

## II

### RESEARCH ARTICLES



# SUSTAINABILITY CERTIFICATION SYSTEMS AS GUIDELINES FOR EARLY-PHASE URBAN DESIGN PROCESSES

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## ABSTRACT

The German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen or DGNB) has one of the most comprehensive sustainability certification systems for urban districts (UD). Their explicit aim is that the system should impact the very earliest design decisions. The Technical University of Denmark has tested the DGNB-UD system in two experimental design projects for similar locations to find out how it can be used in the early-phase design process. This paper describes these two independent design processes, compares them and discusses their general features.

We found that DGNB-UD addresses a broad sustainable focus and can be used as a tool for setting sustainability goals from the very first design steps. The system tends to promote multifunctional compromise solutions that meet several criteria at the same time. Using the DGNB-UD certification system in the early design phases therefore does have some effect on the urban design in terms of a bias towards certain design traits.

## KEYWORDS

urban design, urban design drivers, earliest design phases, German Sustainable Building Council

## INTRODUCTION

A great many of today's societal challenges are expressed in a condensed form in the field of urban design. The challenges are numerous and involve climate change and CO<sub>2</sub> reduction issues, which again are linked to health and social stability problems. This complex knot of interlinked aspects is at the heart of urban design. There is a demand to manage this complexity in a systematic design process in which very large amounts of information on all aspects is infused in the earliest design phases. Based on a decade of research, the Deutsche Gesellschaft für Nachhaltiges Bauen has proposed a certification system for urban design (DGNB-UD) that contains all this complexity. The 45 criteria are arranged in 5 sub-groups: environmental quality, economic quality, sociocultural and functional quality, technical quality and process quality. Every criterion is assessed through measurements, simulations or initiatives and accounts, through a weighting, for the overall score.

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With these 45 criteria, the entire range of issues that impact on the sustainability of an urban scheme are taken into account. But is it practical in an open-ended, interdisciplinary architectural process? And if it is, how can it be made operational in the early-phase design process and what kind of design process does it lead to? And last but not least, will working with DGNB-UD from the very first sketches of an urban design project dictate specific design features?

## METHOD

To answer these questions, two test design projects were developed over a three-month period of time addressing the same area and problems. Two groups of qualified students with both architectural and engineering skills tried out using DGNB-UD from the conceptual phase and onwards. The two teams had several design projects in their portfolios working with integrated design as a means of achieving large amounts of information in all design phases. The two design teams did not know each other and did not communicate. In this project, they were able to plan their own design process entirely as they wanted. Both groups aimed at achieving the highest score for their urban design for a neglected industrial area in the Copenhagen docklands. One group was working with the Paper Island, and the other group worked with Teglholmen. At the end, the design processes and designs developed by the two groups of students were compared and discussed.

## RESULTS

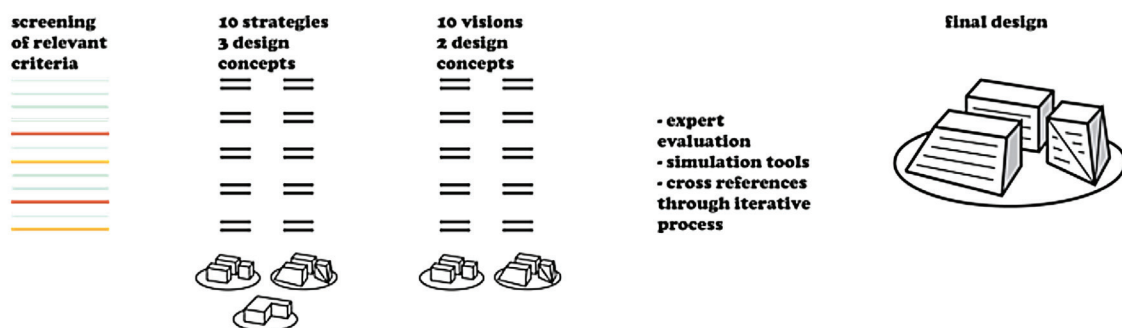
### Case study 1: The Paper Island Project.

The site of the first project for investigation was “Paper Island” – a centrally located islet in the centre of Copenhagen, prominently located next to the Royal Opera, the National Theatre, and a number of other central urban amenities. The warehouse function of the islet had come to an end in 2012 – five years before the expected lease termination. A typical site for urban development in a neglected industrial area, the site was chosen for testing out the efficiency of the design-driving capacity of DGNB-UD.

The design process of the Paper Island was designed and applied through the following steps: screening of relevant criteria, development of 10 design strategies, application of the 10 design strategies, expert evaluation and final design proposal.

**FIGURE 1.** The Paper Island design process. Diagram depicting the entire design process developed by the team.

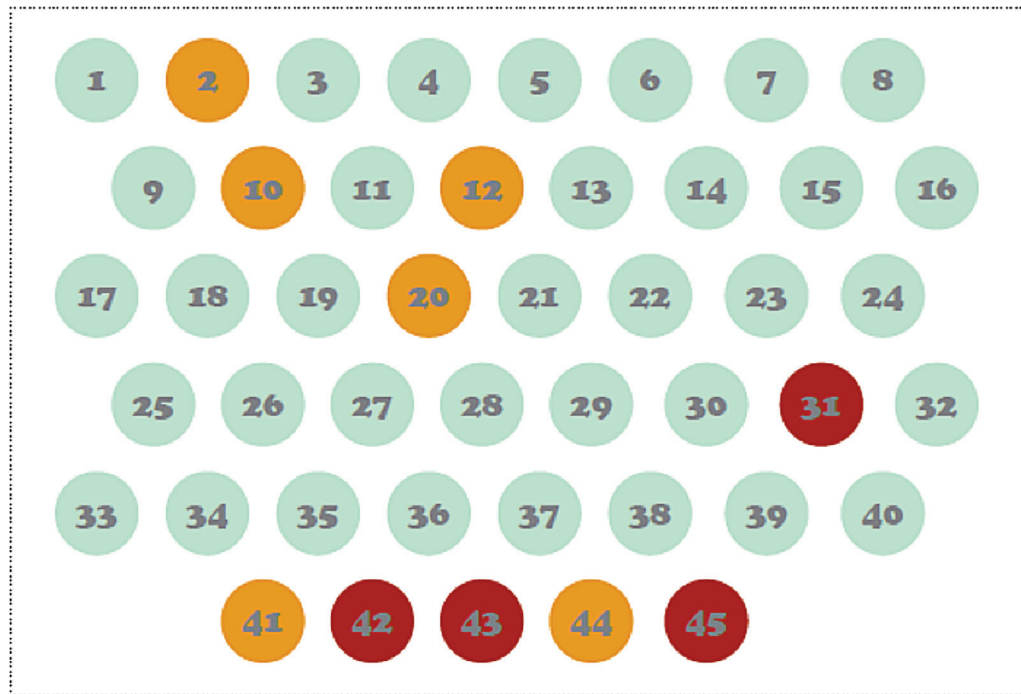
#### Design process for the Paper Island Project



## Screening

The design team developed a method in which they started the design process by screening all 45 criteria of the certification system to identify exactly which criteria could be used as design drivers. Of the 45 criteria, 35 were found to be very relevant as urban design drivers, six were found to be of limited relevance as urban design drivers, and four were found to be of no relevance as design drivers.

**FIGURE 2.** An overview of the DGNB-UD criteria with high relevance (green), limited relevance (yellow), and no relevance (red) as architectural design drivers developed by the team.



## 10 design strategies based on the selected criteria

To organize and operationalize the 41 criteria with full or limited relevance as urban design drivers, the team developed ten design strategies aimed at embracing all the relevant DGNB-UD criteria. Furthermore, the team aimed at merging classical civil engineering theory and tools with classical architectural practice in a cross-disciplinary way to accommodate both the qualifying and the quantifying aspects of the DGNB-UD certification system (the 10 strategies below). These ten strategies translated information and requirements from the 41 relevant criteria into operational design guidelines without being directly linked to specific DGNB-UD criteria.

### The 10 Strategies:

- **Programming:** Creating the right mix of functions and users in the area
- **Light:** Working with good daylight design in buildings and urban spaces
- **Density:** Creating the right density of buildings and functions
- **Materials:** Choosing building materials based on life cycle assessments and life cycle costs

- **The blue and the green:** Implementation of sustainable rain water management and vegetation
- **Wind environment:** Optimizing wind flows through public spaces to encourage leisure activities and protect buildings
- **Energy and resources:** Renewable energy, energy infrastructure, and waste infrastructure
- **Transport infrastructure:** Implementing ways of getting to and from the site as well as on-site transport
- **Process:** Creating an efficient framework for the design process, using recognized models and strategies
- **Aesthetics:** Creating an aesthetic narrative to give the area its own identity.

### ***Applying the 10 strategies***

This methodical screening was followed by an architectural investigation of the site and its potential in sketches – an analysis derived from traditional architectural practice. In particular, the team enquired into the islet's historical value and its potential for being an infrastructural key to natural flows in the city. Important ideas and positions from academic and political discourse relevant to the site were considered. This phase functioned as an intermediate phase between generating the 10 strategies and applying them. The design team formulated a context-specific vision for each of the 10 design strategies, which was then elaborated upon, resulting in explicit standards for the design to work with. The design process was open in the sense that the team used a high degree of improvisation and intuition to incorporate the 10 strategies into design concepts. (Figure 3).

### ***Evaluation***

The team had arranged a “board of experts” to support them throughout the design process. This board included researchers in the fields of rain water management, infrastructure, building materials, construction and architecture from the Technical University of Denmark. Moreover, professionals from the construction industry and their peers from relevant planning authorities also contributed with expert knowledge throughout the design process.

Based on the evaluation by experts and estimation of scores in the DGNB-UD system two design concepts were chosen (fig. 3).

The process was documented through a log showing the iterative procedure by which the group would focus on one strategy at a time and revisit it later, when other strategies proved to impact on that strategy.

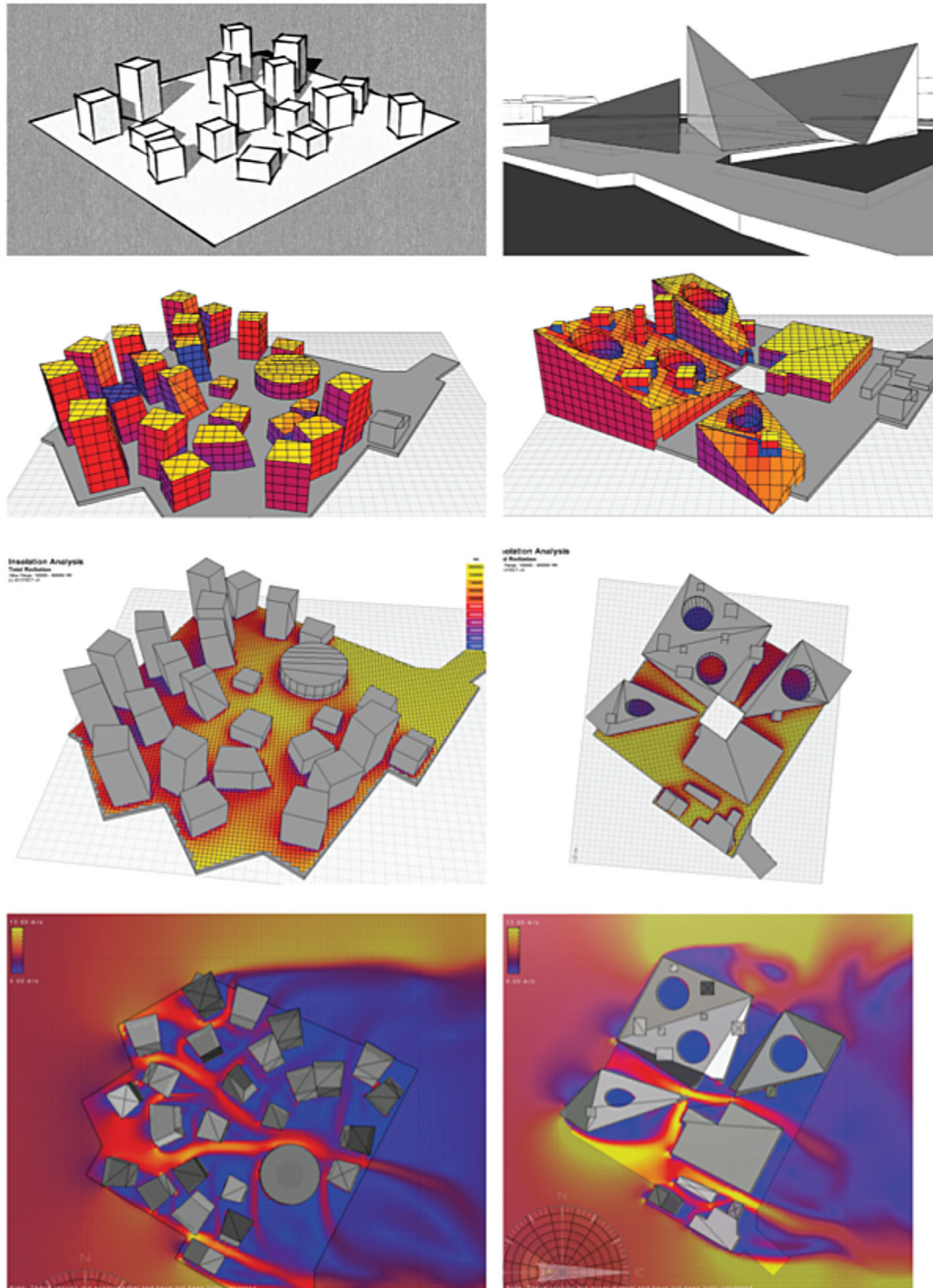
### ***The final design***

The final design proposal (Figure 4) was selected on the basis of a second evaluation in the light of the 45 criteria of the DGNB-UD certification system. This evaluation revolved around how the 45 criteria had been incorporated in the two design concepts, along with a discussion of the specific benefits in respect to each criterion.

Table 1 shows the correlation between DGNB-UD criteria, the 10 operational design strategies developed to address all the individual DGNB-UD criteria, and the information input and simulation tools used to qualify and quantify the design process.



**FIGURE 3.** The design process evolved around two (three) sketch proposals based on programming requirements. Each Sketch proposal underwent quantitative evaluations: Solar potential analyses for facades (top row) and urban spaces (middle row), wind analysis (bottom row). Qualitative assessment where involved to adjust and optimize the proposals.



**FIGURE 4.** The Final sketch proposal and its validating simulations: Volumetric concepts (top), Solar potential analysis for facades (top Middle), Solar potential analysis for urban spaces (bottom middle), wind flows from prevailing direction (bottom).row). Qualitative assessment where involved to adjust and optimize the proposals.

### ***Paper Island Project – a partial conclusion***

Using DGNB-UD as a ‘design tool’ challenged ‘traditional’ architectural design phases. The design proposal resulting from the iterative design process had a level of detail best described as being between an elaborate brief and a sketch project. The team found that quite a few of the criteria were too detail-oriented, when the criteria were used as literal and quantitative guidelines. An example is the emphasis on life cycle assessment (LCA), which has a prominent role in the current system. DGNB-UD expects a full LCA as part of a final certification, but as a design driver, a full LCA makes little sense due to its great detail. Nevertheless, the team found that with a little effort, most of the criteria could be used as design drivers, if the criteria were reformulated to take a catalysing/generic rather than a validating approach.

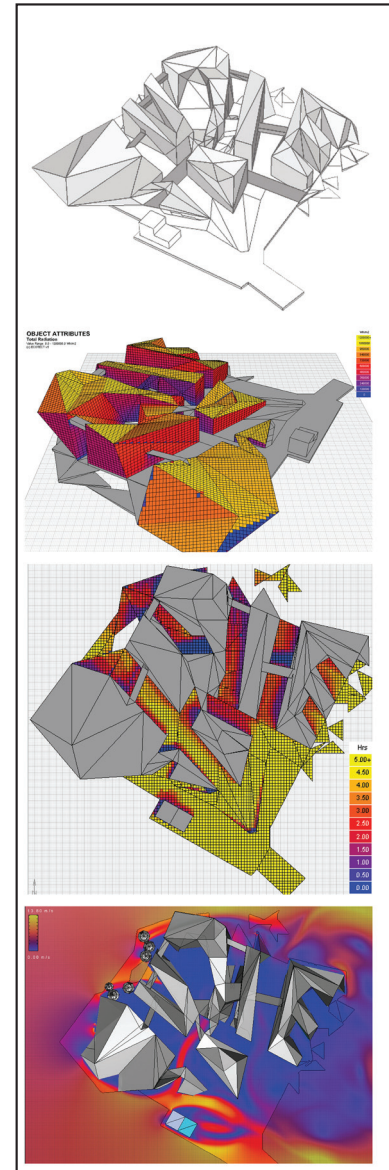
As a certification tool, DGNB-UD brings into play a discussion about *quality* vs. *quantity*. The team found that the balance worked well in this project. Keeping in mind that DGNB-UD was developed primarily as a validation tool, it is no surprise that the main emphasis is on quantitative aspects.

The approach chosen in this project was to stay loyal to the flat structure of DGNB-UD and regard all (relevant) criteria as equally important for the design process. This resulted in a rather generic sketch design that needs further development to achieve identity as an urban driver and as architecture. In this sense, DGNB-UD did not lead to any specific design features as such; the final project has a more generic character. However, some of the design features, such as green roofs with public access, became part of the final proposal because they had high scores in several of the 45 criteria.

The ambition of making DGNB-UD both the objective and the tool to reach this objective naturally creates an inner tension. As a qualitative tool for sustainability implementation in the urban design process, DGNB-UD works well as a constant ‘reminder’, but as a quantitative tool in the design process, it makes the process very complex and too detailed.

### **Case Study 2: The Teglholmen Project**

Before 1916, Teglholmen, another islet in Copenhagen Harbour, consisted mainly of a clay pit providing material for Copenhagen’s tile, brick and chalk factories. In 1916, it was decided to transform the pit into a dock area, and the area housed several industrial yards and foundries





**TABLE 1.** The correlation between criteria, design strategy and information/tools used

DGNB-UD criteria	Design strategy	Information input/simulation tools
1, 3, 9, 12, 19, 25, 26, 32	Materials	Expert interview Literature study including Jan Gehl's 12 quality criteria from <i>Life between buildings</i>
4, 6, 10, 13, 14, 15, 16, 17, 19, 21, 23, 24	Programming	Expert interview Literature study incl. Jane Jacobs, Richard Florida and Høgni Hansen
3, 6, 8, 15, 21, 23, 24	Urban density	Expert interviews Literature study including Gehl Architects
2, 3, 4, 5, 19, 21, 30	Blue and green design	Expert interview Maps on rising sea water level, hydraulic conductivity and infiltration range
11, 24, 25, 29, 30, 33, 34, 35, 36, 37	Infrastructure	Expert interview Site data (planned initiatives by municipality)
3, 7, 8, 19	Sun	Sunlight hour potential analysis using Autodesk Ecotect Solar energy potential analysis using Autodesk Ecotect
3, 19, 21	Wind	Project Vasari Literature study including Jan Gehl's 12 quality criteria from <i>Life between buildings</i>
3, 7, 8, 28, 29	Energy performance	Autodesk Ecotect Analysis Political strategies/plans
23, 38, 39, 40, 41	Process	Literature study including Hirotaka Takeuchi and Ikujiro Nonaka
4, 13, 19, 21, 25, 26, 27, 44	Aesthetics	Expert interview, 'critique', and pin-up.

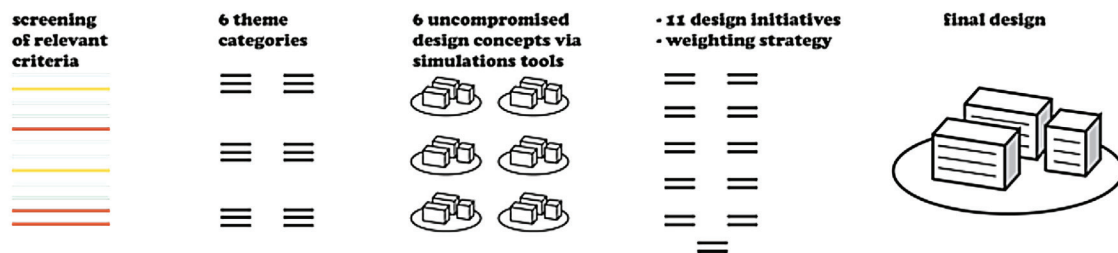
throughout the 20th century. In 2005, the municipality of Copenhagen decided to re-populate the gradually deserted Teglholmen and made a masterplan for the area. The old factory buildings had been demolished over time and a clean canvas created an opportunity for doing urban design from scratch on its 20 acres.

The design process of Teglholmen was designed and applied through the following steps: screening relevant criteria, development of six theme categories, development of six uncompromised design strategies, combination of six design strategies through 11 broad design initiatives and final design proposal.

The approach for Teglholmen aimed for a high score in terms of DGNB-UD as an expression of the most sustainable solution. The initial phase for this design group evaluated the DGNB-UD criteria in the context of the existing Teglholmen and the masterplan drawn up by the municipality.

**FIGURE 5.** The Tegllholmen design process. Diagram depicting the entire design process developed by the team.

#### Design process for the Tegllholmen Project



#### Screening of relevant criteria

Creating a design that would fit in the surroundings and meet the expectations of the community was the main issue for the team, so the first step in the initial phase compared the scope of the municipality's masterplan with the criteria presented in DGNB-UD. The team discussed how some of the DGNB-UD criteria would contribute to a broader and more sustainable perspective for the masterplan and how the municipality addressed other important issues than those included in the DGNB-UD criteria. This process ended up excluding the DGNB-UD criteria that did not comply with the overall purpose of the municipality's ideas and hopes for the area. Furthermore, DGNB-UD addresses the quality of the planning process, but the municipality had already created the basis for a high quality process by implementing the public hearings that are required under Danish legislation, so these DGNB-UD criteria were excluded as well.

The framework for choosing the final criteria from DGNB-UD was created by investigating the city structure. Some DGNB-UD criteria refer to large city grids of sewer and electrical systems ('28 Energy Technology' and '31 Information and Telecommunication Infrastructure'). Others address distinct add-ons ('27 Art in Public Space' and '10 Local Food Production'). These criteria were excluded due to their limited influence on the initial design phase of an urban district's structure and form.

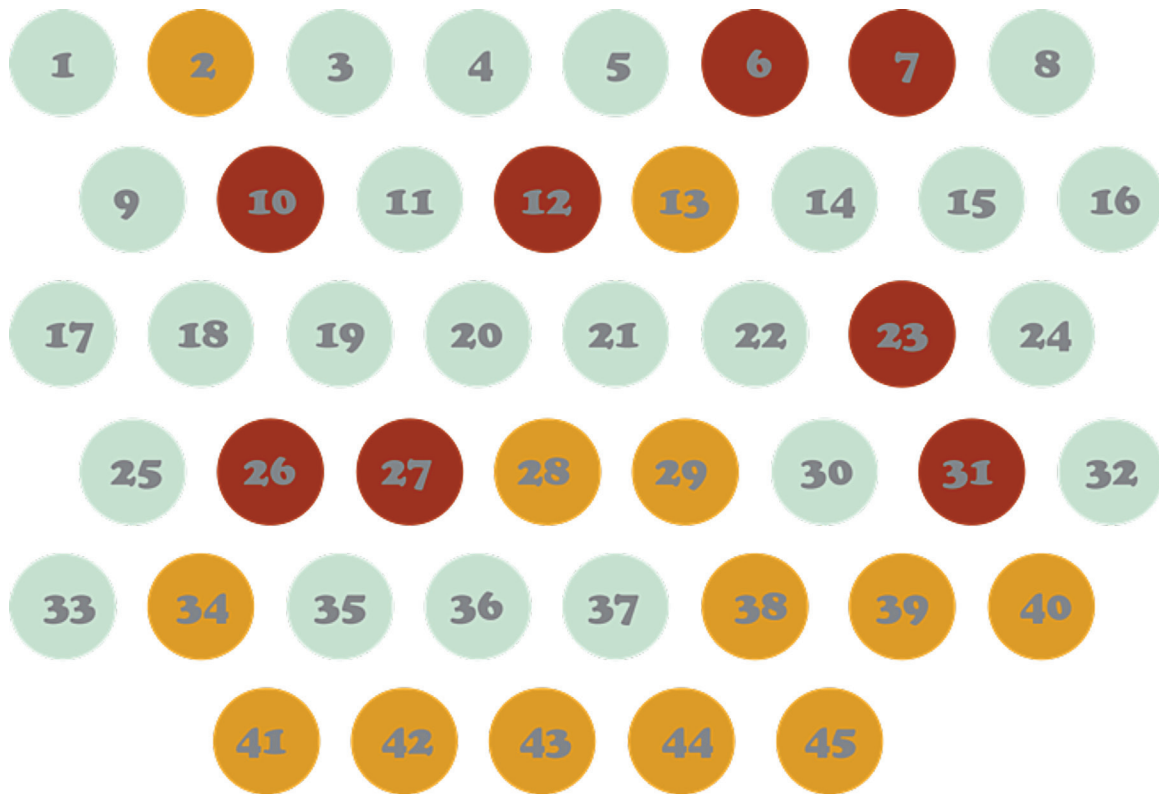
#### Development of six theme categories

This initial phase resulted in the selection of 24 criteria that were all seen as very relevant to the design process for Tegllholmen. These 24 criteria were classified under 6 new theme categories created by the design team (not to be mistaken for the criteria groups in the DGNB system). Each theme category referred to background knowledge and discourses in urban design. This would ensure 6 different approaches in the design process, all aiming at high scores.

The six themes created by the design team:

1. Cultural and social quality (DGNB-UD criteria 19, 14, 16, 18, 4)
2. Comfort in urban spaces (DGNB-UD criteria 3, 20, 21)
3. Architectural design (DGNB-UD criteria 25, 15)
4. Climate change adaption (DGNB-UD criteria 11, 30, 5)
5. LCA (DGNB-UD criteria 1, 8, 9, 32)
6. Infrastructure (DGNB-UD criteria 17, 22, 24, 33, 35, 36, 37).

**FIGURE 6.** An overview of DGNB-UD criteria for Teglholmen with high relevance (green), with limited relevance or already managed under Danish legislation or the local masterplan (yellow), and of no relevance, in conflict with or not mentioned by the local master plan (red), as architectural design drivers.



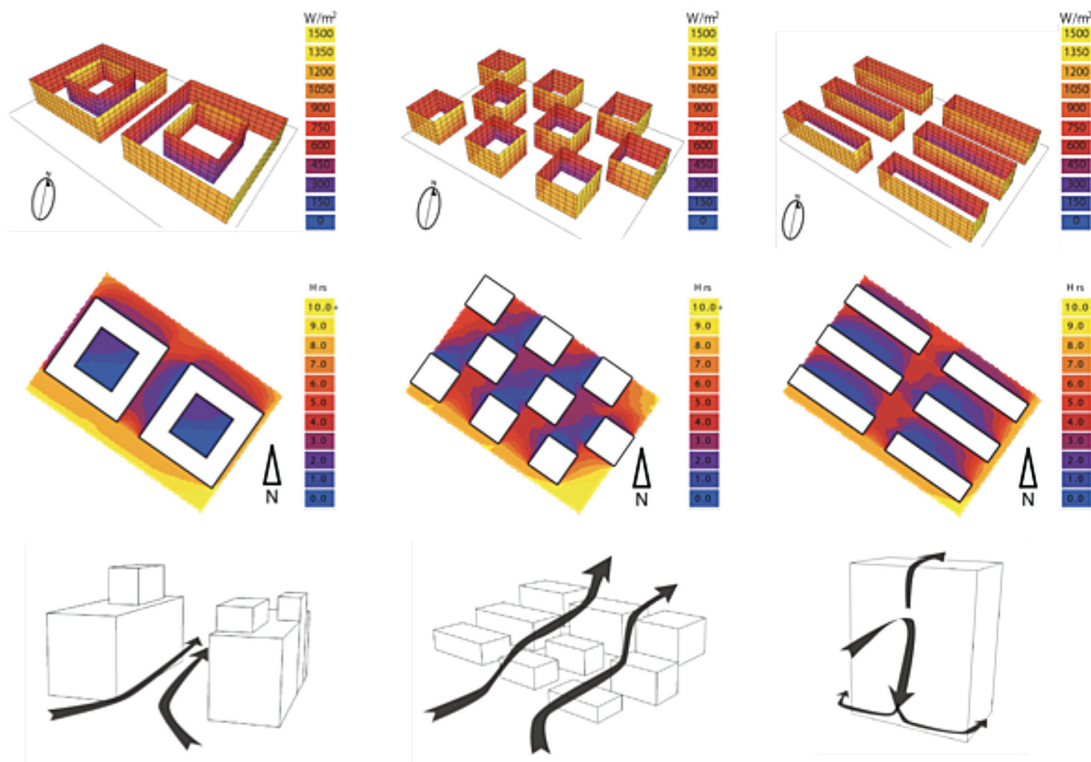
### ***Development of six uncompromised design strategies***

Within each theme, an uncompromising design proposal for the layout was developed. The theme was allowed to fully dictate the design decisions in order to obtain the highest DGNB\_UD score in that specific category. The optimal design was found and documented by using simulations tools.

In the category ‘LCA’, for instance, the team conducted an expert interview on materials and various LCA approaches used in cities globally. The criterion ‘8 Energy-Efficient Development Layout’ refers to the possibilities of harvesting solar energy from building façades, and a study on different urban typologies was carried out using Autodesk Ecotect as simulation tool (figure 7). Another theme, Climate change adaptation, was framed by the drainage and flooding maps from the municipality of Copenhagen that provided the basic information for a design strategy within this theme. For the theme category Cultural and social quality, Jan Gehl’s social theories from *Life Between Buildings* were used as the design driver because there are no simulation tools that cover socio-cultural aspects.

The original weightings of the DGNB-UD indicators were considered when evaluating and choosing the optimal focus area within each theme category (Table 2). For instance, in the category of ‘Architectural design’, two criteria framed the design: ‘15 Efficient Land Use’ and ‘25 Urban Design’. The weighting of the first was significantly higher than the weighting of the second, so the uncompromising design focused mainly on minimal land use.

**FIGURE 7.** Simulations for three different typologies. Top: the solar potential on the façades; middle: solar potential in the space between buildings; bottom: wind environment desktop studies.architectural design drivers.



Efficient land use is also the strategy highlighted by Echenique et al. (2012), who argue for the dense city as the most sustainable development strategy for cities. On the other hand, DGNB-UD criteria such as ‘19 Public Space Amenity’ and ‘21 Open Space Offer’ call for green areas and a high sunlight potential in public spaces. For Troy (2014), these criteria should be met with a less dense city form, which also has a less stressing effect on the city structures. Troy therefore believes less dense cities to be the most sustainable solution. The question, however, is which development form gives the best social advantages in terms of comfort and walking distances. This was another example of the complexity within the DGNB-UD system and the theories behind. The Teglholmen design process aimed at densifying a central area in the city harbour and therefore chose the more compact development process advocated by Echenique et al. as the most sustainable solution.

### ***Combination of six design strategies through 11 broad design initiatives***

The basic design decisions were made by combining all six uncompromising designs. Where the designs did not conflict with each other, the one with the highest score was chosen. Moving from the layout of the masterplan to working with the geometric volumes of buildings, this method resulted in 11 broad building-scale/urban layout design proposals that addressed surfaces, parking, functions and typologies, wind environment, green areas, lighting, re-using earth, materials, public transport, public ground levels, and the existing geography. Each of them addressed several criteria; for example, an effective parking strategy addressed ‘20 Sound

**TABLE 2.** The 6 theme categories, the criteria attached to each theme, the weightings in percentages, and the simulation tools used for evaluation.

Category	Criteria	Simulation tools
LCA (8.9%)	1 (2.7%), 8 (1.8%), 9 (1.8%), 32 (2.6%)	Expert interview Solar energy potential analysis using Autodesk Ecotect
Comfort in urban spaces (7.2%)	3 (2.7%), 20 (1.8%), 21 (2.7%)	Sunlight hour potential analysis using Autodesk Ecotect Noise map Desktop studies of wind environment
Cultural and social quality (11.7%)	19 (1.8%), 14 (4.5%), 16 (1.8%), 18 (1.8%), 4 (1.8%)	Realdania City Jan Gehl
Architectural design (8.6%)	25 (1.8%), 15 (6.8%)	Architectural concept
Climate change adaptation (7.6%)	11 (1.8%), 30 (4%), 5 (1.8%)	Maps on rising sea water level, hydraulic conductivity and infiltration range
Infrastructure (14.2%)	17 (1.8%), 22 (1.8%), 24 (2.7%), 33 (4%), 35 (1.3%), 36 (1.3%), 37 (1.3%)	Expert interview

Emissions and Sound Insulation', '22: Inclusive Access' and '33-37 Transport Systems and Infrastructure', among other criteria.

### ***Final design proposal***

Using this method, the design concept was created directly from the DGNB-UD criteria. The 11 design proposals did not form a whole, but worked like pieces in a jigsaw puzzle to be combined for the final design solution. This was a trade-off process taking the different weightings into account and discussing feasible options that scored high in several DGNB-UD criteria at the same time.

### ***Teghlolmen Project – a partial conclusion***

The building-scale/urban layout design features that met several criteria at the same time came out as the best solutions when assessed by using DGNB-UD as guide. In this project, they were:

- - smooth surfaces aiming at comfort e.g. for wheelchair users and prams,
- - a multi-storey car park located near the entrance to the area,
- - public-access green roofs,
- - public-access ground floors.

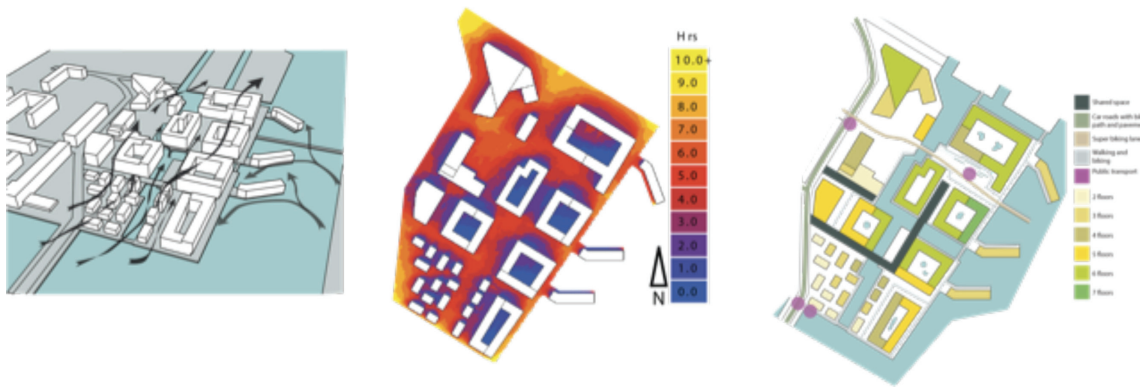
### ***Partial Conclusion for the Teghlolmen Team***

The quality of Urban Design (criterion 25) is only one out of 45 criteria in DGNB-UD, and there is a risk that the quality value of the design has too little weight when an architectural concept is not developed from the beginning. However, DGNB-UD calls for the system to



be used from the earliest design phases, so there is a built-in dilemma between architectural quality and the more quantitative criteria. This dilemma is especially apparent in the very diversity-demanding criterion, '16 Social and Functional Mix', with its balance of buildings for public/private and business/housing. Here the DGNB-UD guidelines are quite limiting and prescriptive and do not work together easily with a strong architectural concept. In this phase of the design process, 'architectural value' tends to have a lower weighting than solutions found in the 'infrastructure' or the 'cultural and social quality' theme categories that quantitatively demand certain solutions and are therefore easily met without an architectural concept. Moreover, within the theme category of 'architectural design', the actual urban design has less than 25% of the weighting (the rest is taken up by '15 Efficient Land Use'). So it must be concluded that the DGNB-UD guidelines indicate the compact city as the most sustainable solution.

**FIGURE 8.** Analyses of wind environment, solar access, infrastructure and building height in the final design proposal



The need to adjust climatic comfort parameters and environmental criteria in particular to meet country-specific standards is another significant point to consider. For instance, the approach towards rainwater and wind should be a matter of discussion. With regard to wind, a separate design process was developed in this project to enable a design decision suited for the location. The ambiguous DGNB-UD weighing of wind as quality more than risk was addressed by using the skimming effect to create a comfortable low-velocity wind environment and at the same time reduce the urban heat island effect by implementing canals and green areas. (In Denmark wind is more a risk than a quality).

As a more general remark, it was notable that inspiration from other sources was necessary in the theme category 'Cultural and social quality' to make it possible to create design proposals based on social indicators. Gehl's (2007) methods proved valuable for finding specific geometrical solutions. Some rather blurred indicators from DGNB-UD were not helpful as design indicators in the ongoing design process.

## CONCLUSION

The DGNB-UD inspired design process of Tegllholmen had a very straight forward score weighting structure compare to the iterative structure found in the Paper Island process. It resulted in design with a high degree of visual diversity and iconic sustainability proposals.

The question is whether visual and iconic proposals can also promote sustainable development and be used to educate citizens to have a more sustainable everyday life. Using DGNB-UD in a design process does not point to specific technical solutions as such, but this kind of visual 'education' and the iconic sustainable design features both score well in the DGNB-UD certification for the district and also indirectly encourage the implementation of more technical solutions later on, such as infrastructure and rainwater management, due to the higher level of sustainability consciousness amongst the inhabitants of a DGNB-UD-certified district.

Both teams had to reduce the number of criteria to make using DGNB-UD practical in the design process. And both teams 'translated' the reduced number of criteria into an intermediate level that sought to create a synthesis of the many parameters.

The Paper Island team developed a process close to 'traditional' architectural practice, in which intuition and improvisation were used to work with the reduced and 'translated' criteria. They formed architectural design concepts quite early and used the DGNB-UD as a kind of 'check list' to inform their design decisions indirectly. However, the team's final proposal was loyal to the 'flat' structure of the DGNB-UD system and the constant evaluation of design ideas in relation to DGNB-UD weightings. According to the team's own evaluation of the final design, it lacks distinct architectural identity in spite of their early forming of architectural concepts based on an artistic, intuitive synthesis of the many parameters. The closer the team kept to the quantitative character of the DGNB-UD system, the more complex and blurred the design process seemed to become.

The Teghlholmen team developed a design process in which the design concept was created directly from DGNB-UD criteria. By keeping the original weightings of the criteria and by directly linking the DGNB criteria to the theme-categories developed by the team to start the design process, the Teghlholmen team stayed closer to the DGNB-UD structure. They did not find the design process too complex or 'blurred'. However, keeping close to the structure of the system created situations where the space for making design decisions was narrow. Unlike the Paper Island team, the Teghlholmen team did not involve an external board of experts, but used the DGNB-UD system as such.

Despite their aim of pushing the design process to the extreme with their phase of 'uncompromising' design proposals, the Teghlholmen team felt that their final proposal was a bit vague and lacked character. The more formal analysis pointed to the fact that urban design is weighted low in the system. In that sense, it could be concluded that DGNB-UD could influence the aesthetical quality of urban design in a negative sense.

Both teams noted a tendency to favour what could be called 'multifunctional features': architectural traits capable of addressing several criteria at the same time: e.g. green roofs with public access. This could indicate that using DGNB-UD in the early design phases might favour certain traits.

And both teams felt the need to add tools to facilitate the decision-making in the design process. These could be quantitative tools such as simulation software for gaining information on the effect of wind and rainwater on the urban design in question. But the need was also felt in relation to social aspects, for which both groups independently included Jan Gehl's methods in their processes.

With regard to the question of whether DGNB-UD prescribes specific technical solutions, the two teams answer in different ways. The Paper Island team points to a break with the traditional scaling of architectural design processes where the designers go from a more generic view to a more specific and detailed solution. In the DGNB-UD process, the demand

for a high level of detail is apparent in relation to LCA, but the flat valuation of many criteria simultaneously creates a bias towards remaining at a generic level, even in the final design proposal.

The Tegllholmen team is more explicit in arguing that the DGNB-UD system does not prescribe specific technical solutions. Instead, visual, iconic indicators of sustainability in a broad sense are valued in the DGNB-UD system. These, in a transferred sense, could create a kind of ‘mindfulness’ for certain technical solutions later on.

To conclude, DGNB-UD addresses a broad sustainable focus and can be used as a tool for setting sustainability goals from the very first design steps, and it might even be a means to create sustainable inputs to everyday life later on. The system tends to promote multifunctional compromise solutions that meet several criteria at the same time, and it encourages interdisciplinary work from the very first design steps. However, it can be relevant to involve other design parameters to achieve a broad sustainable urban design. Using the DGNB-UD in the early design phases does have some effect on the urban design, but further work is needed to demonstrate clear evidence of a bias towards particular design traits.

The system can be used as a check list to measure solutions against, but it can also be applied more directly with early-phase design solutions being explicitly derived from the analysis of criteria weightings.

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