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Solar Energy in Turkey, Germany & Spain

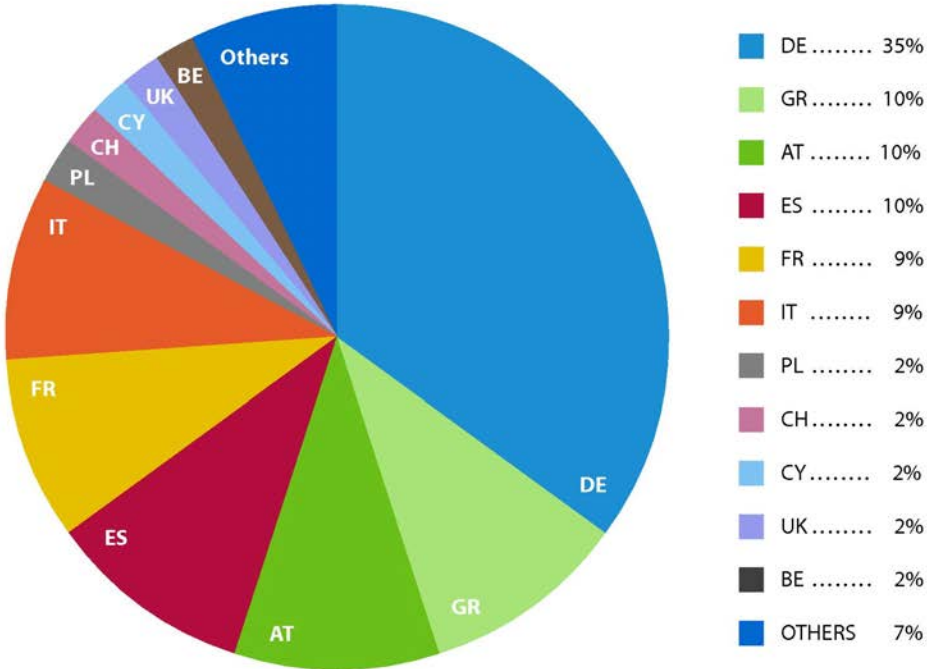
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I. Solar Energy Market in the EU¹

In 2007, Greece, Spain, France and Italy were able to significantly increase their share of the total EU market and now account for 9-10% of European sales, each. Germany on the other side saw its share decrease from 50% in 2006 to 35% in 2007.

Shares of the European Solar Thermal Market (Newly Installed Capacity), 2007

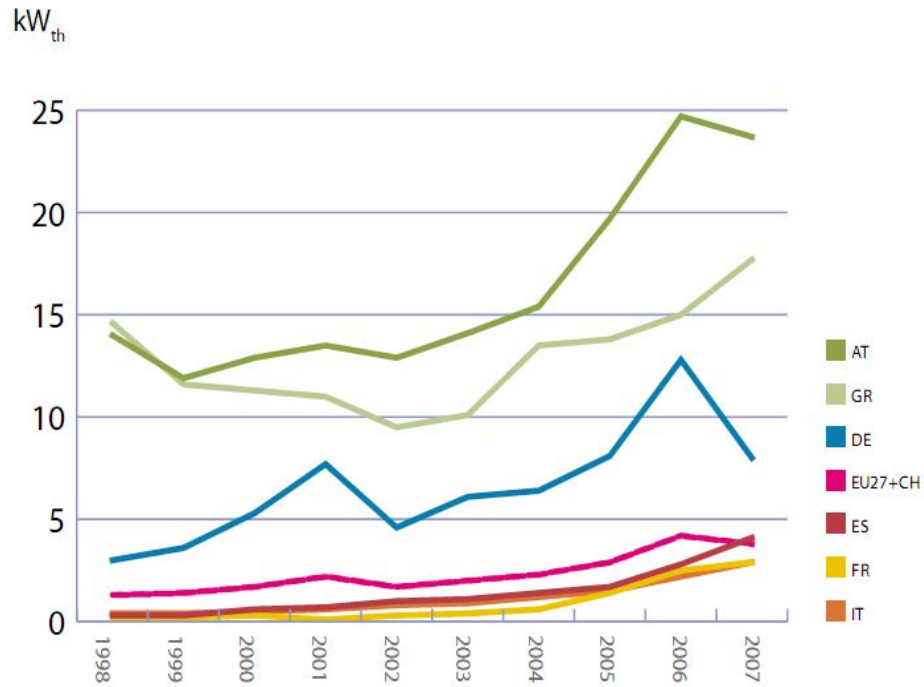


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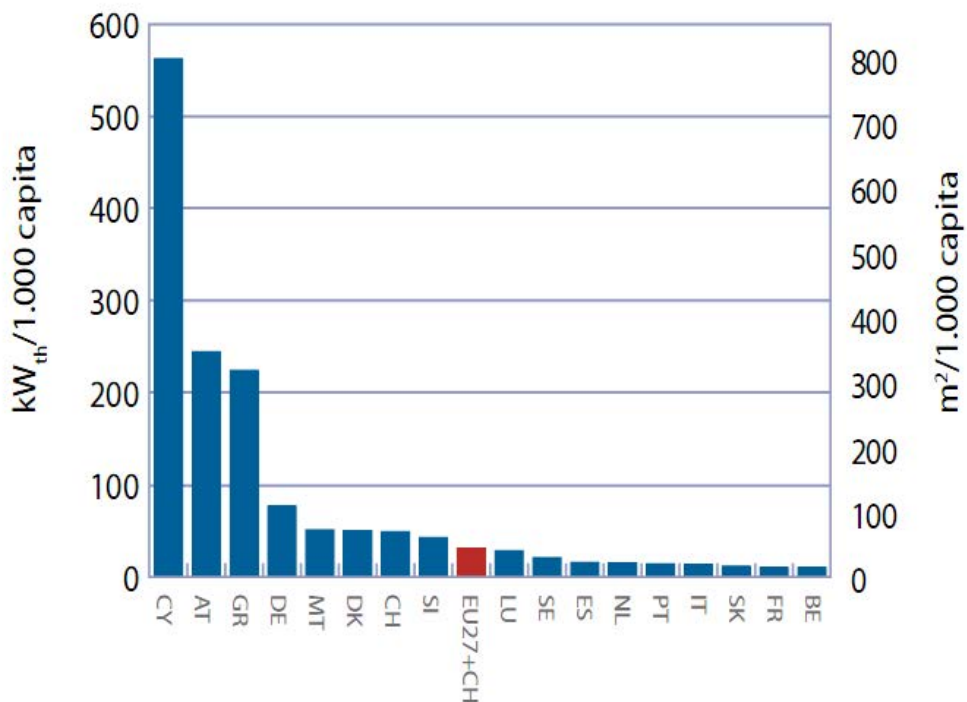
Source: European Solar Thermal Industry Federation

¹ Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

Development of Market Per 1000 Capita in the EU (Newly Installed Capacity Per 1000 Capita)²



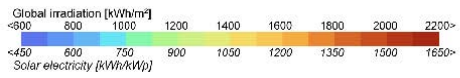
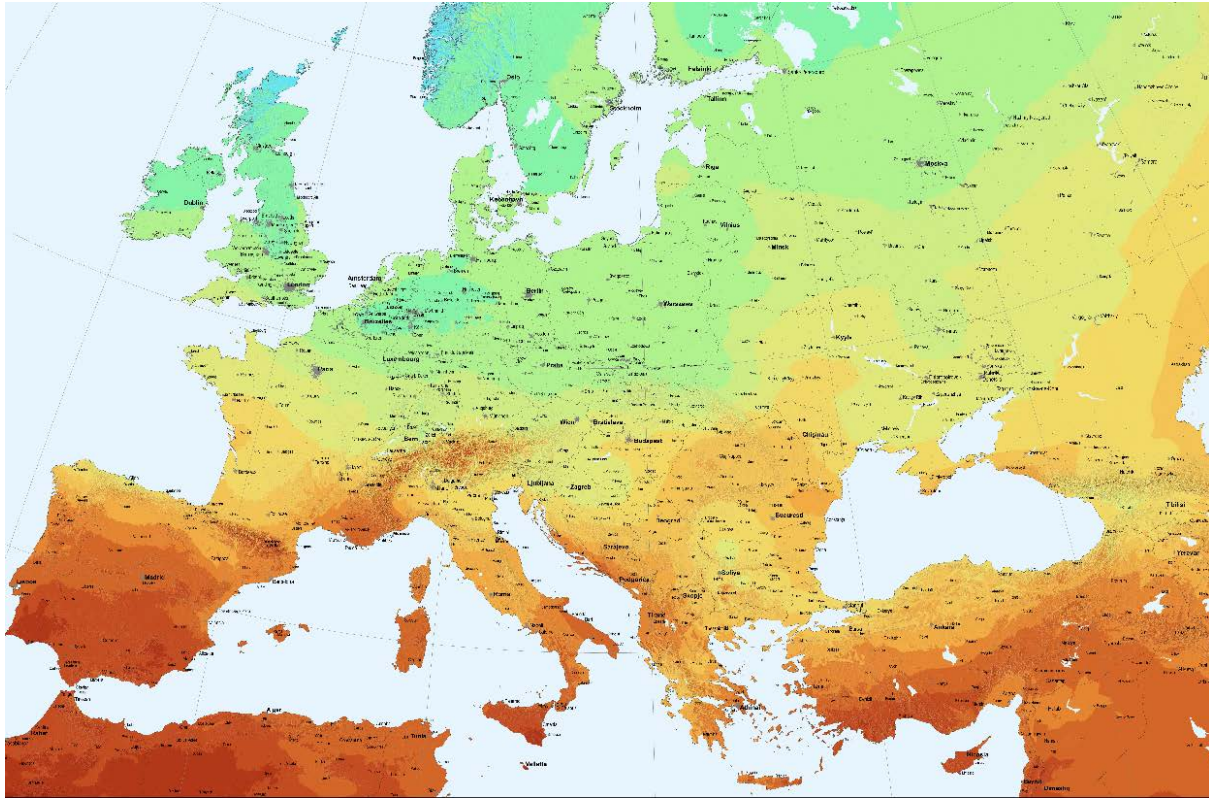
Solar Thermal Capacity in Operation per 1000 Capita in the EU in 2007³



² Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

³ Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

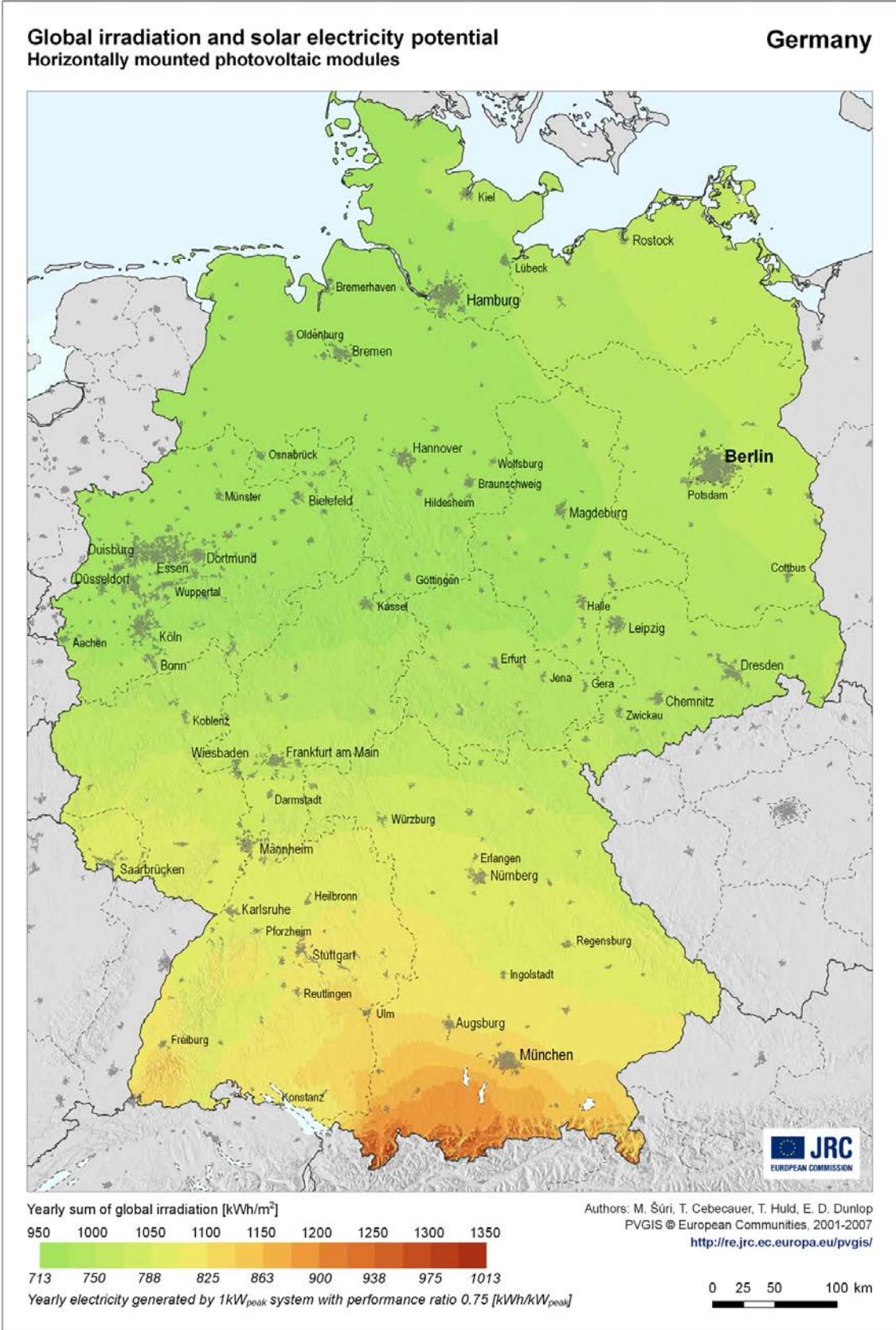
Photovoltaic Solar Electricity Potential in European Countries



Yearly sum of global irradiation incident on optimally-inclined south-oriented photovoltaic modules
Yearly sum of solar electricity generated by 1 kWp system with optimally-inclined modules and performance ratio 0.75

Source: European Commission, Photovoltaic Geographical Information System

II. Solar Energy Market in Germany & Spain



Source: European Commission, Photovoltaic Geographical Information System

GERMANY⁴

In 2007, Germany saw a huge decline of its domestic solar thermal market: 37% less than in 2006. At 658 MWth the newly installed capacity (940,000 m² of collector area), remained just below 2005 figures. Several factors, for example the increase of the VAT rate in January 2007, contributed to the decline in Germany. The decline was strongly influenced by the overall heating equipment market, which decreased by approximately 30%.

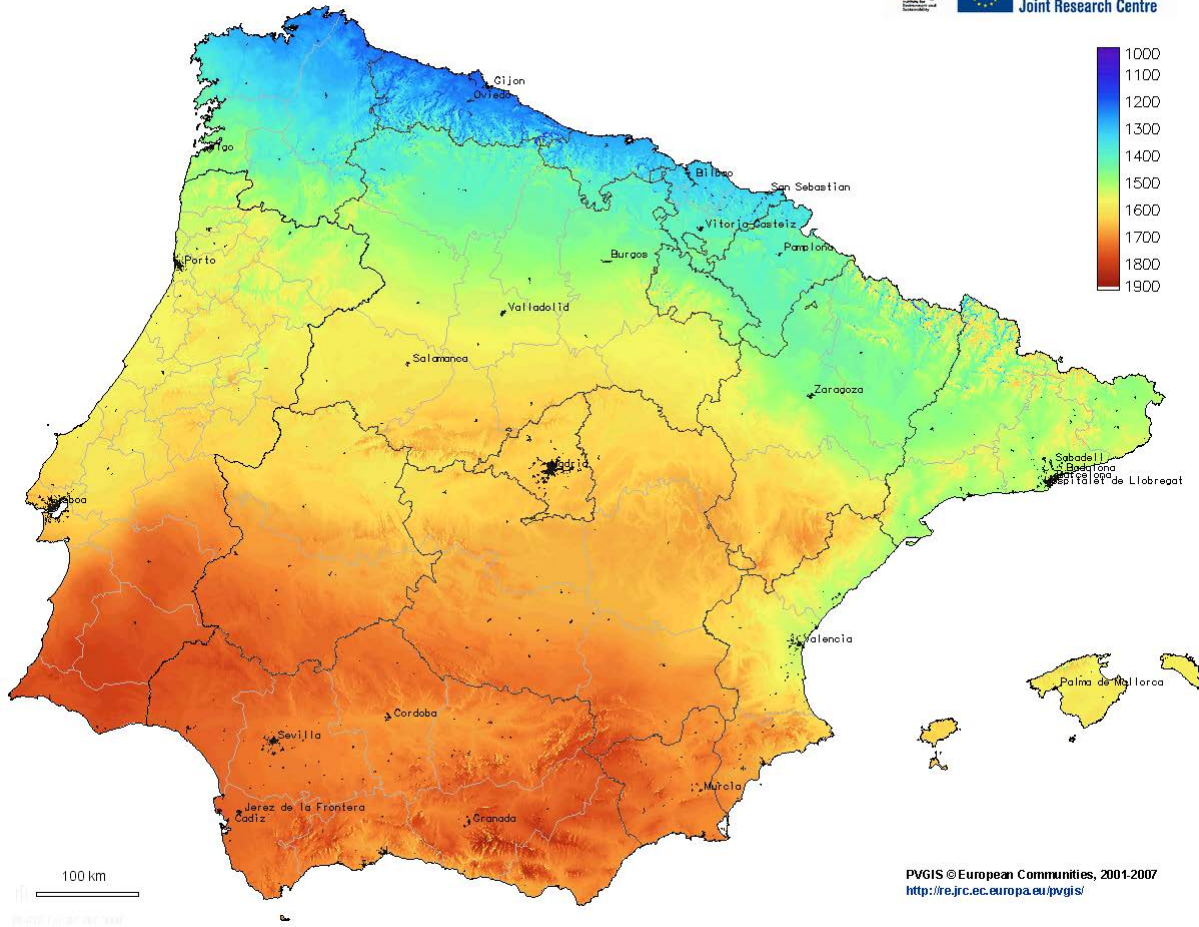
Solar Thermal Market in Germany



Source: ESTIF (European Solar Thermal Industry Federation)

⁴ Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

Yearly sum of global irradiation on a horizontal surface - Spain and Portugal



Source: European Commission, Photovoltaic Geographical Information System

SPAIN⁵

In Spain 183 MWth of capacity were newly installed during 2007 (262,000 m²), 50% more than in the previous year. As most buildings constructed in 2007 were planned before the new building code came into effect, the solar obligations have not yet had a significant effect on the market. The impact should start to show in 2008. However, Spain currently experiences a slow-down of the construction sector, which may also have an effect on how the building technical code (CTE) is applied.

⁵ Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

Solar Thermal Market in Spain



Source: ESTIF (European Solar Thermal Industry Federation)

Germany, Spain & EU

Market Size in Terms of Collector Area (kW _{th})	In Operation ²	Market (=Newly Installed)					Market Growth
	2007	2005	2006	2007			2007/2006
	Total Glazed kW _{th}	Total Glazed kW _{th}	Total Glazed kW _{th}	Total Glazed kW _{th}	Flat Plate kW _{th}	Vacuum Collectors kW _{th}	Total Glazed %
Germany	6,295,800	665,000	1,050,000	658,000	588,000	70,000	-37
Spain	674,916	74,760	122,500	183,400	175,700	7,700	50
EU27 + CH	15,370,212	1,434,508	2,102,395	1,917,893	-	-	-9

Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

Notes

¹The relation between collector area and capacity is 1 m² = 0.7kW_{th} (kilowatt-thermal)

²Capacity "in operation" refers to the solar thermal capacity built in the past and deemed to be still in use. ESTIF assumes a time of use of 20 years for all systems installed since 1990. Most products today would last considerably longer, but they often cease to be used earlier, e.g. because the building is torn down, or the use of the building has changed.

Market Size in Terms of Collector Area (m ²)	In Operation ²	Market (=Newly Installed)					Market Growth
	2007	2005	2006	2007			2007/2006
	Total Glazed m ²	Total Glazed m ²	Total Glazed m ²	Total Glazed m ²	Flat Plate m ²	Vacuum Collectors m ²	Total Glazed %
Germany	8,994,000	950,000	1,500,000	940,000	840,000	100,000	-37
Spain	964,166	106,800	175,000	262,000	251,000	11,000	50
EU27 + CH	21,957,446	2,049,297	3,003,422	2,739,847	-	-	-9

Source: ESTIF (European Solar Thermal Industry Federation), Solar Thermal Markets in Europe: Trends and Market Statistics 2007 - June 2008

III. Solar Energy Market in Turkey

A. State of the Market⁶

The leading solar technology in Turkey is that of the flat-plate solar collectors. Flat-plate solar collectors were first employed at the beginning of 1970's in tourist hotels and summer houses located in western coastal areas of Turkey. Simple technology, brought from neighbouring Mediterranean countries in Europe (Italy, Greece), was copied and adopted to the local economical capacities of small workshop manufacturers. The urgent need to supply hot water in touristic towns and coastal vacation houses in summer months mushroomed the production of the flat-plate solar collectors and the number of manufacturers. Production was rapidly expanded from the Aegean (Izmir, Kusadası, Ayvalık) region to the south-west (Marmaris, Fethiye, Mugla) and southern coastal areas (Antalya, Alanya, Mersin, Adana, Hatay) and, in the last decade, to south-eastern towns (Diyarbakir, Gaziantep, Urfa). This inexpensive method of hot water production from the sun for domestic use was welcomed by the public in seventies and eighties. This led to an increase in the number of collector production companies and growing collector sales.

Resistant tempered glass is used in glazed thermal solar collectors for covering the surface area. Tempered glass is produced in major by the largest Turkish glass firm of TSCF-Turkiye Sise Cam Fabrikaları A.S. (www.sisecam.com.tr).

Compared with the developed countries of USA, Japan, and the Sun Belt countries, Turkey is a major user of solar technology, especially for solar thermal systems. The solar collector market now is based on two different types of solar collectors: technologically poor traditional collectors and technologically advanced high efficiency ones. Technologically poor collectors are marked by low efficiency and bad quality, while high efficiency types consist of selective surfaces raising overall system performance and, with it, the price.

Nowadays, some attempts have been made to use the sun as a natural heat source by building solar houses. In Turkey, solar buildings are beginning to find a place in new building designs and developments.

Turkey is located in the Sunbelt and is therefore rich in solar energy. Using solar energy for various purposes already attracts consumers. People are using solar energy mostly in domestic hot water systems, as well as electricity production. Solar collector producers take full advantage of this situation in influencing consumers. In many congresses and/or fairs, producers attend to advertise their products. Also, TV ads and advertising papers attract consumer attention to solar thermal systems. Consumers use such technology and take full advantage of their installed systems, especially in their summer resorts, for the rapid availability of hot water for their daily needs, for free heating of water and for low-cost of maintenance of production systems. Industrial users, such as hotels and industrial facilities, improve their image through the employment of clean energy based systems and of course lower energy-related expenses.

⁶ Source: European Solar Thermal Industry Federation, Sun in Action II – A Solar Thermal Strategy for Europe, Volume 2, The Solar Thermal Sector Country by Country - 21 National Reports, April 2003.

B. Solar Energy Potential of Turkey⁷

Currently, there isn't any licensed producer of solar energy in Turkey. However, Turkey is located in a relatively advantageous geographical position for solar energy production. According to Ministry of Energy and Natural Resources, the potential of electricity production using solar energy in Turkey is 380 billion kWh/year, which is approximately two times of the total electricity production of the country. The solar energy potential evaluations made by EIE (General Directorate of Electrical Power Resources Survey and Development Administration), based on the data measured by DMI (State Meteorological Services) during 1966-1982 revealed:

- The annual average total insolation duration as 2640 hours (7.2 hours/day)
- Average annual solar radiation as 1311 kWh/m²-year (3.6 kWh/m²-day)
- Total solar energy potential of Turkey is calculated as 35 Mtoe per year.
- Solar energy production is expected to reach 602 Ktoe in 2010 and 1,119 Ktoe in 2020.

Monthly solar energy potential of Turkey is given in Table 1. Solar energy potential according to the geographical regions is given in Table 2.

However it has been recognized that the existing meteorological data is lower than the actual solar energy data of Turkey. EIE and DMI have been taking new measurements since 1992 to determine the more accurate solar energy data. Although the measurements have not been completed yet, the collected data indicates that the actual solar energy radiation values are 20-25% higher than the existing data.

A model was developed with the data from the 8 measurement stations of EIE and with the data from the DMI measurement stations. Accordingly, the solar radiation and insolation values are calculated for 57 cities of Turkey. The study is published as a report.

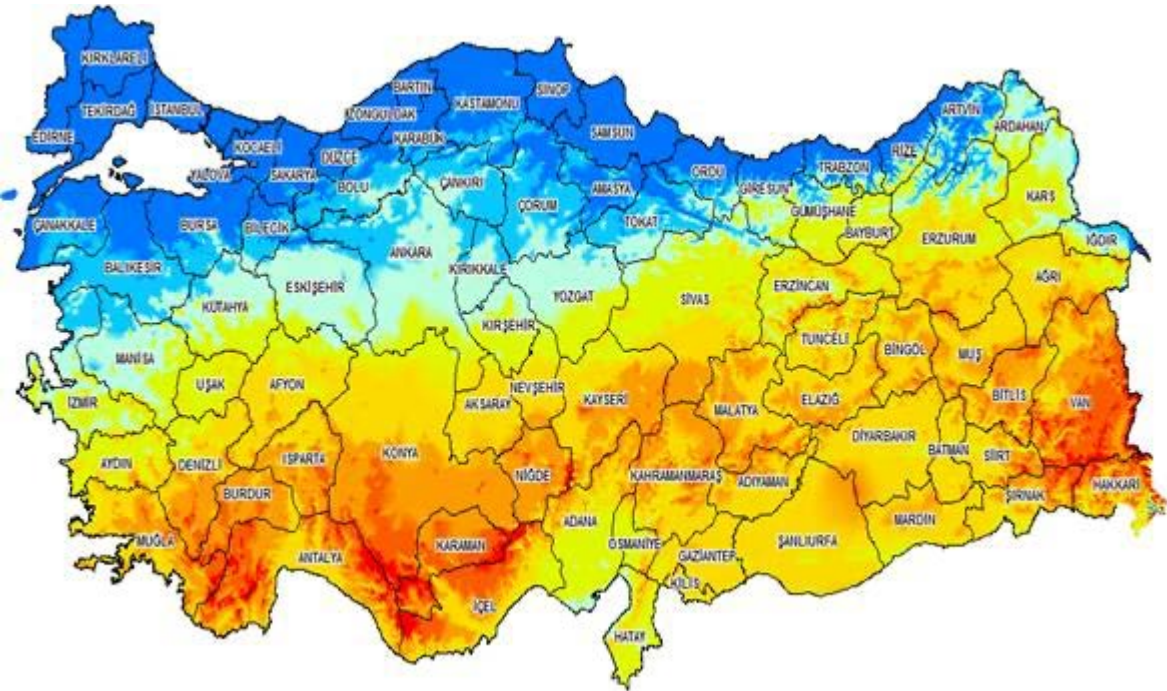
MONTHS	MONTHLY TOTAL SOLAR ENERGY (Kcal/cm²-month) (kWh/m²-month)		SUNSHINE DURATION (hours /month)
January	4.45	51.75	103.0
February	5.44	63.27	115.0
March	8.31	96.65	165.0
April	10.51	122.23	197.0
May	13.23	153.86	273.0
June	14.51	168.75	325.0
July	15.08	175.38	365.0
August	13.62	158.40	343.0
September	10.60	123.28	280.0
October	7.73	89.90	214.0
November	5.23	60.82	157.0
December	4.03	46.87	103.0
TOTAL	112.74	1311	2640
AVERAGE	308.0 cal/cm ² -day	3.6 kWh/m ² -day	7.2 hours/day

Source: DMI, EIE

⁷Source: EIE

TABLE 2 REGIONAL DISTRIBUTION OF SOLAR ENERGY POTENTIAL OF TURKEY		
REGION	TOTAL SOLAR RADIATION (kWh/m ² -year)	SUNSHINE DURATION (hours/year)
Southeastern Anatolia	1460	2993
Mediterranean	1390	2956
East Anatolia	1365	2664
Central Anatolia	1314	2628
Aegean	1304	2738
Marmara	1168	2409
Black Sea	1120	1971

Source: DMI, EIE



Total Solar Radiation (KWh/m² – year)



Source: EIE

C. Domestic Production of Solar Panels

Solar Thermal Collectors⁸

There are more than 50 companies in Turkey carrying out production of solar thermal collectors. The industry is well developed with high quality manufacturing and export capacity. Total production capacity is estimated to be 1 million m², and total production volume is approximately 700 thousand m². The exports volume is estimated to be 200 thousand m² and the imports volume is negligible.

Photovoltaic Modules⁹

The photovoltaic sector in Turkey is still fairly small, providing work for only a small number of employees. The main actors consist of several companies and a number of research institutes. There are approximately 30 companies which are operating in Turkey's PV sector. The main business types are importer, wholesale supplier, system integrator and retail sales. The companies serve in the installation, engineering and project development sectors. PV modules, battery charge controllers and inverters are mainly imported. Batteries, solar lighting systems, etc., may be supplied by the domestic market. Some of the domestic products (batteries, tempered glass, etc.) are exported.

Currently, there isn't any production of solar cells (photovoltaic modules) in Turkey. Therefore, there is a significant potential for investment in this field.

⁸Source: EIE

⁹ Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University.

Producers of Solar Thermal Collectors in Turkey¹⁰

SERGÜN GÜNEŞ ENERJİSİ SİSTEMLERİ İML. SAN. LTD. ŞTİ.	Address: Hürriyet Mah. Atatürk Bulvarı No: 322 / Yeşilbayır - Antalya Phone: +90 (242) 444 07 01 Fax: +90 (242) 443 11 90 info@sergun.com www.sergun.com
HER-AY GÜNEŞ ENERJİSİ VE TERMOSİFON İMALATI SAN. VE TİC. LTD. ŞTİ.	Address: Bakırcılar Sanayi Horozluhan Mah. Adıbelli Sok. NO: 48 Selçuklu-Konya Phone: +90 (332) 248 48 58 Fax: +90 (332) 320 12 95 heray@heray.com.tr www.heray.com
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EZİNÇ METAL A.Ş.	Address: Organize Sanayi Bölgesi 23. Cad. No:31 38070 Kayseri Phone : +90 (352) 321 13 21(Pbx) Fax : +90 (352) 321 13 25 aezinc@ezincmetal.com www.ezinc.com.tr
ERASLANLAR GÜNEŞ ENERJİSİ SAN. TİC. LTD. ŞTİ.	Address: Cacabey 2. Çarşı Kemalhocaoğulları Apt. No:2 Merkez İlçe 40100 Kırşehir Phone: +90 (386) 212 15 00 Fax: +90 (386) 214 27 69
DERYA GÜNEŞ KOLLEKTÖR A.Ş	Address: 3.Organize Sanayi Bölgesi Vali İhsandede Cad. 13.Sok. No:29 42050 Selçuklu Konya info@deryakollektor.com.tr Phone: +90 (332) 239 15 70 Fax: +90 (332) 239 15 62
GÖKSAN A.Ş	dasci_27@mynet.com
AGES GUNES ENERJISI SAN. VE TIC. A.S.	Address: Millet Cad. Sim Apt. No: 2/A Meram Konya Phone: +90 (332) 320 12 00 Fax : +90 (332) 322 40 61 bilgi@ages.com.tr www.ages.com.tr
KOCSAN GÜNEŞ ENERJİSİ SAN. VE TİC. LTD.ŞTİ.	Address: Meram San. Sitesi Nilüfer Sok. No: 30 Meram Konya Phone: +90 (332) 320 51 86 Fax: +90 (332) 322 80 05 kocsan@kocsanenerji.com www.kocsanenerji.com
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FENİŞ TEKNİK ÜRÜNLER A.Ş	Address: Beylikbağı Mah. İstanbul Cad. No:21 41400 Çayırova-Gebze/Kocaeli Phone: +90 (262) 742 18 30 Fax: +90 (262) 742 18 37 fenisteknik@fenis.com.tr www.fentek.com.tr
EFSUN METAL ISI İMALAT İNŞ. TUR. TEK. SAN. VE TİC. LTD. ŞTİ.	Address: OSB Atatürk Bulvarı No: 4 Phone: +90 (242) 258 11 53 Fax: +90 (242) 258 10 72 info@efsunsolar.com www.efsunsolar.com
TANSUĞ MAKİNA SAN. VE TİC. KOLL. ŞTİ	Address: Adana-Ceyhan Yolu 10. Km 01340 İncirlik/Adana Phone: +90 (322) 346 49 00 Fax: +90 (322) 346 50 08 info@tansug.com.tr www.tansug.com.tr
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KODSAN KAZAN A.Ş.	Address: OSB Karamanlılar Cad. No: 10 Sincan 06935 Ankara Phone: +90 (312) 267 07 67 Fax: +90 (312) 267 05 54 faruk@kodsan.com.tr info@kodsan.com.tr www.kodsan.com.tr
İZOCAM A.Ş	Address: İzocam A.Ş Dilovası Mevkii, 41455 Kocaeli Phone: +90 (262) 754 63 90 Fax : +90 (262) 754 66 88 izoposta@izocam.com.tr

¹⁰ These companies are the members of the International Solar Energy Society – Turkish Section, www.gunder.org.tr

D. Domestic Market of Solar Panels¹¹

Main solar energy utilization in Turkey is the flat plate collectors in the domestic hot water systems. Total area of installed collectors in Turkey is around 12 million m². The systems are mostly used in Aegean and Mediterranean regions. Total energy production equals to 420,000 TOE (ton oil equivalent). The contribution of solar collectors to the primary energy production is given below:

Year	Solar Energy Contribution (thousand TOE)
1998	210
1999	236
2000	262
2001	290
2004	375
2007	420

Source: DMI, EIE

Utilization of photovoltaic systems is limited with the usage of some governmental organizations in remote service areas such as telecom stations, forest fire observation towers and highway emergency. Total installed peak power has reached about 3 MWp¹².

E. Foreign Trade

In Turkey, the volume of foreign trade of water heaters using solar energy and solar cells is in a trend of increase. Turkey is a net exporter of water heaters using solar power.

Product	M/X	Unit	2002	2003	2004	2005	2006	2007	CAGR 07/02 %*	2008/8
Water heaters using solar energy (HS code: 841919000012)	Import	000 \$	337	567	1,607	2,817	2,884	3,287	58	5,074
		tons	82	181	453	977	992	1,130	69	1,536
	Export	000 \$	723	1,609	2,811	2,998	3,657	5,787	52	8,962
		tons	306	498	755	812	956	1,341	34	1,720
Solar cells (HS code: 854140900011)	Import	000 \$	388	247	835	1,189	233	2,128	41	3,276
		tons	31	10	28	76	5	69	17	158

Source: Turkish Statistical Institute

*Compound annual growth rate between 2002&2007

¹¹ Source: EIE

¹² Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University

Turkey imports water heaters using solar energy and solar cells mainly from China and Germany.

Distribution of Imports of Water Heaters Using Solar Energy According to Countries, 2007		
Country	Imports, 000 USD	Share %
China	2,827	86
Germany	460	14
Other	0	0
Total	3,287	100

Source: Turkish Statistical Institute

Distribution of Imports of Solar Cells According to Countries, 2007		
Country	Imports, 000 USD	Share %
China	786	37
Germany	721	34
Japan	486	23
USA	134	6
Other	0	0
Total	2,127	100

Source: Turkish Statistical Institute

Main destinations for Turkish exports of water heaters using solar energy are North Africa, Europe and Middle East.

Distribution of Exports of Water Heaters Using Solar Energy According to Countries, 2007		
Country	Exports, 000 USD	Share %
Marocco	1,252	22
Spain	1,077	19
Italy	787	14
Bulgaria	545	9
Portugal	400	7
Lebanon	353	6
Tunisia	348	6
France	338	6
Syria	251	4
T.R. Northern Cyprus	192	3
Other	243	4
Total	5,787	100

Source: Turkish Statistical Institute

F. Research & Development in the Sector

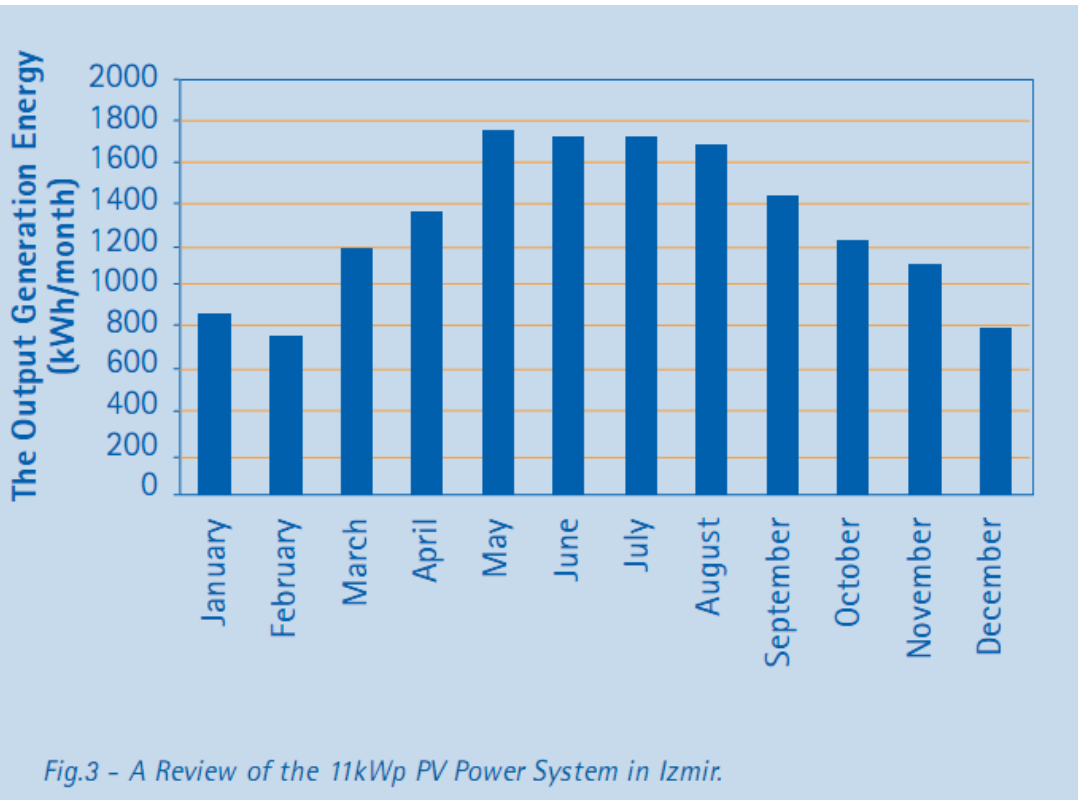
Solar Energy Activities of Ege University - Solar Energy Institute¹³

PV research has been realized in the Turkish university research laboratories to gain further experience in PV. The Solar Energy Institute, situated on the campus of Ege University in Izmir, was founded in 1978 for graduate education and research on Solar Energy and its applications. Ege University Solar Energy Institute is still the only research institute which mainly works on solar energy research topics. The institute also supports some projects of the municipalities and the other societies to increase the PV applications in Turkey. A project which is mainly financed by United Nations with the support of the institute has been executed as a solar lighting system in Gokceada which is the biggest island of Turkey. The studies are maintained in the production of organic dye-sensitized solar cells by the Solar Energy Institute of Ege University. Ege University Solar Energy Institute increases its PV power capacity by producing the solar modules with the lamination technique of silicon solar cells (Figure 2). The total PV capacity has reached to 24 kWp. The grid-connected PV power systems were followed/examined during the year (Figure 3). 14 kWp of the PV system has reorganized as a new stand-alone hybrid PV power system at the end of 2007 (Figure 4).



Source: IEA - PVPS Annual Report 2007 Solar Energy Institute, Ege University

¹³ Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University



Source: IEA - PVPS Annual Report 2007 Solar Energy Institute, Ege University



Source: IEA - PVPS Annual Report 2007 Solar Energy Institute, Ege University

The recent historical development of the solar energy sector in Turkey can be summarized as follows:

2001

- The Solar Energy Institute of Ege University began to R&D studies on organic dye-sensitized solar cells to realize and to simplify the production processes and to lower the cost.
- A 14 kWp PV power plant was installed for starting up energy of some units in Berke Dam.

2002

- Installation of the largest grid connected PV power plant to date in Mugla University with 10,4 kWp capacity.

2004

- Mugla University increased the total PV power capacity to 54 kWp.

2005

- The Solar Energy Institute of Ege University installed 22,2 kWp PV grid-connected power plant in Izmir.
- TUBITAK (The Scientific and Technological Research Council of Turkey) initiated the first Formula-G solar car race between the Turkish universities. The TUBITAK plans to continue these solar car races in the next years in order to introduce solar electricity energy to the university students.

2006

- The Solar Energy Institute of Ege University set up a PV module production laboratory which is the first of its kind in a university.
- A Turkish company (Akkanat Technologies A.S.) began to produce PV modules with 5 MWp/year capacities in Istanbul (The manufacturer stopped the production at the present).

2007

- The first PV-wind-diesel generator hybrid power system was installed in a island by Girasolar Ltd. (Figure 5). Ege University Solar Energy Institute contributed to the project, as well. The project was performed on an island (Fethiye-Kizilada) which doesn't have any utility grid connection. On the island, a restaurant provides the required energy with this hybrid system (17,5 kWp multi-crystalline solar modules, 15 kWp wind turbine, 35 kVA diesel generator, 48 V 3000 Ah battery capacity).
- In March 2007, the Energy Minister of Turkey opened a "Clean Energy House" in Pamukkale University, Denizli-Turkey. The house has a PV system that totals 5 kWp , which will also be used for hydrogen production.

- 30 kWp grid-connected PV power systems were installed in the TESCO-KIPA supermarkets in Marmaris and Kusadasi (totally 60 kWp PV systems) by Enisolar Ltd. (Figure 6). Some attractive small PV applications were also performed by Enisolar Ltd. in 2007 (Figure 7).
- TUBITAK-MRC has installed a stand alone renewable hydrogen demonstration park in Gebze. Ege University Solar Energy Institute was a participant of TUBITAK-MRC in the project. The autonomous system includes PV-wind-fuel cell hybrid power components (Figure 8).
- Turk Telecom has decided to install a 250 kWp photovoltaic power system for telecommunication systems. The company of Analtech Ltd. began to install these PV power systems in 2007. Some small PV systems were also installed for GSM telecommunication systems (Figure 9).



Fig. 5 - PV-wind-diesel generator hybrid power system in an island in Fethiye-MUGLA by Girasolar Ltd.

Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University



Fig. 6 – 30 kWp grid-connected PV system in Marmaris by Enisolar Ltd.

Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University

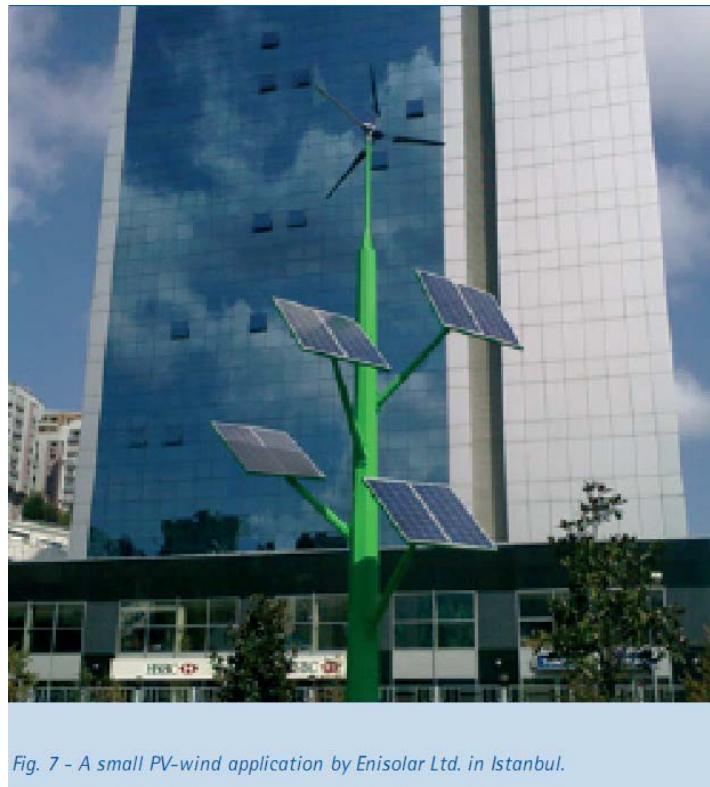


Fig. 7 - A small PV-wind application by Enisolar Ltd. in Istanbul.

Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University



Fig. 8 - HYDEPARK Project in TUBITAK-MRC in Gebze. (12 kWp PV modules, 5 kWp wind turbine, 2,4 kWp PEM type fuel cell, 48 V 1500 Ah battery capacity, inverters, a meteorology station, etc.).

Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University

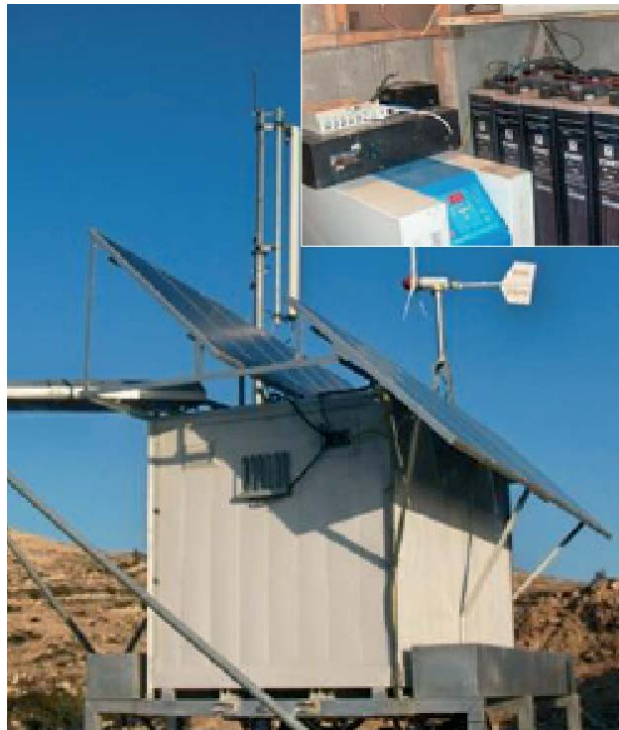


Fig. 9 - A hybrid PV-wind application for telecommunication systems by OZMAK Ltd. in Cesme-Izmir.

Source: IEA - PVPS Annual Report 2007 - Solar Energy Institute, Ege University

Solar Energy Activities of EİE (General Directorate of Electrical Power Resources Survey and Development Administration)¹⁴

Solar Energy Division of EİE has been carrying on research, development, information dissemination and demonstration activities since 1982.

1. THERMAL ACTIVITIES

Solar Collector Tests

Test platform was installed at the Renewable Energy Park of EİE, with the aim of supporting the manufacturers for a more efficient production.

Thermal performance experiments of the Turkish Standards on solar collectors “TS-3680” is also performed in the test laboratory.

Efficiency test of the collectors developed by any person, manufacturer or entity can also be performed in the test laboratory.



Ground Source Heat Pump

Ground source of heat pumps are a form of geothermal energy utilization. In order to investigate the technical and economic aspects of GSHP's a demonstration system was installed in the Renewable energy Park of EİE in 2002.

Solar Cooker

Solar cookers concentrate the solar beam to reach to a high temperatures and are used especially in the under developed countries. The experimental solar cooker manufactured by EİE for demonstration purposes can reach to temperatures around 750 °C.

¹⁴ Source: www.eie.gov.tr



2. PHOTOVOLTAIC ACTIVITIES

Photovoltaic Lighting Units

Battery of the system is charged by the electricity generated by photovoltaic modules during the day. Currently 5 units are installed, 2 in Ankara AOÇ, 2 in Didim Research and Training Center of EIE and a 1 in the EIE building in Ankara. There is also a 160 Wp lighting system in Didim.



Photovoltaic Area Lighting

A 1000 Wp PV system is used for outdoor area lighting in Didim Research and Training Center.

Photovoltaic Water Pumping Systems

Of the systems that can be used in small scale agricultural irrigation, the first consists of 616 Wp PV modules, an inverter and a submersible pump. The economical calculations indicated that the system is economically competitive with diesel engines, in sites without grid.

Another water pumping system with 756 Wp power is installed at the Renewable energy Park of EIE.



Photovoltaic Traffic Warning System

The system consists of a 50 Wp pv module and 70 Ah battery, as well as a flashing lamp.



Grid-Connected 4,8 kWp Photovoltaic system

While the traditional utilization of photovoltaic system has been the remote areas without grid, in recent years, the number of grid connected PV systems has increased greatly.

Since Turkey has a very high electrification rate, a research on grid connected project was realized. As the first grid connected photovoltaic system in Turkey, the 4,8 kWp system installed in Didim Research and Training Center has been operating since 1998.



Grid-Connected 1,2 kWp Photovoltaic System

Another grid-connected system with a 1,2 kWp, was installed in EIE Renewable energy Park for demonstration purposes.



3. SOLAR ENERGY POTENTIAL ACTIVITIES

As a beginning to the solar energy potential determination, EIE had evaluated the historical solar energy data measured by the State Meteorological Organization between the years of 1968-1982. The results were published in two reports in 1983. On the basis of these evaluations, it is concluded that the average annual value of sunshine hours is 2640 and annual average solar intensity is 3.6 kWh /m²-day, while maximum annual sunshine hours is 3016 hours and maximum solar intensity is 5,8 kWh/m² –day.

Since the existing meteorological data was not technically sufficient, EIE has initiated a second project in cooperation with the State Meteorological Service. The aim of this project is to

determine the actual solar potential nation wide with the help of data to be measured with 5 solar data acquisition systems. Data gathering period is 5 years for each station. The measured data are the total and diffuse solar radiation on the horizontal surface, bright sunshine duration and ambient temperature.

To this end, solar data acquisition systems have been installed in total 8 locations: Antalya, İzmir, Ankara, Aydın, Adana, Isparta, Kayseri and Balıkesir. The measurements in Antalya, İzmir and Aydın were completed.

Antalya	İzmir	Aydın	Ankara
Adana	Isparta	Kayseri	Balıkesir

With the data gathered from these measurements and by using the data from the stations of State Meteorological Organisation, the solar radiation and sunshine duration of 58 cities were calculated using a model. The report was published in 2001 as “The Solar Radiation and Sunshine Duration of Turkey”.

G. Governmental Institutions Operating in the Sector

EIE (General Directorate of Electrical Power Resources Survey and Development Administration), TUBITAK (The Scientific and Technological Research Council of Turkey) - Marmara Research Center and some state universities (Ege University Institute of Solar Energy, Muğla University, METU, Kocaeli University, Fırat University, Harran University) are the institutions in Turkey operating in the field of solar energy research and development. Measurement of solar energy data is carried out by DMI (State Meteorological Services). EIE has been building up its own solar energy observation centres since 1991. Standards in the sector are determined by TSE (Turkish Standards Institution):

-TS 3680 – Solar Energy Collectors- Flat

-TS 3817 – Solar Energy – Water Heating Systems Manufacturing, Installation and Operation Rules

IV. Comparison of Turkey, Spain & Germany in Terms of Solar Energy Potential¹⁵

	Global yearly irradiation (kWh/m ²)					Solar electricity generated from 1kWp (kWh/kWp)*									
	min	min_urb5	countr_avg	max_urb95	max	min	min_urb5	countr_avg	max_urb95	max					
Horizontal mounting															
Spain	1128	1313	1586	1732	1856	846	985	1190	1299	1392					
Turkey	1119	1313	1541	1683	1833	839	985	1156	1263	1375					
Germany	949	958	1014	1106	1381	712	718	761	829	1036					
Optimum angle mounting															
Spain	1179	1500	1819	1965	2094	884	1125	1364	1474	1570					
Turkey	1172	1454	1724	1894	2051	879	1090	1293	1421	1538					
Germany	984	1087	1157	1264	1795	738	815	868	948	1346					
Vertical mounting															
Spain	644	1003	1182	1253	1385	483	753	887	939	1039					
Turkey	626	920	1089	1186	1282	470	690	817	890	962					
Germany	537	754	804	874	1368	403	565	603	655	1026					

* performance ratio of the PV system = 0.75

All year optimum angle (degrees)					
	min	min_urb5	countr_avg	max_urb95	max
Turkey	14	30	32	32	33
Spain	18	32	34	36	39
Germany	18	34	35	37	45

Difference between "optimum angle" and "horizontal" mounting															
	Difference in yearly irradiation (kWh/m ²): OPT-HORIZ					Solar electricity generated from 1kWp (kWh/kWp)*					Difference in yearly irradiation (%): (OPT-HORIZ)/HORIZ				
	min	min_urb5	countr_avg	max_urb95	max	min	min_urb5	countr_avg	max_urb95	max	min	min_urb5	countr_avg	max_urb95	max
Spain	51	187	233	233	238	39	140	175	175	178	3,6	12,3	14,2	13,2	13,2
Turkey	53	140	183	211	218	39	105	137	158	164	4,7	10,7	11,5	12,2	11,8
Germany	35	129	143	158	414	26	97	107	119	310	3,7	13,5	14,1	14,3	30,0
Difference between "optimum angle" and "vertical" mounting															
	Difference in yearly irradiation (kWh/m ²): OPT-VERT					Solar electricity generated from 1kWp (kWh/kWp)*					Difference in yearly irradiation (%): (VERT-OPT)/OPT				
	min	min_urb5	countr_avg	max_urb95	max	min	min_urb5	countr_avg	max_urb95	max	min	min_urb5	countr_avg	max_urb95	max
Spain	535	497	636	712	708	401	372	477	534	531	32,6	28,4	34,0	35,5	34,5
Turkey	546	533	635	708	769	409	400	476	531	576	46,3	35,6	34,9	36,0	36,7
Germany	447	333	353	391	427	335	250	265	293	321	45,4	30,6	30,5	30,9	23,8

* performance ratio of the PV system = 0.75

- min** absolute country minimum (all data grid cells included)
- min_urb5** 5% occurrence (only built-up residential areas)
- countr_avg** country average (all data grid cells included)
- max_urb95** 95% occurrence (only built-up residential areas)
- max** absolute country maximum (all data grid cells included)

¹⁵ PVGIS © European Communities, 2001-2008

Source: Šúri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy, 81, 1295-1305. <http://dx.doi.org/10.1016/j.solener.2006.12.007>