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Principles to Promote Solar Energy at Urban Management (Case Study: Berlin & Tehran)

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Abstract
The majority of the world's population now lives in cities. This poses great challenges, but also great opportunities in terms of tackling climate change, resource depletion and environmental degradation.
Nowadays, city planners and authorities around the world have been promoting principles to achieve a sustainable city. In this regard, Policy agendas have increasingly focused on how develop renewable energy as a clean energy can help to have integrated sustainable urban development.
This paper identifies subjects that should be noticed for sustainable urban development and need to be in place for promoting renewable energy. The paper also, by drawing on three case studies (Germany, China and Iran), examines the key 'success factors' to traverse a pathway to a more sustainable future in urban development by using solar energy and it also gives some example about these countries and their main cities' experiences.
Finally, it is hoped that the conclusions and recommendations drawn in the present study would be useful to energy scientists, engineers and policy makers.
Keywords: Sustainable urban management, solar energy policies, Germany, China, Iran

Introduction

At present, with more than half of humankind living in cities, our planet has entered the urban age. Rapid urbanization and industrialization have offered to humanity the abundant fruits of modern civilization, but at the same time, they have brought unprecedented challenges. Population explosion, traffic congestion, environmental pollution, resource shortages, urban poverty and cultural conflicts are becoming urban problems with a global scope.

While cities occupy 2% of the earth's land surface, they consume 75% of the global Resources used by humans each year (Pearce, 2006) Overuse of fossil fuels causes pollution of the environment that result in negative affects for human health and causes global warming. To tackle these problems urban planners and managers have been considering sustainable development principles and developing new ways to utilize renewable energy as an alternative energy.

Driven by perpetually rising demand for energy, many countries have enacted policies and programs for harnessing solar energy. This review provides the practitioner perspective and reviews the progress made in development of solar energy in Germany, China and Iran.

1. Methodology

The main target of this paper is studying and obtaining key success factors of promoting solar energy in urban areas. In this regard, at the first step, principles to have a sustainable urban management have been classified and presented by the focus on energy management and especially promoting solar energy at urban area. At the second step, Germany and China have been chosen and main success factors of these two Vanguard countries have been taken understudies. At third steps, the achievement of Tehran municipality- as base place of study- has been described. Finally, the precious learned lessons have been summarized.

2. Sustainable Urban Management (Note 1)

The word 'sustainability' can be similarly ambiguous and flexible. In 1987 Brundtland Commission (Note 2), defined sustainable development as development that 'meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Sustainable development should integrate social, environmental, and economic sustainability and use these three to start to make development sustainable (Goodland, 1995).

Energy supply including the amount and types of renewable energy provided as part of utility electric power "grid" is one of the main factors that Cities with a sustainable management actively and regularly should monitor (Dengler & Rodriguez, 2009).

3. Urban energy management

Environmental sustainable seeks to sustain global life-support systems indefinitely. Source capacities of the global ecosystem provide raw material inputs-food, water, air, energy; sink capacities assimilate outputs or wastes. These source and sink capacities are large but finite; sustainability requires that they be maintained rather than run down. Overuse of a capacity impairs it`s provision of life-support services (Goodland, 1995). In this regard, if cities are to become sustainable, they must reduce their use of all resources and decrease their waste outputs (Newman & Kenworthy, 1999).

Generally, cities can manage their energy consumption by two main actions: Optimizing the fossil fuel consumption & Promoting renewable energies.

3.1 Role of Municipality at Urban Energy management

As local governments manage or oversee all city activities and city development, they play a central role in determining the energy and carbon emissions picture of their cities. They also have direct access to their citizens and are best place to know their needs and to influence their behavior.

These are some of the ways in which municipalities as a local government play a central role in the energy picture of their cities:

- They plan and manage city development and growth
- They establish and enforce building codes and approve building plans
- They are the primary providers of basic services such as water, waste management, street lighting and other related services
- They are responsible for transport planning and management within a city
- They are usually responsible for the distribution of electricity and for billing and may be responsible for some generation capacity
- They are big energy users themselves – in their fleets and buildings
- As they are major employers, they can directly influence their employees energy-use patterns
- They are engaged in significant procurement – of paper, fuel, building materials, light bulbs, vehicles etc (ICLEI (Note 3), 2009).

3.2 Role Developing renewable energy in city

Achieving solutions to environmental problems that we face today requires long-term potential actions for sustainable development. In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions. That is why there is an intimate connection between renewable energy and sustainable development. Potential solutions to current environmental problems are identified along with renewable energy technologies (Dincer, 2000, Pages 157–175).

3.2.1 Developing solar energy at urban area

This paper has focused on developing solar energy as a kind of renewable energy that is available and easy to use at urban area.

Solar energy refers to sources of energy that can be directly attributed to the light of the sun or the heat that sunlight generates (Bradford, 2006).

In cities, solar energy technologies can be classified along the following continuum: 1) passive (Note 4) and active; 2) thermal and photovoltaic; and 3) concentrating and non-concentrating.

3.2.1.1 Advantage of promoting solar energy

Solar energy is the largest exploitable renewal resource as more energy from
Sunlight strikes Earth in 1 hour than all of the energy consumed by humans in an
Entire year (Lewis & Nocera, 2006). Solar energy is also appealing because stabilizing the carbon dioxide–induced climate change is mainly an energy problem, and thus stabilization will require the development of renewable sources that do not emit carbon dioxide to the atmosphere (King, 2011).

3.2.1.2 Barriers to the development of solar energy References

Barriers to the development of solar energy can divide in to two main sectors. First, Barriers to the Solar Urban Planning which is influenced by Town planning without solar targets at programming infrastructure, Economic concerns, Weak legal instruments to prescribe solar targets (Gaiddon, Kaan and Munro,2009).and unwillingness of private companies to invest.

Second sector is Barriers to the solar energy technologies. These barriers can be classified as technical, economic, and institutional. For example, in the case of PV, the main technical barriers include low conversion efficiencies of PV modules. The economic barriers mainly pertain to initial system costs (Jacobsson & Johnson, 2000). Finally, both PV and solar thermal technologies face common institutional barriers. Such as: limited institutional capacities for workforce training (Govinda & Timilsina& Kurdgelashvili & Narbel, 2012, 449–

465).

4. Case studies

To understand how different countries around the world develop solar energy to achieve sustainable cities, Germany, China and Iran have been chosen to study their policy. these three countries have been chosen because Germany is currently the world's largest PV market and China is now the largest producer and consumer of solar water heaters (SWH) in the world, with a high possession and market growth rate. In addition, Iran as a country that tend to promote solar energy especially in urban area in last decade has been chosen to present its capital city`s Urban experience.

4.1 Germany

Over the last decade, solar PV was the fastest growing renewable power technology worldwide. Cumulative installed capacity of solar PV reached roughly 65 GW at the end of 2011, up from only 1.5 GW in 2000. In 2011, Germany and Italy accounted for over half the global cumulative capacity (website iea). Germany With 81.8 million inhabitants, is the most populous member state in the European Union and is currently the world's largest PV market.

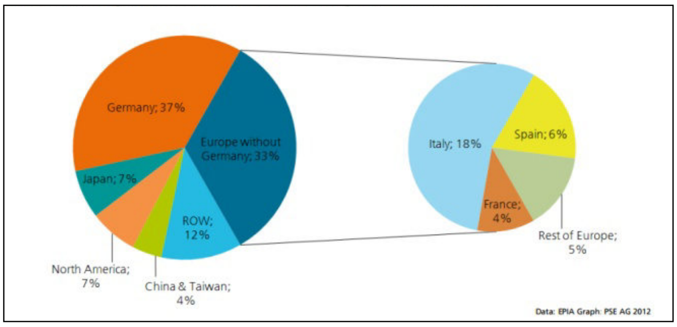

Diagram 1. The percentage of installed PV around the world
(Source: EPIA,2012)

4.1.1 Germany`s solar irradiation and the share of installed solar systems

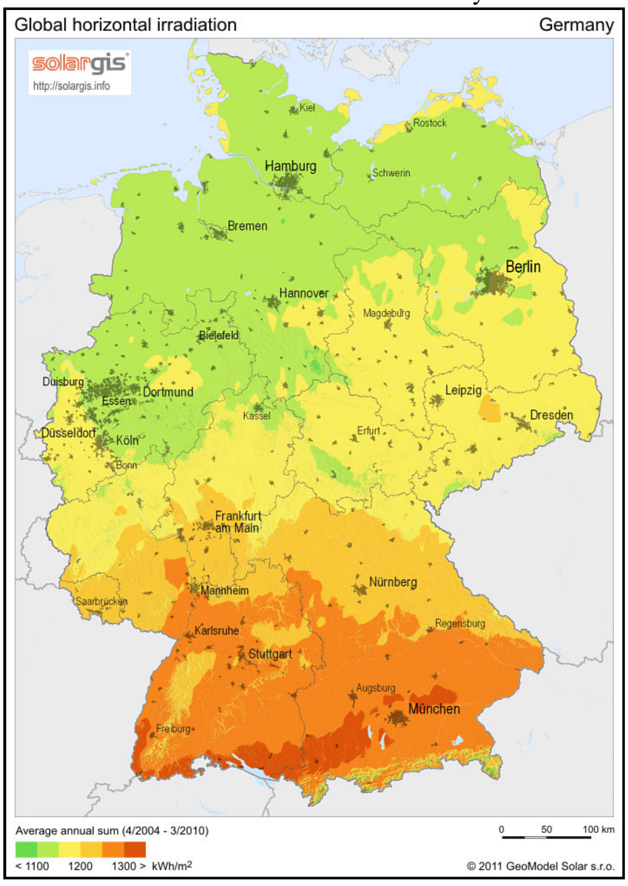

figure 1. Germany's solar irradiation map(source:http://.solargis.info)

Germany by the average irradiation of 800-1,000 kWh/m2, is one of the world's top photovoltaic's (PV) installers, As from first half of 2012, there was a cumulative installed total solar PV power of 29.1 GW(Böhme,2011).

Year	2010	2011	2012
Capacity (GW)	17.3	24.8	29.1
Generation (TWh)	12	18	14.7
% of total electricity consumption	2.0	3.2	5.3

Table 1. Germany's Solar power data from 2010 to 2012,
(source: Böhme,_2011)

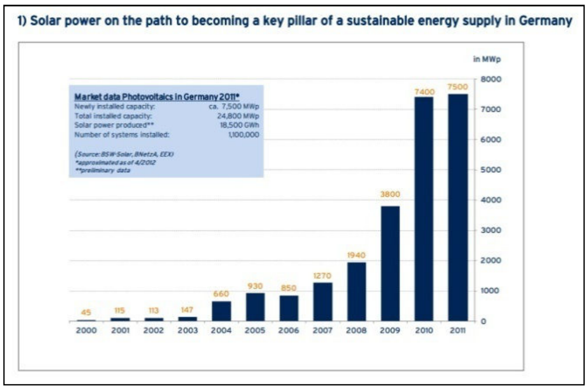

Diagram 2. the growth of solar power from 2000-2011 in Germany
(source: website solarwirtschaft, 2012)

4.1.2 Germany's Strategy for utilizing solar energy

Generally, the main elements of the framework that affect promoting PV in Germany include:

- Enhanced feed-in tariffs for renewable system
- National, regional and local planning policy for renewable systems

4.1.2.1 Enhanced feed-in tariffs for photovoltaic systems

The tariff is based on the cost of electricity produced plus a reasonable profit for the producer. This policy has been implemented in more than 75 jurisdictions around the world as of early 2010(REN21, 2011).

A study evaluating renewable energy policies in EU countries found that the FIT is the most effective policy instrument to promote solar technologies (CEC, 2008).

FIT has played a major role in boosting solar energy in Germany, which is currently leading the world in solar energy market growth. PV feed-in tariffs inspired by the German example have been adopted in many other countries.

German feed-in payments are technology-specific, such that each renewable energy technology type receives a payment based on its generation cost, plus a reasonable profit. The FIT is further subdivided by project size, with larger projects receiving a lower feed-in tariff rate in order to account for economies of scale, and by project type, with freestanding systems receiving a low FIT (S○semann, 2007).

Each tariff is eligible for a 20-year fixed-price payment for every kilowatt-hour of electricity generated.

Experts believe that, over the last decade the Feed in Tariff (FIT) model popularized in Germany has proven to be the most successful public policy for driving solar demand and industry growth (website

Germany - FIT			Tariffs for October 1st 2010 through January 1st 2011
20 year feed in tariff	Roof - Building - Facade Installations	Free Field Installations Conversion Areas	Free Field Installations Other Area Types
<30 kWp	0.3303 €	0.2426 €	0.2537 €
30 kWp<100 kWp	0.3142 €	0.2426 €	0.2537 €
100 kWp<1 MWp	0.2973 €	0.2426 €	0.2537 €
>1 MWp	0.2479 €	0.2426 €	0.2537 €

Table 2. Germany FIT(source:Website http solarfeedintariff)

4.1.2.2 National, regional and local planning policy for renewable systems

Nowadays, government regulations mandating installation of solar thermal systems is the main policy driver for the development of solar thermal applications in many countries.

In addition, governments have introduced laws mandating transmission companies and electricity utilities to provide transmission or purchase electricity generated from renewable energy technologies, including solar. In Germany, all renewable energy generators are guaranteed to have priority access to the grid. Electric utilities are mandated to purchase 100% of a grid-connected PV system's output, regardless of whether the system is customer-sited or not(Govinda &Timilsina& Kurdgelashvili& Narbel,2011).

In 2000, the German government decided to phase out nuclear plants by 2020, and has adopted legislation promoting the development and use of renewable energy sources. The most important piece of legislation is the Renewable Energy Sources Act (EEG) which was approved in spring 2000. According to this law, grid operators have to pay fees for electricity from renewable energy sources (website pvupscale).

In Germany, Planning policies promoting renewable energy tend to be developed, at least at the detailed level, at a municipal or regional level. This may link to a national planning policy for renewable energy. The municipality’s role is limited to the provision of information and encouragement. In Germany municipalities can define new quarters but the development of individual buildings is up to private investors. The role of the municipality is to set targets and to inform and inspire investors. Some municipalities have found methods of setting specific requirements for the implementation of PV. For example in Gelsenkirchen in Germany the city is imposing solar requirements in the contract of land purchase (Website pvupscale). In this regard, Germany initiated a master plan to illustrate Berlin`s solar potential for people to use.

4.1.2.2.1 Reviewing Berlin solar master plan as a successful case study

Berlin is capital city of Germany with a unique history of urban development due to the division of the eastern and western parts. Areas situated in the very center of the city were not developed because they were close to the borderline. Now those areas have a huge potential for urban renewal. Urban renewal in Berlin represents an opportunity for the implementation of building integrated PV systems (Bruno & Kaan & Munro, 2009).

In this regard, Ecofys (Note 5) created a solar urban master plan for the city of Berlin in 2004 at the request of the City Council in order to determine the solar potentials of the different city quarters. During the solar planning process, 20 types of city quarters were identified each with a solar potential (Gaiddon & Kaan & Munro, 2009). Data (Note6) on such matters as the roofs’ slope, compass orientation, and amount of shadow vs. sunlight received by each roof were used in calculating each building’s solar potential. As a result of this solar master plan, Specific areas were selected as high priority areas for solar development by a solar atlas. This assessment has now been combined with an urban renewal program and a PV campaign is planned to inform building owners of the possibilities of PV and motivate them to invest in PV (Website pvupscale).

The color of each roof directly correlates to the potential to capture solar energy. The Atlas provides key information at a glance on such matters as the potential power output, reductions in CO2 emissions, and investment costs. A 2D web application (Note 7) with no plug-ins required allows you to start the Solar Atlas in your browser directly and simply enter any address and click on a building to obtain information about its solar potential. The Berlin Solar Atlas also lists approx. 30 solar industry producers, associations and research institutions and provides detailed information about more than 40 main photovoltaic installations and solar-thermal systems(website german-renewable-energy).

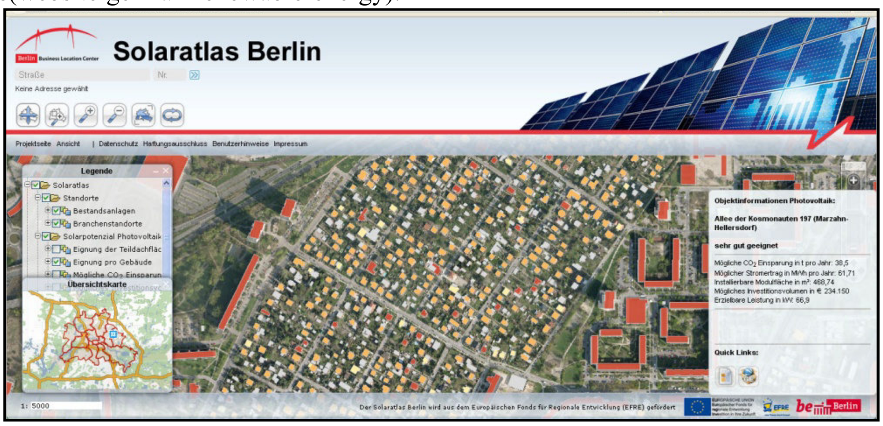

figure 2. Berlin`s Solaratlas, 2D map(Source: www.businesslocationcenter.de)

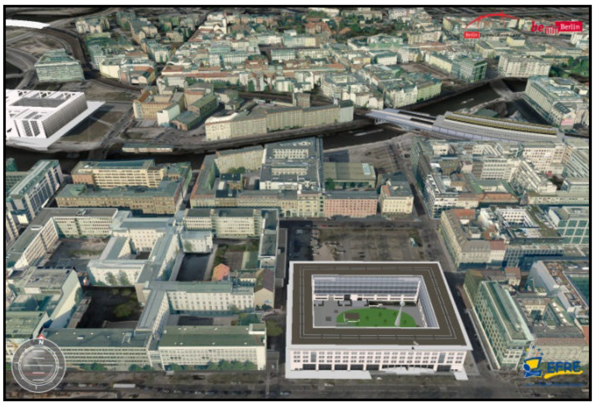

Figure 3. Berlin`s Solaratlas, 3D map
(Source: www.businesslocationcenter.de)

Figure 4. Berlin`s Solaratlas, 3D map
(Source: www.businesslocationcenter.de)

For Berlin's solar potential, the result was: approximately 3 million MWh per year electric current can be produced from about 220,000 building roofs from a total of 560,000 buildings in Berlin. [27] (Ludwig,2012)352,850 buildings are suited for solar thermal installations. The installable area is 30.81 km² with a possible heating output of 11,355.89 GWh/a (website gaccny*)*.

After collecting data and presenting the results, the planning workshop was held in Berlin in July 2007 and brought together the planning team for the urban renewal program, (in this case the Berlin urban planning office and representatives of the urban development department commissioned with renewal planning), and people involved in the solar planning process. This workshop used local network as a platform to spread information on the possibilities and potential of solar systems by creating a solar roof campaign. In addition, the business network will be used in order to get access to the owners of the roofs and facades of this area and to motivate them to invest in PV and to inform them about the possibilities of financing or contracting (website pvupscale).

4.1.2.3 future plan

The aim of the Renewable Energy Sources Act – the 'Erneuerbare-Energien-Gesetz' (EEG) is to increase the share of renewable energy in Germany, with the goal of reaching a share of 30 percent of the overall electricity supply by 2020(website erneuerbare-energien,2009).

7The nine key targets of the German photovoltaic industry are:

- Cut systems prices by more than 50% by 2020
- Install 52 to 70 GW of photovoltaic capacity by 2020
- Limit apportionment for solar power on electricity tariffs to about 2 euro cents/KWh
- Invest at least 5% of sales in R&D
- Secure at least 12% share of the growing world market for German production
- Build up approx. 8.5 GW of PV production "Made in Germany"
- Employ at least 130,000 people around German PV technology
- Generate a net economic contribution of at least EUR 25 billion by 2030
- Make photovoltaics a key component of the future power system (Berger, 2010).

4.2 China

China is the world's most populous country with over 1.3 billion people. It has experienced tremendous economic growth over the last three decades.

China is now the largest producer and consumer of solar water heaters (SWH) in the world, with a high possession and market growth rate.

by the end of 2010, China has installed 117.6 GWth of solar water heaters, about half of the world's total (195.8 GWth corresponding to 279.7 million square meters)(Weiss and Mauthner,2012).

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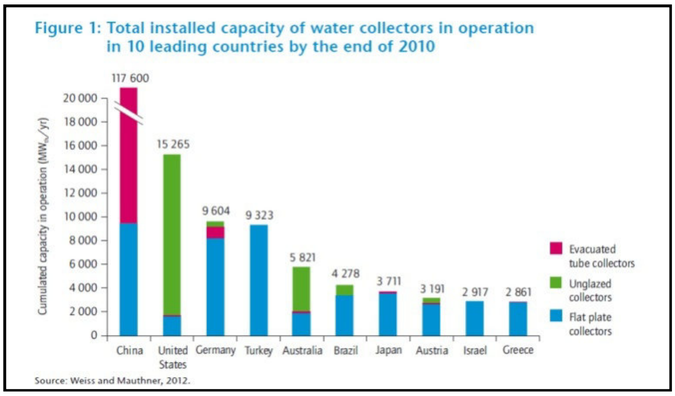

Diagram 3: Total installed capacity of water collectors in operation in 10 leading countries by the end of 2010(source: Weiss and mauthner, 2012)

4.2.1 china`s solar irradiation and Solar energy usage

China`s Yearly Average Solar irradiation is about 3.0-7.5 kWh/m2/day. (figure5)

In China, the use of solar domestic hot water heaters is still growing rapidly. They are increasingly popular due to their cost-effectiveness compared to electric and gas heaters (Note 8) (IEA, 2010).

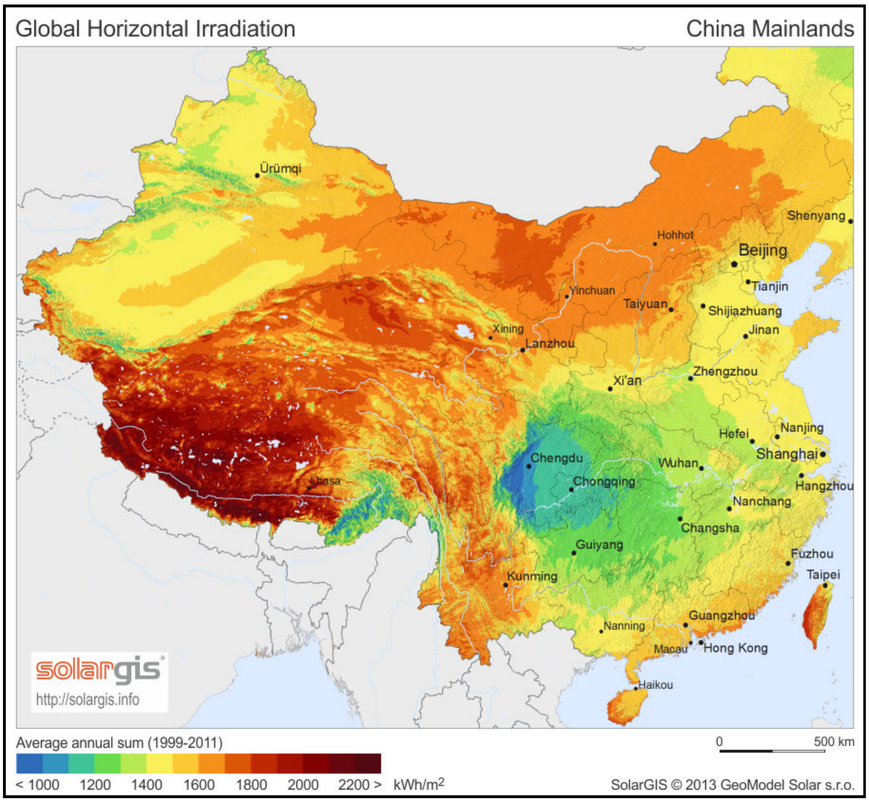

Figure 5. China`s solar irradiation map (source:http://.solargis.info)

4.2.2 China's Strategy for utilizing solar energy

Generally, the main elements of the framework that affect promoting solar water heaters in China include:

- Renewable Energy Law
- Supporting the SWH industry

4.2.2.1 Renewable Energy Law

Renewable energy had been encouraged by a number of early laws in China, but these were intended more for rural development in distributed generation schemes. The laws generally state goals or what has to be accomplished, and lay out a framework. The details on how goals will be achieved are determined later, usually

by the NDRC (Note 9).
The 11th Five-Year Plan for Renewable Energy stated the necessity of policy formulation to mandate integration of buildings and solar water heaters. In regions with high solar radiation, hot water intensive public buildings (such as schools and hospitals) and commercial buildings (such as hotels and restaurants) should be gradually mandated for SWH installation. New buildings should reserve spaces for future SWH installation and piping (NDRC, 2008).
At provincial and local levels, the government has issued various policies for SWH promotion, for instance, Jiangsu, Gansu and Shenzhen require buildings less than 12 floors to be equipped with solar water heaters, and in some areas, a certain amount of subsidy is provided to buyers of solar water heaters (Hu, 2006 & 2008).
The Program of Improvement and Expansion of Solar Water Heating Technology in China ran from 2003 to 2006, with United Nations funding and Chinese government co-financing. A set of technology standards and building codes has been promulgated, as well as a guidebook and design model for integrating solar water heaters into buildings.
4.2.2.2 supporting the SWH industry
The market for solar water heaters (SWH) has grown very fast in the last 10 years in China along with the economic development and associated increasing demand of Chinese households for hot water supply. The Government of China is supporting the SWH industry through technology standards, testing facilities or R&D activity.
4.2.2.3 Future plan
Solar water heaters are market competitive in China. Instead of focusing on subsidies and reducing costs, governmental policies are aiming at capacity building in the solar water heater industry, including setting up technological standards, testing centers and guidance for future development.
During "The Twelfth Five-Year-Plan"(Note 10), solar thermal production is expected to increase 20 percent than "The Eleventh Five-Year-Plan" in China.
For the goals of China's solar thermal industry during "The Twelfth Five-Year-Plan", it is expected to achieve a 20% output than “The Eleventh Five-Year-Plan”. It is predicted that by 2020 the annual energy demand in China is about 5 billion tons of coal, during which 15% is non-fossil energy, solar thermal application accounts for 16% of non-fossil energy, 2.4%of the total energy application.
4.3 Iran
Iran with a population of around 75 million is located in the Middle East and has the world’s third largest oil (website opec) and the second richest gas reserves. Historically oil has been the predominant source of primary and final energy in Iran.
4.3.1 Iran`s solar irradiation and the share of installed solar systems
Iran has a great solar energy potential among other countries. Development of solar energy systems requires precise knowledge of Iran solar radiation. Solar thermal power plant site selection is possible by accurate knowledge about country. This project defined by Solar Energy Department to provide basic knowledge for planning solar projects.
I n the first phase of project, solar irradiance of Iran has been concluded by data from Satellite pictures and solar study stations.
The main objectives of this project are:
- Providing Iran solar atlas
- Determining the place and capacity of appropriate sites for installing solar thermal power plants
- Fiscal and technical investigation and prioritize suitable sites for installing solar power plants
- Verifying appropriate sites for solar power plants in Iran
- Providing software algorithm for fiscal study of solar systems in Iran
- Developing Iran solar energy data base (website suna).

Based on the solar atlas The level of incoming global radiation (~2,200 kWh/m2 per year) in Iran is globally one of the highest (Note 11) (website suna). Taking into account the size of the Iranian territory (~1,648,000 km2) the total amount of radiation in Iran is about 3.3 million TWh per year – this is thirteen times higher than the total energy consumption in Iran (Note 12).

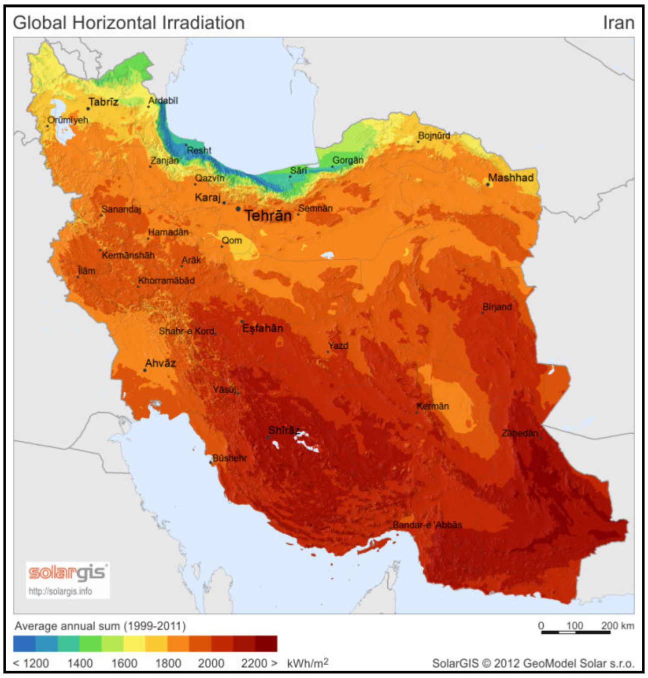

Figure 6. Iran`s solar irridation map
(Source:website solargis)

Over the past twenty years some research on solar energy have resulted in development and the establishment of a few small- and medium-scale electricity generation plants, which are powered via solar energy. In addition, there has also been the development of solar water heaters (Sabetghadam, 2005).

Two main solar power plant projects of Iran Are: Yazd solar thermal power plant and Shiraz solar power plant which are described at table 2.

Table 2.main Solar power plant projects of Iran

Name	Location	Capacity	Type	Operational	Notes
Yazd solar thermal power plant	Yazd	467 MW	Integrated Solar Combined Cycle	2009	Yazd solar thermal power plant is the world's first integrated solar combined cycle power station using natural gas and solar energy. It is the largest solar power plant in the Middle East and the eighth largest in the world.(website zawya)
Shiraz solar power plant	Shiraz	250 KW	Concentrating solar power	2009	Shiraz solar power plant is Iran's first Solar power station; Currently being upgraded to 500 kW·h(website suna)

4.3.2 Iran's Strategy for utilizing solar energy

In 1990, at the beginning of the after-war economic reforms, immense domestic consumption of oil products, combined with a rapid rate of growth was recognized as serious threat to the economy. Due to this fact, the main goal was to substitute other sources of energy for oil products in domestic consumption and one of the main policies was: Provision of more clean energy, i.e. electricity, gas and renewable energy, on the assumption that, given the competitiveness of prices, they would be preferred and hence substituted for oil products by customers for indoor heating and cooking (website helio-international).

Actually, Iran was the largest provider of fuel subsidies in the world by 2009(Iran Investment Monthly, 2011) and it`s subsidy system has been inherited from the Iran-Iraq war era but was never abolished (United States Energy Information Administration, 2000). Generally, the high level of subsidies (Note 13) for heating as well as for electricity results in an inefficient use of energy and prevent the use of solar energy and other renewable energies.To solve this problem, the Iranian targeted subsidy plan was passed by the Iranian Parliament on January 2010 To manage subsidy in Iran (Bahar, 2008). 30% of the amount saved by the government will be directed towards improving the efficiency of the utility, fuel and energy production infrastructure; public transportation development, industry and farming (press TV 2010).

Due to the significance of energy issues, Iran places on the agenda to move toward privatization and participation in power market with emphasis on the deployment of renewable energy(Asgari& Monsef, 2010,pp.5582-5599).

4.3.2.1 Iran`s feed-in-tariff

Accomplishment of the energy plans needs legislations to regulate exchange in power market. Power tariff regulations may be the most effective one. Although, Iran has feed-in-tariff directive (National directive of electricity trade in Iran's electricity grid, 2005). But this non-incentive directive belongs to the time before the targeted subsidy plan. Therefore, more sophisticated tariffs are necessary part of power market. Current state of residential power tariff in Iran (Note 14) is based on rates weighted by summer factor (four months a year) and winter factor (three months a year) to take into account seasonal variations in different parts of the country. Currently, peak hours are considered to be between 19 and 23. Figure 1 shows the current schedule for Iran's residential power tariffs, it has been regarded as reference power tariff structure (Motavaselian& Faghih Khorasani,2012).

Iran first introduced FiT in 2008 for purchasing renewable energy from investors. A price of 1300 Rials/kWh was set for renewable electricity. For 4 hours in the mid-night, the price is 900 Rials (Website solarfeedintariff).

Table 3. Iran FIT (source:Website solarfeedintariff)

Iran- FIT	
Peak and medium load 20 hours per day	1300 IRR
Low load 4 hours per day	900 IRR

Regard to all mentioned policies, Iran has promoted some actions to develop solar energy at its capital city that has been described below:

4.3.3 Reviewing the action of Tehran Municipality in the field of developing solar energy (Note 15)

Tehran With a population of around 12 million is the capital city of Iran. it is also Iran's largest urban area and city, the largest city in Western Asia and the 5th-largest city globally.

Regardless of great potential to use solar energy (the annual average of solar irradiation in Tehran is 4/58 KWh/m^2 (Website NASA), Tehran is suffering from high rate of air pollution that is mainly because of fossil fuels overuse. Regarding to the escalating trend of air pollution and the great solar irradiation in Tehran, city planners and managers increasingly consider different use of clean energy instead of fossil fuel, which are not environmentally friendly.

To decrease air pollution and have an environmentally friendly city, Tehran mayor and his counselors have taken some promising actions, which are positive signals that indicate a growing awareness of a structural change in the energy system in Tehran. Some of these actions have been described below:

4.3.3.1 Legislation for developing solar lighting

In 2008, Tehran city council approved an obligation in the subject of replacing 10 percent of conventional power generation in city parks with solar power annually (*website shora-tehran).* In this regard, up to now, Tehran municipality has equipped 73(which are 4% of total) of 1808 city parks with solar lighting.

Figure 7.Velayet park, Tehran, Region 19 (Source: Tehran municipality`s archive)

Figure 8. Khavaran cultural complex, Tehran, Region 15(Source: Tehran municipality`s archive)

4.3.3.2 Installing solar heating systems

Solar heating systems could be an important step towards a sustainable restructuring of the energy supply. In this regard, by this time The Tehran municipality has installed 181 solar water heaters around the city at public spaces, which had no access to other kind of thermal energy.

Figure 9. Mellat Park, Tehran, Region 3
(Source: Tehran municipality`s archive)

Figure 10. Polis Park`s mosque, Tehran, Region 4
(Source: Tehran municipality`s archive)

4.3.3.3 Creating energy parks

To mobilize the potential of a complete city quarter, strong incentives are needed in order to get people involved. In this regard, Awareness of the possibilities of PV systems within urban space, and particularly in combination with urban renewal creates many chances to install PV in public spaces.

An energy park is a separate area used and planned for the purpose of clean energy development, like wind and solar generation facilities. Energy parks make people familiar with various ways of using solar energy in a tangible and practical manner that is effective.

In 2009, Tehran Municipality equipped one of the existing parks with solar facilities and now there are six Energy Park at different regions of Tehran.

Generally, Facilities such as: solar cooker, solar cabin (Note 16), Solar Fruit Dryer, Solar water desalination, solar water heater and photovoltaic modules have been installed at common energy Parks.

Figure 11. Alghadir Energy Park, Tehran, Region 4
(Source: Tehran municipality`s archive)

Figure 12. Bahman Energy Park, Region 16
(Source: Tehran municipality`s archive)

4.3.3.4 equipping urban element with PV

By the purpose of indirectly training citizens to promote the idea of using solar energy in their daily life, Tehran Municipality, has equipped more than 100 bus stops with PV to provide solar lighting and In this regard, Tehran municipality`s energy experts have designed urban element-equipping plan by inspiration of mixture of traditional architecture and renewable energy use.

In addition to bus stops, some pedestrian bridges are also equipped with PVs to provide lighting.

Figure 13. Solar Bus Stop, Tehran, Region 3
(Source: Tehran municipality`s archive)

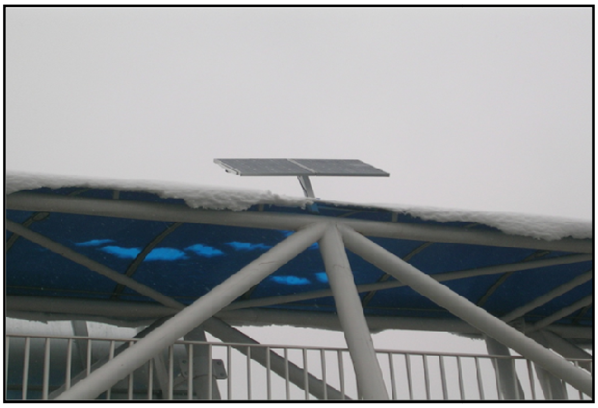

Figure 14. Solar Pedesterian Bridge, Tehran, Region 16
(Source: Tehran municipality`s archive)

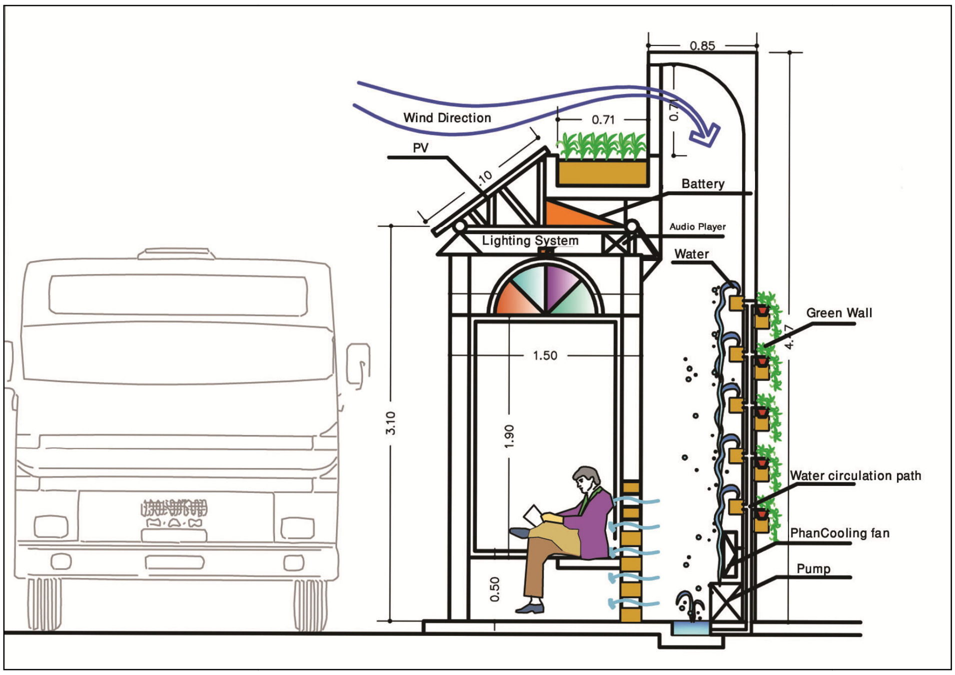

Figure 15. Solar Bus Stop Sketch
(Source: Tehran municipality`s archive)

4.3.3.5 Publishing Hand books

To inform municipality`s employees who are involved in Solar projects around the city, Tehran municipality has initiated a committee to manage the city solar projects and has published 4 handbooks to promote the knowledge of citizens and related stuffs.

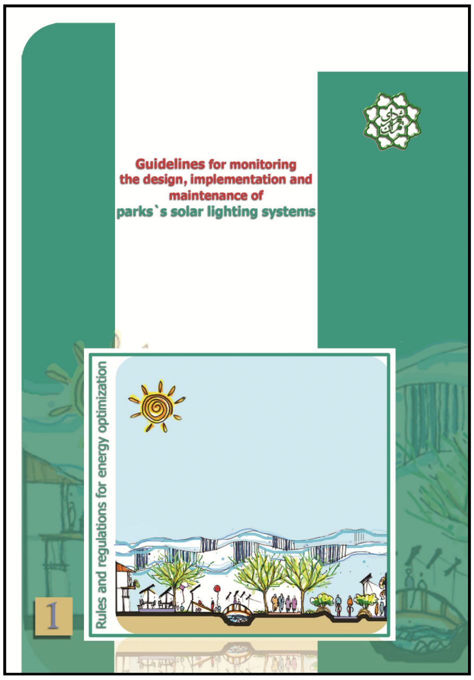

Figure 16: Ruls and Regulations for energy optimization,
Number 1(Source: Tehran municipality`s archive)

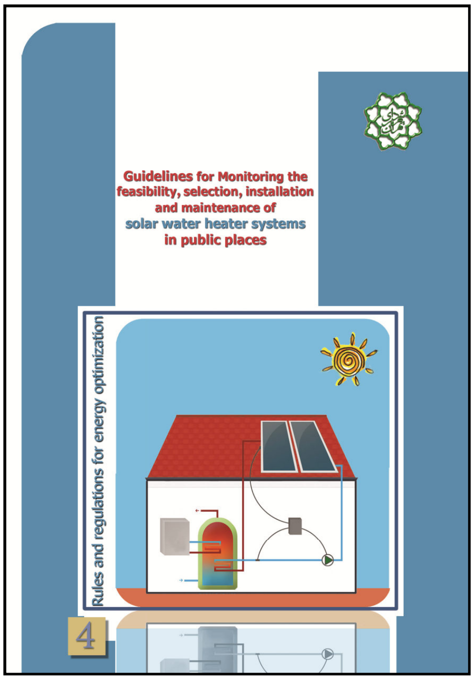

Figure 17: Ruls and Regulations for energy optimization,
Number 1(Source: Tehran municipality`s archive)

4.3.3.6 Future plan

Tehran Municipality has planned to operate at least one energy parks in all 22 districts of Tehran Municipality during the next 2 years, add 40 solar water heaters and replace 10 percent of conventional power generation in city parks with solar power annually.

Result

To achieve Sustainable urban planning and management, Cities around the world should promote the use of renewable energy sources and build low-carbon eco-cities. In this regard, solar energy is expected to play a crucial role in meeting future energy demand because it is constituted the most abundant renewable energy resource available.

Town planning with infrastructure without solar targets is the first barrier to promote solar energy in cities; to solve this problem city needs Integration in the preliminary planning phase and Town planning should focus on solar potential and consider it in the planning process from the beginning. Economic concerns are the second barrier that should be noticed. To solve this problem city needs subsidy and feed in tariff programs and government also should investigate in producing PV and related stuff to decrease their price. Weak legal instruments to prescribe solar targets are the third main barrier, and to solve this, the city needs Commitments in building code and energy. In addition, the fourth factor which is a barrier to the solar urban planning is the unwillingness of private companies to invest. To mobilize the potential of a complete city quarter, strong incentives are needed in order to get people involved. Awareness of the possibilities of PV systems within urban space can create many chances to install PV in public spaces. Finally, some weakness in solar energy technology also leads the unsuccessful solar energy development. To solve this problem, producers should increase the efficiency of PV modules and other related stuff and they should train their workforce professionally to operate solar project skillfully.

City planners should notice that a mix policy for developing solar energy result the best and although some policy instruments have leading roles in promoting solar energy in some countries, a mix of policy instruments, instead of a single policy, would be more effective.

In summary, the discussion presented in this study indicates the impetus behind the recent growth of solar technologies is attributed to sustained policy support in countries such as Germany and China. In comparison with China and Germany, Iran is at the first step to expand solar energy and beside infrastructure problems by depending on high levels of solar irradiation, it has planned to promote solar energy at cities and rural. In this regard, Tehran municipality has done some projects to increase citizens and authorities' awareness about different ways to use solar energy.

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Notes

Note 1. As a global average, surface temperatures have increased by about 0.74°C over the past hundred years (IPCC, 2007).

Note 2. World Commission on Environment and Development (WCED)

Note 3. International Council for Local Environmental Initiatives

Note 4, Passive solar energy technology merely collects the energy without converting the heat or light into other forms. It includes, for example, maximizing the use of day light or heat through building design (Bradford, 2006) (Chiras, 2004). In contrast, active solar energy technology refers to the harnessing of solar energy to store it or convert it for other applications and can be broadly classified into two groups: (i) photovoltaic (PV) and (ii) solar thermal (Sørensen, 2000).

Note 5, Ecofys is an innovation company in the field of renewable energy, energy efficiency and climate change.

Note 6, the data for the solar-potential roof maps is obtained through high-resolution LiDAR (light detection and ranging) remote-sensing technology. Light reflection data from laser beams is recorded via a scanner mounted on the fuselage of a plane. By collecting at close intervals the values of elevation above mean sea level of the structures on the earth's surface (buildings and vegetation).

Note7, for further information visit http://www.businesslocationcenter.de/solarpotential

Note 8, the average annual cost over the lifetime of an electric water heater is USD 95 and a gas water heater USD 82 whereas a solar water heater only has a USD 27 average annual cost

Note 9, National Development and Reform commission

Note 10, Based on the "12th Five-Year Plan on Solar Power Development which is released by China's National Energy Administration (NEA) officially on September 12,2012

Note 11, In Germany, for example, the annual incoming global radiation (~800-1,000 kWh/m2) is less than half of the Iranian average.

Note 12, Climate Policy and Sustainable Development: Opportunities for Iranian – German Cooperation/ The study is a result of a joint German-Iranian project that was funded by the Heinrich Böll Foundation/ May 2005 from: http://www.ceers.org

Note 13, For a more detailed discussion of the structural deficits of the Iranian energy system refer to several articles in: World Energy Council/National Energy Committee of Islamic Republic of Iran (ed.), 2004: The Forth National Energy Congress, May 2003, Key Contributions, Teheran, Iran.

Further information is contained in Massarrat, Mohssen, 2004: Iran's Energy Policy: Current Dilemmas and Perspectives for a Sustainable Energy Policy, in: International Journal of Environmental Science and Technology, Vol. 1, Number 3, pp. 241-252.7

Note 14, Renewable Energy Organization of Iran (SUNA), Ministry of Energy, 2009

Note 15, all given information has collected from data and reports, which are archived at environmental and sustainable development office of Tehran municipality.

Note 16, a cabin that provide electricity for equipments like TV and Cooler.

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