An Overview of the PV Applications in Turkey

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Abstract — Due to the population growth and rapid industrialization, world faces with diminishing energy sources and climate change. At this time, renewable energy takes an indispensible part in the energy agenda of the worlds demand. Besides, renewable energy remain an important topic of the governmental decisions for energy policies. Photovoltaic conversion of solar energy systems (PV) has less prevalence among other renewable sources due to the cost of the PV systems and thereby making the electricity more expensive. Especially for Turkey, despite its huge potential of solar energy, PV applications are limited to only lower level of MW installations.

Keywords — Climate change, Renewable energy, Solar Energy, Turkey.

1 Introduction

Globally, renewable energy technologies are recognized as the foundation of the sustainable energy strategy. Renewable energy share has been shown a dramatic increase in the last decade.

Solar energy has the potential to meet the demand of gradually increasing world's energy supply therewith protecting environment in a sustainable way. Two main types of technologies have been implemented to convert solar power into electricity which are;

- Solar-thermodynamic power plants (solar heat concentrated via sustainable mirror system) and
- Solar photovoltaic systems (direct conversion of solar light into electricity).

Photovoltaic systems (PV) has become a key technology in global energy market in terms of its security for energy supply, economics and environmental friendly technology. Photovoltaic energy is the direct conversion of solar light into electricity and this is first appeared in the 19th century by the French physicist Edmond Becquerel (Jean Baptiste). The advantages of PV are;

- It is compatible with other energy sources,
- It avoids nuisance such as electricity production without emmisions and noise pollution,
- Its maintenance costs are less than solar thermodynamic plants and its more reliable.
- Implementation of these systems is easy (in building integrations, central electricity stations and isolated sites with grid connected systems).

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2 Solar Energy Potential and Photovoltaic Applications

2.1 Global PV Applications

Global solar photovoltaic energy capacity reached about 22 GW with the addition of new 7.2 GW of installations in 2009 and 18.2 GW in 2010 where as the growth was accounted for 5.95 GW in 2008 with a growth about 110%. This total installed capacity representing the electricity demand of approximately 5.5 million households [1, 9].

Table 1. Comparison of the annual added capacities [1]

Annual Installed Capacity (MW)	2007	2008	2009	2014 (moderate scenario)
Global	2800	5950	7200	13730
U.S.A	207	342	475	3000
South Korea	-	280	168	-
Japan	210	230	484	1200
Europe	1969	5060	5600	7980
Spain	560	2600	69	675
Germany	1271	1809	3806	4000
Italy	70	338	711	1200
Turkey (total)	-	-	-	6000*

*Estimated moderate scenario for 2020

World cumulative installed capacity of PV

applications accounted for approximately 22 GW of which only Europe represent 16GW of all installations and United States and Japan stay behind with the installations 1.6 and 2.6 GW respectively. Large portion of the installations of 2009 attributed to the Germanys developing market [1]. German market represent approximately 50% portion of the World PV market. There are countries showed impressive development in the PV installations whereas some countries showed a dramatic decrease in their annual installations due to financial crisis.

It was announced by European Photovoltaic Industry Association (EPIA) 2010 report that EU would deliver electricity less than 10 €c/kWh for industrial systems and less than 15 €c/kWh for residential applications [1]. It can be clearly seen that these estimations and targets wouldn't not be achieved without contribution of the PV installations. However, PV applications requires support for the developing PV markets, regulative decisions and plans for the future generation and setting targets, effectively determined feed in tariffs and proper selection of the PV technologies.

2.2 PV Applications in Europe

Europe achieved 5.6 GW PV installations in 2009 which represent the 78% of total added installations and 14.7 GW of installations are achieved in Europe in 2010. German installations have an important place in the added capacity in 2009 by covering the 68% of the Europe installations thereby making its position as a pioneer country. Additionally, impressive development of Czech Republic, Belgium, France and Italy has been made whereas Spain has shown a dramatic decrease due to financial problems. With the addition of 711MW capacity in 2009, Italy moved its position to the second place. Additionally, as a promising country, Czech Republic takes third place with the 411 added capacities. The top three countries; Germany, Italy and Czech Republic accounted for 4.07 GW of world capacity. Other countries in the south of the Europe are eager to develop their market due to their huge potential [1].

Due to the revisions made in French law, French PV feed in tariff are lowered to 12 €c/kWh for open space PV systems. This revision is pave the way for the new installations. The added capacity in 2009 was announced 185 MW out of which 285 MW is the real capacity to demonstrate. This portion is waiting for the acceptance to make installations [1].

2.3 Country Profiles

2.3.1. Germany

Germany with a cumulative capacity of 10 GW is the largest market of the Europe with the addition of 3.8 GW in 2009. German PV market represents more than 50% of the world market. Germany doubled its annual growth capacity comparing with the installation from 1.8 GW to 3.8 GW [6]. This huge development is directly related to the EEG (renewable energy sources act) which rules the payment for the electricity. The cuts in the second half of the 2009 affected the growth rate of the annual installations. The feed in tariff is determined by the size and type of the system. The decrease in the system prices estimated roughly 30% and this makes the PV market more attractive. According to the EPIA's estimations, Germany will be able to stabilize their annual growth 3- 5 GW by 2014. In the moderate scenario the annual growth is estimated to be 4000 MW possible by the year 2014. [1].

2.3.2 Italy

With the 711 MW applications of PV integration, Italy took the second place in the Europe as well in the world. EPIA makes projections regarding the moderate scenario in which stated that Italy could grow up to 2 GW in 2014.

2.3.2 United States of America

With an installed capacity of 475 MW in 2009, USA challenges the top pioneer countries. According to the moderate scenario of the EPIA, the possible annual growth is estimated as 3000 MW by the year 2014. In the last two years, USA doubled roughly its growth rate bringing the growth rate from 207 to 475 MW.

2.3.3 Japan

Japan is the third largest PV market in the worldwide. With the addition of 484 MW bring its cumulative installations into 2.6 GW. Japanese government has been struggling for an environmental friendly society and taking cautions against carbon emissions. In this sense, Japan set target of the PV installations, 28 GW could be possible by the year 2020 and 53 GW by the year 2030. Besides, according to the moderate scenario of the EPIA, 1200 MW of annual installation could be possible in 2014.

3 Turkey's Solar Energy Potential and Energy Conversion Technologies

Since Turkey is an energy importing country, renewable energy has been constitutes as an indispensible area of the energy demand of the country as being means of improving its energy security and independence from imports.
Turkish electricity generating capacity is based on thermal power plants and natural gas. Turkey lies in a sunny belt between 36°-42° north latitudes and has an advantage of having huge solar energy potential due to its geographical position. Turkey has become

comparable with Spain which is the one of the pioneer countries in the field of solar energy. Turkey has a surface area of 781000 km^2 and annual sunshine duration is 2640 hours whereas annual total insulation duration is 7.2 hours per day; and thereby making horizontal solar irradiation 1311 kWh/m^2 [3]. Figure 1. Shows the solar irradiation ranges changing with the regions in Turkey.

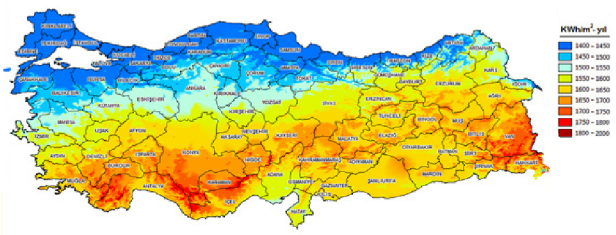

Figure 1. Solar Energy Potential Map (GEPA) [2]

The highest solar irradiation of Turkey belongs to the South East and Mediterranean Region. The South east region of Turkey has 1460 kWh/m^2 annual solar irradiation potential whereas this number for Mediterranean is 1390 kWh/m^2. According to the studies conducted by EİE (General directorate of electrical power resources survey and development administration), solar energy potential of Turkey has calculated as 380 billion kWh/year. The contribution of solar collectors to the primary energy production is 429,000 toe (tone oil equivalent) in 2009 and 420,000 toe in 2008 [4,5]. Generally, flat plate types of collectors are used for the purpose of heating water. There is no exact data given for photovoltaic installations in Turkey. However, it was estimated that total cumulative installed capacity of Turkey is 5 MW. Photovoltaic systems are mainly applied by several universities and companies in Turkey. The related research areas are TÜBİTAK Marmara Research Centre (MAM), Ege University Institute of Solar Energy, Muğla University, Middle East Technical University, Kocaeli University, Fırat University, Dokuz Eylül University and EİE (General directorate of electrical power resources survey and development administration). State Meteorological Service (DMI) and EIE has been collecting data since 1991[6].

There are two standard prepared by Turkish Standard Institute; TS3680 - Flat Type solar energy collectors and TS3817- Rules for the Manufacturation, Installation and Operation of Solar Water Heaters [4].

Turkey has an official target that Turkey will be used 30% of energy from renewable by 2023. However, there has been no target set for photovoltaic and even for solar energy. Turkish PV Technology Platform (UFTP), collected data and defined two different scenarios; one is moderate and another is policy driven scenarios set by 2020. According to this scenarios, it is estimated that 6 and 10 GW could be possible by the year 2020 for Turkey both moderate and policy driven scenarios. The main purpose of this platforms are to develop a partnership between research centres and universities. For example, Mugla University has installed a dual-axis solar tracker with a capacity of 15,6 kWp in 2009. Besides, total PV capacity of the university is 110 kWp [7]. Table 2. gives the values for the capacity installed by some authorities until 2007.

Table 2. The summary of a development of solar energy in Turkey [3,7]

Applications (kWp)	**2001 2002**	**2004 2009**
Berke Dam	14	-
Muğla University	10.4	54 15.6
Ege University The Solar Energy Institute	-	22.2
The Energy Minister of Turkey opened a "Clean Energy House" in Pamukkale University,	-	5
TESCO-KIPA supermarkets in Marmaris and Kusadasi	-	60
Anel Corp. installed PV module in İstanbul	-	22.9
Airfel Corp. installed pilot PV power system in İstanbul	-	10.2
Geo Ltd. installed dual-axis tracker system in İzmir	-	2.2
Kocaeli University installed small test sytem in Kocaeli	-	0.5
Girasolar Ltd. installed BIPV grid connected system in Manisa, dual axis tacker system in İzmir, off-grid PV system in Antalya	-	10 3.2 6.4
Batienerji Ltd. installed grid connected system in Burdur	-	2.4
Solen Corp. installed in Bozcaada, Eşek Island, Istanbul, Kazdağı, Kastamonu		17.2 5 2.6 2.2 0.6

3.1 Related Regulations in Turkey

Feed in tariff schemes for Turkey was given as 5-5.5 €c/kWh in the law on the renewable energy sources accepted in 2005. With the new revisions

adopted on the "Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy" to stimulate the implementation of the photovoltaic applications envisages the feed in tariff support schemes as 13.3 U.S. dollars cent/kWh for the first 10 year of installations [8]. Solar photovoltaic systems are 60% cheaper than they were in 1990's regarding global market.

8 Conclusions

Turkey takes attention with its growing urbanization, industrialization and rapid economic development and plays an important role in the growing markets of the world in the last decade. However, Turkey has still dependent on important energy sources. Limited fossil fuels and its environmental impacts lead implementation of the renewable energy sources. Due to the having huge solar irradiation potential, solar energy conversion technologies can be easily adapted to the especially southern part of the Turkey efficiently. The application of PV system in Turkey is limited with private implementations and research centres. With the adopted revisions in the regulations and improvements made on the way to the European Union elections, governmental decisions will support the entrepreneurs to take action in this field in order to use the potential in an efficient manner.

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