5th SASTech
Iran |Mashhad
May 12 - 17 | 2011
5th Symposium on Advances in Science & Technology

Solar Urban Planning and Design

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Paper Reference Number: 0127-850
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Abstract:

In recent decades, urban population growth, the acceleration of energy consumption and energy price, the increase of public concerns about environmental pollution and the demolition of non-renewable energies, have adverted the attention of different groups to the use of sustainable, available and clean solar energy as a sustainable energy.

Specialists like architects and engineers have considered solar energy in designing systems, buildings and equipments. Straggle success achieved in the case, cause the progress of replacing solar systems in buildings and equipments instead of systems consuming unsustainable resources like fossil fuel to be accelerated. But they have not applied coherently yet. In other words, before the enforcement of solar projects in cities, it is necessary to note all the dimensions related to their execution in order to reach their optimum efficiency. The goal that could be attained by long-time and multi dimensional planning.

This paper guides the focus of urban and town planning and design on the application of solar energy. That urban planners should consider three aspects of environment, economy and society in three related elements of cities consisting buildings and urban spaces, urban infrastructures and urban land uses to achieve sustainable goals is discussed in this paper.

So, after the review of few experiences, the issues and guidelines whose consideration lead to the more efficient solar urban planning and design are outlined.

Key words: Solar Urban Planning- Solar Potential- Sustainable City- Solar Master Plan- Smart Infrastructure

1. Introduction: the increase of attention to solar energy

The increase of urban population, activities and technologies using fossil fuels, energy price, energy consumption and the increase of public concerns about environmental pollution and the destroy of non-renewable energy resources, are causing different experts including specialists related to building and construction to look for alternative ways of energy provision.

Building professionals have not considered the aim of good design aesthetically more and try to design the building's characteristics and requirements in depend on the decrease of using fossil fuels and avoidance of wasting energy.

Hagman(2005) says that great improvements in energy efficiency of buildings or the utilization of solar technologies on buildings have been made since 20 years ago. He says that visionary clients as well as a small but very active and innovativw community of architects, designers and engineers took the risk to use and to develop further solar technologies and strategies for urban plans and buildings (Hagman, 2005). He also addresses to the cultural movement of Bernhard Rudofsky in the middle of 1960's in holding an exhibition " Architecture without Architects" in the Museum of Modern Art, New York. Building examples presented in the exhibition are effective in the attraction of architect's attention to the variety of design and structural solutions, Integration in the local landscape, exclusive use of locally available, natural construction materials, uniformity of the construction structures, application of traditional and time-tested construction techniques.

In Germany, at the end of the 1960's a group of architects, designers, engineers and sociologist, 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 energy gaining and a heat storage. The idealistic goal was the dream of the self-supply(Hagemann,2005). Then, straggle efforts have been done and various concepts such as " Biological design", "Natural Design", "Alternate Building Design", "Sustainable Architecture", "Ecological Architecture", "Solar Architecture", "Organic Architecture", "Vernacular Architecture", "Climate Architecture", "Green Architecture" and "Natural Architecture" have been created in order to create a healthy and environmentally friendly environment. 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(Hagemann,2005).

"Ecological and Solar Building Design" can be described as any form of design that minimizes environmentally destructive impacts by integrating itself with the living processes(Hagemann,2005). Some of the targets Hagman (2005) presented as the targets of ecological and solar design in its paper are 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-oriented 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 construction, creation of a long-term use-value, i.e. the building must be easily adjustable, alterable and repairable.

Although the effort, the limited information and knowledge of architects about new technologies and various designs of solar technologies and its strategies, the scarce of limitations of architectural plan, low knowledge of urban planners on consideration of prerequisites of building development and urban authorities' inadequate attention in financial and educational programs to sample projects, prohibit the vast development of using the energy and related strategies in cities. Therefore, the frequent usage of solar technologies are limited to single buildings having no access to other energy sources or energy transfer to their placement is not economical.

2. The necessity of using solar energy in urban scale

There are three major reasons that interpret the necessity of using solar energy in urban scale and the consideration of its prerequisites in urban planning and urban design scales. The first is the acceleration of urban population growth around the world and the global prediction results showing the exhausting of none-renewable energy resources. In depend on the estimations done in Berlin, urban buildings consume 40% of urban energy mostly achieved by fossil fuel, while each building can provide its necessary energy from cheap, sustainable, clean and healthy solar energy by different methods of using solar energy specially through photovoltaic systems. The third reason is the long life of urban structures in comparison with urban planning life and infrastructures' life. The difference and the possibility of changing urban infrastructure in order to use the maximum possible solar energy and the easy installation and change of photovoltaic equipments on the buildings and even building reconstruction in this regard, are valuable and urgent because each action in urban buildings and infrastructures which are done today have the long result on the total urban structure.

Using the approach, some of the cities such as Berlin and New York have started some changes and reparations of the construction of residential buildings. And also through the application of some bylaws and codes, they appreciate or obeyed occupants to alternate unsustainable energy resources in their houses with solar technologies.

In addition, without any doubt, urban authorities and local management have a key role on empowerment and persuasion of using solar energy among individual parts and different groups of the society by introducing some local policies and an appropriate legal framework. As a result, the development and expansion of solar technologies in urban buildings could not be easily occurred without the consideration of necessary measures in urban scale.

Berlin could be mentioned as a successful city in the application of solar technologies. In the city, in 1996, European Charter for Solar Energy in Architecture and Urban Planning" was set. The charter mentioned some instructions, standards, statutory regulations and laws to guide the design of building and urban spaces in such a way that natural resources will be conserved and renewable forms of energy-especially solar energy-will be used as extensively as possible.

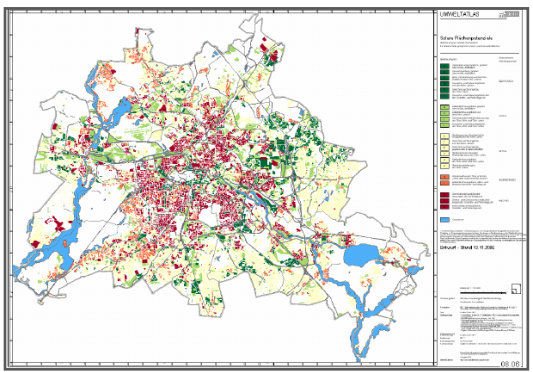
Hagemann (2005) says that today, in some countries, such as Switzerland and Germany, approaches that were seen as "ecological" or "solar" in the past, are considered as a "state of the technology" and are applied for predominantly economic and technical reason.
In this respect, some standards are set for the serious application of solar technologies in Germany. Also, as Guedi et al (2006) say many cities like New York, San Francisco, Tel Aviv and Toronto have defined regulations to keep solar rights from a public point of view or to ensure the full use of private properties. In some countries such as Israel, although there are no general regulations to ensure solar rights for either public or private properties, although environment assessment is required when tall buildings are designed (Capeluto & etc., 2006). Moreover, PV City Guide makes indications and recommendations how strategic urban policies can be developed in order to increase the use of photovoltaics(Nowak & Gutschner, 2001). In addition, a solar urban master plan for Berlin was created by Ecofys in 2004 at the request of the City Council in order to determine the solar potentials of the different city quarters(Lindner, 2007).

3. Methods of using solar energy in cities

In recent years, solar energy is applied by different systems and for different aims. The first method is using solar thermal energy in two ways: in the first method, the energy is used in house equipments and other daily necessity tools such as solar heating, ventilation and air-conditioning system and Solar water disinfection system.
The second method of using solar energy is solar cells or a kind of installation named Photovoltaic (PV). Photovoltaic 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 (Hagemann,2005). Photovoltaics offers unique opportunities to produce (solar) electricity in the urban environment. There is in fact hardly any other renewable energy technology with such a potential in the urban context. This can make photovoltaics increasingly interesting when considered in the local urban design as well as in the local energy portfolio(Nowak &Gutschner, 2001).

4. Solar Urban Planning

The aim of solar building, which is similar to solar building design and ecological design, is the reduction of using fossil fuel, efficient use of energy, providing environmentally friendly, healthy and economical style of life and use the solar energy actively and inactively through the complete and accurate understanding of ecological condition. Solar urban planning means integration of energy efficiency and solar energy in town planning via urban renewal, urban removal and new developments (Lindner,2007). The choose of technical and planning measures that are useful in solar urban planning and solar building projects economically and technically depends on the specific characteristics of each project such as topography, climate, consumers' demands and the financial resources of the project.



In this regard, solar master plans can be mentioned. Solar master plan is a tool to distinguish the solar potential of each part of a city, the determination of regions with high priority, the definition of measures for the conversion of the potential to trial projects. The solar factor ranking in the plan is a tool in order to determine the solar potential of different regions in depend on the absolute area of developed lands of the regions and existed buildings. The main subjects outlined in the preparation of solar master plans and solar planning are the presentation and proposition of instructions to find the solar potentials of each part of cities, the study of orientation and the shading position (through simulation methods), the feasibility study technically and legally, the study of demand and consumption potentials of energy (thermal and power energy) and the identification of regions with high priorities.

Fig 1: solar master plan of Berlin

Determining a correct vision and practical goals are important steps of solar planning like every planning programs. Considering the importance of using solar energy and determining appropriate goals in this direct are essential. For example, the visions of the strategic program of solar city Göteborg until 2050 are the development of sustainable energy systems for a sustainable community, smart and efficient use of energy, renewable energy supply, changing life-styles and shifts in values, energy efficient urban planning, energy storage in a Hydrogen society.

Solar urban planning use three approaches concluding urban renovation, urban clearance and new developments for the expansion of solar technologies application. In addition to the idealist renovation plans like solar floating city in Monaco as a new solar city which provide their necessary energy from clean energies, there are multiple studies done in existed urban textures or urban blocks which are destroying and renovating for the usage of solar technologies.

Fig 2: Solar Floating City, Monaco beach, 2100

Without any doubt, in solar urban planning that consider the goal of sustainable city, three aspects of environment, economical benefit and society must be always considered. Therefore, urban planners should reflect the aspects in three important elements of cities include:

- Buildings and urban spaces
- Urban land uses
- Infrastructures (the provision and transformation grid of energy)

5.1. buildings and urban spaces:

The photovoltaic potential of urban form (which is the product of building's size, height and relationship between buildings and urban spaces) can be greatly enhanced through solar

envelopes. The solar volume is a product of latitude, built context, the size, shape, slope and orientation of the site (Sarkar,2009).

Solar volume is the buildable volume which could be a basis for the design guide in order to increase access to the sun radiations. In addition, solar envelope depends on the context's characteristics and is more dynamic than standard urban design guidelines. Sarkar (2009) says that the concept is essentially a morphological one and addresses a gap between architecture and urban planning. It operates in the sphere of urban design and would be most successful if be implemented at urban block level. The concept is too limited to be applied in whole of a city as it does not address various aspects like transportation or land use which are more important determinants of energy consumption at urban level.

Generally, There are two ways of generating solar envelopes:

- The descriptive method which defines the geometry of the buildings based on solar angles and regulates building heights, setbacks etc Example: San Francisco.

- The performance method which defines the number of desired insolation hours or prescribes required radiation levels at the solar envelope, Example: Melbourne.(Sarkar,2009)

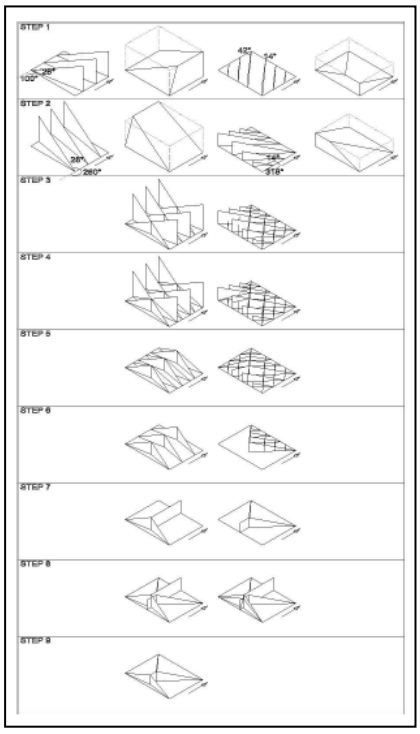


Fig 3:Steps of generating solar envelopes with descriptive method(Sarkar,2009)

The solar rights regulation can be applied in three levels based on the two approaches mentioned above:

The basic level based on the performance approach, defines the required amount of solar radiation for each orientation, urban location and climatic zone. It allows freedom in design. However, a designer using this method must prove meeting the requirements.(Capeluto & etc. 2006)

Ratti and Morello (Ratti et al 2008) has developed a computational process through a DEM (Digital Elevation Model) to generate a solar envelope for required radiation levels. However since this process requires elaborate computation, despite being very flexible and accurate, it would not be intuitive enough to lend itself as a design guideline. More work has to be done on this system to introduce it at the design guideline level.(Sarkar,2009)

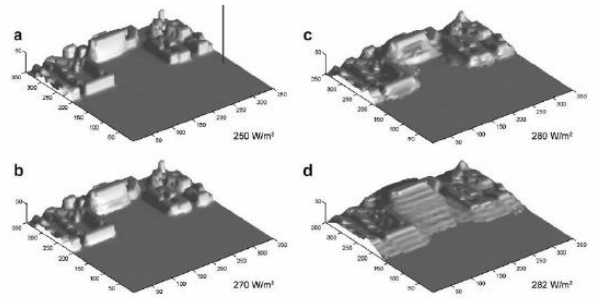


Fig 4: Iso-solar collector surfaces (CSE) developed on site in Milan, Performance method (Source: Ratti et al,2008) (Sarkar,2009)

The second level, also based on the performance approach, indicates the insolation hours which meet the solar radiation requirements. The designer has to present the proof of keeping the surrounding buildings exposed to the sun during that time(Capeluto & etc. 2006).

The third level is a descriptive/prescriptive method, based on the insolation hours indicated. It presents the use of solar section lines as a simple tool for solar rights design. a simple tool for solar rights design. Designing according to these section lines ensures the solar rights of the surrounding buildings and open spaces, without the need to demonstrate further requirements(Capeluto & etc. 2006).

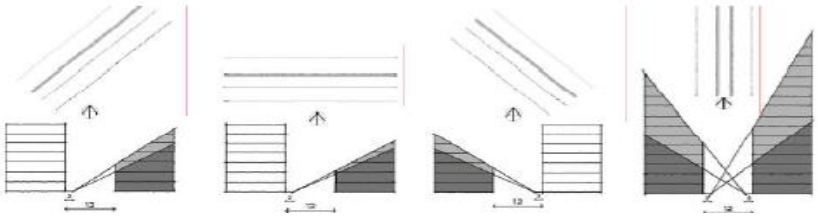


Fig 5: Building heights allowed in differently oriented streets in Tel Aviv to keep solar rights of sidewalks.(Capeluto & etc. 2006)

5.2. Urban land uses and infrastructures

Energy-smart construction

Town Planning/infrastructure without solar targets is one of the barriers of solar urban planning(Lindner,2007). Therefore, it is necessary to consider the targets since the first planning phases and try to implement an integrated infrastructure system in cities.

In order to use solar energy permanently, the solar systems should be connected to the local distribution electricity grid, the energy is saved there and used in different places and hours of a day. Australia government have spent more than 100 million dollars on the establishment of a smart solar energy grid. In fact, the smart grid integrates the developed communication networks and infrastructures which are sensitive to existed energy grids. Smart grid infrastructure use sensors, meters, digital devices and analytic tools that allow the automation, monitor and control of the two-way flow of energy operations – from the power plant to the plug(Garcia, 2010).

In addition, the smart grid indicate the grid capacity to integrate with the electricity generated by renewable energy supply like wind, solar in the existed electricity grid. Therefore, smart grid infrastructure make the energy converting in houses and workplaces possible and set

the voltage automatically and help the consumers to control and decrease their electricity consumption. So, about infrastructure planning of solar cities, it is necessary to apply the consumption controlling methods in various levels considering the limitations of using solar energy in energy provision and also establish a whole network which make the energy saving and energy sharing among housing units and occupation places during different hours of a day.

Related to urban land use and transformation network, the necessity of applying smart growth policies in cities should be focused. For example, smart growth guidelines like the distance decrease of house to workplace and urban commutes and more compact densities can be effective on the reduction of energy consumption.

6. Conclusion and proposed guidelines:

According to the different cities' experiments throughout the world on applying solar energy, three issues including comprehensive study, appropriate and integrated management and legal context in order to efficient solar urban planning are outlined:

6.1.Comprehensive Study: according to the issue, the preparation of solar master plans in order to coordinate different sectors of a city, the correct presentation of visions, goals and objectives for the plan and the realistic definition of administrative procedures, the purposeful survey of local and traditional architecture in order to the discovery of efficient construction methods to decrease energy consumption of buildings, the preparation of priority plans for investment on solar plans in 2 levels including regional and city or neighborhood level, the provision of necessary infrastructure parallel to the expansion of using solar networks in cities to encourage residents to apply solar technologies in their buildings, the consideration of economical proficiency of plans for all of the community groups and the consideration of three aspects of sustainable development during the planning and administration process, applying various forecasting and modeling methods to consider all the aspects of a solar city and using the smart growth guidelines to decrease the energy consumption are recommended.

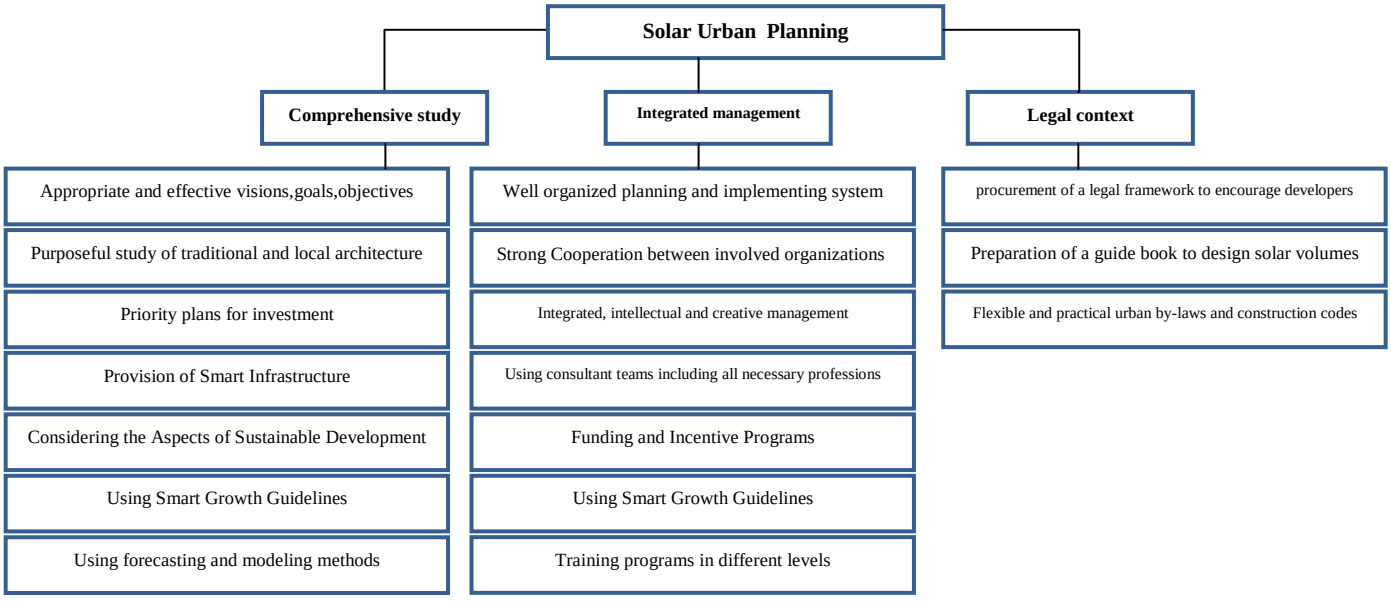


Diagram 1: the major issues for the efficient solar urban planning Resource: writer

6.2.Appropriate and integrated management: integrated, purposeful, intellectual and creative management is necessary in the efficiency of every new plan. Therefore, in addition to the importance of establishing correct and rational relation between involved organizations during the preparation, administration and control of solar plans and projects and applying complete consultant teams in order to propose guidelines for replacing solar energy instead of non-renewable energies which are using in cities, the managers should hold training and informative programs related to the necessity of applying solar energy to various groups of a community and provide the opportunities of more and better cooperation of engineers, architects, urban designers and planners during the urban planning process in order to the increase of solar technologies' application and new construction methods throughout cities. Because the urban managers are the authorities of public financial resources, the funding programs, orienting public and private investments and inventive programs should be prepared by them too.

6.3.Legal context: unfortunately, some urban and construction regulations prohibit designers, architects and engineers in the application their creativity freely to use solar technologies in buildings and cities. Therefore, the preparation of a guide book for designing solar volumes and the determination of radiation hours, the procurement of a legal framework to encourage developers to use solar plans are recommended. In addition, the important role of urban designers in determining and proposing solar volumes must be considered and the urban by-laws of master and detailed urban plans should be designated more flexible to let designers and architects decide more freely and creatively about urban densities and parcels to achieve solar targets.

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