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Reflections on How DGNB(UD) Certification Standards Effect Design Methods

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Abstract: DGNB is an abbreviation of Deutsche Gesellschaft für Nachhaltiges Bauen, a German sustainability standard and certification system that has operated for a decade and that was appointed as the official Danish system by Green Building Council (GBC) Denmark in 2009. In 2012 GBC Denmark launched a second DGNB standard, now focusing on urban districts. This certification standard is currently still in the process of being adjusted to Danish standards. DGNB Urban Districts (DGNB(UD)) pleads for using their system as design ‘tool’ or guideline for the very early design stages. This process has not been investigated or described well. In this paper, the effect of DGNB(UD) on design is investigated in a case study using DGNB(UD) as a ‘design tool’. The effects on the design process is observed and compared to well established methodologies of integrated energy design (IED) and traditional beaux- arts architectural design. The case study addresses the design of an abandoned harbor area to be re-inhabited and to provide new functions.

Keywords: Design Method, Sustainability, Certification System, DGNB, Integrated Energy Design, Urban Planning.

Introduction

A Paradigm Shifts from Energy Matters Towards a Holistic Understanding of Sustainability

When the EU standard of Environmental Impact Assessment was implemented, it profoundly affected the design of infrastructure and other civil engineering projects. The broad and complex directive dictated that aspects other than traditional civil engineering issues should be addressed, thus invited architectural offices to take a more central role in the design process.

Civil engineering systems are present behind the scenes in urban design and will be affected by new ideas of urban design. For example, there is a tendency towards natural systems (for instance handling of rainwater and greywater locally) instead of complex mechanical systems. The sustainability certification system of urban districts, DGNB(UD) (www.dgnb.de) thus, implicitly provides a new framework for civil engineering systems because many of its 45 criteria implicitly address the above mentioned paradigm shift. The focus of this paper is not to investigate the design of large scale structures and civil engineering systems, but on a more general basis it looks into how technical scientific knowledge is integrated in a design process when exposed to the framework of a sustainability certification system in an urban scale.

The DGNB(UD) system is comprised of 45 criteria from 5 major areas (the DGNB System). A

large part of the criteria concerns technical-scientific matters, and design methods for integrating these in architectural design have been researched for two decades in the framework of Integrated Energy Design (IED) Methodology. IED is a family of related design methods that address how the design of buildings can be informed by technical scientific knowledge from the earliest design phases and onwards with the aim of reducing energy consumption for operating buildings (Hestnes *et al.* 2008).

IED is operational today, after two decades of continuous advancement in facilitating software. IED is limited in the number of parameters that vary in the design process because the focus is on reducing energy consumption for operating buildings (heating, cooling, ventilation, lighting). This precise goal has made it widely applicable.

Architectural Design processes are not informed by the necessary technical scientific knowledge. This makes meeting sustainability demands a result of chance or later adjustment. The resourcefulness in architectural design methods lies in the ability to create ideas of form from zero.

However, the DGNB(UD) has a broader and complex focus, which challenges both IED and existing Architectural Design methods. Using DGNB Urban Districts (DGNBUD) as a framework for design work implies a step into a broader realm, with a multitude of parameters, most of which are not yet facilitated by adequate software.

Focus on the reduction of energy needed to operate houses limits a perspective for the future. We can already limit the energy we use for operating houses to zero. The focus will thus turn to the embodied energy in existing structures, materials and LCA of materials. Social and economic issues and issues of toxicity and health will also find a place in a broader design process. Trying DGNB(UD) out as a sort of design tool or method is thus a step into a design method of far larger complexity than IED.

We know from research that the urban design is determining a large part of the energy profile of a building (Strømmand-Andersen 2012). We also know that climatic comfort in urban spaces influence the use and thus have an effect on the social characteristics of the city (Gehl 2010).

A framework for forming a design method in regards to the above mentioned is a need. This makes it worthwhile to try out DGNB(UD) as a design tool because DGNB(UD) has the broadness required for the next generation of integrated design processes.

Hence, this paper asks: can DGNB(UD) generate ideas and form and is it operational in a design process as the DGNB organization urges designers to do?

Method: DGNB (UD) as a Design Tool

Case Study – The Paper Island Development, Copenhagen

A preliminary hypothesis of the paper is that DGNB(UD) can be used from the earliest design stages in the design of large scale structures and urban spaces. The DGNB(UD) society suggests that it is to be used to provide design guidelines from the earliest stages. In an exploratory case study, DGNB(UD) is investigated as a generator of design guidelines from the earliest of design stages. In what sense does it make the design process different from traditional architectural design and Integrated Energy Design (IED)?

The effect of the DGNB(UD)-influenced design method is observed and compared to the well-established methodologies of integrated energy design (IED) and architectural design.

Architectural Design

Architectural design is outlined by the beaux arts tradition where the design process is organised by a 'zooming' in scale (Shawe-Taylor 1993). Before the founding of first architectural academies in the late 17th century, the builders referred to construction tradition and classical canon (Vitruvius). In the Beaux-Arts tradition, this knowledge was systematized and taught in a master-apprentice relationship at the ateliers (Prentice 1985). In the 20th century, the modern movement who placed emphasis on intuition challenged the Beaux-Arts system. In the

Bauhaus academy, the first year was reserved entirely for artistic exercises in exploring the design potential deriving from a subjective and intuitive approach (Findeli 1991).

In this paper, the architectural design tradition is defined as the systematic 'zooming' in scale controlled by architectural meaning (story behind the concept) and giving form based on the architect's intuition and experience.

Integrated Energy Design (IED)

There is a multitude of IED concepts, which address these subjects:

1: Process focused methods (how to work in multidisciplinary, integrated design teams, what to consider when and by whom).

2: Design evaluation methods (structured evaluation of potential design solutions, design criteria).

3: Information about the design process by (simulation) software. What to apply and in what order and how to integrate the results in the ongoing design process (Petersen 2011).

The design of buildings with the aim of reducing the energy demand for operating is the classic topic of IED. This paper presupposes a multidisciplinary team for both the IED and DGNB(UD) process (not in relation to the architectural design method). IED is defined as a systematic parameter variation, evaluated and informed by simulations. This processes moves forward in a series of iterations structured in 3 tempi: reduce (energy consumption), optimize (HVAC systems) and produce (energy) (Eurima, web).

The case study is a real urban development of an abandoned harbor area to be re-inhabited and to perform new functions in Copenhagen, Denmark. This case study developed around 3 main phases: the initial phase, the layout of the site, and the design of building volumes.

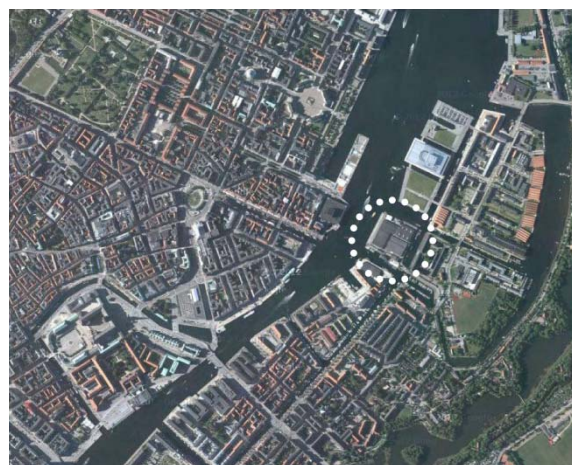


Figure 1. The Location of the Paper Island in the Inner Harbour of Copenhagen



Figure 2. The Current Look of the Paper Island



Figure 3. The Present Distribution of Functions in Close Proximity of the Paper Island

Initial Phase

The methodological framework inspired by DGNB(UD) is set up, and the final approach is decided to be a multidisciplinary approach loyally structured by the relevance of singular DGNB(UD) criteria. Specialist team meetings and interviews were conducted to inform the design decisions, and traditional architectural design methods and DGNB(UD) influence on the design process are observed and compared.

Layout of Site

An iterative design process based on the DGNB(UD) criteria was carried out. Quantitative and climatic design parameters interacted with qualitative design decisions based on specialist input. The influences of Architectural Design methods and DGNB(UD) on the design process are observed and compared.

Design of Building Volumes

Similarities and differences between IED, Architectural Design methods and DGNB(UD) and their influences on the design process are observed

and compared to meet a conclusion as to the relevance of DGNB(UD) as a design tool.

Findings: Case Study: Paper Island

DGNB Urban Districts and its Potential as a Design Tool

Initial Phase

The Paper Island in the Inner Harbour of Copenhagen (figure 1) is an artificial island of 22.000 m² developed to facilitate naval activities from 1740 and onwards (Rasmussen 2009). Since the 1930s, the island has served as a storage area. This function has been unchanged for almost a century despite the central part of Copenhagen developing around the harbour and thus out-phasing the industry (figure 2). During the past decades, intense discussions on the use of the island and its integration into the urban fabric have had a significant place in the public debate (Juul Nielsen, 2012). In 2012, the island was the only remaining industrial function in the area, and in November the company announced its sudden withdrawal from the contract, leaving the buildings with no purpose. Once again public debate was launched; this time more present than ever due to intense public and private investments in the area and its new status as an “experience landscape” with the Opera House, the Playhouse and other major cultural institutions as its neighbours (Juul Nielsen, 2012).

Thus, the first task was the programming of the area (figure 3). The choice of new functions for the area affects the ability to meet the DGNB(UD) criteria. Interviews with stakeholders were organized to inform those demands also described in DGNB(UD) criteria 38 *Participation*, 39 *Concept development process* and 41 *Municipal involvement*.

The dilemma concerning social diversity in DGNB(UD) criteria 16 *Social and Functional Mix* and economical balance in DGNB(UD) criteria 13 *Fiscal Effects on the Municipality* and 14 *Value Stability* is addressed in a new book by Gehl Architects, *Urban Spaces as a Platform for Growth* (Gehl, 2012), which inspired the choice of possible stakeholders to be interviewed as the publication had a holistic view on urban development by integrating both business functions and residential opportunities. The stakeholders interviewed were an urban planner from the Copenhagen municipality responsible for the area, the project manager of the Gehl publication as well as the CEO from the urban development project *Kvaesthusprojektet*, where private investors are investing in a subterranean parking space with a recreational urban square to service the playhouse and the urban area around the historic center of Copenhagen (www.kvaesthusprojektet.dk).

Based on this process, a spread of functions, their location on the site and the priority they were to

receive in the project concerning square meters were proposed. It was determined that the chosen combination of functions would enhance the compliance with several DGNB(UD) criteria within the social, the economic and the environmental categories.

The mix of functions chosen was by the qualitative interviews carried out with the stakeholders and an analysis of the existing urban grain and its functional character. The analysis showed that main cultural institutions, diverse shopping possibilities and a combination of sprawled and dense dwelling surround the area, whereas commercial leases are under-represented. Considering the DGNB(UD) criteria and their plea for mixing residential, cultural and commercial functions, the decision was made to emphasize commercial functions by creating a functional three-fold model with leases for one major company (25.000 m²), a total lease of 12.000 m² for small companies, 6000 m² for young entrepreneurs, 6000 m² for collective housing for entrepreneurs and 6000 m² for common facilities like open canteens, meeting facilities, auditoriums and workshops.

Partial Conclusion on the Findings of this Phase

The main issue investigated in the initial phase is whether DGNB(UD) alters the design process compared to how a traditional architectural design process or urban planning process would be laid out.

The early inclusion of stakeholders in the planning of urban areas is present as a demand in Danish legislation already, (By-og Landskabsstyrelsen 2007). The EU standard of Environmental Impact Assessment (EU 1985) also contains criteria concerning social diversity and social economic balance.

Thus, the social diversity of DGNB(UD) criteria 16 *Social and Functional Mix* is already demanded. The municipality and the property developers balance the economy in negotiations, but oftentimes the final financial model is rather a result of prevailing market based circumstances and long-term sustainable financial benefits are not always implemented.

In a Danish context, due to the existing legislation, the DGNB(UD) criteria 16 *Social and Functional Mix* and 38 *Participation* concerning the choice of stakeholders, choice of functions and priority and location of these functions and inclusion of stakeholders in the process, does not cause new design processes differing from existing architectural design processes.

The method of IED in general does not address this design phase and scale, and thus DGNB(UD) conveys new aspects to be taken into account compared to the IED method.

Layout of Site

IED – Different Scale but Same Design Method?

The IED process implicitly presupposes an architectural idea that can be optimized in a series of iterations. (Hansen *et al.* 2005) IED can help prescribe a set out geometry, but it depends on an architectural concept. The geometry approach of the IED method is that of reducing energy consumption for operating the building, and in this phase it would leave out a large part of the many other parameters that an urban scale architectural design process and a DGNB(UD) design process can include. In this sense, IED is not a relevant comparison at this stage.

However developments in software allow that some of the methods of IED can be extended into this phase. The CFD-based software Project Vasari can rapidly link to Google Maps and draw data from the nearest weather station. Very early, rough 3D models can be examined with the simulations tools concerning wind and solar energy (<http://labs.autodesk.com/utilities/vasari/>). This still does not solve the black-hole-problem of IED meaning that the design process implies an initial design concept as its starting point, even though software development means that even the earliest of urban concepts can be informed and assessed on a technical scientific level.

The DGNB(UD) criteria 3 *Changing Urban Microclimate* includes climatic comfort in the urban spaces of the development plan. This leads to a focus towards wind simulation as a design parameter, and thus the combination of Project Vasari and Autodesk Ecotect was chosen as the digital design tool because it made it possible to link simulations of shadow, solar radiation and wind in a reasonable timeframe for carrying out analyses. Simulating the wind conditions and solar environment on site provided useful information and guidelines for the design in an urban scale. By analysing prevailing wind directions, it was possible to reduce and improve the wind conditions in the areas with the most wind. Simulations were furthermore used to design building masses (overall geometry) in order to guide the prevailing winds around the urban district and not through it (figure 5).

Simulation of solar potential, movement of shadows and the number of sun hours in the urban space were carried out in every phase of the design period in several iterations (figure 4).

By analysing the simulations, it was possible to make evidence based decisions. For instance, the ideal locations of solar panels, material choice, people flow and park design decisions were affected by the simulation results.

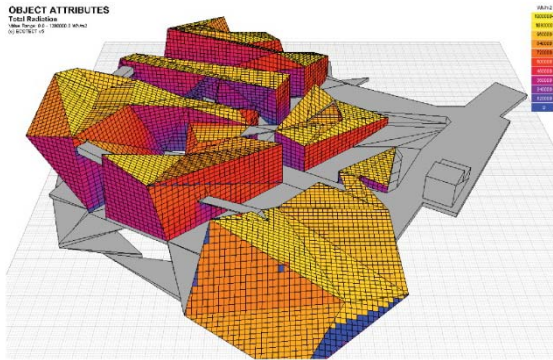


Figure 4. Simulation Results from Ecotect on the Proposed Building Volumes on the Paper Island

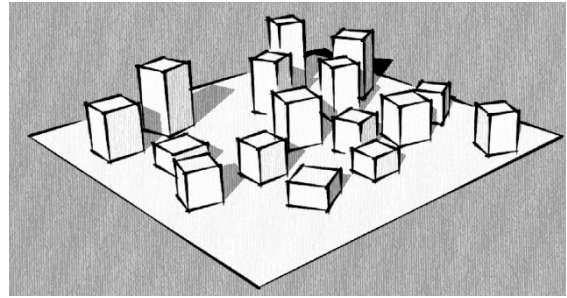


Figure 6. Design Concept 1

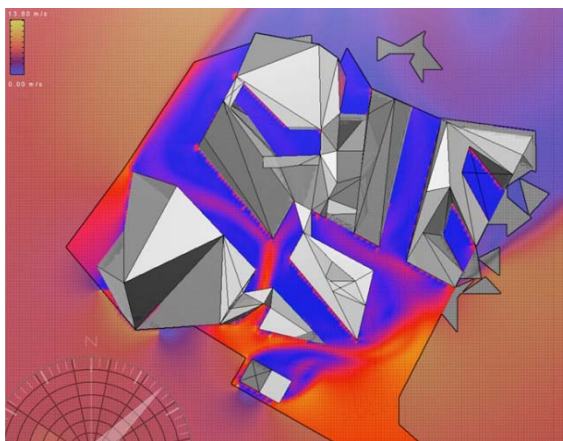


Figure 5. Simulation Results from Vasari of Wind Conditions at the Pedestrian Level Between the Proposed Building Volumes on the Paper Island

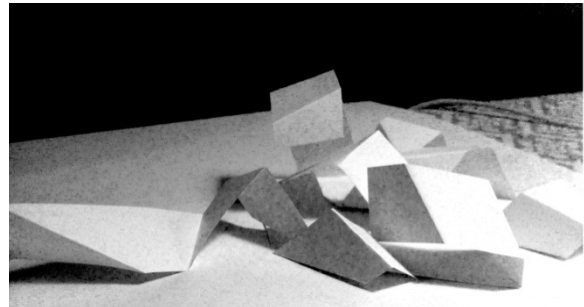


Figure 7. Design Concept 2

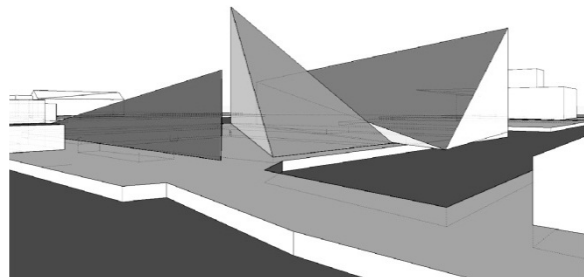


Figure 8. Design Concept 3

Architectural Design Process

To outline a possible effect of DGNB(UD) on the design process, 2 design methods are used: A traditional architectural concept phase and process, and a ‘DGNB(UD)-design process’ where a spread of design solutions for the site and functions were suggested to each DGNB(UD) criteria.

In a traditional architectural design process during the concept phase, the story behind the project, will to a large extent determine the initial work with building geometry. To start the process 3 concepts were developed, that complied with the decisions of the 1 phase. This is following the pattern of a general architectural design process.

The three design concepts each had a different volume concept. One proposal was based on small juxtaposed volumes resembling the scale of a town with streets, squares and alleys (figure 6). One was inspired by a landscape arranging a fragmented building mass in a hilly formation (figure 7). The last proposal was distributed in three major compact building volumes (figure 8).

DGNB(UD) Design Process

The 3 architectural proposals described above were screened according to 10 strategies, and the best fitted volumetric design concept was chosen to serve as a point of departure for the next stage in this phase (figure 9). The 10 strategies derived from the 45 DGNB(UD) criteria were chosen in the following way.

The first measure that was taken to handle DGNB(UD) as a design tool was to set up a generic framework for the workflow. The process of setting up DGNB(UD) as a design framework presupposed a selection of DGNB(UD) criteria relevant to this phase. All criteria were analysed for their design potential to influence the initial phase and the defining decisions. Each criterion was given a color code resembling their relevance on a scale from green (very relevant) to red (not relevant). Four criteria were ruled not relevant for the design process, six criteria were considered only to have limited

relevance for the design process, and 35 criteria were assessed to have major relevance with regards to the layout of the site.

The assessment of the relevance of each criterion was followed by a stage in which the relevant criteria were condensed into 10 interdisciplinary design strategies. This measure was taken out of two considerations: Firstly, the highly detailed criteria and load of content to be considered in the design process had to be made operational with regards to a design process. Secondly, a large part of the criteria were covering the same issues. To avoid a rigid workflow 10 “strategies” were formulated and applied to the design process.

The purpose of the 10 strategies was to comprise a “dramaturgy” for the iterative design process that would lead to a final volumetric design with proposed facade openings, distribution of functions and materials selection. Before commencing the actual design process within the matrix rolled out in the above, the site chosen had to be investigated in order to apply the strategies and thereby implicitly the DGNB(UD) criteria.

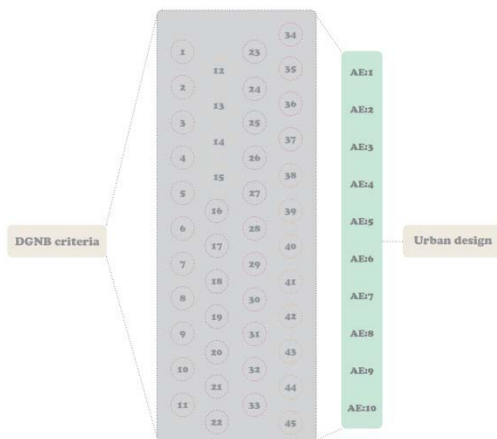


Figure 9. The 45 DGNB(UD) Criteria were Reduced to 10 Interdisciplinary Strategies to make the Criteria Operational

The DGNB(UD) design process was laid out as an iterative process with inspiration from the IED methodology. Quantitative studies (simulations of climatic design parameters like solar radiation, wind conditions and shadow range) informed the relevant DGNB(UD) criteria, were intertwined with qualitative design decisions informed by the specialists engaged in the study. This led to an iterative process in five steps, where the initial architectural design concepts were changed four times due to investigations of the current performance when analysed through the optic of the 10 strategies. The aim was to achieve an optimized building mass that addressed holistic sustainability measures, in both an urban scale as well as a smaller, building specific and user-oriented scale.

Partial Conclusion: Findings from this Phase

In order to be operational in a design process DGNB(UD) has to be reduced in complexity. However, the richness and broadness is one of the major new contributions of DGNB(UD) compared to IED. The question of how to preserve this quality and at the same time make DGNB(UD) operational is not clearly solved in the case. The highlight of 10 criteria was made from site specific considerations and experience with IED and architectural design methods.

Like IED the DGNB(UD) design process has a ‘black-hole-problem’ meaning that the DGNB(UD) criteria cannot create an initial conceptual form. Like IED, the DGNB(UD) process depends on a strike of conceptual thinking which the intuitive architectural design process can handle.

However the initial volumetric distribution of square meters (the priority and location attached to the functions) profited from the systematic approach in DGNB(UD). This meant that the choice between the architectural concepts was based on a deeper and broader level of information. For instance, focus on possible solar energy harvest, urban microclimate of public squares, transportation strategies, social diversity in choice of functions, reuse of existing buildings and biodiversity placed priority on multifunctional features in the concept. The concept that was chosen was the one that was considered to have the largest amount of such multifunctional potential. An example is the green roof that results in a high score in the DGNB(UD) criteria concerned with local handling of rainwater, urban microclimate, biodiversity, public squares and access to green areas. Likewise, the geometry chosen must create both a good urban microclimate (shield public squares for wind), enhance solar energy harvesting and enhance social diversity and activities.

DGNB(UD) does not dictate standard solutions and geometries because so many of the criteria address the relation to site-specific issues that are not exclusively dependent on orientation and climate region. However this singular case study cannot determine if DGNB(UD) in the long run, like IED, will have a tendency to enhance a certain set of standard solution. The focus on multifunctional solutions that will come out well in many criteria might lead to a tendency towards a set of standard solutions, like green roofs with public access.

Methods and software related to those developed for decades in the framework of IED but presently expanded to include wind and solar energy on an urban level create a good starting point for addressing and informing DGNB(UD) criteria concerning urban micro climate and solar energy harvest at a very early design stage. The comfort in urban spaces are much defined by the geometry of the buildings and DGNB(UD) thus actually serves as

a remedy to have a holistic approach to design of building volumes and urban spaces as a unit. DGNB(UD) advances decisions concerning buildings to a site-layout phase.

Architectural design methods are still needed to start the design process, but the take-off concerning iterations of technical scientific information can start from a very early stage hereafter because of software like Project Vasari. In this process, DGNB(UD) functions as a systematic way to ensure that a broad, holistic set of parameters are addressed apart from the 2 criteria that Project Vasari can optimize.

The combination of initial architectural design, software like Vasari and the DGNB(UD) criteria will lead to other solutions than would have come from a purely architectural design process or IED process. The keyword for these new design solutions is *multi functionality* understood as design decisions that will result in parallel good assessment in many DGNB(UD) criteria at the same time.

Design of Building Volumes Phase

Architectural Design

The architectural design process in this phase is traditionally about detailing and choice of materials whether it be a choice of glass for windows or surface of walls and facades. The project did not aim at this level. However several of the DGNB(UD) criteria address choice of materials and in this DGNB(UD) proposes something new.

Choice of materials effects several LCA-related DGNB(UD) criteria at the same time. For instance, the urban microclimate is affected by the choice of facade materials. The water handling criteria are affected if the facade materials create toxic downwash. Like in the layout design phase, the design of the building phase will be affected by DGNB(UD) in the sense that focus is on multifunctional solutions that will score well in many criteria at the same time.

The classic architectural design process is organized in a kind of zooming process going from large scale to small scale. This hierarchy of scale is severely challenged by DGNB(UD). DGNB(UD) introduces problems to be considered at an urban level, normally considered on a building detailing level. When reaching the building volume phase, most decisions are already made.

IED

The Design of Building phase is the central area of interest in an IED process. Here, the potential of optimizing the building in regards to energy balance and indoor climate can be realized in a series of iterations. As in the architectural design process, criteria concerning the buildings energy balance are considered in an earlier design stage than normal.

DGNB(UD) does not prescribe how the energy consumption of a building can be reduced in an urban design, but singular criteria place emphasis on solar energy harvesting on facades. However, a classic IED process would, in many cases, prove that an excess of solar energy on facades will lead to a cooling demand and thus an increase in energy consumption or an intolerable indoor climate.

DGNB(UD) Design Process

The role of DGNB(UD) in this phase is that of a checklist. It serves to conserve holistic decisions from the previous stages when challenged, for instance, by better indoor climate simulations as described above. In general DGNB(UD) has outplayed its role when reaching the building phase but implicitly a line of dilemmas and conflicting priorities exist in the transition between urban space and buildings.

Partial Conclusion: Findings for this Phase

The more elaborate design of the actual buildings in the scheme is the classic topic of IED. In IED, various simulations tools are used for optimizing the design in regard to energy and indoor climate. The process of informing the design of the geometry by simulations tools is the classic IED process.

A perspective added to the design process as compared to the IED process is that DGNB(UD) broadens the range of parameters considerably. For example, DGNB(UD)'s LCA-criteria includes the choice of building materials at a much earlier stage. The DGNB(UD) criterion of reuse of existing structures severely affects design solutions concerning LCA and choice of material because embodied energy in existing structures gets a role to play. Nontoxic and low-emission building materials can get a preference by DGNB(UD). Choosing to refurbish existing structures instead of building new ones is also a design that might be promoted by the LCA related criteria.

The holistic approach manifest in the 45 DGNB(UD) criteria draws attention to issues other than energy and the indoor climate of the building, which is the core of the IED methodology. Issues like materials, rainwater management and the distribution of functions are explicitly addressed in the DGNB(UD) design process, thus informing design decisions to a broader extent.

The choice of materials affects the energy and indoor climate calculations conditions. No simulations tools and methods are prescribed for assessing this relationship. In this respect, IED is more elaborate and specific and will thus inform the design decisions more precisely concerning energy and indoor climate conditions. The focus on solar energy on facades would not have been prioritized to this level in IED or an architectural design process.

The DGNB(UD) criteria 8 *Energy-efficient development layout* focuses on solar energy potential. Excessive solar energy on facades can increase the cooling demand and thus have a negative effect on the energy and indoor climate balance of a building, but this is not an issue in any of the DGNB(UD) criteria. In this regard, DGNB(UD) fails to give a holistic perspective on both building and urban spaces, whereas IED reaches further and deeper in this complex problem.

Conclusion

A DGNB(UD) design process introduces a wider range of sustainability issues very early in the design process – earlier than the IED and architectural design methods. However most of the initial inquiries concerning social diversity, choice of functions and inclusion of different stakeholders are addressed in the architectural design method.

Like IED the DGNB(UD) design process is in need of an architectural concept in order for the process to start. Neither can generate an initial layout. The intuitive approach to the initial form is not avoided by using DGNB(UD). However in later design stages, both IED and DGNB(UD) serve as decision making tools and thus as form generators. For example, the DGNB(UD) design method will draw focus towards design solutions that will be assessed well in a multitude of criteria. Only a limited set of solutions have this potential. There might be a potential risk or opportunity that a DGNB(UD) design process will lead to standard solutions, such as green roofs.

DGNB(UD) challenges an architectural design method by questioning the classic ‘zooming’ in scales. For example, the focus on LCA of materials when designing on an urban level provokes new approaches.

IED has developed over several decades, and the software industry has continuously facilitated with software for different sorts of iterations at different levels in the design process. In DGNB(UD), this is not the case. Certain areas such as climate comfort in urban spaces and the energy potential on facades can be addressed by software such as Project Vasari (wind and solar energy). For example, the work with LCA of materials on an urban level is not facilitated by software.

The relationship between choice of geometry and choice of materials are well developed on a building design level (classic IED subject), but the connection to decisions on an urban level is not facilitated by software. For example, the risk of high indoor temperature due to excessive solar energy harvesting is not addressed.

The interface between the DGNB(UD) and the building scale (DGNB building) calls for further

investigation if the DGNB should function as a design tool.

IED is very operational today after 2 decades of continuously advancement in facilitating software on a building level. However, IED is limited in the number of parameters that are varied in the design process which makes it operational. Using DGNB(UD) as a framework for design implies a step into a much broader realm of a multitude of parameters where the majority are not yet facilitated by adequate software. Therefore, it is necessary to narrow the criteria down in order to make it operational in a design process. In the case examined in this paper, a generic reduction or hierarchy was not obtained. The 10 criteria derived from the 45 were to a large extent site and project specific.

Discussion: Mapping of a Holistic Sustainability Design Process

It took 2 decades to make IED truly operational with a span of software development on the side track and a slow transformation of the building industry and design practice. DGNB(UD) introduces a wide range of criteria early in the design process, but the assessment of the design solutions for each criteria is not based on simulations or calculations. This makes the DGNB(UD) design process less objective than IED and the results more speculative. The question is why DGNB(UD) does not present simulations tools along with the criteria? For instance VISSIM (Vissim web) is a simulation tool that would give the assessment of the traffic related criteria considerably more substance. Concerning the management of rainwater, software that simulates the flow of water from different categories of rain exists. The same goes for LCA. In regard to a fast running design process, simulations also have an advantage because they can give information at the right pace and level. The research in the context of IED provides knowledge of how to use different simulation tools in different stages of the design process which could be transferred to DGNB(UD). In this respect, DGNB(UD) is a checklist that has the potential of developing into an intelligent design system. This could create the leap in information level that is needed.

The question of making a very rich and complex system operational in a design process without losing the complexity calls for further investigations. The lack of hierarchy in DGNB(UD) is carefully constructed together with the choice of criteria and assessment methods. However in a design process hierarchies are central.

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