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environmental architecture fundamental and advanced technologies

ABSTRACT

Environmental architecture in itself is nothing new. In fact, all forms of traditional buildings are designed to alter environmental conditions. During the long history of mankind mainly passive strategies were applied that created habitable buildings in otherwise unpleasant or even harsh environments. In modern times many more active strategies were invented that made the passive appear obsolete, but the price we pay is an ever increasing and excessive use of energy generated from non-renewable resources that has many deleterious effects on the environment. To limit these negative effects fundamental and advanced technologies can be applied in the building sector. Furthermore, the application of widespread energy generation from renewable resources creates new opportunities, as buildings change from passive through active to self-sufficient modulators of environmental conditions.

INTRODUCTION

Mankind is building houses for many reasons. To alter environmental conditions, to shield and protect the inside from unpleasant or unwanted conditions that occur outside has been a very basic one since the first primitive hut was erected. Pre-modern structures can be ingeniously designed environmental devices, utilising existing environmental conditions as the daily or yearly available resources of wind, sun, water, trees, sand or stones up to the fullest to create an internal climate that might be far from what we call ideal nowadays, but provided local residents with a habitable shelter to satisfy their basic needs. But the development of modern lighting, heating, ventilating and air-conditioning systems have turned the architecture inside out. They have empowered mankind for the first time in their history to create inside conditions almost independently of external conditions, everywhere, anytime. Banham (1984) has called this the "liberation [of] performance from form" (p. 310).

Unfortunately, great opportunities have often a price that has to be paid for their achievement and the price that we pay for making any form and environment habitable is previously unknown, excessive energy consumption. The energy is mainly generated from non-renewable fossil fuel resources and the emission of CO_2 causes global warming which is the reason for predicted deleterious changes of the environment on a global scale. Generally speaking it is an accepted matter that we need to reduce

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Japanese Strategy for Global Warming Issues and Energy Conservation in Buildings

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energy consumption and decrease CO_2 emissions. Although there are no commonly accepted roadmaps of how to achieve it, but the wise exploitation of available knowledge and technology can make a big contribution.

DISCUSSION

In the building sector fundamental and advanced technologies can be applied. This very simple differentiation separates well-established and widely used mature technologies on one side from frontier technologies, still under research with the strong potential of becoming fundamental technologies in the near future on the other side. Fundamental technologies can be further divided into passive and active strategies. Passive strategies utilise or shield from prevalent environmental conditions. Banham (1984) described the application of such strategies as "conservative mode" and "selective mode" (p. 23). In a purely conservative mode the building is designed to prevent unwanted conditions from entering while keeping desired conditions inside. On the other hand, in a purely selective mode the building is designed to admit desirable conditions from outside and expel unwanted conditions from within. Traditional architecture has always been a mixture of both "modes", with preferences according to different climatic conditions. Both passive strategies regulate available conditions without the use of additional energy. Examples include building geometry and orientation, interior zoning, heating by the sun or shading from the sun, open or closed envelopes, insulation and inside thermal mass for heat storage, cross ventilation and daylighting. In pre-modern times, buildings were designed to make full use of the climatic conditions, or in other words, the environmental performance of a building was dictated by its form.

The other fundamental technology are active strategies that use additional power and Banham (1984) calls their application the "regenerative mode" (p. 23). In pre-modern times the utilisation of active strategies included heating with open fires or stoves using fire wood, charcoal, etc., and lighting from the same sources, torches or candles. Their effect was limited as the resources were usually scarce and the burning inefficient. Only modern inventions greatly improved variety and efficiency. Examples include electrical lighting with incandescent light bulbs, fluorescent tubes, ventilation and air-conditioning systems with the possiblity of humidity control, hot water supply systems, basically, what is generally summarised as electrical and HVAC systems. Initially such systems were developed to simply improve climate conditions, but their availability and the sudden ability to design buildings without the need to consider external conditions resulted in a revolutionary "liberation [of] performance from form" (Banham, 1984, p. 310). An emphasis on active strategies resulted very often in buildings that neglect and even counteract passive potentials, further increasing the energy demand.

When only considering the fundamental technologies, a double strategy can help in reducing energy demand. Firstly, the wise utilisation of passive strategies to reduce the

need for additional energy, and secondly, the development and installation of highly energy-efficient appliances. The latter includes for example heat-pumps or LED-lighting. The focus of passive strategies lies very often on the insulating performance of the envelope, but should not be limited to it. Considering daylighting to limit the need for artificial lighting, but avoiding heat gains if undesirable, or admitting natural cross ventilation instead of using mechanical ventilation, but avoiding draughts are just two examples. In other words, the demands on the regulative capacity of the envelope have steadily increased. In fact, the envelope itself is changing from a passive mediating element into an active, energy-regulating device. Here, the advanced technologies will have a major impact.

As described earlier, advanced technologies are frontier technologies, mostly still under research but with the strong potential of becoming fundamental technologies and widely-used in the near future. Two fundamentally different developments can be distinguished. On the one side are those technologies, that aim at further improving the overall energy efficiency. Examples are cogeneration systems, heat recovery

<table>
<tr><td>Technology</td><td colspan="3">Elementary</td><td>Advanced</td></tr>
<tr><td>Strategy</td><td>Passive</td><td colspan="2">Active</td><td>Passive/Active</td></tr>
<tr><td>Mode according to Banham</td><td>“Conservative“ and "Selective"</td><td colspan="2">“Regenerative“</td><td></td></tr>
<tr><td>Heating</td><td>sun heating closed envelope</td><td>open fire or stoves</td><td rowspan="3">air-conditioning and mechanical ventilation with humidity control</td><td rowspan="2">cogeneration, solar thermal heating and cooling</td></tr>
<tr><td>Cooling</td><td>sun shading wind open envelope</td><td>adding moisture (dry climates)</td></tr>
<tr><td>Ventilation</td><td>cross ventilation</td><td>manual fan</td><td>heat recovery</td></tr>
<tr><td>Humidity</td><td>-</td><td>-</td><td></td><td></td></tr>
<tr><td>Lighting</td><td>day lighting</td><td>torches, candles</td><td>incandescent lighting</td><td>distant daylighting with fiber optics</td></tr>
<tr><td>General</td><td>building geometry, orientation, interior zoning, envelope</td><td>“liberation [of] performance from form“</td><td></td><td></td></tr>
<tr><td>Power</td><td>sun</td><td>fuel, mainly from renewable resources</td><td>electricity, mainly from fossil, non-renewable resources</td><td>electricity from renewables (solar, wind, biomass, geothermal), waste heat</td></tr>
<tr><td>Storage</td><td>thermal mass (short term)</td><td>fuel (long therm)</td><td>supply on demand</td><td>battery, water, ground (short to long term)</td></tr>
</table>

Table 1: Elementary and Advanced Technologies

systems using used air, sewage water or geothermal energy, solar thermal heating and cooling systems. On the other hand are a completely different kind of technologies. I am speaking of devices that transform the renewable, abundantly and freely available environmental energies, store them and retrieve them when needed, to liberate performance from supply. The most striking example are photovoltaic cells, that transform solar light into electrical energy, completely noiseless and maintenance free. Woven into the building's fabric they can charge batteries and supply the required energy for achieving the building's intended performance when needed. Thus a building changes from an energy consuming structure into a truly self-sufficient, environmental energy modulating device. If the generated energy greatly surpasses the building's demand, it may even liberate the building from the currently prevailing energy efficiency only paradigm and opens the door into a still unthinkable future of abundant energy.

CONCLUSION

To achieve a significant reduction in energy consumption as well as CO_2 emissions the following measures should be combined.

– Energy regulating, high-performance envelope (passive strategy, fundamental technologies)
– Energy saving, highly efficient equipment (active strategy, fundamental technologies)
– Energy recovery, generation from renewables and storage (advanced technologies)

As an outlook into a near future, passive elements as for instance the building's envelope may be upgraded with clip-on or integrated solutions into active elements, that can regulate the internal climate more efficiently than in the passive mode. Genereally speaking, buildings are changing from pre-modern, mainly passive through modern, active to future, self-sufficient modulators of environmental conditions. They will provide ideal internal conditions while making full use of external renewable resources.

REFERENCES

Banham, R. (1984). *The Architecture of the Well-tempered Environment* (2nd ed.). Chicago: University of Chicago Press.