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Nordisk Arkitekturforskning
Fakultet for arkitektur og billedkunst, NTNU
Eivind Kasa, Editor-in-Chief
Alfred Getz vei 3
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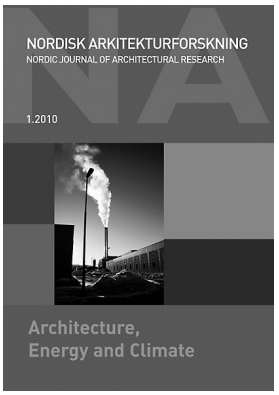

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NORDISK ARKITEKTURFORSKNING – NORDIC JOURNAL OF ARCHITECTURAL RESEARCH

From ecological houses to sustainable cities. Architectural minds

Michael Lauring

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Michael Lauring
Aalborg University, Department of Architecture and design, Denmark

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Abstract:
Most Danish architects are educated in the Beaux-arts tradition playing down technical and infrastructural aspects of architecture. This has influenced the development of environmental and sustainable architecture, of which the article gives a brief survey covering the period from the first oil crisis in 1973 to present day also seen in relation to resource, political and cultural pre-conditions. The article shows that in order to optimize the interplay between architecture, energy and climate architects will have to reintegrate techniques and urban aspects as crucial parts of design considerations, the article thus questioning the more autonomous approaches to making architecture.

Keywords:
Sustainability, ecology, low energy, environmental architecture, beaux-art tradition, integrated design

INTRODUCTION

In the summer of 2009 most Danish architectural offices seem to have gone green. Homepages tell about sustainable awareness, and the Danish architectural magazines contain lots of articles, news stories and advertisements related to the subject. The title of the 2009 summer exhibition at the Louisiana Art Museum near Copenhagen sums it up: The future of Architecture is Green [web: Louisiana].

Indeed, there has been a remarkable shift during the last two or three years in which sustainability has moved from being a marginal and sometimes joked about phenomenon to being an indispensible part of building programs and architectural competitions, a phenomenon at the very center of the architectural field, at least when it comes to rhetoric.

For this, several reasons can be identified. In 2006 the Danish building regulations concerning energy consumption of houses were changed and sharpened in accordance with an EU-regulative in such a profound way that it is now difficult to do architectural sketching while ignoring concerns of heating and cooling [web: Erhverv- og Byggestyrelsen] - energy and climate is no longer just an engineering concern. In 2007 the Intergovernmental Panel on Climate Change (IPCC) and Al Gore were given the Nobel Peace Prize marking a breakthrough in the worldwide acknowledgement of the current and predicted manmade global climate changes [web: Nobel Peace Prize]. In December 2009 the Copenhagen Summit took place, where the world leaders tried to settle on a treaty' to succeed the Kyoto Protocol, making agreements for reducing emissions of carbon dioxide causing climate changes - the biggest and most important political gathering ever in Denmark, with preparation causing spin-off to a broad field of activities including green building [web: Cop15]. And of course, leading up to current situation, since the first oil-crisis there has been 35 years of good-hearted attempts of linking architecture, energy and sometimes climate in a responsible way [Dirckinck-Holmfeld 1995], [Ibler 2008].

There have been societal and economical barriers to such responsible action, but also resistance within the architectural society itself, vigorous ecological images colliding with the cool modernist mainstream of Danish architecture. Now the architectural barriers seem to break and there is a general acceptance of the importance of reducing the need for fossil fuels for running buildings and society, in order to keep down carbon dioxide emissions. The question is to what extent have architects identified the relevant problems and developed trustworthy solutions in order to optimize the interplay between architecture, energy and climate? Are there any inherent barriers in the architectural approach?

Most Danish architects are educated in the Beaux-art tradition opposed to those being educated at departments of architecture under technical faculties naturally emphasizing the technical aspects of architecture. 'Beaux art' covers a wide range of positions. In 'Arkitekturværkets netværk' [Nordic Journal of Architectural Research 2002 No 3, pp 7-22]Niels Albertsen with references to the british philosopher W.B. Gallie describes architecture as a 'conception which essence is disputed' characterized among other things by being a wholeness which components are given different weight by different disputing parties. Albertsen identifies four main positions: The classical Vitruvian position where architecture is perceived as the unity of utility, strength and beauty. Architecture is the art of building. This perception was strongly opposed by Boullée (1728-99) who claimed that Vitruvius spoke as a working man and not an artist. Architecture was not the art of building but the art of creating and bringing to perfection any building. Just as art, buildings should somehow be poetry. This position has later been supported by Hollein who (1962) also emphasize that architecture should not please the needs of the mediocre but is a matter of the elite. A third position is taken by Semper (1803-79) who perceived architecture as coverings in family with clothing and art ware or 'arts and crafts', a position later supported by Adolf Loos. The architect covers human beings with impressive tissue providing atmosphere. A totally different, forth position is taken by Bauhaus' Hannes Meyer who defines architecture as 'buildings' leaving out the artistic aspects. Buildings like all other things are a product of the formula 'function multiplied by economy', a position Albertsen defines as 'social engineering'.

Those taking these positions defend different regimes or worlds: The world of inspiration, the world of domesticity or the world of industry for instance. In the world of inspiration – naturally supported by the artistic wing – the

grandeur relies on spontaneity, feelings and originality, avoiding both routines and 'the inertia related to having knowledge'. In fact, architects inspiration will often derive from former architectural projects as seen on location or in magazines.

Practicing architects will of course have to deal with both functional demands, aesthetic issues and building construction not to mention economy, law and regulations, whilst the Vitruvian position is often identified as the 'professional' position. But architectural education, writing and debate may take other directions. If one hold Albertens four positions: Architecture as art (Boullée), architecture as 'arts and crafts' (Semper), architecture as the art of building (Vitruvius) and architecture as social engineering (Meyer) up against the Beaux-art influenced Danish tradition, in a historic perspective the first two positions stands relatively strong as the beaux-art name itself indicates. As Albertsen mentions, the Vitruvian position and to some degree the social engineering position may have dominated in the sixties and early seventies (during the period in which the building sector was industrialized), but in the eighties and nineties the artistic positions gained ground again, though also some technical matters reached attention, especially the matter of energy savings.

Ecological houses – The seventies

The first oil crisis in 1973 came as no less than a shock to the Danish society. The year before on the initiative of the so-called Rome Club a group of MIT-researchers had released its report, Limits to Growth, which on the basis of then advanced computer calculations predicted a global ecological collapse in the 21st century if the growth rates of population, food production, use of raw materials and energy and the emission of pollution that one had seen in the sixties continued [Meadows 1972]. The publication initiated much debate, though primarily in academic circles. But the oil crisis affected everyone. Suddenly it became obvious how depended we are on certain natural resources. Denmark was met by a total boycott by the Arab oil-suppliers due to pro-Israeli statements during the Yom-Kippur war. Out of the total Danish use of energy which had increased heavily during the previous fifteen years of increased wealth - including a doubling of the housing area and a car for a majority of Danish households - over 90% was covered by Middle-East oil [Lind 1999]. Now the taps were closed. In retrospective the oil crisis marks the end of the 'happy sixties' and the foundation of a new, much more energy-conscious and energy-oriented Danish society. In the following years, long term political goals were defined: Using different fuels instead of just oil , developing a collective heat supply based on combined heat and power plants, intensifying the search for and production of oil and gas in the North Sea and seeking energy savings. But the short time tactics in the winter of 73-74 had to rely on the ordinary efforts of common man. Car driving was prohibited on Sundays and people were advised to turn off electric light if not needed, which people did. They also shut the doors and windows and installed wood burning stoves [Lind 1999]. Indoor climate was not yet a subject.

In the mid-seventies modern architecture and the ideals of rationalism, internationalism and structural honesty had already long been criticized. The thousands of grey concrete blocks erected according to rigid layout schemes that had spread over the Western (and Eastern) world, were being heavily criticized for their lack of beauty, lack of relation to site and history, lack of psychological qualities and lack of contact between the occupants. The reactions against modernism were many and some included ecological considerations.

At Kunstakademiets Arkitektskole in Copenhagen the so-called Freja-group was founded, Freja being the Nordic answer to Aphrodite. The group had strong emphasis on ecological concerns and a very skeptical view to the modern city, it´s most famous publication being Handbook in rural settlement [Bak 1977], a guide book for urban residents who wanted to move to the country. The rural associations also blossomed in the names of experimental dense/low housing schemes of the seventies such as Gallows Hill (Galgebakken ,

Picture 1:
Storgaard, Ørum-Nielsen & Marcussen (1974): Galgebakken. Entrance way and inner court. Dense/low dwellings with strong focus on social interaction.

Picture 2:
Vandkunsten (1978): Tinggaarden. Bearing concrete constructions with wooden cladding. Dense/low housing with very flexible house units and fine spatial potentials for user democracy.

1973-74), The Village Pond (Gadekæret , 1975-79) or Thingstead Court (Tinggården , 1978) [Dirckinck-Holmfeld 1995], though all situated in urban contexts and using concrete as bearing construction, while the aesthetic expression slowly evolved towards traditional architecture with pitched roofs and even wooden coverings in the latest project.

Tinggården designed by Vandkunsten was the end-result of a competition initiated by the Danish Building Research Institute in 1970 about dense/low housing. The ambitions of this winning project were both social and ecological. Often seen as the incarnation of Danish architecture of the seventies, with a groundbreaking spatial scheme it succeeded in facilitating social interactions between occupants, and has inspired many dense/low housing complexes both in Denmark and abroad. But some of the social and aesthetical attempts had disadvantages concerning energy: The wings surrounded inner squares and thus could not all face the sun. The building volumes had great variations going up and down and in and out giving it all an informal homebuild character, but at the same time providing more building surface and heat loss. The wooden coverings may well signalize ecology, but in fact demanded some chemical maintenance. After a long planning period, in the final project the scheduled number of solar collectors was heavily reduced due to economy, and calculations show that the heat-consumption of the housing complex is not below standard [Lauring 1998]. While the actual energy savings failed, this and contemporary building projects helped linking 'ecological housing' to rural expression or settlement.

Picture 3:
Storgaard, Ørum-Nielsen & Marcussen (1974): Tubberup Vænge. Dense/low dwellings with common wintergardens.

Concerning energy savings, other initiatives showed better results. On the heels of the oil crisis the Building Regulations of 1977 contained two new important rules [Bygningsreglement 1977]: The total area of doors and windows could not exceed 15% of the total floor area. And thermal bridges could only be accepted to a very limited degree. The first rule meant that for the next eighteen years buildings with limited daylight conditions were built. Those modernist dreams of glass facades that had - during the sixties - slowly become reality not only in office buildings but to some degree also in housing had now crashed, leaving once again the window as a hole in a wall and the occupants in darker rooms.

There was a way to get around this obstacle: Rooms that were not heated could have lots of glass. This resulted in thousand of intendedly non-heated winter gardens and other glass extensions of existing houses. And a lot of the architectural designed so-called ecological houses and housing complexes built in the following years were supplied with some sort of winter garden meant to pick up solar heat that could be transported to the fully heated parts of the house, thus reducing the need for supplied energy [Arkitektur DK]. The winter garden became a crucial ecological element and symbol.

The second rule about thermal bridges had an interesting architectural side effect on the brick-built Danish houses. The fact that the outer walls outer leaf and inner leaf were no longer attached as they had been for instance around doors and windows also meant that the outer leaf was in general no longer part of the bearing system but functioning primarily as a rain screen. Brick walls are not the optimal rain screen, and the new rule accelerated a development towards multi-layered outer walls, each different layer serving its specific purpose. As rain shields can have many forms,

the possibilities for architectonic expression were widened, and the old modernist dogma that a building should express its construction became redundant by the cause of heat insulation [Marsh 2000].

At the late seventies, modernism was on its heels. Romanticism was preferred to rationalism, traditionalism and regionalism to internationalism, desired images to structural honesty [Nygaard 1995]. Concrete was covered by non-concrete, and small windows had replaced glass facades which only survived as winter gardens, the new 'eco-architectural' element: A light room producing passive solar heat. Ecological architecture was now a common term having something to do with energy consumption. But in fact, no one has ever come up with a convincing definition of ecological architecture or ecological houses. The term was and is free for use. Slowly, during the seventies 'ecological' evolved from being a scientific, descriptive term to being a normative one, without any norm-criteria, but with lots of images and associations mostly of a rural kind [Lauring 1998].

Back to the City - The eighties

As the Shah of Iran was overthrown in 1979, the Iranian oil production dropped and prizes rose. They continued to rise the following year as the Iran-Iraq war broke out and thus the decade started with huge transfers of capital from the Western to the Arab world causing inflation and unemployment in Western countries including Denmark [Lind 1999]. Slowly the prizes fell again and slowly the Danish long term energy strategies started to work. Oil was replaced by coal. Combined heat and power plants where the heat loss from producing electricity could be utilized for heating, were built across the country, and more buildings joined district heating. All in all the total energy consumption were kept stable. The North Sea production of oil and gas started to grow, and by the end of the decade the self-sufficiency of energy had gone from about zero to 50 % [web: Energistyrelsen maanedsstatistik].

In Denmark the seventies had both politically and culturally been dominated by the left wing, but now there was a markedly swift to the right. Danish youth abandoned the multi colored, hippie-like or rural dress code of the past decade and started wearing black, as did architects. Architecturally there was a strong shift from social and ecological concerns to aesthetical. I 1977, Charles Jencks had introduced the term postmodern architecture, indicating that modernism was a finished chapter [Jencks 1977]. In international architecture historical references now blossomed, from the merry works of Venturi and Stirling to the severe new rationalism of Ungers [Nygaard 1995]. Along with this historical orientation there was a renewed interest in the city. Where the modernists had expanded the city with new building projects out in the open fields, architects now returned to the historic remains. As heavy industry were shut down or moved away due to economy or environmental demands, the industrial areas could be used for other purposes. The architectural positions of how to reuse and restore the city were many, but one thing was certain: Urbanism was in, rural approaches were out. Urban planning as it had been practiced in the Marxist seventies using social science and lots of statistics went down. Urban building with a formal and aesthetic intention went up with the Krier brothers as main sources of inspiration [Nygaard 1995].

Ecology was out too, at least among architects. Being strongly connected to rural or even anti-urban approaches and aestheticism, ecology was considered a rural phenomenon of the past. The baby was thrown out with the bath water. And as oil prizes were low for most of the decade, the economic stimulus for saving energy was low. A few architects, especially Boje Lundgaard went on exploring the architectural potentials of passive solar heat through a number of housing projects [Dirckinck-Homfeld 1995], but most architects lost interest. The site was the city, the subject granite rather than greenery, and energetic city life rather than fossil fuels.

While the architects left, ordinary people stayed on the subject of ecology and housing. During the eighties and nineties several country-side eco-villages were established, often with people building their own free-standing houses in their own designs, colorful villages with a variety of forms far from both modernism and postmodern infill-design, thus widening the gap between the ethic and social oriented ecology and aesthetical focused architecture [Bech-Danielsen 1997]. Regarding the question of countryside versus city, there are several energy-problems related to free standing houses in rural context such as much building surface and heat loss per floor area, lack of effi-

Picture 4:
Rural eco-village at Torup, Hundested on the outskirts of Northern Sealand.

cient infrastructure and the use of cars, so the actual environmental impact and ecological results of country life can easily be questioned.

In the late eighties two Australian researchers, Kennworthy and Newman carried out a global survey of 32 major cities showing a very close interdependency between density of population and use of gasoline for transportation [Kennworthy 1990]: The closer we live together the less fuel we use. In cities with less than 30 human beings per hectare the gasoline consumption rises dramatically. The close relation between density and use of gasoline was later confirmed is a survey including 22 Nordic cities [Næss 1994].

The urban-oriented architects had many environmental arguments on their side, but they did not use them as they did not think of this matter. At the end of the eighties architects were far from being green, and environmentally seen things were turned upside down.

Urban ecology and more passive solar - The nineties

Our Common Future, the so-called Brundtland Report written by the World Commission on Environment and Development and published in 1987 [World Commission 1987], introduced the term Sustainable Development linking environmental sustainability closely to social and economic sustainability, and described in broad terms the principles to avoid that ecological collapse being foreseen in 'Limits to growth'. Emission of carbon dioxide and the resulting green house effect was mentioned as one out many threats, but in the following years this matter grew in importance among the environmentally concerned.

In 1993 the highly influential politician Auken took over The Danish Ministry of the Environment. A year later his field of responsibility covered both environment and energy thus paving the way for foresighted strategies linking energy with climate [Energistyrelsen 1995], resulting among other things in a marked increase in wind (and wind turbine) production and several environmental urban and building initiatives, all in all making environmental issues a central part of both research and politics and putting Denmark in the forefront of environmental action including the negotiation of the Kyoto Protocol of 1997 [web: Cop15].

In this decade of stable economy, increasing employment and growing optimism, postmodernism were on retreat and slowly being replaced by New Modernism in favor of glass and light. The new Building Regulations of 1995 concerning energy were still totally focused on space heat consumption [Bygningsreglement 1995]. With better insulating windows the allowed area of windows and doors went up from 15 to 22%. Also the alternative 'energy target'-calculation method was now in use, including heat loss due to transmission and ventilation and heat contribution in the form of passive solar heat, internal heat gains plus the effect of heat accumulation in thermal mass. Using the energy-target method, there were no restrictions on the amount of windows, as long as the calculated heat consumption did not exceed a given limit corresponding to the consumption of a standard house.

Those architects, whose visions of glass facades had been suppressed for almost two decades, quickly caught the opportunity. Beside the current modernist tendencies and a legitimate wish for better daylight conditions in buildings, passive solar heat had gained a strong reputation for being ecological, so the urge and arguments were many. In 1996 a national architectural competition called Ecohouse 99 was arranged. Five out of six proposals had large glazed areas facing south-southwest, and the two winning projects had almost 100% glass on the southern facades. Besides these and other environmentally ambitious housing projects a lot of totally glass-walled office buildings were erected in the late 1990's.

Terrible indoor climatic conditions and energy consumption three times as high as regular offices – mostly due to immense cooling demands covered by electrically driven cooling systems – were a common result [Sinding-Jensen 2002] . The glass offices looked modern but were not geared for the energy critical 21st century.

Now the architectural strategies of the so-called ecological houses were being questioned. As the two Eco-house 99 winning projects were built and taken in use, the one showed big problems with overheating with temperatures between 30 and 45 degrees Celcius in the 1st floor rooms during the summer months, while the other one showed that predicted advantages of passive solar is in reality very dependent upon the habits of the occupants [Dollerup 2002], [Hans Bjerregård 2001]. Calculations later carried out by the Danish Building Research Institute showed that the reductions in primary energy consumption were very limited, partly because it is difficult to utilize so much passive solar heat, partly because there is a great heat loss through big glass facades, and partly because the energy embedded in glass production is relative big [Marsh 2000] [Statens Byggeforskningsinstitut 1999] .

In 2001 another survey showed that most of so-called ecological housing projects with winter gardens built since the late seventies had a considerably larger need for heat supply than ordinary houses [Dollerup 2002]. An obvious reason could be the fact that Danes long for daylight also on the darkest days, therefore heating the so-called non-heated winter gardens. The survey was carried out in co-operation with the Danish Centre of Urban Ecology, another institutional initiative supported by the Ministry of the Environment and Energy [Lauring 2004]. Urban Ecology was characterized as an environmental effort with participation of occupants and other users in a specific city-area heading for holistic solutions to problems concerning resources, environmental impacts and nature [Miljøministeriet 1994], and some of the main efforts in this field were the renewal of urban city blocks, especially their inner courts, with Hedebygadekarréen being the most ambitious example [Erhvervs- og Byggestyrelsen 2004].

At the end of the nineties, issues of environment and energy had a relatively strong position in peoples mind, very much due to political initiatives and State financial back-up. In spite of the first attempts of urban ecology resulting in attractive green urban courtyards, ecology was still considered very much a rural phenomenon, as first impressions seem to linger. There had been reconciliation between architecture and environmental ambitions, with aesthetical very convincing examples of passive solar housing. Though, among architects environmental architecture was still a marginal phenomenon, often associated with rural, homemade and untalented design. First impressions linger amongst architects, too.

Picture 5:
Vandkunsten (1998): Ecohouse 99. One-storey apartments with two-storey apartments on top. Solar rooms to the south.

The actual environmental results of the eco-houses were questioned, both regarding indoor climate and energy savings. On top of that, important energy issues were overlooked or ignored: Since the Building Regulations of 1995, in new typical terraced houses the pri-

Picture 6:
GBL-architects et al (2002): Hedebygade urban block. Renewal of urban block in Copenhagen including solar cells, greenery, and common house.

mary energy consumption of electricity (non-heating purposes) had been marked higher than the primary energy consumption of heat (covering both room heating and hot water), due to better insulation, district heating and increased use of electrical appliances. This tendency was even stronger in offices [Marsh 2006].

Another comparison is quite as interesting: At the first oil crisis in 1973 the total Danish energy used for room heating was twice as high as the total energy used for transportation. In 1998 the steadily increasing transport energy for the first time topped the relatively stable amount of energy used for room heating [Energistyrelsen 1995] [web: Energistyrelsen aarsstatistik]. As stated previously spread rural or suburban settlement causes much more private transportation than dense urban settlement. This was not a topic being discussed, going green.

Efficient houses - The new millennium

The attack on the 9th of September 2001 and the response in form of wars in Afghanistan and Iraq once again put the relation between the Arab and the Western World and the global oil interests on top of the international agenda. A few months later, a new Danish Government not only gave evident political and military support to the US response, it also cut down the support for those national renewable energy systems including three major offshore wind farms being planned, that could have eased the dependency on oil. Energy and Environment were once again split on two different Ministries, the new Minister of Energy claiming that he did not consider manmade carbon dioxide to be pollution [web: Folketinget], then stopping national research in solar cells and wave energy. In all fields the support for green initiatives ceased, researchers and alike being questioned in the Prime Ministers New Year Speech, when he claimed that 'the public shall not accept lifted fingers from so-called experts, who claim to know best' [web: Wikisource].

Picture 7:
Bolig+, project 5 by Vandkunsten, Wissenberg, Brian Edwards KA, Rockwool International and Danfoss.

Architecture itself was slowly swaying away from the cool new-modernism of the nineties towards more irrational and often soft and organic forms, very much helped by heavily improved computer designing techniques. In some of these projects the traditional relations between building and landscape were being questioned, buildings becoming landscape to walk on, Snøhetta's Oslo Opera being an international well-known example, and several works by Danish BIG being realized in and around Copenhagen, VM-Mountain internationally rewarded best housing complex of 2008 [web: VM-bjerget]. The measurable energy and carbon dioxide impacts of these projects may well be questioned, but they do represent an aesthetical urge to inspire from and interfere with nature although in a very cultural way, providing artificial landscapes for cities.

With Danish government backing out and financial sources drying out the green impulses had to come from elsewhere. Some came from municipalities. Some Danish Cities marked themselves with green and carbon dioxide-conscious profiles on planning, regulation and support, Copenhagen taking the lead including urban and architectural projects such as a wind farm outside the harbor, a coherent network of bicycle routes going through green areas, two harbor baths in the cleaned up harbor and further establishment of green parks and courts in the city [web: Københavns Kommune]. But also smaller cities like Albertslund and Kolding became front-runners for instance with rules for energy consumption in new buildings stricter than the standard demands.

Another impulse came from EU. In 2006 the Danish Building Regulations concerning energy was changed profoundly as a consequence of an EU-directive on the energy performance of buildings [Europa-parlamentet 2002]. The new rules had to take their starting point in two premises: To assess the whole and the primary energy consumption. Now included was the energy for heating, cooling, hot water, lighting, pumps, ventilation and system losses plus reduction of overheating. The energy production from build in solar panels and solar cells also counted. Primary energy consumption deals with the fact that most types of energy experience loss during production and distribution. The production of electricity had a current effectiveness of only 40%. Therefore electricity needs had to be multiplied by 2.5. Gas, oil and

district heating were multiplied by 1.0. Also important was that The Building Regulations dealt with two classes of low energy buildings: Class 2 equals 75% of the energy frame, while Class 1 equals 50% of the energy frame [web: Erhvervs- og Byggestyrelsen].

To architects, the rules have all in all had great importance. While sketching buildings and especially facades, you now have to make close considerations concerning the need for heating and cooling when deciding the size and orientation of windows. What was once considered an engineering discipline is now an integrated part of architectural activity (causing lots of in-training courses).

The low energy-classes were meant to encourage optimization of energy performance of houses, and some municipalities have made the stricter energy classes part of the demands for new buildings on all or chosen development areas. Also the so-called Passive House-concept originally developed in Central-Europe has gained attention resulting in predominantly single family houses with very low heat consumption [web: Passivhuse]. Some Danish Architect firms have now designed passive houses, including some aesthetically very convincing examples with good indoor climates [web: Komforthusene]. In the summer of 2009 passive houses are considered the state of the art among Danish architects, though also being teasingly competed by the so-called Active Houses having more focus on daylight, solar panels and solar cells [web: Active House]. All in all there are dozens of Danish architecturally promising examples of single family houses with very low heat consumption and a fruitful debate among architects about technical means.

One important energy aspect is almost totally left out: The sustainable aspect of how to get to and from the houses. In 2004 there was an average emission of 6.06 ton carbon dioxide per Danish citizen related to personal matters, divided on household (2,54), transportation (2.02) and material goods (1.49). [web: Klima- og Energiministeriet]. 2.02 ton carbon dioxide for transportation equals approximately 840 liters of gasoline or 13300 kWh. Compared to average figures, the household consumptions and emissions in modern houses are somewhat lower. In a typical terraced house of 120 m2 built according to the Building Regulations of 2008 and with three occupants the primary household energy consumption is 6600 kWh (2200kWh for heating and 4400 kWh for electricity) per person [Marsh 2008]. In low energy houses these figures are of course lower. This should be compared to the 13300 kWh the average person uses for transportation. In simpler words: Transportation counts several times as much as household in low energy or just new built houses.

Picture 8:
Bolig+, project 2 (winning project) by TEAM+ / Arkitema, Leif Hansen and Thornton Thomassetti, Esbensen, Faktor3, DONG Energy and Boligforeningen Ringgården.

In the fall of 2009 the very ambitious, public and privately funded housing competition Bolig+ supported by Akademisk Arkitektforening and Ingeniørforeningen was settled [www.boligplus.org]. The task was to design a housing complex near Aalborg that produces more energy per year than it consumes, the narrow site running from north to south giving limited access to southern sunlight. The five pre-qualified teams all included both architectural and engineering firms, most of them very well-experienced, in order to obtain both good housing qualities as well as reaching the very well-defined quantitative energy goal.

In spite of this only team, Team+ reached both the qualitative and quantitative goals. They did this with relatively simple, architectural means (project 2): A compact, high-insulated building with balconies shading for the summer sun, not too deep flats with good daylight conditions and flexible plan solutions. Plus a cupboard for wind-drying clothes on the balcony, solar cells on the balcony fronts etc.

Two teams (project 4 and 5) apparently lead by the architectural firms contributed with beautiful projects but inadequate daylight and energy calculations. In both projects each flat has a glass room both to the east and the west. As the judge committee remarks, the glass rooms produce passive solar when the sun is shining, but when the sun is shining there is no need for heating the high-insulated flats. A side

Picture 9:
Bolig+, project 4 by Lundgaard & Tranberg, Dominia and Danfoss Heating Pumps

effect of the glass rooms is that they reduce the access of daylight to the flats thus reducing the architectural quality. The two architectural firms have both practiced such solar rooms in a number of projects also mentioned earlier in this article.

In most cases the collaboration between architects and engineers has not resulted in convincing results. The judge committee speaks of a "polarization between the 'architectural' energy concept [project 4, 5 and partly 1] and the more energy-technical concept [project 2 and 3]. So even if the contributions in many ways bear witness of collaboration and synergy effects between the different professions, this evident polarization has also [...] revealed a certain 'blindness' towards the technical realities [project 4, 5 and partly 1] to such a degree that the notion of energy neutrality [...] are far from being fulfilled".

Conclusion

As this brief survey shows energy issues have had a major impact on Danish political and societal affairs. It also shows that energy issues have had huge influence on the conditions of architecture both in the form of energy supply, infrastructure and building regulations and indirectly in the form of notions of being ecological, green or sustainable. To what extent have then architects identified the relevant problems and developed trustworthy solutions in order to optimize the interplay between architecture, energy and climate?

Looking at the current situation, in general architects have not identified the most relevant problems. When dealing with the issue of sustainability and energy savings Danish architects have maintained the strong focus on heat consumption that was relevant after the first oil crisis. The fact that heat consumption due to better insulation and district heating supplied by heat and power plants have lost in importance and that other household functions driven by electricity plus transportation have gained in importance has not yet had any significant effect on architectural discussion or practice. The frontrunners of low energy architecture are primarily designing single family houses focused on low heat consumption. This of course has to do with the market situation: It only takes a single, environmentally engaged family to ask and pay for a low energy house, while dense urban development geared for soft road users is a much more complicated task. But even if the task is zero energy housing (including total household energy consumption) in dense urban context, as the Bolig+ competition shows many architects have maintained strong focus on traditional heat saving strategies: External glass rooms or 'glass galleries'.

When it comes to the one problem actually identified – heat consumption – the proposed architectural solutions in general have not worked. The winter gardens of the seventies and eighties caused a measured increase in heat consumption, because occupants used them during wintertime as not intended. In the nineties the winter gardens were replaced by big glass facades causing overheating and very limited energy savings partly because very big quantities of passive solar cannot be fully utilized and because big glass facades causes big heat losses too. In the recent architectural competition where winter gardens/glass galleries are used as buffer zones in high insulated multi storey housing they do not reduce heat consumption either, but they reduce the daylight qualities of the flats.

Are there any inherent barriers in the architectural approach?

Firstly it is important to emphasize, that we are not dealing with incompetent architects. Danish architects have won lots of international competitions often due to strong and simple architectural concepts, user-oriented approaches and convincing aesthetics, and the architectural firms mentioned in this article are among the best. Then why do they fail when it comes to energy and (indoor) climate?

It seems obvious that the beaux-art schooling tradition is a major reason. Architectural schooling that plays down technical or infrastructural aspects not only determines what is

learned in school but also limits what aspects of architecture are brought to life in the minds of students and what is discussed, found important and later on learned more about. It is true that some practical and technical competences will be acquired during practice and profession, but not handled and integrated with the same affection as those aspects one has learned to care about during education.

Not only has the technical aspects been played down, they have also been perceived as threats or regarded as something architecture were opposed to – architecture versus engineering. Why is that? In'Human ecology's notion of nature' the philosopher Hans Fink [Fink] observes that nature is often understood as a contrast to something else. Nature is seen as the wild opposed to the cultural, as rural and green opposed to urban, as earthly opposed to heavenly, or nature is perceived as that which concerns the (scientific) laws of nature as opposed to abstract, subjective, symbolic or cultural phenomenon. Fink notices that human science during the last hundred years has perceived it's identity as something opposed to natural science, insisting that it is wrong to regard man as 'just' nature. This oppositional attitude is evident in the architectural education and among architects where calculations and rational considerations (the world of the engineer) are often seen as obstacles to spontaneity, inspiration and artistry. Albertsen [NA 2002 No 3, pp 7-22] speaks of defending different regimes or worlds, the world of inspiration being one of them. The oppositional attitude not only characterizes the elitist 'architecture as art' positions but also the representatives of socially engaged architecture focusing on optimizing the environment of common man and fighting technocracy and insensibility.

Playing down the technical aspects of architecture means that crucial potentials remain undeveloped. This goes for statics and construction, but never the less constructive aspects hold such a strong a position in the architectural tradition that it is not totally ignored. Even the most ethereal artist acknowledges that houses should not fall apart. It is different with architectures relation to energy and climate including indoor climate, ventilation, cooling, artificial lighting etc. These are relatively new disciplines, and the building physical conditions change so rapidly that only the technical observant will keep up. In the nineties architects still argued against high insulation in favor of fresh air (though insulation and air tightness are different subjects) as if good indoor climate could rely on leaky walls. Winter gardens may have been relevant as solar collectors to the poor insulated houses of the early seventies, but not to new built high insulated houses of 2009. If you do not design according to current conditions but instead copy a visual perception of former, historic projects you will fail. The problem of relying on visual image is also evident in the perception of rural living being most sustainable. Well, it looks so but is not so.

Optimizing the interplay between architecture, energy and climate there are two ways to go, focusing either on the processes or the knowledge of the architect:

Either the architect can maintain the humanist role as the one taking care of aesthetics and human functional demands. This route requires that engineers and possibly other professions are included in the design process from the very beginning on fairly terms, not having to give in to 'architectural' energy concepts raised above laws of nature, as indicated in the Bolig+ competition. Kongsli et al [Nordic Journal of Architectural Research 2008 No 3 pp 7-20] proposes a more humble role, where the environmental architect is a participant in rather than a conductor of the design and building process.

Or else the architect and the architectural education must integrate knowledge in new fields, profoundly changing the traditional profile of the architect, thus enabling him or her to maintain a leading role in the design process. Such change will undoubtedly be met with skepticism: Does knowledge and awareness of technical and infrastructural aspects mean that architects should transform to social engineers in the Hannes Meyer-sense that architecture is not about art or artistic approach at all [NA 2002 No 3, pp 7-22]? Does physical sustainability promote a technocratic society? Well, if people shall live in energy effective buildings in dense urban environment, in rich countries the great majority will choose to do so only if the building and urban conditions seems aesthetical attractive and offer good, sensuous experience. Thus aestheticism itself becomes a sustainable parameter. Artistry and aestheticism should not be suppressed in favor of sustainability, a Vitruvian approach will do.

The idea that technical knowledge and skills should harm aesthetics or the architectural wholeness is an idea based on an artificial division between humanity and science. Hans Fink [Fink] proposes a non-oppositional notion of nature: Nature as the whole. "If we shall understand the nature of man and mans place in nature and deal with the concrete problems of the unintended effects of human life it is crucial to counteract all scientific, religious and everyday tendencies to perceive ourselves or parts of ourselves as so unique that we or it does not belong to the remaining context. [...] it is important, that human ecology in this way insists on being a challenge to the existing structure of professions, as this structure apparently contributes to block that understanding of wholeness that are so urgently necessary".

AUTHOR

Michael Lauring
Assistant Professor
Aalborg University, Department of Architecture and design, Denmark
mlau@create.aau.dk

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