Abstract
Sustainability certification schemes experience grooving popularity. Only few years ago, Denmark got its own sustainability certification scheme based on the German DGNB certification scheme run by Green Building Council Denmark [1]. The objective of this study is to investigate if and in what way a DGNB-certification scheme will affect the decision-making and design process. The study takes point of departure in four Healthcare Centres, all DGNB silver certified – A case study design, using semi-structured interviews. The results show that it is important to collaborate in the design team from the beginning also with the DGNB consultant and create commitment to the project. Additionally, the research show that in some cases the architectural design have been taken too fare in the initial phases without analysing and documenting several sustainable parameters. It creates a “point of no return”, which means it is not possible to priorities the assessment points in the certifications scheme when needed. Therefore, the paper recommends firstly, more focus on the planning of future design processes using DGNB. Secondly, the paper suggests further research about how to improve and support the iterative design process in the initial design phases securing decision-making on sufficient level of knowledge.

Keywords - sustainability certification; DGNB; design process; case study

1. Introduction
In recent years, research and the building industry greatly focused on issues as regards to lowering and optimising the energy use of buildings during operation. It has resulted in several pilot projects, which illustrates how it can be achieved (e.g. The Comfort Houses [2], Home for Life [3]). At the same time voluntary sustainability certification schemes (BREEAM, LEED, DGNB), have been developed around the world - certification schemes that have a broader approach to sustainability than solely energy. However, first generation of schemes still have a large focus on energy [4]. Recently, the Danish sustainability certification scheme, DGNB-DK, was developed [1][5]. The scheme is voluntarily, however more and more clients have requirements for sustainability. Along with growing focus on energy use in buildings new design methodologies was developed – like the Integrated Design Process (IDP) [6][7] and newer variations some with slightly different names like “Integrated Energy Design” by the INTEND project [8]. To what extend the IDP approaches are used in practise is hard to say, however some research show a tendency for more integrated approaches...
than earlier, however there is still room for improvement based on case studies of the Comfort Houses [9]. This research investigates the decision-making and design process (DMaDP) behind four DGNB certified Healthcare Centres in Northern Jutland in Denmark. In general, knowledge about the DMaDP is important for us to constantly improve our design approaches and become more efficient. A conventional design process is highly complex as illustrated by Bryan Lawson:

“As well as letting in daylight and sunlight and allowing for natural ventilation, the window is also usually required to provide a view while retaining privacy. As an interruption in the external wall the window poses problems of structural stability, heat loss and noise transmission, and is thus arguably one of the most complex of building elements”. ([10]:59)

As requirements to energy use and indoor environment tightens, the complexity of design is increasing even further. And with the recast of the EPBD, EU Member States face new tough challenges moving toward new and retrofitted nearly zero-energy buildings by 2018 and 2020 [11]. The goals cannot be reached by using technology alone (e.g. efficient ventilation system and photovoltaic cells) since the strategies to fulfil low-energy and indoor environmental goals are highly related to the architectural design of the buildings (e.g. passive solar heat gains and passive cooling) and not to forget user-behaviour. The general perception is that the “Traditional Design Process” cannot facilitate this complex task. On the other hand, a more integrated design approach can deal with the higher levels of complexity [6], [7]. It is important we keep the quality of the built environment both technically, functionally and aesthetically. Therefore, we need to become better to handle very complex design processes and it is important to find out how DGNB-DK comes into plays in an already highly complex design process. A sustainability scheme deals with low-energy and indoor environmental goals but the method also includes a wide approach to sustainability and focus on the whole life-cycle of the building taking into account e.g. accessibility, flexibility, Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) [1], [5]. By adding more issues to the design, the complexity of the design process is therefore even larger in a case with sustainability certification compared to a conventional low energy project.

The objective of this study is to describe if and in what way a DGNB-certification scheme will affect the DMaDP in the case of the four Healthcare Centres. And find out what we can learn from these projects about future DMaDP in DGNB certified projects?

2. Methode

This section will firstly describe the setup of the research design. Secondly, describe the methods of data collection and finally explain the assessment of the DMaDP.

Research Design

All four projects have the same developer – the Region of Northern Jutland in Denmark and they chose turnkey contracts as tender. It means the projects have two
overall “design processes” – before and after the licensing round. To simplify, it will be called phase 1 and phase 2 in this research, see Table 1 for an overview of the content of phases and the involved stakeholders.

The research design is carried out as a case study design, which has to be seen as a kind of experiment. It relies on analytical generalisations where a particular set of results is used to state a broader “theory” about the phenomenon [12]. Multiple case study designs allow the researcher to compare and contrast the findings derived from each of the cases. The cases and the design teams are made anonymous as the intentions is to provide a general understanding of the challenge related to DMaDP in DGNB assessment and not to highlight specific design solutions and design teams. Table 1 show the distribution of design teams on the individual project and the specific phase. Note that some design teams appear on more projects.

Data Collection

The DMaDP were analysed through qualitative interviews of key actors in each design team [13]. Each interview was semi-structured, meaning the interviewer had a question guide with a series of questions in a general form [14].

Assessing the DMaDP

In order to reach high-performance and high quality design of buildings the complex design processes, as described in the introduction, is ideally analogous to an integrated design approach. Therefore, the fundament to assess the DMaDP of the DGNB certified Healthcare Centres take point of departure in principals of the Integrated Design Process (IDP) developed by IEA, Task 23 [6] and Mary-Ann Knudstrup, Aalborg University [7]. The following text and Figure 1 outlines the key elements, where the reader needs the primary literature to acquire the full and detailed description of IDP.

Firstly, both IDP methodologies underlines the importance of having an iterative process – An iterative process means that ideas and solutions are tested against constrains in loops where the level of knowledge and understanding about the design problem groves as the process moves forward – one iteration are used as the starting point for the next iteration. As the process is moving forward, the design is approaching its final stage. Working iterative means, you might also have to take larger steps back in the process if greater amount of conflicts in the design show.

Secondly, it is important in an IDP to involve all relevant stakeholders from the beginning of the project bringing-in necessary competences earlier than in a “traditional Design process”, typically engineering knowledge. This allows additional test of constrains in the early design stages resulting in a holistic concept and avoids repair-work later in the design process, which usually has drawbacks for the economy and quality of the design.
Figure 1. Illustrates the phases of the two similar IDP methods. The main difference is that the method by Mary-Ann Knudstrup [7] is developed for problem-based teaching environments, where the IEA Task 23 [6] is developed for practice. Both methods start from overall ideas and goals, to conceptual sketching/calculations and finishing with a synthesis phases with detailed calculations/documentation and selection of specific technologies.

Thirdly, by bringing together the different stakeholders earlier, the principal is to evaluate the design continuously in loops of iterations throughout the process as regards to both technical, functional and aesthetical issues. It can be supported by overall estimation/calculations/simulations of e.g. energy use and indoor environment in the beginning, which then become more and more advanced and detailed as the project finds it’s final. Therefore, an awareness of assessment tools in the specific phases is therefore essential. An example could be evaluation of thermal indoor environment by 24-hour average calculations in the initial phases and moving to thermal simulations in software like BSim in the synthesis phase. The same principle expects to be added when working with sustainability certification schemes – also regarding the DGNB matrix, e.g. overall estimation/calculations in the beginning and more detailed in the final stage. Therefore the anchor points in the assessment of the DMaDP are:

- Methodology with iterations
- Stakeholders and collaboration
- Assessment tools

All topics are interrelated and overlap, however treated separately to communicate the results. Together they contribute to determining the overall character of the design process. Within the scope of this paper, it is not possible to discuss the process of each case, why key common aspects are presented in a more general manner through quotes to illustrate points.

### 3. Results

In the following, selected topics present the results, starting with Contract Form, followed by Methods and Collaboration, moving on to Assessment Tools and ending with Architectural detailing contra Assessment of the Performance.
**Contract Form**

The type of contracts have shown to have a significant impact on the design processes, firstly because two different design teams worked on the same project in respectively phase 1 and phase 2. Secondly, because the designs was highly detailed in phase 1. The latter the paper will get back to later. The shift from Team 1 to Team 2 has especially two concerns. Firstly, the project change hands in the middle of the design process and can influence the knowledge transfer and ownership to the project, as the second team has to finish another team’s project. Secondly, the teams change character. In phase 1, they are a team of consultants for the clients, where the aim is to deliver a product fulfilling the needs of the client – focus mainly on the quality and having ownership to the project. Where in phase 2 the team is sub-consultants for the contractor, they provide a service for the contractor by detailing the building based on the outline proposal – focus mainly on economy, exemplified in the following:

“He (contractor) is not interested in turning up the volume to more than silver, but on the other hand he needs to be sure to reach the minimum requirements. ...and we need to get there for the minimum cost.” (Architect, team E2)

The focus was to adjust the project to the level of fulfilling the DGNB certification. Perhaps some design teams have been “hunting scores” instead of discussing holistic sustainable design.

**Method and Collaboration**

As regards to collaboration in the teams in phase 1 especially one team had great experience with working closely together from the beginning. It had significant influence on the approach to the project:

“I feel they (engineers and DGNB consultant) have been involved earlier than normally. And it has actually been profitable. Sometimes it can be difficult to get them to come out in the open, so to speak. It has not been the case in this team where they have been involved earlier in the sketches.” (Architect1, Team A1).

”...they (engineers in general) need material that is more concrete. Some engineers are skilled in thinking conceptual and others are expert in calculating facts. It depends on whom you work with. In several years, the engineer and DGNB consultant in this team has been front-runners in the whole field of sustainability. Therefore, they are naturally very pleasant to work with and they are skilful. Not all have those competences.” (Architect2, Team A1).

The other two teams in phase 1 was not equally explicit in their description of the collaboration. However, the following quote indicates to a larger extend solo-run from the architect in the beginning and later the support came in from the engineer.

"The architects sketched the building the usual way and then I came in and evaluated on the sustainability criteria. Then I said things like; perhaps you should tune a little here and there. The energy concept was perhaps discussed a little more because it is not easy to fulfil low-energy class 2020, it has some consequences for the building (design), it had in any rate also a large impact on the progression of the project” (DGNB consultant, Team C1).

However, when asking them to reflect upon a good process with DGNB-assessment they all highlights the importance of implementing the DGNB assessment early in the project.

“You need to bring in the matrix (DGNB-assessment matrix) early to be able to get all the aspects in. In a way, you need to have it in the back of your mind all the time. The DGNB person (consultant/auditor) needs
to be involved from the beginning, it is not something you can add on later, you risk that things are unaligned” (Engineer, Team B1).

Generally, the design teams in phase 2 expressed that they took over a project that was architecturally too detailed; floor plans, facades and detailed description were included in the tender documents. They did not feel they had enough parameters to play with and there were no room for innovation in regards to architectural design and sustainable design.

“An area where we could do some changes was in selection of materials, but it is already in the quotation stage where we had three weeks and everybody (sub-contractors) had to calculate their prize. But the assignment was limited because they (Team A1) had written in the tender document almost exactly what they wanted. Therefore, we did not have much selection.” (Architect, Team D2).

Several design teams explained that the level of detailing has nothing to do with the DGNB-assessment but a choice from the client. However, you can question if the high level of architectural detailing in phase 1 is an advantage or not for the quality of the assessment. According to several stakeholders, the areas with the most design freedom in phase 2 was the selection of materials and placement of windows. Aspects that could be argued to fit into the synthesis phase where the complexity is high. But how well have the architectural design been verified in this phase? Next paragraph will discuss this question.

**Assessment Tools**

Table 1 shows which tools are used in each phase cross cases and reveals that few tools are used in the phase 1. It is a bit surprising taking into account the relatively ambitious goals of the projects as regards to demands in DGNB and the level of architectural detailing in phase 1. The question is if the level of knowledge was sufficient when taking some of the significant design decisions. Stakeholders from phase 1 express that they only did overall energy calculations to make sure they were on the right track. As regards to indoor environment, they did not investigate the performance of the project, but settled with specifying the requirements in the tender document and then it was up to the contractor to fulfil the goals. In relation to LCC and LCA they explained that is was too early to calculate in phase 1 as especially the selection of materials was up to the contractor. In phase 2, the use of tools were more extensive however, it is self-evident because the DGNB scheme demands a relatively high documentation level. One team explain parts of their work like this:

"To take the challenge with the daylight as an example, we did not finalise the design solution totally. It was discussed at a very early stage...therefore, we had on-going dialogue about what we need to do to make it look like the outline proposal with that façade expression and window placement. Therefore, it has been a kind of ping-pong back and forth: if we do this, what does the engineer say to that as regards to daylight etc.” (Architect, Team E2)

The quote is an example of the iterative process in phase 2, here in regards to daylight. In contrast, another stakeholder expresses that he did energy calculations too early – It was too demanding to do so many iterations even in phase 2 where the architectural design is highly detailed.

“We have made (energy) calculations from day one but that was a mistake... Then came a little change in a g-value and then you can start all over. We have done that two or three times. We too quickly did the
adjustments...Postpone the final documentation, the energy frame...go with the gut feeling...to avoid making changes and use resources.” (Engineer, Team D2)

This engineer is perhaps the kind that prefers to calculate facts, instead of doing conceptual analysis, as exemplified by Team A1 in previous paragraph. The mind-set in an IDP is to do appropriate analysis as the project move forward making sure the project sticks to the goal. It will potentially minimise use of resources later in the process. If a team wants to work in an integrated manner, everybody needs to agree on it and see the benefits of it [6].

Table 1. Present a general overview of content and stakeholders in the two phases. Including presenting the tools used in the different phases.

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
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<tbody>
<tr>
<td><strong>Content</strong></td>
<td><strong>Phase 2</strong></td>
</tr>
<tr>
<td>1. Pre-qualification</td>
<td>4. The contractor/ entrepreneur is found based on the tender</td>
</tr>
<tr>
<td>2. An outline proposal was designed</td>
<td>5. The preliminary project (regulatory project) was developed based on the outline proposal and the financial frame in the tender</td>
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<tr>
<td>3. Tender documents was developed which included goals of the DGNB criteria</td>
<td>6. Main project is finished</td>
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<thead>
<tr>
<th>Stakeholders/Teams</th>
<th>Licensing Round</th>
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<tr>
<td>Architect 1</td>
<td>Architect 2</td>
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<tr>
<td>Traditional engineer(s) 1</td>
<td>Traditional engineer(s) 2</td>
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<tr>
<td>DGNB auditor/consultant 1</td>
<td>DGNB auditor/consultant 2</td>
</tr>
<tr>
<td>Case 1: Design team A1</td>
<td>Other specialist</td>
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<td>Case 2: Design team A1</td>
<td>Client design advisor:</td>
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<td>Case 3: Design team B1</td>
<td>Architect or engineer 1</td>
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<td>Case 4: Design team C1</td>
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<tr>
<th>Tools – calculation, simulation, visualisation</th>
<th>Tools – calculation, simulation, visualisation</th>
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<tr>
<td>▪ Overall calculations of energy use</td>
<td>▪ BSIm (indoor environmental simulations)</td>
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<td>▪ Calculations of U-values</td>
<td>▪ Be10 (energy calculations)</td>
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<tr>
<td>▪ Revit – BIM (only one team) (visualisations)</td>
<td>▪ Daylight calculation/simulations</td>
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<td>▪ Revit – BIM (visualisations, extract quantities)</td>
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<td>▪ LCA &amp; LCC</td>
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**Architectural Detailing contra Assessment of Performance**

As mentioned earlier, the design teams explained that the projects were too detailed as regards to the architectural design and not much design freedom was left for phase 2 – “room of choices” was limited. One explains that it can be a conscious strategy by the client to have more control and influence on the quality of the architectural design in a
situation of a turnkey contract. However, as regards to the quality of the DGNB-assessment, is it the most appropriate strategy? In these cases, the “room of choices” are reduced after the licensing round both as regards to architectural design and thereby also limiting possibilities for well-integrated sustainable issues – both technical, socially, economically and environmentally issues. Mapping of the tools (Table 1) show that they were primarily used in phase 2 which show lack of documentation of initial concepts and lack of an iterative process. It show a more traditional and linear process where there the engineering knowledge comes in late or in the end. Instead of developing and informing the design by an ongoing assessment of the sustainable parameters in both phases, it indicates that the design have used the tools to control if the criteria have been fulfilled.

4. Discussion

Knowledge from only four cases forms the basis of this study, which means the findings will be tendencies or hint about how the DMaDP could be in other DGNB projects. Additionally, the findings are limited to a situation of turnkey-contracts. Therefore, the way the DGNB-assessment affects the DMaDP is not clear-cut. However, the findings in this study have its eligibility – it will improve the awareness of possible challenges in such projects.

It can be problematic in the later design stages if too many parameters are fixed (design and economy), as it must be possible to change the prioritisation of issues in an iterative process – It also goes for prioritising the points in the DGNB-assessment. It is important that “room of choices” are present when needed and the “points of no return” are made at the right time and not too early (Figure 1). Working with highly complex buildings it is important to do analysis by using appropriate tools for the specific stage of the design as mention previously. Comparing the detailing level of the design with the use of tool in phase 1 there is divergence at least if thinking in an integrated manner. The strategy of detailing the design in phase 1 to be able to hold on to a specific architectural design in a turnkey-contract is kind of a sensible argument. On the other hand, it is a shame if it has consequences on performance and innovation in the project as many stakeholders describe. One explanation could be the lack of ownership and responsibility for the project. In respect to the turnkey contracts, the design teams in phase 1 does not have the final responsibility of the building and the DGNB certification. Therefore, the incitement to do thorough analysis is absence and they save the resources.

It seems like the DGNB consultants has been a part of the entire project (both phase) and guided the teams in the direction of a silver certification. However, the overview and responsibility of the performance in the DGNB-assessment has only been on the DGNB consultant. Therefore, the consultant holds a considerable level of power and can affect the design significantly. It means, the competences of the consultant are highly important, as the DGNB assessment scheme is performance-based. It means he/she needs to have a certain amount of experience and overview of how the different criteria affect each other already in phase 1. Alternatively, knowledge form the entire
team should be able to be a part of the DGNB-assessment and assessment matrix should become an integrated part of the toolbox. However, it means that the process of doing an assessment need to be more operational than today.

Despite the challenges highlighted in this study all cases are silver DGNB certified today. Is the certification system too easy to fulfil or has the design in any case suffered on that behalf? The aim of the study is not to judge the certification scheme or final quality of the outcome. However, the process of getting there could perhaps have been improved. The aim with IDP, besides handling complexity, is to reduce large amount of resources to solving problems late in the process. By optimizing the DMaDP resources may have been reduced. Practice still seems to work in a traditional matter – not using an integrated design approach. Perhaps we need to look more into how we can improve and make the iterative process in the initial phases more operational than today, without using more resources. It is important that the design teams can see the meaning and incitement to do early analysis of the design.

5. Conclusion

As interest for DGNB certification grows, the need to understand how to approach the design process become evident. With the point of departure in IDP the paper has presented result from four case studies – four DGNB certified Healthcare Centres. The results show that it is important to collaborate in the design team from the beginning also with the DGNB consultant and create commitment to the project, as sharing knowledge will improve decision-making.

It became clear that the turnkey-contract and the prioritisation within, had significant impact on the possibility to work integrated with DGNB-assessment. When planning the project one needs to be aware of the challenges by fixing too many parameters in the initial phases without doing profound analysis resulting in “points of no return” and therefore eliminate the possibility to priorities the assessment points. Consequently, when planning a project with the client, a discussion about the design approach is highly important, so the different interests are align. The paper also suggests further research about how to improve and support the iterative design process in the initial design phases securing decision-making on sufficient level of knowledge.

Acknowledgment

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References