

SOLAR DESIGN IN ARCHITECTURE AND URBAN PLANNING

Dr.-Ing. Ingo B. HAGEMANN
Architect and Consultant
ARCHITEKTURBÜRO HAGEMANN, Annuntiatenbach 43, D-52062 Aachen, Germany
Phone: +49/(0)241/34530, Fax: +49/(0)241/30547
E-mail: Ingo@architekturbuero-hagemann.de
www.architekturbuero-hagemann.de, www.GIPV.com

Abstract

In recent years, society has become aware and therefore sensitive for the destruction of the natural environment with its unpredictable economic and ecological consequences. There is an increasing demand to think and to behave ecological. These emerging changes of our relationship with the environment and our society require also new concepts for town planning, building design and construction. The demand for a sustainable and solar building design is given! The know-how and the technologies available today are sufficiently developed to design appealing buildings which at the same time make use of the sun as an unlimited source of energy. The buildings of the past were energy producers. The buildings of the future will be energy producers. In particular non-technical barriers still need to be solved to apply successfully such concepts and technologies on a broad scale, starting already with innovative solar town planning concepts. This paper gives an introduction to the topic and identifies basic framework conditions, which are necessary for the successful introduction and application of ecological and solar design strategies in the built environment.

1. Introduction

In recent years, society has become aware and therefore sensitive for the destruction of the natural environment with its unpredictable economic and ecological consequences. With the purpose of conservation, goals have now been set to reduce the consumption of fossil fuels and to utilise energy more efficiently and cost-effectively (Fig. 1). As a result of these goals, specifications and requirements for the construction and design of buildings are changing [1].

In the last twenty years, great improvements have been made in the energy efficiency of buildings or the utilization of solar technologies on buildings. Visionary clients as well as a small but very active and innovative community of architects, designers and engineers took the risk to use and to develop further solar technologies and strategies for urban plans and buildings. Today urban plans can be optimized to secure the right of sunlight and to minimize possible heat losses of the buildings. Active and passive solar design principles can be used within a building to lower its energy demand, to provide hot water or electricity. In Germany or Japan some solar technologies got already extremely popular, such as for example the integration of photovoltaics in buildings. However the gains already made are just a start of a process to convert our homes from an energy user to an energy producer.

In spite of these first achievements the vocabulary of "solar", "ecology" or "sustainability" has not been generally accepted by architects and town planners. Many of them are still not very keen on using such technologies and strategies. They view such a design as a limitation rather than an opportunity. Although it has been used already in a large number of projects, many architects and clients still have the feeling that solar and ecological architecture implies rigid design limitations, regarding orientation, placement of windows, sloping roof elements, sun spaces, choice of building material and so on [11]. At the same time such a design is also felt as a restriction of life style by requiring occupants to take care for the operation of technical equipment.

But this viewpoint is based on a lack of understanding and knowledge about today's achievements and design variety of solar technologies and strategies. In particular non-technical barriers still need to be solved to allow a wide-spread use of sustainable design principles in Architecture and Urban Planning. Extensive information, training and education campaigns will be necessary to resolve these barriers and to allow their wide spread application.

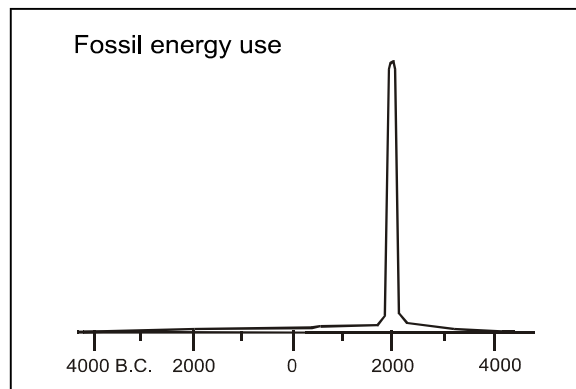


Fig. 1: Options to influence the future energy demand of a building



Fig. 2: Patchinko-Palace, Nagoya, Japan

2. Building construction and life in a city

The original meaning of building construction can be traced back to the human being's first step towards an independence from nature. According to archaeological discoveries the human being is able to survive in nature without additional aids except in rather cold and hot climatic regions. The emphasis lies on the word "survive". But to develop further beyond this mere fulfilment of basic requirements, the human being needs more snugness and leisure than is given to it in its daily survival in nature.

Through the development of social forms of organisation and the construction of technical aids the human being succeeded to erect buildings which allowed it to regulate the environmental influences. No longer the human being needed to continue a daily survival in nature. It was the mankind's first step towards the independence from nature, which helped us to find time and leisure.

The city is a part of the nature which has been wrest away from it. Here the human being lives in independence from nature. The night becomes day (Fig. 2). One is freed from the social control of rural family- and neighbourhood associations. The city is like a "service machine" that frees the individual from specific work and responsibility. The household became a passing station: consumer goods come in, garbage and dirt come out. The city acts as a huge organism, which takes care of the supply and the removal of what is needed. The city is the germ cell of cultural life. The life in the city is indicated through independence and a fast life style. To maintain these living conditions much energy is needed.

Since the early days of building construction the design and construction of buildings developed to a skilful art and science. Today buildings have to perform many other functions as well. One of them is that they serve as an image carrier. For example: remaining buildings from the past such as churches and houses of the rich and prevalent people today still give a testimony of the powerfulness, the wealth, the strength and the dreams of their builders.

Today in a time of general prosperity and freedom most of the individuals in Europe are able to document their lifestyle, their ethos, their needs and their dreams consciously or unconsciously with their house, their apartment or their individual room. An almost open ended access to building materials, fitments and



Fig. 3: Mansion, Breisach, Germany (Architect: Spiegelhalter)

technical know-how allows turning diverse individual's dreams into reality (Fig.3). However these dreams and needs are very often a mere reflection of the expectations and moods of the associated social environment.

At the same time the individual has to accept the contractors, builders, architects and town-planners ideas about the realisation of their vision of a home. To be able to design and construct buildings, which meet the people's needs and dreams, requires an intensive dialogue and exchange of ideas among the users and all people being involved in the design and construction process of a building. To allow for that, time, readiness for the listening and compromise ability are required from all participants.

In the wake of escalations of energy prices, energy shortages and concerns about pollution, environmental degradation and resource depletion, the awareness of the environmental impact of building construction among the building professionals has increased [3]. Building professionals with vision have come to understand that it is no longer the goal of good design to simply create a building that is aesthetically pleasing. Buildings of the future must be environmentally responsive as well.

3. Necessary social and ecological value change

In 1866 Ernst Häkel described "ecology" as a "teaching of the household of nature" as a "science of the relationships of an organism with the encircling outside world"[4].

Since "Ecology" is brought together with an environmental benign behaviour, the term "ecology" is comprehended as the science of the relationships of organisms to their physical environment and to one another. Ecological thinking tries to develop greater contexts of our living conditions and to provide insights into the long-term consequences of human behaviour.

Step by step we get conscious of the limits of the earth, of her wealth, her resources and her regeneration capabilities as well as about her possible environmental catastrophes. Consequently the more we get aware of them, the more it appears to be necessary to think and to behave ecologically.

We have to acknowledge the regeneration laws of nature and the necessity of ecological cycles, which need to become the foundation of our structures in society, technology and settlement.

Hallmarks of a social and of ecological value change

1. In addition to the agents of land, capital and labour the environment becomes increasingly an asset in the economy.
2. The relationship between the human beings and the environment attempts to line up to a gentle attitude towards the nature and their resources.
3. The standards of a social behaviour do change: Concepts like idealism and group motivation gain more importance. One gets stronger orientated towards the community, the co-determination and the self-realisation.
4. Dual economy forms spread out: The interest of work that is paid for is taken away in favour of self-help, shadow economy, home work and neighbours help.

These emerging changes of our society and our relationship with the environment require at the same time new concepts for town planning, building design and construction. The demand for ecological and solar building design and urban development is given!

Among different renewable energy sources the most pollution free, limitless source of energy is the solar energy, which can be utilized with active and passive solar design strategies and technologies. Going "Eco" and "Solar" is simply a physical manifestation of living intelligence and the architectural landscape requires changing accordingly.

4. Solar design in building construction and urban planning

4.1 The beginning

In the post war period several initiatives and events created the beginning of awareness that there are alternative answers to a conventional building design, construction and power supply:

In the middle of the 1960's Bernhard Rudofsky presented an exhibition "Architecture without Architects" in the Museum of Modern Art, New York, which documented examples of a climate-appropriate building design which has been developed in detail and tested for good by generations (Fig. 4) [5]. Dependent on the individual site conditions and the building materials being available close by the site, in the various climatic regions people developed different types of dwellings and means to protect themselves in a simple way against the environmental influences. Regardless the variety of design and structural solutions it is possible to indicate the following mutualities:



Fig. 4: Sanaa, Jemen



Fig. 5: Annex building out of tins, Taos, New Mexico

- Integration in the local landscape (construction materials, outlook)
- Exclusive use of locally available, natural construction materials
- Uniformity of the construction structures
- Application of traditional and time-tested construction techniques
- Easy to repair with simple means by everybody
- High care neediness of the buildings
- Building construction was understood as a process

At about the same time, with the start of the "alternative movement" of the 1960's, pictures of outlaws and people from the flower power generation came from the USA to Europe. These people created individual built environments from the waste of affluent society. "Making Architecture" became a question of life style. With technical skills and artistic creativity construction techniques of the Indian cultures, the European immigrants and the most recent know-how in building construction were mixed together [6]. As a result pictures of story-book attraction have spread dreams of architecture into the world since then (Fig. 5).

Out of this cultural movement the beginnings of a solar architecture gradually developed in the USA. A passive solar architecture got popular which was marked by houses orientated strictly to the sun to use winter sunlight for heating. Large south-facing windows were used to collect solar heat, which was stored in massive walls and floors for gradual release throughout the night. Overhangs would allow to heat the homes in the winter and to shade out the sun in summer [12].

In Germany at the end of the 1960's a group of architects, designers, engineers and sociologists, called LOG ID, were aiming at a life within a green environment. The life and work in a greenhouse got tested and promoted. Home designs, similar to glass houses, served simultaneously for the food production, energy gaining and as heat storage. The idealistic goal was the dream of the self-supply. Models of non-centrally organised product production and an energy supply from regenerative energy sources were propagated as alternatives to the big industry.

By the end of the 1970's a whole number of single initiative and concepts developed from these first approaches. They are all based on the search for a life style, which tries to create a healthy and environmental friendly environment. The number of names for the designation of these different concepts is long:

1. "Ecological Building Design",
2. "Biological Design",
3. "Sustainable Building Design",
4. "Natural Design",
5. "Climatic Building Design",
6. "Alternate Building Design",
7. "Sustainable Architecture",
8. "Ecological Architecture",
9. "Solar Architecture",
10. "Organic Architecture",
11. "Vernacular Architecture",
12. "Climatic Architecture",
13. "Green Architecture",
14. "Natural Architecture", etc.

An obligatory definition of these different individual concept names and a precise delimitation of the single measures connected with it do not exist. Most likely such a definition will not exist in the future either. Today these single approaches of the various directions are adopted under the umbrella of an "ecological and solar building design" which aims at a holistic design approach.

4.2 Definition

"Ecological and solar building design" can be described as any form of design that minimises environmentally destructive impacts by integrating itself with the living processes.

It is a design approach which infuses on all levels of the planning, design and construction process a rich and detailed understanding of ecology and active and passive solar power utilisation. It connects scattered efforts from different design and engineering disciplines with the goal to create a healthy and socially beneficial life for us as well as for future generations. It requires an interdisciplinary dialog, which bridge conventional design disciplines.

The buildings impact on the nature household is the scale for the appraisal of all these attempts, regardless at which place and at which time it will occur during the life-cycle of a building.

Rather than refusing modern construction materials and techniques across the board it is necessary to investigate critically and subsequently, which contribution each old or new construction material or technique is able to make for the environmental relief and to use them accordingly.

It must be judged individually, which of the abundant planning and technical measures are technically and economically useful for a town planning or building project. It depends on the individual boundary conditions of each project, such as local topography, climatic conditions, user demands and financial resources.

Not all approaches are applicable to an object at the same time. Some measures work well together, others exclude each other or do not fit for other reasons in a particular project. There is no clearly defined list of solar and ecological design strategies and technologies, which need to be followed. For each project a specific concept must be compiled along with different measures. The enclosed target list gives an initial reference point of overall demands which should be considered:

- Considerations across the environmental relationships of all living beings and modesty with regard to the own role within these relationships
- Lowest possible pollutant delivery at the environment
- Lowest possible power consumption from fossil energy resources
- Maximum use of renewable energy sources including the use of active and passive solar systems
- Exclusive use of renewable, recyclable and environmentally harmless construction materials
- Exclusion of all building materials with unhealthy out gassing, in particular if they are used inside the building
- Lowest possible interference of the environment including the use of land
- Improvement of the natural conditions for a diverse local-orientated animal and plant world
- Lowest possible consumption of drinking water

- Reduction and avoidance of the settlement waste to be deposited
- Optimal life-hygienic conditions and socially beneficial living conditions
- Cost effective building constructions
- Creation of a long-term use-value, i.e. the building must be easily adjustable, alterable and repairable

4.3 The building routine

Out on the construction field it becomes clear that a true sustainable consciousness is still missing to a great extend. The predominant part of the buildings is still constructed with traditional building methods along with and without architects, unless building regulations or the client demand for something else.

However symbols of a "making-ecological" consciousness building design, such a bio-pond, rain barrel or glass patio, etc. sell well themselves. But they are no more than cosmetic equipment which expresses the good will of the people being involved. In these cases the search for a new quality of a built environment sticks in a bare expression of external form.

But in some countries, such as Switzerland or Germany, one got already a step further. Approaches that were seen as "ecological" or "solar" in the past, are considered today as a "state of the technology" and are applied for predominantly economic and technical reasons. This applies primarily to approaches which allow for energy savings, such as the use of low-temperature heating systems, such as water saving taps for a reduction of the drinking water consumption, or the use of active solar systems such as hot water collectors or photovoltaic (Fig. 7,9,11,12) [7].

In Germany the standards for the energetic performance of new buildings have been successively increased in the past years. Predominantly great progress was obtained in the window making and new technological developments of the heating and ventilation systems, which improved the energy balance sheet. By law new buildings have to fulfil a so called "Low Energy House Standard" [8]. Further ambitious engagements seek now for the new target mark, called "Passiv-House-Standard"[9], with a primary power consumption of less than 15kWh/m²a (Fig. 12).

But without the further development of the technology, the building components and their suitable integration concepts into the building fabric such targets can not be reached on a broad scale. To convince the majority of people working in the building sector ecological and solar design must become really attractive not only with regard to the technology but also with regard to appealing design solutions, which stirs up our creativity and emotions in a positive sense. One solar technology which already succeeded in doing so is the "Building Integrated Photovoltaic (BIPV)".

5. Example of a successful solar technology: Building Integrated Photovoltaic (BIPV)

Photovoltaic (PV) is perhaps the most promising active solar technology utilized on a building. Different from other solar technologies it has achieved a popularity and offers sophisticated design solutions for various applications on a building.

Basically it may be considered a covering material which has the added value that given the right conditions it can produce electricity during certain periods of the day. The production of electricity may be considered thus a bonus to this unique exterior building material. Its integration in the building envelope offers cost advantages and is attractive for urbanised regions in countries with not sufficient unoccupied land available.

In some countries it has become a popular part of the building vocabulary. It can be used today on both existing and new buildings. Its use in the building envelope is very varied and open ways for creative designers. In particular semitransparent photovoltaic glass modules can be changed into a truly multifunctional building component which is able to serve in addition to an electricity production other functions of the building envelope as well.

Such synergy effects of a photovoltaic module only turn out to be successful if its integration in the building fabric is carefully understood and the photovoltaic is fully integrated into the overall design and energy concept of a building. In particular non-technical barriers still need to be solved to allow an intelligent and wide spread application of photovoltaic in the built environment.

Examples of different ways how to integrate structurally PV into the building fabric are:

5.1 Roofing materials

Roofs are ideally suited for PV integration. There is usually less shadowing effects at roof heights than at ground level and a roof usually provides a large unused surface for integration. For PV integration purpose, a distinction between pitched and flat roofs is made.

Pitched Roofs

PV modules can simply be fixed on top of pitched roofs. This type of low-cost application is still used most to mount smaller PV systems (approx. 5 kWp) on private homes as well as on existing roofs in Germany. A more elegant way to integrate PV is to use PV-Shingles or PV-Tiles which permits the mounting of the PV module like any shingle or tile by a roofing contractor. Successful developments from Germany are for example "Terra Pitta Solar" from Pfeleiderer, the Braas Solar Roof Tile or the Solar Roof Tile from Laumans (Fig. 6, 12).

Flat Roofs

Flat roofs have the advantage of good accessibility and ease of installation. The classical way of integration has been to mount the array on a substructure which is then fixed to the roof. As with pitched roof, special care must be given to fix the array without breaking the integrity of the roof. Additional care must also be given to the added weight of the array on the roof and against uplifting force of the wind which could

blow the modules away. Experiments and developments in this field have lead to lighter, easier and quicker to handle standard array structures, such as SOFREL®, SOLBAC®, SolMax®, ConSole®, etc.. In addition to such standard mounting systems still a number of custom made flat roof structures are carried out in Germany.

5.2 Building Facade Panels

PV modules can be added on the existing wall to provide an aesthetically successful facade. They are just added on to the structure and there is no need to provide a weather tight barrier, this being performed by the structure underneath the modules. PV systems can also be an integral part of the building element of the facade. Glass PV laminate used as a cladding material are basically the same as tinted glass. They provide long lasting weather protection and can be tailor-made at any size, shape,



Fig. 6: PV-Roofs, Solar Settlement „Nieuw-Sloten“, Amsterdam, The Netherlands



Fig. 7: Wall cladding with amorphous PV-Modules, Thyssen, Duisburg, Germany



Fig. 8: Wall-cladding with crystalline PV-Modules, Solar Ark (Sanyo), Gifu, Japan

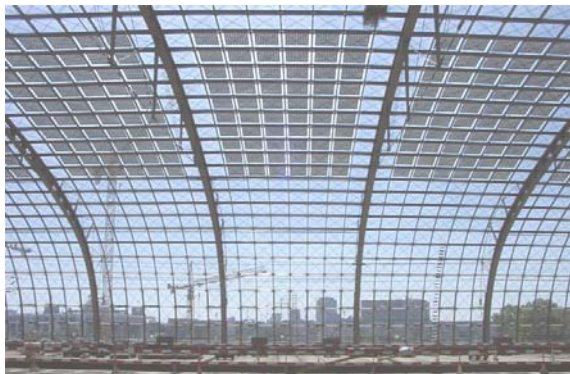


Fig. 9: Overhead glazing with crystalline PV-Modules, Lehrter Bahnhof, Berlin, Germany



Fig. 10: Glass facade with semitransparent amorphous PV-Modules, Barcelona, Spain



Fig. 11: PV Shading System, Eschweiler, Germany

pattern and colour. PV-modules can be also configured as a multifunctional building element (Fig. 7,8).

5.3 Semi-transparent facades

As windows, glass PV laminates can realise its transparency function in two ways. The PV cell itself can be so thin or laser grooved that it is possible to see through it providing a 20-50% filtered vision to the exterior.

Semitransparent amorphous silicon modules are especially appropriate for this but have not yet used much for building integration in Germany. A new option is the use of semitransparent crystalline solar cells (Photo 2).

On the other hand cells on the laminate are spaced in such a way that partial lighting filters through the PV module and illuminates the room (Photo 3). Light effects from these panels lead to an ever changing pattern of shades in the building itself. The room remains shaded yet not constrained.

By adding layers of glass to the base unit of the semitransparent PV glass module thermal and acoustic insulation as well as other special requirements can be designed according to individual requirements of each application. This type of a truly multifunctional building component with PV is most successful in Germany and is able to serve a large market in the building sector (Fig. 9, 10).

5.4 Skylights

Skylights structures are usually the best from a solar point of view since they can combine the advantage of light diffusion in the building while providing an unobstructed surface for the installation of PV modules of laminates. The PV elements thus provide both electricity and light to the building. The PV modules and support structures used for this type of application are similar to those of semitransparent glass facades. These structure, which may appear unpretending from the outside, produces fascinating light hallway walks and floors and allow a stimulating architectural design of light and shadow (Fig. 9).

5.5 Shading systems

There is a growing need for carefully designed shading systems on the building market due to an increasing use of large window openings and curtain walls in today's architecture. PV modules of different shapes can be used as shading elements above windows or as part of a roof structure. Since many buildings already provide some sort of structure to shade windows, the use of PV shades should not involve any additional load for the building structure. The exploitation of this synergy effect helps to reduce the total costs of such a PV installation and to create added values to the PV as well as to the building and its shading system (Fig. 11). New market opportunities for PV could be developed if a mass production of PV shading elements could be achieved. PV shading systems may additionally use one way trackers to tilt the PV array for maximum power and at the same time provide a variable degree of shading.

6. Solution strategies for the successful application of solar design strategies

Today, many different projects in Germany show vividly manifold options to turn ecological and solar concepts into the building practice of domestic and non-domestic buildings (Example: Fig. 12). Generally they succeed to optimise the use of resources, provide a healthy indoor environment, reduce operational costs and can provide commercial advantages compared to traditionally designed buildings. The user satisfaction is very high.



Fig. 12: PV-Roofs, Solarsettlement, Freiburg, Germany

However, detailed projects analysis [11] have shown that a simultaneous integration of design, structural, environmental and energy aspects has been successful in only a few building projects. In most of the projects planning approaches often seemed to remain too simple and too one-dimensional. Planning premises already filter away the complexity of the ecological and solar reality. In addition assessment standards and criteria, which allow to estimate and to compare easily the environmental impact of various measures, are not available. In case they exist, they seem to be so complex that they can not be handled in the design and building practice.

The utilisation of ecological and solar design strategies is largely dominated by an isolated view of technical concepts and technologies. On the basis of further investigation as to the cause of this situation, several sticking points have been determined:

- Architects and construction personnel have insufficient information and lack of knowledge about ecological and solar technologies, their boundary conditions and their integration possibilities;
- Clear documentation and planning aids allowing to make competent decisions in an early planning phase are missing;
- Communication problems and distance between those participating in the construction project exist;
- The complexity and interdependence of the demands set on the building are too difficult for a single person to overview;
- The persons involved limiting themselves to isolated aspects of ecological and solar building design instead of taking an overall concept into account



Fig. 13: Options to influence the future energy demand of a building

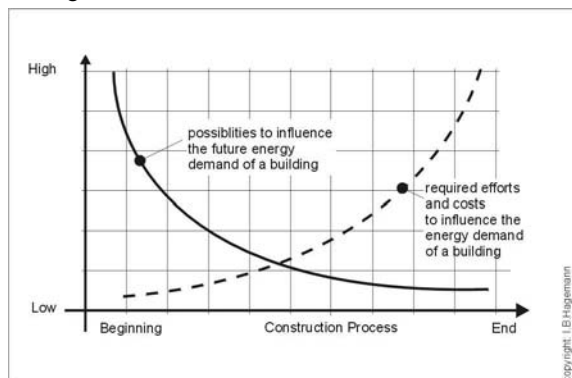


Fig. 14: Options to influence the future energy demand of a building

- Co-operation among those involved in the building process is lacking and thus the view and purpose of the total concept are lost;
- Due to the lack of knowledge, understanding and interest, the persons involved do not take the time or trouble to examine the work and the targets set by the others involved in the planning and construction process;
- Liability risks arising from the lack of construction codes and standardisation reduce the interest in using new design concepts and technologies.

It seems to be apparent that on a broad scale neither the market nor the building industry in Europe is sufficiently prepared today for the development of ecological and solar building designs and for its place in the overall concept of the building.

It was found that problems in the planning and implementation of ecological and solar design concepts and technologies originate in a large information gap between research results and knowledge being drawn on and applied in practice. As a result, there are problems in synchronising the needs of the different experts at work on the planning and construction aspects, planning and co-ordination conflicts develop, as well as mistakes in execution.

6.1 Planning requisites for successful solar designs

It could be pointed out that designing and constructing a sustainable building, which is environmentally friendly, energy efficient and architecturally stimulating, requires essentially a holistic design approach, which is comprehensive in its consideration of design issues, assesses carefully these different issues and finds a harmonious and evolving balance between them.

To employ successfully ecological and solar strategies and techniques the design of these systems must be always seen in the context of building procedures. Some ecological and solar design strategies and techniques can be used to complement one another or can be used next to one another while other, in turn, exclude each other as different requirements for their realisation must be met. In the worst case they even might have a negative effect on each other.

For examples: Figure 13 show a building where creepers, which have big green leaves in summers, use the vertical steel structure at the south face of the building as a climbing post. The benefit of these leaves is that they act as a kind of passive cooling system. The leaves evaporate water and in summer shelter the south-facing exterior from direct sunlight which reduces the heat load in the rooms as building exterior does not heat up and gives glare-free light. On the other hand, the big leaves are also a drawback as they cast shadows or partial shadows on some of the photovoltaic modules. This results in losses in the photovoltaic electricity production of some or even most of the installed photovoltaic modules at a time where an optimal electric power generation would be possible. Consequently, the use of greenery at the facade of the building in this form is not consistent with the simultaneous use of photovoltaic elements on the building exterior.

The list of such faulty designs is long. To avoid them it is necessary to know and to take into account the requirements

and limits of the different technologies used for buildings and to take them into account in a general building concept. An overall ecological and solar concept must be developed for the building right at the beginning of the project because the use of different ecological and solar technologies for a building are initially determined and affected decisively in the drawing board stage by the layout of the building shape, orientation and window openings. The chances of having any influence on the future energy requirements decrease with every further step of the planning and building process and the effort to make any changes to these requirements increases accordingly (Fig. 14).

In principle, the architect or the person in charge, must have a considerable knowledge of the various options with regard to ecological and solar energy applications and must be in possession of the proper information to make decisions so that he is in the position to select quickly and with little effort the most suitable solar energy techniques according to cost-effectiveness.

This decision procedure is already difficult for one person in small projects and in larger projects cannot be managed alone. Such building projects are so complex that an individual cannot keep all the details in mind in order to make rational decisions concerning the ecological and solar energy requirements.

When the requirements are not sufficiently clear, the architect customarily uses his intuition in order to find a solution. In the planning of ecological and solar energy requirements for a building, this method only leads to unsatisfactory results as any ecological and energy-related decisions for a building can only be based on scientific knowledge, insights and rational decisions.

This is why it is necessary to expand the drawing board procedure to include a scheme for energy requirements and to allow for rational decisions. The architect can no longer produce the initial design of a new building and then include the experts involved in the construction process in the subsequent planning stage. In the future, all those being involved in the building and designing process must work together at the beginning of a new project to create a new building [10].

It must be made clear that the integration of ecological and solar systems in the drawing board drafts, design and building construction is always the result of a mutual effort of all experts. None of the experts involved is in the position to find alone the best possible solution. Successful ecological and solar architecture is the result of a mutual effort. With regard to the six case studies it was the common interest and the motivation of the people being involved which ensured the success of these innovative building projects.

6.2 Guidelines

The different technical and operational lessons learned so far in Germany can be summarised in a set of guidelines for a sustainable design in architecture and urban planning, which involves ecological and solar design principles while simultaneously being of high architectural design quality [11]:

1. Work in a multi-disciplinary design team

All persons with influence on the design and construction need to participate actively in the different phases of the building process. Right from the outset of the building project creative decisions are needed not only from the architect but also from the engineers and other experts, who have key information and ideas regarding energy savings and ecological and solar measures for the building. They are the ones who need to convince the client that the future building will be economically and environmentally sound while at the same time providing a high standard of interior comfort levels and user satisfaction. The architect may lead the design team in becoming its co-ordinator and moderator.

2. Find a compatible design team

Teamwork among experts only brings fruit to bear when everyone shares the same attitudes, values and objectives, for instance, with respect to the quality of design, dedication to work etc. The experts also need to have the right skills and understanding of the issues or at least be ready and quick to learn them.

3. Involve the client in the design process

The client and if possible the occupants should get involved in the key steps of the design process. Once the building is finished, both also need to get advice and guidance how to operate and use the new building.

4. Be prepared to call for additional professional advice

If required, further specialists should be able to join the design team at any phase of the building project. Research and new development should be carried out as much as it fits within the time schedule and the client's budget.

5. Introduce a pre-design phase

At the beginning of the building project the requirements should be defined with regard to the different targets of a sustainable building design. In fact this might lead to the outline of the whole ecological and solar design strategy for the building at this planning stage.

6. Use computer and physical modelling

Computer modelling helps to predict the service performance of the building with regard to different design aspects, such as massing, thermal behaviour, ventilation, daylight, acoustics etc. and ensures that the targets are being met. It also helps to develop an integrated understanding of the different measures employed within the building.

7. Get the right time management

In order to avoid "blind activism" in planning and executing a construction project you should devote sufficient time to communication. Only in this way you can focus on a colleague's suggestions and ideas and come to know his or her perspective. This takes less time than the time it would take to make corrections and changes afterwards. Since time pressures will always remain a factor in the building trade, it becomes necessary to plan time judiciously.

8. Make use of intensive communication and reviews of the design

The communication of the project "ideas and the ecological and solar principles they are based on is crucial to ensure that the building project develops smoothly. The information should be exchanged directly rather than through third parties in order to prevent mistakes when information is passed along. Decisions being made at the institutional level should be made by those having the professional competence and decision making authority for each work area under discussion. In this way a fruitful discussion can arise and binding statements and approvals can be given more readily when changes or new design parameters are proposed. Structured design reviews are considered as a valuable control tool during the ongoing design and construction process.

9. Do cost-planning and cost-benefit evaluations

Cost calculations which include direct costs, indirect costs and benefits of added values, should be carried out on a short and a long term basis. Benefits of an ecological and solar building design, which can not be expressed directly in economic terms, such as a higher user satisfaction, lower percentage of health complaints, energy savings etc., need to be communicated to the client.

10. Protect the project goals and their basic principles

Problems and conflicts are the order of the day in building projects and one should not be distracted by them. Instead you should concentrate on the common goal in conjunction with the flexibility to adapt and to reconstruct the goal if circumstances change during the course of the project.

Each expert should add at his best his own mastery of his area to those of his colleagues and should be ready to give up his own preconceptions or ideas in favour of a mutually worked out approach. The own contribution should be seen as a contribution to the common aim to create the best possible design solution.

7. Conclusion

In conclusion it should be pointed out that sustainability must be the central goal of building design in Europe. Therefore the design objective is how to affiliate human activities, such as the construction of buildings, to the ecosystem in the least destructive way, within the inherent limitations of the ecosystem.

Sufficient scientific know-how and technical information do exist today so that together with the system components on the market or under development, architecturally and conceptually successful ecological and solar buildings and town plans can be realised. In order to achieve this on a broad scale the described non-technical problems still need to be solved. Necessary steps in the right direction has been summed up in the guidelines.

Such an ecological value change in town planning and building construction is not easy to attain. Most likely it will take the time of more than one generation to achieve a major breakthrough because old habits and thought processes need to be suspended and pointed in the right

direction. This shift in design practice makes also clear that the design practice will no longer be one of a single individual.

8. References

- [1] a) cf. the German laws "*Richtlinien zur Förderung von Maßnahmen zur Nutzung erneuerbarer Energien*" (23rd July, 2001) and "*Energieeinsparverordnung (ENEV)*" (1st February, 2002);
b) cf. European research programmes: "COMBINE", "INNOBUILD" or "READ";
c) cf. international research programmes: IEA, "SHCP" and "Energy Conservation in Buildings and Community Programme"
- [2] a) cf. Enquete – Kommission "Schutz der Erdatmosphäre" des Deutschen Bundestages (Ed.). 1995. "*Mehr Zukunft für die Erde. Nachhaltige Energiepolitik für dauerhaften Klimaschutz*". Bonn: Economica Verlag GmbH;
b) cf. Ministerium für Wirtschaft, Mittelstand und Technologie des Landes NRW (Hg.). 1992. "*Klimabericht Nordrhein - Westfalen*". Düsseldorf
- [3] cf. Schneider, B. (Ed.). 1991. Die Globale Revolution, Club of Rome Bericht 1991. Hamburg
- [4] cf. University of California (Ed.). 2002. Ernst Haeckel (1834-1919).
- [5] cf. Rudofsky, B. 1964. Architecture without Architects. New York: Doubleday
- [6] cf. Schmidt-Brümmer, H. 1983. Alternative Architektur. Köln: DuMont
- [7] in Germany:
a) "Richtlinien zur Förderung von Maßnahmen zur Nutzung erneuerbarer Energien" cf. BUNDESREGIERUNG (Ed.). 2001. Richtlinien zur Förderung von Maßnahmen zur Nutzung erneuerbarer Energien vom 23. Juni 2001. Bundesanzeiger Nr.136 vom 25. Juli 2001, p. 15434;
b) "Energieeinsparverordnung - EnEV" cf. Bundesregierung (Ed.). 2001b. „Verordnung über energieeinsparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden“ vom 17. November 2001. Bundesgesetzesblatt. Teil I. Nr. 59;
in Switzerland:
c) "MINERGIE-Standard" (www.minergie.ch);
- [8] cf. Bundesregierung (Ed.). 2001. Verordnung über energieeinsparenden Wärmeschutz und energie-sparende Anlagentechnik bei Gebäuden (Energieeinspar-verordnung - EnEV) vom 17. November 2001. Bundesgesetzesblatt. Teil I. Nr. 59
- [9] cf. "Passiv Haus Standard", Passivhaus Institut, Dr. Wolfgang Feist, Darmstadt, Germany (www.passive.de)
- [10] Hagemann, Ingo B. (2002). "Gebäudeintegrierte Photovoltaik. Architektonische Integration der Photovoltaik in die Gebäudehülle. Köln: Rudolf Müller Verlag (ISBN: 3-481-01776-6)
- [11] Hagemann, Ingo B. (2002). "Ecological and Solar Architecture in Europe - Presentation of Case Studies". Master-Thesis, RWTH Aachen, Germany

[12] cf. Butti, K. and Perlin, J. 1980. A Golden Thread. 2500 years of solar architecture and technology. Palo Alto: Cheshire Books

Fig. 1-3: Ingo B. Hagemann, Gemany

Fig. 4: <http://www.ringlers-reisebilder.de/jemen>

Fig. 5: Horst Schmidt-Brummer

Fig. 6-7: Ingo B. Hagemann, Gemany

Fig. 8: Tadahi Itou, Kajima Technical Research Institute, Chofu-shi, Tokyo

Fig. 9-12: Ingo B. Hagemann, Gemany

Fig. 13: Uwe Haberland, Hamburg

Fig. 14: Ingo B. Hagemann, Gemany