute to product and process performance (Herazo and Lizarralde, 2015). GBCs imply a process where actors meet to weigh their capacities to respond to new challenges. However, to attain GBCs, important management innovations must be conducted by the client at strategic, tactical and operational levels. In the same manner, design teams and contractors need to engage in innovative processes, systems, technologies, products and materials. The four tensions show that important changes were implemented at different levels after GBCs were identified as project objectives. The results of the study infer that the earlier the stakeholders participate in the process, the more efficient the process of collaboration becomes and the less risky it will be. GBC processes encourage client organizations to choose 'Integrated Design' procurement methods (Herazo and Lizarralde, 2015).

A study by Kovacic & Sreckovic, 2012 argued that a little effort has been invested into the rethinking of the design and planning process for sustainable buildings which are still planned in a traditional manner, where planning tasks are broken down into sequenced, highly specialized disciplines (Kovacic and Sreckovic, 2013). The authors stated that practitioners, when designing the planning process for sustainable buildings are aware of the need for a paradigm change in the planning culture and are asking for methods towards a more integrated, collaborative practice. Special emphasis lies on the need for developing soft tools for the design of interdisciplinary communication and knowledge management since the hard tools, e.g. LCA & LCC have been accepted in practice. The authors have identified the advantages of the integrated planning practice, by conducting a role-playing experiment simulating integrated and sequential planning processes for an energy-efficient structure and identified the need for collaborative interaction between actors and development of a holistic life-cycle oriented planning strategy and mechanisms supporting the interdisciplinary communication, knowledge creation and transfer within the integrated planning processes. Critical herewith is the collaboration of all process stakeholders (planners, users, managers) from the early planning phases, since those are crucial for the latter building performance. They concluded that all roles were more satisfied with Integrated Design Process (IDP) (Kovacic and Sreckovic, 2013).

The (IDP) method is applied in sustainable certification of buildings in Denmark, however it does not ensure aesthetic or sustainable solutions, especially in an early design phase, but it enables the designer to control many parameters that must be considered and integrated in the project when creating more holistic sustainable architecture in order to achieve better sustainable solutions, because all different parameters are considered during the process (Tine Ring, 2005). The main concern is the integration of the many different parameters, as this is considered the key to create more holistic sustainable architecture. The idea is that control and integration of so many different parameters in a project ensures a better interaction of systems and therefore also can raise the degree of sustainability. People involved in sustainable building design need to adapt to trans-disciplinary teamwork which calls for new means of communicating (Tine Ring, 2005).

A case study conducted on four DGNB certificated health center's in Denmark highlighted the importance to collaborate in the design team from the beginning also with the DGNB consultant and create commitment to the project (Brunsgaard, 2015). Sharing knowledge will improve the decision making. The design team did not find difficulties in implementing DGNB-assessment in their work, however, responsibility and fee for the work is not clear. The quality of the process, and the final design of the building can be improved by a more conscious planning and management of the process (Brunsgaard, 2015).

Landgren & Jensen, 2017 (Landgren and Jensen, 2017) investigated how DGNB certification affect the design process in an architectural office in Denmark, concluded that Integrated energy design (IED) must be expanded to include a broader range of parameters in the DGNB certification process, fulfilling in this way a bigger number of DGNB criteria and consequently obtaining an easier process through design phase (Landgren and Jensen, 2017). The spread and variation in the DGNB related parameters addressed in the projects are symptomatic of the lack of a systematic design method for addressing DGNB. The design process is affected when certification systems are used, as new parameters must be in focus from the very early design phases. In the DGNB-system, LCA & LCC encourage adaption of holistic methods with a wider array of parameters and tools to quantify sustainability in terms of economic and environmental impacts. Both calculations include the energy consumption results generated by IED. Integrating LCA & LCC into the early design phases is a new challenge for practitioners and researchers, which requires further investigations. Landgren and Jensen recommended developing new methods and tools to increase the use of DGNB in the early certification process, it will be expected that this will lead to high complexity, due to the bigger number of parameters, but the rapid development of tools will be capable of dealing with that complexity (Landgren and Jensen, 2017).

A survey among Danish DGNB consultants (Brunsgaard, 2017), show that they are not involved early in the design process and they find it difficult to implement LCA & LCC early in the design phase. At the same time, LCA & LCC are well-documented in early phases and only partially implemented until the final stages (construction phase), questioning if the calculative models are really holistic and fit to produce adequate and solid foundation to choose among alternatives. Thus, potentials for optimizing sustainability, equivalated to the collected points in DGNB assessment can be missed, at the same time the choice of materials is highly linked to the architectural qualities, e.g. aesthetics and perception and buildings physical performance (Brunsgaard, 2017). The study shows a potential in developing new methods and tools to support the initial design phases facilitating an iterative decision making and design process based on sufficient level of knowledge and covering many topics (Brunsgaard, 2017).

All stages of a certification process should take into account the environmental considerations, unfortunately, practitioners encounter difficulties in case of brand new products due to the absence of environmental impacts feedback. To solve this problem, it is argued that the functional analysis of products (early stage in the design process) and LCA (late stage in the design process) can benefit each other in a collaborative process (Moreno et al., 2015). A critical literature review conducted by Anand & Amor, 2016 (Anand and Amor, 2017) highlights the gaps in LCA and consider it as one of the most complex applications in analyzing sustainable buildings due to the numerous materials and processes involved, especially in the operation phase compared to the construction phase. The construction phase inventory data for LCA of a whole building is highly dependable on LCA data of buildings components and materials, in addition to several challenges through the various phases of a building's LCA, e.g. the building design, stakeholder criteria, cost, environmental targets and user's. Building inventory data is obtained from building industry, databases or Environmental Product Declarations (EPD) which is directed by the Danish Technological Institute. The availability of product data for design phase in LCA of buildings seems to be a challenging issue for designers due to the absence of environmental feedback. There are various areas which requires industrial involvement and collaborations to promote the use of LCA by developing better databases to cover the gap of missing data for new and old products and to integrate LCA in buildings industry for environmentally conscious decision-making (Anand and Amor, 2017). Other challenges, is the

uncertainty in data collection methods, thus Anand & Amor propose to develop a standard and ISO for better guidance (Anand and Amor, 2017).

The DGNB framework

The DGNB framework operates a hierarchy of criteria organized in six qualities, which unfolds the holistic framework assessing the overall sustainability of the building. They include the environmental, economic, social and technical qualities, which each present 22,5 % of the total score, while the process quality presents 10 % of the total score. The site quality is evaluated separately. According to the weighted qualities, the building will be granted (platinum, gold or silver) certification (DK-GBC, 2012). The required documentation includes; DGNB evaluation matrix, LCA and LCC calculations, EPD's, buildings description and built-up areas, installation services, day light and indoor air climate simulations, energy calculations and energy concepts, water calculation, building site, etc. in addition to the documentation siding the certification process e.g. meeting references, contracts and organizational charts.

A life Cycle Assessment is a holistic approach to determine the total environmental impacts of a product or service from extraction of raw materials and processing, to distribution, use, and end of life. It is measured from a multitude environmental category, such as global warming, acidification, or human toxicity. In practice, LCA is intended to produce information to compare different alternatives in the design of products or decision-making processes (Birgisdóttir, 2015). The Danish States Building Institute (SBI) on behalf of the Danish Transport, Construction and Housing Authority have developed LCAbyg and LCCbyg tools to conduct the calculations (SBi, 2016). The LCA tool contains a catalog of a range of construction products based on generic data from the construction database Ökobau.dat (Kuhnhenne et al., 2010). At product level, Environmental Product Declarations (EPDs) is a method of documenting and declaring the sustainability of construction products and is based on Danish environmental declarations. DGNB uses the EPDs life cycle analysis to calculate the overall environmental impact of the building during its entire life cycle (DK-GBC, 2014). Economical quality requires that there is a balance between costs and achieved quality over the life of the building, and that there is focus on the value creation generated in construction and operational phases. Economical quality is ensured by applying the calculation of total economy for buildings construction, operation and maintenance expenses, through its entire life (SBi, 2016).

Integrated Design Process (IDP) is a holistic method that intertwines knowledge elements from engineering with the design process of architecture to form a new comprehensive strategy to optimize building performance. This implies evaluation and weighting of very different building performance characteristics that are often non-comparable and requires willingness from all participants to reach acceptable compromises (Resources, 2007).

Analytical frame

We have applied a framework from (Orlikowski & Gash) (Orlikowski and Gash, 1994) and (Yrjo¨ Engestrøm) (Engeström, 1987). Orlikowski has written extensively about organizations and technology, especially about ICT introductions in organizations. She has argued that users are less prone to 'appropriate' technologies as they are to 'enact' technologies to co-join the local practices. The continuous enactment of technologies can either confirm and reproduce prevailing organizational structures and cultures or can produce changes and transformation in the organization. Interviews were analyzed to detect and unfold challenging issues and barriers related to the work processes and work in a DGNB certification process. According to the analysis

framework defined by Orlikowski & Gash (1994), the three domains that will cover what the technology is, why it was introduced and how they were used, are:

- **Nature of Technology** refers to people's images of the (generic) technology and their understanding of its capabilities and functionality, benefits and demands.
- **Technology Strategy** refers to people's understanding of the motivation behind the adoption and its likely value to the organization, in relation to actual plans assisting its implementation.
- **Technology in Use** refers to people's understanding of how the technology will be used on a day to day basis and the likely or actual condition and consequences associated with such use.

Here Orlikowski & Gash use opinion-making process in which actors develop expectations, knowledge and assumptions to technology. According to the analytical framework by Orlikowski & Gash, the three domains characterizing the enactments of the subjects acting to make practical use of the DGNB framework in their particular position in the construction project organization. The domains overlap and interacts but are useful for directing questions and interpreting answers.
Our interview guide had organized questions along the following four domains:

- Documentation and process of work
- Organization and responsibilities
- Collaboration
- Tools and programs

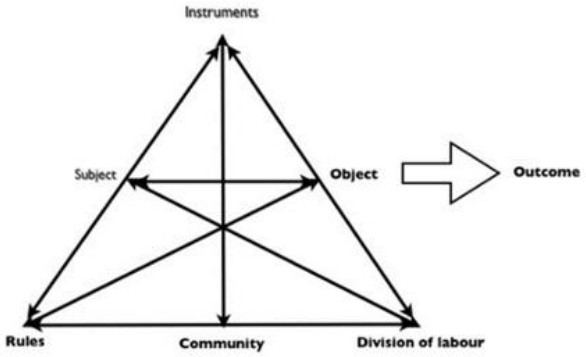

Figure 1The structure of human activity by Engeström, 1987

The premise of Activity Theory (AT) as shown in figure 1, is that a collective work activity, with the basic purpose shared by others (community), is undertaken by people (subjects) who are motivated by a purpose or towards the solution of a problem (object), which is mediated by tools and/or signs (artefacts or instruments) used to achieve the goal (outcome). The activity is constrained by cultural factors including conventions (rules) and social organization (division of labor) within the immediate context and framed by broader social patterns (of production, consumption, distribution and exchange). AT provides a conceptual framework from which we can understand the inter-relationship between activities, actions, operations and artefacts, subjects' motives and goals, and aspects of the social, organizational and societal contexts within which these activities are framed.

Research Method

As we are conducting a single embedded case-study with multiple units (Yin. Robert K., 2014) to investigate changes and challenges of the work processes related to DGNB-certification, we have applied several research methods to gain information and qualify our findings (aka triangulation). The choice of case study design is due to sensitivity towards relational and contextual data and information from the respondents, as each respondent take different positions and are referring to different construction projects. We have conducted literacy assessment as presented in Literature Review chapter and several semi-structured interviews (Kvale, 1996) conducted with selected respondents involved in (ongoing) DGNB certification processes.

Selection of respondents

Our project design aimed to produce information from multiple positions who took part in the process of certification in the organization, to capture the controversies and diverging assessments of the single movements undertaken in the certification process. We have made in-depth interviews

with five respondents who are experienced professionals with profound knowledge and experience with DGNB certification system and have designed the interviews to gain insight into their experiences with practical processes in the organization. Our main project involves interviews with five respondents: one Architect, two Builders, one Contractor and a DGNB auditor. Two of the interviews constitute the backbones of this article, that are a DGNB Auditor (Au) and an Architect (Ar), which were rich in information required to investigate the challenges in a certification process.

Interview design and execution

We firstly made an interview guide, following the strategy for 'semi-structured interviews' (Kvale, 1996). A questionnaire and a mediating chart were sent to the respondents by mail a week before the interviews. The chart depicts the standard building phases and our idea was to stimulate the respondents to identify the DGNB documentation work related to each phase, and especially where they had experienced significant changes in working processes and challenges in production of documentation work (changes in organization). The charts served as a structuring common object during the interview and as an agent for producing insight into our investigation, questions and debate during the interviews. The interviews were recorded, then transcribed by UCN students.

Research findings

What is the Impact of Danish Green Building Certification (DGNB) on organizations, their work processes and documentation work?

In the analysis we are focusing upon the various sensemaking domains (Orlikowski and Gash, 1994), and the relations shaping outcome as framed in AT (Engeström, 1987). The informant's statements are organized so they respond to the analytical domains, and sketches the activities of the various subjects (informants):

Work demands and process of work

Au is employed as consultant and has participated in a number of DGNB certification before being a certified auditor, when he was asked to evaluate which phase is the most demanding in relation to documentation work, he stated: *"There are some elements that, in all conditions, must be done in the context of certification, sometimes it starts earlier than usual, it extends until the building construction is completed and continues 1-2 months in the operation phase too…the are several activities that require extra work and are distributed across all phases".*

Au pointed out that the documentation for DGNB certification work runs across all building phases and cannot be attributed to a specific phase. It can be produced in different times through the process, but the earlier it is, the better it will be to obtain higher quality of work. He highlights that during the long certification process, there are some activities, especially the LCA & LCC that require extra work and time (as they start early and continue in operation phase) and it's here where the biggest potential in optimizing the documentation in a certification process is essential.

Documentation work

Au clarified how the type of documentation produced in a traditional building deviate from a DGNB certificated one, he distinguished between Standard Documentation (SD) to comply with Danish Building Regulations (e.g. energy frame, indoor climate and accessibility regulations) and other documentation required for a DGNB certification and emphasizes that SD is typically prepared in each building phase and presents 95 % of the documentation work which is required in a DGNB certification. Au points to the role of DGNB in establishing an overview of the building's overall documentation. However, the DGNB system introduces several tools that are used to convert data

(from the documentation) to obtain points for fulfilling criteria. It is in connection with the use of these tools where Au identifies that there can be 'more work'. According to Au's opinion, there is no doubt that LCA & LCC calculations require the biggest amount of documentation work in setting the quantities of materials, collecting and defining data. Both calculations weights about 23 % of the whole certification, so accordingly it is evident that many points can be gained here. In addition, there are also the water calculations and day light simulations, which are similarly considered as 'more work'. Au explains how the desired level of DGNB (platin, gold or silver) influences the nature of documentation work, as the higher the DGNB ambitious level is, the more work it requires to gain the highest scores. Thus, huge efforts must be made to fulfill the different criteria if the ambitious level is platin. He adds that in this way DGNB certification affects the entire organization and the knowledge gained in the different areas. However, Au clarifies that it is possible to start the certification process earlier if the Revit models are set correctly from the beginning, so it becomes easier to extract the right data and quantities. On the other hand, Ar admitted the production of new documents in DGNB projects in comparison with traditional ones. The new 'extra' documentation work is mostly produced in the programming phase, but it gets more extensive in the construction phase. It was declared that the certification process will be more time and resource consuming if the required certification level is Platin.
Au adds that the most important benefit by making a DGNB certification is that the documentation work, is a comprehensive collection of all documents and assumptions for all buildings data and materials, so it is easy to refer to these documents when the building is operated, and in case of maintenance and renovation, which saves a lot of time and efforts to find the right data of materials. By that, the builder will also have a well-documented building with all relevant documents, calculations, or meeting minutes, so one can refer to them and see what was really agreed in the meetings, if for example, any complains arises later by the buildings users. He provided an example of a certificated building, in operation phase, where occupants experienced overheating problems in meeting rooms, and by referring to early client meetings and indoor climate analysis, it was found that the rooms where designed for a max. of 6 persons and not 10!

Ar also points out that, regardless of whether more work is done or not, a DGNB certification only provides a higher quality of building, plus in relation to the sustainability aspects, the building will have a more flexible use, that it can be changed to another type of use in the future.

Collaboration strategy

In relation to the collaboration between Au and the other involved actors, Au clarifies some new work strategies that will influence the documentation work:

"The way we <u>always</u> start up a DGNB project, is by having a workshop where we review the various stakeholder's responsibilities to know what must be provided and required, just to get into this with the fact that you have to deliver something early in relation to areas (gross, net and utility areas)".

Here, Au highlights the importance of the actors understanding of their responsibilities and work tasks, when starting a DGNB project. He provides an example, that one of the first important steps is to set up Revit models correctly from the beginning, so all areas will be calculated automatically, and by that avoiding a bulky process. In addition, Au mentions that the way that engineers and architects work with each other is different in a DGNB project, and from his point of view, the DGNB certification is beneficial for an efficient work process. As when starting a DGNB certification, some documents and data are required early in the process and by that DGNB locks the projects in some

areas, preventing to make many design changes. In many cases he experiences that architects have other interests than engineers, where they like to consume more time in the design. Au clarifies:

"*The process now is locked, as we all know that we have the areas defined from the beginning and if you move something in Revit, then other things will be influenced, so it's been revealed to all that it has a consequence, while before it was just a silly mail from the engineer that they should stop moving the door, because now we have 4 men sitting there and are moving outlets".*

In comparison, Ar is aware of the importance of acting in a flexible way together with the rest of team members (total contractor and engineer) and must be open to any decisions without influencing fulfilment of DGNB criteria's. For example, many criteria are linked to each other, and a single modification in the DGNB matrix will influence other criteria. This requires documentation of these criteria which influence each other before proceeding the rest of the documentation work.
Ar mentions that they have most often participated in DGNB projects that have been offered in competitions, so there have been naturally several meetings in the competition team. She mentions that it is vitally important that all facets are present before voting and that the team make a pre-agreement on the desired DGNB level, before the crosses are marked on the DGNB matrix. On the other hand, she confirmed that working with a DGNB project adds a great advantage to the work processes as it will bring all actors in a close relation, with a common and determined aim to achieve the required level of DGNB:

"When working with DGNB, you will have a very close collaboration with others, if the aim is the platin certification, then all actors must work towards the same target, willing for the good process, so if you want to change something, then you need to think about the consequences, what does it matter to price, materials, etc. Otherwise you'll have to go through the whole process again".

In addition to above, Ar declares that DGNB system today have contributed to architectural firms, by directing their attention to the design phase and considering the points that they have not addressed previously. Ar mentions that despite the architecting company has a green profile and they have probably been aware of material choices, but the difference today is that they must consider other parameters in the matrix too.

On the other hand, Au confirmed that working in an IDP will bring the right skills and disciplines into play along the whole process. Similarly, Ar admits the importance of IDP and how it's part of their team 'DNA' and work traditions in all projects and that the buildings complexity requires that all facets should be involved very early in the certification process with a common goal and ambitious intentions to achieve the certification in an efficient way.

Document management strategy

When Au was asked if they use any document management system or a certain platform to collect the documents, he clarified that he has his own folder structure, where all documents are gathered in relation to the individual qualities. In addition, he has self-developed, a responsibility and delivery matrix where he has set up who is responsible for what and who are the producers. He also further processed the changes that have been in DGNB manuals. On the other hand, they are aware that some new tools have been started to be used, but they haven't used any of them yet.
Au adds that according to DGNB, there is still so much analogue in relation to documentation as there is no sort of system where you can have for example access to the client meeting-minutes, or any required documentation. It is important that documents are transparent to all involved actors. Having a common document management tool is essential to retain the process running effectively

and to involve all actors in all phases. It will make it easier to refer to any document at any time, specially that it's a long process and it might be difficult to remember what was done earlier. Thus, it will consequently serve as a quality assurance tool for all documents. In addition, he proposed digital delivery of the documents to Dk-GBC, which will save resources. Ar mentions that they have self-developed their own spreadsheet in Excel to control the documents, which is a user friendly and easy tool. They have listed the criteria, so they can gain an overview of what they began, what is missing, which documentation is delivered and when it must be delivered. However, Ar requests for some guidelines or common templates form, for example, DK-GBC or other organizations, so they can be downloaded and re-used in all projects. Further developments as recommended by Ar, could be done by linking the DGNB matrix to the excel files or calculations, so the results will be automatically adjusted in case of any changes.

Technology in use

As mentioned previously by Au, the biggest resources are without doubt related to the LCA & LCC calculations, as there are numerous quantities of materials and data to be collected and processed in LCA & LCC tools. He also addressed the extra efforts to lack of materials data and EPD, which makes it difficult to define in the LCA tool and can create some obstacles, which requires extra efforts to find the most suitable material: *"The biggest challenge is (if you can) in the LCA analysis document the materials. Right now, it's build on some databases and you can add your own materials, but then you must have some declarations of the components, what they include, the primary energy and everything related to the material".*

Furthermore, Au mentioned that when they first started working with DGNB certification at the beginning of 2013, there was almost no EPD's available. Today, more EPD's are provided by producers and the Danish organization (EPDDanmark) ('EPD Danmark', 2018). He adds that it will be beneficial if producers support their products by providing data for a wide range of products and not only traditional ones.

Au adds: *"The problem is probably more than it's a fairly heavy process of collecting data, as one must be right in the long run of the project to be able to estimate some reasonable amounts".*

The problem from Au's point of view is not only about considering the environmental impact of the materials, but also estimating reasonable quantities and ensuring that the various decisions make sense by analyzing and following-up the consequences related to other aspects e.g. the total cost calculations, energy aspects, fire and sound requirements, loadbearing of the structure, methods of construction, etc. On the other hand, Ar confirms that the extra efforts related to DGNB today, will pay back in the future with less efforts, high qualified process and new experiences and knowledge.

Discussion

It is evident from the empirical analysis that the certification process requires extra efforts and time, as many activities start earlier than usual, they continue along all building phases and extend in the building's operation phase. Similar, research work by Herazo & Lizarralde mention that it is essential to start up the process early (Herazo and Lizarralde, 2015), they agree that the earlier the sustainable projects are started, the more efficient and less risky they will be. Results from interviews show that the documentation work related to LCA & LCC are one of the extensive ones, due to the huge quantity of collected data, that start early in the design phase, then become more extensive in the construction phase. A survey by Brunsgaard & Bejder mention that documentation work related to LCA & LCC is mostly conducted in design and construction phases, meaning that

they don't have a holistic nature through the whole process (Brunsgaard, 2017). However, they mention that it is difficult to integrate LCA & LCC into early design phases. Similarly, Landgren and Jensen mention that it is a new challenge for practitioners (Landgren and Jensen, 2017). Our results agree with the reviewed studies (Landgren and Jensen, 2017), (Brunsgaard, 2017) to develop new methods/ tools to support the initial design phases. It can be by simplifying the use of LCA & LCC tools or by implementing Revit to them, so material quantities will be extracted from Revit and exported to them. Both, our research findings and a study by Anand & Amor (Anand and Amor, 2017) agree that lack of materials data and their EPDs, obstructs the certification process. Producers must make a jump in their profession and provide data of their materials, so documentation work will be reduced and improved.

DGNB brings all involved actors in a close collaboration. Both interviewers confirmed that they usually work in an integrated design process and highlighted the benefits of it and their determination to collaborate early in the process, which is very essential when working with DGNB projects. Similarly, Kovacic & Sreckovic confirmed that actors are aware of the need for collaborative interaction, supporting the interdisciplinary communication and knowledge management between them (Kovacic and Sreckovic, 2013). Brunsgaard highlighted the importance to collaborate in the design team early and concluded that quality of the process, and the final design of buildings can be improved by a more conscious planning and management of the process (Brunsgaard, 2015). Our analysis confirms the awareness of different actors in taking decisions, as the wide spread of parameters and DGNB criteria force them to act differently by not making many design changes and to be aware of the consequences in taking decisions and ensuring that they make sense by analyzing them in relation to other aspects, as many criteria are linked to each other. However, Landgreen & Jensen found that the spread and variation in the DGNB related parameters addressed in the projects are symptomatic of the lack of a systematic design method for addressing DGNB. The design process is affected when certification systems are used, as new parameters must be in focus from the very early design phases (Landgren and Jensen, 2017). According to our findings, it is recommended to develop common guidelines to support the complexity of wide range of criteria and parameters, especially in the design phase.

It is found that organizations today develop their own document management systems. Our findings and reviewed literature emphasized the importance of simplifying and qualifying the certification process and documentation work by digitalizing it. This can be by developing common document management tools accessed by all users, so all documents will be saved in one platform with a clear definition of actor's tasks and their activities, supporting the interdisciplinary communication. However, at the end of the process, DGNB serves as a comprehensive way to document buildings.

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Conclusion

This study provides an insight in how DGNB certification influences working processes and documentation work in organizations. It provides awareness of the issues that need to be addressed and suggests solutions to facilitate DGNB certification. It is concluded that an increased interdisciplinary interaction between involved actors in an early phase is necessary to tackle the increased complexity of sustainable building process. Actors work in a more goal-oriented way to achieve the required level of DGNB. They are also aware of the nature of DGNB criteria which prohibits changing many deign parameters and have influenced the actor's way of behavior by

making them understand the consequences of any decision changes. Activities, specially LCA & LCC calculations, requires extensive efforts through the whole certification process. Lack of data for buildings materials is also an obstruction in conducting the LCA. Actors request digitalizing documentation work processes by developing common skillful tools for efficient management of documents accessed by all involved actors to facilitate the collaboration between them, increase work efficiency and ease off documentation management with a clear definition of the actor's responsibilities. Benefits associated with DGNB certification include a well-documented and qualified building, directing the attention of practitioners to many important parameters that were not considered before. According to the research findings, we recommend the following:

- A discussion to facilitate the certification process by having a common digital platform accessed by all users to manage all documents, allowing effective communication between them.
- Developing utilities to simplify the use of LCA & LCC tools, a solution can be by making Revit compatible to them, enabling data extraction from Revit into these tools. Further research can be made to investigate the challenges and possible solutions related to these tools.
- Producers must facilitate the process by providing a wide range of materials data and EPDs.
- Linking DGNB matrix to the various calculations to avoid extra efforts when adjusting any criteria.
- Providing instructions to support decision makers when working with DGNB matrix and criteria.
- Using common documents or calculation templates, provided by DK-GBC, to ensure the quality of the documentation and to enable using them in other projects.

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