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Being and becoming – sustainable architecture in the USA

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ABSTRACT: The Kyoto Protocol was passed ten years ago. Counties that ratify this protocol commit to reducing their emissions of carbon dioxide and other greenhouse gases. America, the country with peak values of CO_2 emissions, is the only nation to have just signed but not yet ratified the law. Although the former American government was not willing to get involved in climate issues, educated American people seem to be developing a general interest in sustainability and in involving it in their daily lives. The Schools of Architecture at American Universities are opening up to the topic and are appointing experts from Europe to integrate sustainability as a central element into the teaching of architectural design. What is the situation in the United States and how can sustainable principles be adapted to the American way of life? This paper defines the term sustainability in reference to contemporary architecture. It deals with the pre-conditions required to be able to implement the principles of sustainability in American Architecture at European standards, taking Germany as a practice example, and it looks at ways to find solutions for the situation in the American countryside.
Keywords: sustainability, architecture, energy consumption, efficiency, natural energy cycle, laws of nature

INTRODUCTION

There are three methods with which we can reduce our consumption of fossil-based energy: developing and exploiting renewable sources of energy, increasing the efficiency of our machines and buildings, and reducing our levels of comfort. If we do not implement the first two strategies in good time, the last will inevitably be forced upon us.

At this stage, in the early 21st century, architects should feel a responsibility when designing their buildings to reduce daily energy consumption. Preparing architecture students for their later professional lives means that apart from their design and technical education, they must also learn to build in an energy-conscious manner. The moral issues of sustainability must be anchored in them such that they become conscious of their responsibilities as future architects and of the contribution, which they will make to the environment.

WHAT IS SUSTAINABILITY?

And how can we define the task of an architect regarding sustainability?

On a faster moving, more densely populated planet, new problems are constantly emerging that need to be addressed. Population explosion, pollution and depletion of natural resources are the three most critical factors that influence human living space.

Our neglect of sustainability is leading to many irreversible environmental problems. Our lives are defined by energy. We need high energy levels to maintain the standard of living that we are used to. The more technology-based life becomes the more power we use. We are now faced with the challenge of on the one hand, repairing damage already done over 200 years of industrialization and on the other hand, of finding ways of producing large amounts of energy without causing further damage.

As resources become scarce, fuel prices will become ridiculously high over the next two generations, making life unaffordable for the average person. Investigation into alternative energies is indispensable if we are to reduce our dependency on fossil fuels and avoid inevitable societal disaster. We also need to change our attitude, that energy supply is endless.

The only sustainable way to escape the existing and pending energy disaster is to reintegrate our civilization into natural energy cycles. Rather than turning the clock back to the time before industrialization, this means using technology to produce renewable forms of energy, like wind, geo-, solar, water, tidal, biomass and waste energy. All of these forms of technology have been sufficiently established to do so today. The broad variety of energies available and their geographical dispersion would make it easy to ensure adequate stability despite fluctuations in the power-supply

network.

According to data issued by the US Green Building Council, 65% of electricity consumption in the US can be attributed to buildings and their maintenance, including heating, air conditioning, lighting and electrical installations. By its daily behaviour, the occupant has a considerable influence on these aspects, but it is up to architects and engineers to lay the first foundations and to find solutions.

Sustainable building does not have to become a new architectural language as far as style is concerned. It can be applied to any style. It is rather energy efficient, has intelligent facades, uses materials optimally and has balanced and adequate building services. Constructive elements are the building blocks of sustainable design processes. New materials are generating new aesthetics. The secret of a well-balanced energy efficient building is hidden in equilibrium between saving and gaining, always in terms of local conditions.

Neither sustainability, nor ecology is merely a matter of technically expensive solutions.

They are rather about tapping into the specific potential of a location using systems that intelligently adapt to local and climatic conditions. These are always different, because there is never a single correct solution. Such systems are based more on natural processes than on technically supported systems. Strongly self-regulating processes include activating storage masses, exploiting thermal effects and aerodynamics for ventilation and generating coolness through water evaporation.

It is one of our main duties and responsibilities to make students aware of these matters, to sensitize them to present problems and to teach them how to treat their environment much more vigilantly and a great deal less ignorantly than their forefathers did.

STATUS - ENERGY CRISIS

In 2005, the richest 17% of the world inhabitants consumed more than 50% of its energy. In other words: if every person in the world were to consume the same amount of energy as the average US American, the world's entire consumption would be 6 times higher than it is today. Our fuel reserves would have disappeared in eight years time.

According to data issued by the BP Amoco Statistical Review of World Energy the kW consumption of the world's inhabitants ranges from 150kW (Bangladesh) to 15,000kW (Singapore). For example, a German regularly consumes 5,000 kW of effective power per day, 365 days a year; a Chinese person consumes 1,200 kW, and an American 10,500 kW. These huge differences are caused by climatic zones (moderate versus extreme), local situations (urban density versus countryside), average standards of living and different technological backgrounds.

Comparing German to American statistics is like comparing apples to oranges. America is approximately 30 times bigger than Germany and is inhabited by only approximately 4 times more people; however, accepted standards of living and comfort, technological influence on daily life and education levels are very similar.

CURRENT SITUATION IN GERMANY

The 1973 and 1979/80 oil crises caused recessions in European industrial states that awakened their awareness of how dependent they are on fossil fuels. Direct constrictions on daily life such as a general ban on motorized vehicles on Sundays or speed limits morally influenced people, but did not have any financial consequences for them. Public interest focused on nuclear energy, regenerative energy sources, alternative fuels like Biodiesel and vegetable oil, and also energy generation through waste incineration. As far as construction was concerned, people focused on insulation and improving the efficiency of heating.

In the aftermath of the oil crisis, daily life was influenced by an increased awareness of energy-conscious behavior. German architects and engineers started to optimize building coverings, worked on passive design concepts and developed active energy gain installations (i.e. solar). New laws defined the goal to reduce the maintenance costs and therefore the energy consumption of new and converted buildings.

The design principles of passive houses and low energy houses – such as orientation, compactness and super insulation, heat recovery and natural light - were defined and are now the basic principles of much building within the European context.

As they strive to reduce the energy consumption and therefore maintenance costs, office buildings have recently come to be designed according to the principles of climate sensitive design.

Buildings are optimally oriented along the path of the sun, natural ventilation and lighting, and storage masses such as walls and ceilings are also activated. Although in such cases building costs may be higher than in conventional office buildings, low-tech buildings that are in harmony with the laws of nature prevent the sick building syndrome from occurring and

raise the productivity of the user.

A demand for renewable energy and its promotion culminated in the introduction of feed-in tariff laws (EEG) to push forward the development of energy supply facilities based on renewable energy in order to reduce dependency on non-European fossil fuels. The production of hydro power, landfill gas, bio-mass energy, geothermic and solar power (photovoltaic) are being promoted. The basic idea was to pre-define a rate of reimbursement for the electricity produced over a certain period of time to facilitate economically viable operations despite high investment costs for the construction and activation of such facilities.

CURRENT SITUATION IN THE US

It is important to differentiate between urban, metropolitan America and the spacious and more rural parts of the country when regarding the present situation in this country.

Due to the fact, that it seems to be possible and easy to apply the proven principles of sustainability to urban regions, I would like to focus my observations on the American countryside, which represents the main portion of the entire American carbon footprint.

In contrast to Europe, United States city and regional planning revolves around the fact that there is no shortage of space at all. One result is the American dream of owning (and at best building) a single-family house on a site that is spatially independent of its neighbors or urban density. Such free-standing houses are located in the countryside in places of particular beauty. One consequence is that the car becomes indispensable to daily life. Public transport is rare and is socially stigmatized. This kind of planning can be defined as a car-oriented regional planning.

The American reaction to the 1970s oil crisis was an ambitious and visionary energy and environmental policy introduced by President James Earl "Jimmy" Carter, who started by installing a solar plant on top of the White House. Aware of the finiteness of fossil resources, he founded the first ministry of energy. He even challenged Americans to restrict their personal lives, to wear thick clothing instead of turning on their heating; however, these ideas did not attract too much interest.

When his presidency ended, the solar plant at the White House was pulled down while his successor Ronald Wilson Reagan focused on other topics. The subject of energy policy was discussed no further until Albert Arnold "Al" Gore started his global warming campaign.

In contrast to European architecture, American homes are mostly built in lightweight construction. This method of construction was brought to America by the first European settlers 400 years ago and has since been in constant development and improvement. It is based on the construction methods use in typical German half-timber building.

Wood for construction is available all over America; it is cheap, structural and it insulates to a certain degree. The invention of large sized timber panels with bracing qualities meant that these methods could be simplified to a basic wood frame construction. Generally this building type has no basement, its skin and partition walls are made of processed timber products or plaster building boards and its insulation is placed in the spaces between the panels. Its sparse insulation in comparison to European standards and a lack of solid components for storage mass means that this building type has to accommodate increased heating and cooling input.

By the end of the Second World War, the air-conditioning system had found its way into private households. "Conditioned air" was promoted to the public as a part of modern day life. The promised benefits were healthier air, clean interior spaces, but also the enjoyment of nature through huge glazed exterior walls without the interference of heat and humidity during the summer. These days air-conditioning is a standard installation in every American household. Remarkably, lack of thermal comfort in a building has nothing to do with a building's geometry, the orientation or the quality of the building's skin but rather with the power of the air-conditioning system.

To this date there is still no American directive that workplaces or permanently occupied areas must be naturally lit or have a visual connection to the outside.

While in Germany the energy efficiency of new buildings is legitimately defined by a EU directive, America only has a facultative system of evaluating concepts and planning of sustainable buildings.

The U.S. Green Building Council in Washington D.C. has developed a LEED (Leadership in Energy & Environmental Design) certificate to evaluate the correct handling of new buildings or conversions in terms of natural resources, nature and the environment.

The personal ambition of a client or architect determines whether the goal of a silver, gold or platinum LEED certificate is strived towards or not.

SUSTAINABLE MEASURES FOR AMERICA

America is a huge country; it seems impossible to come up with a single catalogue of sustainability that could apply to the entire country. There are several very different climatic zones within the country, which, according to my understanding of the term sustainability, must be addressed individually. European concepts for energy efficient and sustainable life can easily be adopted within urban contexts. Keywords such as urban density (also in suburbs), community-driven block heating stations, and public transportation can be realized without a doubt.

The real challenge is the transferability of sustainability theories to rural regions of the United States. Since the country has such an amount of space, it is unimaginable for people in the countryside to be forced to live in more dense settlements according to European standards.

Architecture must react to local conditions. Instead of merely consuming energy, buildings should gain the energy needed to run them (ideally including enough for the car too). Rather than building cheap, short-sighted, ephemeral houses whose envelopes at most serve as awnings and whose HVAC systems make them energy traps, we should be creating living spaces of probably higher building costs but lower maintenance costs and at least the same or higher levels of comfort.

Let me introduce three concepts of energy saving buildings that are based on the idea of reducing investment through energy efficient design. All of them follow clearly defined rules, which qualify the buildings for a state-issued certificate.

PASSIVE ENERGY HOUSING

The term passive house (*Passivhaus* in German) refers to the rigorous, voluntary, passive house standard for energy use in buildings. It results in ultra-low energy buildings that require little energy for spatial heating. The first passive house buildings were built in Darmstadt, Germany, in 1990, the first one in North America was built in Urbana, Illinois, in 2003.

The passive building design follows the concept that buildings have to be compact in shape to reduce their surface area, with windows oriented towards the south (in the northern hemisphere) to maximize passive solar gain. Passive houses can be constructed from dense or lightweight materials, although some internal thermal mass (a dense mass such as concrete or stone that stores heat or cold from its surroundings and releases it to the inside in reaction to rises and falls in interior temperature) is normally incorporated to reduce summer peak temperatures, maintain stable winter temperatures, and prevent possible over-heating in spring or fall before normal solar shading becomes effective.

Passive houses are normally ventilated mechanically to maintain air quality and to recover sufficient heat to dispense with a conventional central heating system.

Although not compulsory, earth-warming tubes are often buried in the soil; they act as earth-to-air heat exchangers and they pre-heat (or pre-cool) the intake air for the ventilation system.

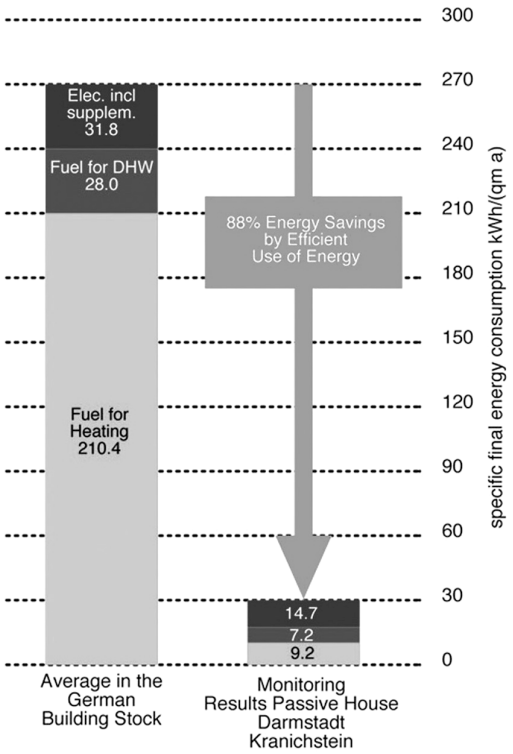

Figure 2. Energy consumption average and passive house

In addition to using passive solar gain, passive houses make extensive use of their intrinsic heat from internal sources – such as waste heat from lighting, white goods (major appliances) and other electrical devices – as well as body heat from the people and animals inside the building. Due to the comprehensive energy conservation measures taken, a conventional

central heating system is not necessary, although they are sometimes installed as a result of client scepticism. Just to give an example of the verifiable benefit: in the United States, a house built to Passive House standard needs between 75 and 95% less energy for spatial heating and cooling than current new buildings that meet today's US energy efficiency codes. (Fig 2)

ZERO ENERGY HOUSING

A zero energy building (ZEB) or net zero energy building is a general term applied to a building with a net energy consumption of zero over a typical year. This can be measured in different ways, relating to cost, energy, or carbon emissions. Irrespective of the definition used, different views are taken on the relative importance of energy generation and energy conservation to achieve energy balance.

The zero-energy approach is seen to be a potential solution to a range of social and environmental issues, including reducing carbon emissions, reducing dependence on oil power, fuel imports, and the use of fossil fuels in general, and providing a measure of energy security against future energy crises.

A zero energy house is designed according to the same principles as a passive house. The main differences are that it has a maximum of solar design elements to provide as much as energy as the building needs and that the materials used should be available locally. Another difference to a passive house is that the inhabitants of a zero energy house must be more conscious of and careful with the amounts of energy they are using.

ENERGY PLUS HOUSING

The energy plus house was invented as a logical consequence of the passive energy house and the zero energy house. An energy plus house produces more energy from renewable energy sources, on average over the course of a year, than it imports from external sources. This is achieved using a combination of low-energy building techniques, such as insulation and careful site selection and placement, and micro-generation technology such as photovoltaic for solar power generation, heat recovery and earth-warming transfer.

The first prototype was built in 1994 in Freiburg in Breisgau, Germany and was followed by several solar-powered residential settlements.

They often involve a sort of modern minimalism, providing lower levels of modern comfort as they try to save energy rather than waste it. Others are more similar to "normal" homes, since they simply use the most efficient of everything throughout the house.

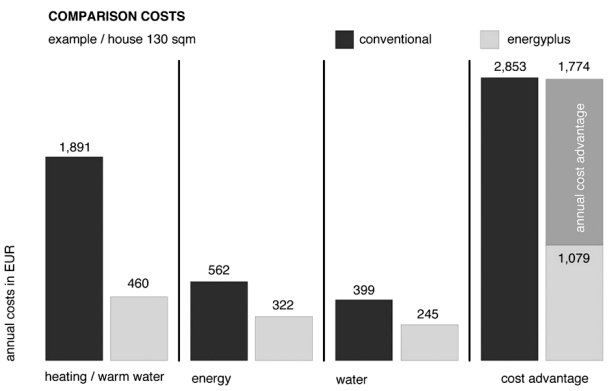

Figure 3. Comparison costs conventional and energy plus house

CONCLUSION

It is our task to introduce the future generation of architects to these concepts. We must convince them, that architecture which initially appears to be more affordable and faster to build, is the more expensive solution in the long term; it does not contribute at all to the protection of our environment and therefore to the future.

Energy is a physical entity and can thus be precisely measured. This means, that energy efficient buildings have also become quantifiable, a dreadful notion for many architects. It is not clever for architects to go on the defensive when confronted with sustainable building. They should continue working towards good architecture and merely include the ideas of sustainability in their working methods.

Sustainability aims to merge socio-cultural, ecological and economic aspects, integrating form and function, construction and aesthetics, architecture and nature to a complex ensemble. This is what architecture of the future has to move towards.

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