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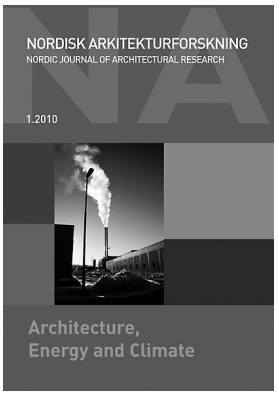

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NORDISK ARKITEKTURFORSKNING – NORDIC JOURNAL OF ARCHITECTURAL RESEARCH

Three types of environmental efforts – behavioural changes, technical development, architectural design

Claus Bech-Danielsen

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Abstract:

In this article three generations of sustainable constructions in Denmark are presented, and on this background three types of environmental efforts in the built environment are pointed out. In one of them the environmental results are achieved through development of techniques, in another type the environmental results are achieved through changes in behaviour, and in the third type the environmental results are achieved through architectural design.

It is important that architects are aware of the different types of environmental efforts. Firstly, they can all lead to significant environmental results, and therefore they should all be considered in relation to specific projects. Secondly, it is important that the three types of environmental efforts are combined and planned in relation to each other in order to make them interact in fortunate ways.

Finally, the article emphasizes that architects in the initial design phase make a series of choices that are crucial to resultant consumption in the construction – and that the environmental considerations can act as the fundamental architectural idea.

Keywords:

Sustainable constructions in Denmark, change in behaviour, technical approach, architectural approach..

Introduction
In Denmark the first environmental efforts in constructions were developed about forty years ago (Jensen, 1994). Subsequently, there have been three generations of sustainable constructions. In all three, the objective was to reduce the environmental impacts of construction, but the environmental outcomes were achieved in different ways.

In the 1970s environmentalists and grassroots movements - at the tail end of the youth revolt and as part of a protest against 'bourgeois life' in the established community - experimented with alternative ways of living (Jensen, 1994). They quit their jobs in modern society and moved into production collectives where they grew their own vegetables in order to rediscover the fundamental qualities of life and by using inexpensive recycled materials in DIY construction they freed themselves from the economic constraints of the wider community. 'Sustainability' was not yet a topic, but many of the changes and efforts of the grassroots movements became fixtures in sustainable constructions of the following decades.

In the 1980s engineers, researchers and technicians entered the scene. The report of the Brundtland Commission, launched in 1983 and published in 1987, identified 'sustainable development' as an important societal goal (World Commission 1987), and it was realised that 40-50% of total energy consumption in most Western countries are used for construction and operation of building (Østergaard 1992), and as such focus was put on buildings and settlements. Thus the efforts of increasing insulation standards, which had been an important goal since the energy crisis in 1973, was extended and expanded with the development and use of other forms of resource saving techniques (heat exchangers, solar panels, water saving fittings, etc.). Also there was increased focus on environmental management and on the use of software and LCA analysis (Dinesen et al. 1997), which charts the total environmental impact from cradle to grave.

Finally, in the 1990s the architects entered the scene. From an environmental perspective both grassroots and building engineers had achieved interesting results, but the architectural outcome was less satisfactory (Bech-Danielsen et al., 1997). As a result, sustainable constructions were only attractive to a narrow group of residents, and during the 1990s awareness arose that sustainable constructions had to be designed in modern and beautiful architecture in order to create credible alternatives to conventional solutions. And it was realized, that architects during the design phase make a series of choices that are crucial to later consumption in the building. Therefore, initiatives were taken to have the environmental considerations taken into account in the architectural design, and in some projects the environmental considerations even became the fundamental architectural idea.

The three generations of sustainable construction show three different types of environmental performance. Grassroots primarily achieve their environmental results through a *change in behaviour* (habits, routines, patterns of consumption etc.). Engineers primarily achieve their environmental results through *development of technologies* (constructions, materials, insulation techniques, renewable energy supplies etc) Architects primarily achieve their environmental results by basing the *architectural design* on environmental considerations (the layout of the house, minimising the building surface, climatic adaptation etc.)

As an architect it is important to know all three types of environmental efforts. First, because they can all lead to significant environmental results, and therefore they should all be used. Secondly, they can (which will be given examples of in the following) interact in unfortunate ways, if they are not planned in relation to each other.

Therefore, this article presents the three kinds of environmental efforts, and gives examples of how they interact - fortunate and unfortunate - with each other. The article is based on experience from research projects conducted at the Danish Building Research Institute in the last fifteen years.

Environmental effort – focusing on behavioural changes.
In the Danish context, suburban one-family houses and the associated lifestyle have often been considered as environmentally problematic. From a theoretical and logical point of view there is also no doubt that a detached house having outer surfaces all around, potentially has a greater heat loss and therefore should be more energy consuming than for

example a dwelling in a multi-storey building surrounded by other dwellings.

However, this is not always the case. Quite often green accounts reveal that energy consumption in one-family houses is not necessarily higher than in other housing types - sometimes their energy consumption is even lower.[1] Why is that?

One explanation you get, when you look into similar consumption measurements / green accounts made in other housing types. For example, a few years back a Copenhagen suburban municipality made green accounts in all dense/low settlements of the municipality (Albertslund Kommune 2008). The energy consumption in the settlements was measured, and it turned out that it varied dramatically between settlements. Since they were built during the same period, constructed using the same building techniques and had the same standards of insulation, the variation in energy consumption had no technical explanation. The main explanation parameter was ownership. In rental housing, (where a caretaker is in charge of heating and where the tenants are not directly responsible for his/her heating) the energy consumption was, in some cases, twice as much as that of a similar privately-owned house.

The importance of focusing on lifestyles and behaviour was pointed out during the preparation of the doctoral thesis "Urban Ecology and aesthetics" at the Danish Building Research Institute (Bech-Danielsen, 1996). As part of the research project the patterns of consumption in a residential block were studied, and it was found that the use of resources varied dramatically between the individual apartments - even though they were provided with the same water saving techniques; in one apartment the daily water consumption was 66 liters/person, in a second home, it was 287 liters/person. Thus there was a variation of approx. 440%. In comparison, specialists attribute the use of water-saving technology a savings potential of approx. 30%. The doctoral thesis concluded that technical measures certainly lead to environmental achievements, but it stressed the importance of also focusing on the residents' behaviour. The behaviour and the routines in everyday life are crucial to the environmental performance.

Behavioural changes could be, for example, that residents take shorter showers, that they turn down the heating, that they turn off the lights when they leave a room, that they separate waste, that they use public transport, etc. This behaviour may not be influenced directly by the work of the architects, however, in some projects they have tried to increase the environmental awareness among residents in order to influence their behaviour. This has happened in projects where residents are involved in the design of the sustainable concept of the buildings. This was the case in a very interesting housing project that was built back in 1990 - 'Ökohaus-Cornelius Strasse' – designed by the German architect Frei Otto. To ensure the motivation and the involvement of the residents, Otto is convinced that sustainable changes should start with the individual choices of each resident. Therefore, in the current housing project information on environmental issues was an important part of the sustainable concept. Environmental experts were hired to inform the residents about environmental problems and to teach them how to deal with these problems (Bech-Danielsen, 1996). Subsequently all professionals and experts stepped back and left it up to individual families to decide the extent and nature of their environmental efforts.

Thus the initiatives taken in the individual dwellings in Ökohaus are very different and in this way the ideals of diversity that penetrate architecture during these years and which are certainly expressed in the architecture of Ökohaus, are also expressed in the sustainable concept of the settlement. One family has built their home of clay, a second family cleans and recycles the grey water directly in the dwelling, while a third family (where the man is an electrician), has reduced the electromagnetic radiation from the home network. Otto, however, does not so much emphasise this range of technical solutions but rather the process that the residents have been through. He is convinced that it has influenced residents' awareness and behaviour in an environmentally sound direction (Bech-Danielsen, 1996).

Another interesting observation we made at the Danish Building Research Institute when we were linked to an urban renewal project in Kolding. We were asked to do green accounting on the consumption of energy and water before and after the planned renewal - in order to clarify whether the planned savings were achieved. The objective of the urban renewal project was – through the use of a number of

technical measures - to save 10-15% of water, electricity and heat (Jensen 2000). For various reasons the project was postponed for a year, nevertheless, the researcher from the Danish Building Research Institute took the opportunity to send the results of the green accounts to the residents. This way the residents were informed about their personal consumption and about the environmental effects related to this consumption. A year later the green light was given for the planned renewal, and the researcher was again asked to determine the residents' consumption of water, electricity and heat immediately before the renewal. Surprisingly it appeared that all the targeted savings had been achieved even before the actual work on the renewal had started.[2] The conclusion is that visualization and the resulting awareness can be effective ways to achieve important changes in the patterns of consumption - and thus a very inexpensive way to achieve environmental results.

A fundamental reason why environmental problems grow and grow, despite the ¬technological progress, increased efficiency and improved standards of insulation is our increasing wealth. So far the increasing wealth has resulted in increased consumption. For instance, the Danish energy consumption for domestic heating has not decreased at any time in the last 100 years - despite the fact that the Danish Building Regulations have made ever stricter requirements to building insulation. One major reason is that in parallel with our growing efficiency in heating each residential square meter, the residential space has increased considerably in size.[3] Thus our total living area is growing every year, and therefore we fail to reduce the energy used for space heating.

Environmental effort – focusing on technical development.

Most Danes associate environmental action in the built environment with a technical approach, and they are quite confident that the environmental problems can be solved through the use of new techniques and by developing new materials. Action at the infrastructural level – improved efficiency of power plants and district heating and increased use of renewable energy sources[4] have been followed by technical efforts and improved efficiency at the building level. Among the most well-known techniques are building insulation, solar panels, photovoltaics, heat pumps, ground heating and fuel cells, but also various forms of water-saving technologies for recycling and reuse have been quite popular.

The development of the technically oriented environmental effort is primarily the domain of engineers, and a number of technical features can be located in basements and ceilings which therefore have no impact on either architectural design or on the residents' well-being and lifestyle. Thus it is a typical feature of the technical environmental effort that it does not impose specific requirements on residents' participation and environmental awareness; a lot of techniques reduce the environmental impact of the dwelling regardless of residents' behaviour. Therefore the technical solutions are particularly suitable in residential settlements, where the environmental interest and enthusiasm among the residents is small.

Figure 1:
In a research project conducted by SBi, energy consumption in various residential areas in Århus Municipality was mapped. Not surprisingly, the most affluent neighbourhoods have the largest consumption. Our traditional way of spending our wealth leads to greater consumption and environmental problems. (Bech-Danielsen et al, 20041; Jensen and Olsen 2003).

Building insulation is the energy-saving technique that has been particularly highlighted in Denmark and the other Nordic countries. Since the first energy crisis in 1973, the requirements for insulation of buildings have been reinforced repeatedly by changing Building Regulations. These have had architectural implications. For instance, the single-family houses of the 1970s and 1980s had a closed and massing appearance to the north (having only small and few windows). However, in recent versions, the Danish Building Regulations have changed, so the previous requirements for each part of the building have been replaced by a definition of the amount of consumed energy allowed. This leaves more freedom for the architectural design.

At the same time there have been significant improvements of the insulating effect of materials. This has especially been the case with windows, which were previously associated with very high heat losses. The development of highly insulating windows is now reaching a stage where the glass insulates almost as well as a solid wall. When adding the passive solar heat (gained through the windows), a façade of glass can now be more heat-efficient than a solid outer wall. This makes it possible - at least in theory - to construct low-energy housing as 'boxes of glass'. There have been experimental buildings in Denmark that have tested the possibilities of the new types of glazing, including a low-energy housing project by architects Lundgaard and Tranberg (SBi, 1999). The 1970s and 1980s closed architecture had disappeared, and instead the low-energy building appeared in glass and steel. In this version, the architectural ideal of modernism became sustainable.

Figure 2:
Low-energy housing transformation - the development of new types of glazing have turned architecture inside out, in which now appears with an open 'skin' of glass and steel. (Architects: Boje Lundgaard and Lene Tranberg).
Photographer: Bech-Danielsen.

In the latest version of the Danish Building Regulations (BR08), the insulation requirements were tightened: the energy consumption in new buildings is now required to be less than 70 kWh /m² per. year.[5] It is expected that the energy requirements to buildings will be tightened further in the near future. In 2010 it is the plan to further reduce energy consumption in new buildings by 25% and in 2015 new building requirements are expected to cut further 25% off the energy consumption. It is the Danish as well as the European intention that building regulations will require the equivalent of 'passive houses' by 2020. The increased requirements imposed on new building make it increasingly essential to focus on the energy consumption of existing buildings.

The Danish Building Research Institute recently conducted an assessment of the potential heat savings in existing Danish housing (Wittchen, 2004). It was stated that it is possible to save more than 30 Peta Joule, simply by replacing windows and improving insulation of walls, floors and roofs. The biggest energy savings can be achieved in old houses built before 1930, but also in houses built in the period 1961 to 1972 major energy savings can be achieved.

The technical development is strong, and important energy savings and environmental results can be achieved by means of new environmentally-oriented techniques. However, one-sided confidence in the technical development can foster the result that the environmentally favourable effects fail to materialise. This has been the case in a number of housing estates that were fitted with glass-enclosed balconies with a southern exposure in connection with a comprehensive process of sustainable urban renewal (Svensson & Wittchen 2003). The working notion behind the glass enclosure is to turn the balcony into a seasonal conservatory, which is then supposed to induce passive solar warmth into the remaining sections of the apartment. However, the residents did not always make use of the glass enclosures as intended. Electric radiators were placed in the glass-enclosed balconies, so that these spaces could be used all year round, with the consequence that the anticipated savings in terms of energy failed to materialise and the end result was an increased consumption of energy.

Environmental effort – focusing on architectural design

As the architectural qualities in grassroots sustainable settlements as well as in engineers environmental experiments had repeatedly been questioned, the sustainable construction had an image problem.[6] It simply did not appeal to a wide audience of users, and a number of initiatives were launched in the 1990s to develop the architectural design of the sustainable construction. It was, among other things, the essential goal of 'The Green Fund' initiated by The Danish Environmental Ministry (Gram-Hanssen, 1998): Sustainable construction had to be designed in architectural quality in order to appeal to a wider circle of people.

When architects entered the scene, a new type of environmental action was developed. Already in the initial design phase, architects make a series of choices that may be crucial to later consumption in the building, and on that background the environmental considerations were now taken into account in the architectural design in line with other considerations. The environmental considerations impinge directly on the architectural design – the environmental considerations can even act as the fundamental architectural idea.

This has been proven in many projects designed by the German architect Thomas Herzog. For example, in a two-family house in Pullach-Munich the main environmental objective was to exploit daylight optimally - partly in order to achieve passive solar energy (for heating) and partly to minimise the need for electricity (for artificial lighting). This has led to a long, narrow building body that lets sunlight reach deep into all the rooms. The large overhang of the building is also environmentally justified, as it protects the facades against weather and thus reduces the need for future maintenance - and extends the life of the building. The architectural form is the environmental effort.

Also the Australian architect Glenn Murcutt has achieved environmental results by putting the building-related consumption in the design work. Murcutt's buildings are designed based on conditions at the actual place - the culture of the place, the planting on the site, the local climate etc. Wind conditions and the height and course of the sun over the year are some of the local qualities that are crucial for his design.

Figure 3:
Semi-detached house in Pullach near Munich. (Architect: Thomas Herzog).
Photographer: Bech-Danielsen.

Thus Murcutt's design is always related to a specific place, and this should remind us that an architectural / sustainable concept that works well in a building in one specific place cannot necessarily be repeated uncritically in a building somewhere else: A sustainable concept cannot be regarded as a fixed guideline that can be repeated again and again. For example, have a look at some of the sustainable constructions in Berlin, where architects have made great efforts to ensure that the rainwater can seep directly into the groundwater. In the neighbouring settlement you might find massive pipes installed to pump ground water away from the area. The fact is that Berlin is built on wetlands, where groundwater is extremely high - and that recent years' major construction activity in Berlin has only been possible by pumping tonnes of groundwater out of the city. So although it is common sense elsewhere to let rainwater seep into the groundwater, it is nonsense in Berlin.

Traditional buildings are often designed in terms of a specific place and inspiration of the development of sustainable construction can often be found in historic construction. Previously, economic resources were scarce, the buildings were badly insulated, and domestic heating often involved hard work by the residents. Consequently the use of energy was wisely minimised and many efforts were made to retain heat. Building location (with an emphasis on shelter and protection, rather than panoramic views and visibility), wooded areas (creating shelter and related to the prevalent winds), interior (with porch, centrally located chimney / fireplace, north-facing pantries etc.) are examples of traditional hous-

ing qualities that are now reinterpreted in sustainable construction.

One of the most inventive Danish sustainable housing projects was designed a few years ago, as a result of a prize competition at the design schools and architecture schools in Denmark. The students were asked to develop the future housing - with emphasis on sustainability (Bech-Danielsen 2001). The winning project, Boase, aims to establish wooded areas on the contaminated sites in the cities, integrating nature in the city, while the plants purify the polluted soil.[7] The housing area is constructed on pillars to ensure that the tree roots can clean the soil under the buildings, and walkways connecting the dwellings are established at a level with the tree crowns. This way the environmental efforts are related to interesting experiences and new ideals of urban life.

The private residences in Boase are clustered around a flexible common room, and while private residences appear in a tight, cubic design, the common space is enclosed by a tent-like structure. The structure consists of a textile that accumulates energy in small fibres of photovoltaic woven into the material. Thus the development of photovoltaic is a good example of how the different types of environmental efforts can interact in fortunate ways. The production of the photovoltaic has become so sophisticated that they can be incorporated into building materials - the technical development made it possible to integrate the technical solution into the architectural design.

Postscript

Actually, architects have been working on how to solve environmental problems for almost a century. When the modernism concept of architecture and planning was developed in the early 20th century, the starting point was pollution in the rapidly growing industrial cities.[8] At the building level the modernist found the solution in a light and airy architecture with white walls and large windows that accommodates hygienic issues at the time. At the settlement level they opposed the traditional urban structure in the development of park settlements that were oriented towards the daylight. And at the city level the ideal of zoning was developed in order to move housing away from noisy and polluting industries, and suburban development in the urban periphery also grew from a desire to get out in to the 'light and air' - away from the noisy and polluted inner cities.

Thus the urban planners of the 20th century solved urban problems of the time by establishing a distance. Residential areas were moved away from polluting industries and urban development was created at a distance

Figure 4:
Boase – the architectural concept is based on solving an environmental problem in urban areas: Contaminated sites.

from the dense and crowded inner cities. This strategy also characterises the environmental work of the post-war period: With the renovation systems, sewerage and tall chimneys, waste and other pollution were exported still further into the surroundings.

Towards the end of the 20th century, environmental problems, however, reached a global scale, and they were not to be solved by building chimneys even higher or by sending waste substances even further out into the surroundings. Today, even the farthest corner of the world is affected by environmental pollution – neither the atmosphere, the sea nor the landscapes can hold more - and we are forced to deal with them in a more preventive manner.

This is actually happening in projects like Boase. Boase is based on a fundamental urban and environmental problem – the contaminated sites of the industrial period. The project combines a solution to the environmental problem with development of new urban and architectural qualities. Technical, cultural and architectural developments are linked to the formulation of new ideas about living in green surroundings in an inner city area.

Architectural design always starts with the formulation of a problem, and architectural quality occurs when an architectural concept addresses the problem in a convincing way. At a time when environmental problems are fundamental, it is crucial to the ability of the architects, that the environmental problems are part of the formulated problem. Solving the problem then become an important architectural task.

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NOTES

[1] To give an example: In Albertslund (a Copenhagen suburb) the heating of 100 m^2 detached housing leads to 0,86 tons/year of CO_2 in average. In the rental blocks it leads to 1,28 tons/year (Albertslund Kommune 2009).

[2] Consumption of heat was reduced from 5255 kwh/person/year to 4813 kwh/person/year, consumption of water was reduced from 135 l/person/day to 121 l/person/day. Consumption of electricity was reduced by ap. 10%. (Jensen 2000).

[3] Each Dane has 52 m^2 of dwelling on average - and here is not counted the approx. 200,000 Danish second homes such as weekend cottages etc.

[4] In Denmark 10% of the total use of energy is produced by renewable energy sources – mainly wind [Source: www.energistyrelsen.dk].

[5] Building's overall need for additional energy for heating, ventilation, cooling and hot water per. m^2 heated floor-space must not exceed 70 kWh /m^2 per. year conferred 2200 kWh. years divided by the heated surface area.

[6] This was stated as one of the main reason, when the Danish Environmental Ministry launched 'The Green Fund' in the late 1990s (see following description).

[7] For more information: www.boase.dk

[8] At this time the pollution was a local problem - related to health of the local population. Later in the century the environmental problems became global, and related to the basic existence of human beings.

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