

# Turkey

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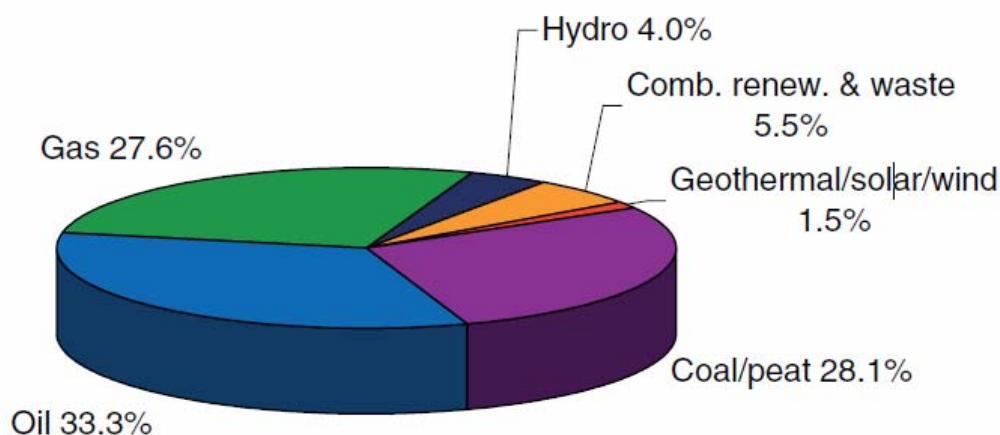
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### *1. Overview of Electricity Supply*

The Republic of Turkey has renewable energy potential in many different renewable fields. Turkey is ranked seventh in the world for its geothermal resources, and the country also has over one percent of the world's hydropower potential. Nearly the entire country is suitable for solar power, and wind and biomass are also very plausible options for renewable resources in Turkey.

Despite Turkey's great renewable resource potential, the country still relies on thermal power plants for nearly 74 percent of its electricity needs. Hydropower does produce over a quarter of electricity, but renewables make up a mere 0.2 percent of electricity production (EIA, 2005). However, as shown in the pie chart below, renewables in Turkey play a larger role in energy production. Presently, renewable resources are being used more for heat generation and less for electricity generation.

### Share of Primary Energy Supply in 2006 (Source: IEA)



Approximately 99 percent of Turkey is connected to the electricity network. Integrating large scale renewable installations could pose a problem, due to the technical capacity of the electricity network. This issue is currently being discussed by the Government of Turkey (REEEP, 2006).

The table below displays summary information for Turkey.

<b>Demographical Information</b>	
Population, millions (2009)	76.8
Land area, thousand sq km (2009)	781
<b>Macroeconomic Information (2008)</b>	
GDP, billion US\$	906.5
Real GDP growth rate, percent	1.50
Foreign direct investment (net), million US\$ (2007)	19,923
<b>Electricity disposition, billion kWh (2006)</b>	
Generation	181.56
Consumption	141.46
Exports	2.58
Imports	0.86
<b>Generation capacity, GW (2005)</b>	
Nuclear	0.00
Thermal	27.38
Hydro	13.06
Other renewables	0.12
<b>Total</b>	<b>40.57</b>
<i>Sources: CIA World Factbook, U.S. Energy Information Administration, United Nations Conference on Trade and Development.</i>	

#### Turkey Country Summary

Turkey has taken recent steps to reform the energy market, and continued action is needed to ensure a successful conclusion. A restructuring of the state-owned enterprises to operate in a competitive market, to create independent electricity and gas operators and to remove cross-subsidies from electricity and gas prices is needed to foster successful market reform (IEA, 2005).

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## 2. Energy Policy, Barriers and Incentives

The Ministry of Energy and Natural Resources (MENR) is responsible for preparing and implementing energy policies, plans and programs. MENR reports directly to the Prime Minister; it has the following tasks and objectives:

- Coordinate between dependent and related institutions and other public and private entities.
- Prepare and/or supervise programs in compliance with energy policy.
- Supervise and control all exploration, development, production and distribution activities for energy and natural resources.

The Energy Market Regulatory Authority was established as the independent regulatory authority by the Electricity Market Law in March 2001. The Electricity Market Law's purpose is to unbundle generation, transmission and distribution activities to ensure progress towards a liberalized electricity market.

Turkey regulations define renewable energy resources as installations using wind, solar, geothermal, wave, tide, biomass, hydrogen and canal- and river-type hydropower as well as hydropower facilities with an installed capacity of less than or equal to 50 MW and a reservoir area less than 15 square km or a reservoir less than 100 million cubic meters. The regulation provides several incentives for such installations:

- Exemption from annual license fees for the first eight years of operation.
- The transmission company and the distribution licensees are obliged to provide a network connection to renewable electricity generation facilities.

In May 2007 Turkey passed the Energy Efficiency Law. The purpose of this law is to promote the efficient use of energy, prevent waste, mitigate the burden of energy costs on the economy, and protect the environment.

The government has also recently passed a Renewable Energy Law, which promotes the use of renewables in a free energy market. The law introduces feed-in tariffs and a purchase obligation for the distribution companies from certified renewable energy producers. The new law allows each new project implemented before 2011 to benefit from seven years of feed-in tariffs. Hydro and geothermal power producers should receive a fixed feed-in tariff of 15 percent above TETAS's wholesale electricity price. All other renewable energy producers will receive a tariff of 20 percent above the wholesale electricity price. The minimum of 5 Eurocents and a maximum of 6 Eurocents will be applied (IEA, 2005).

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## 3. Wind

Turkey has considerable wind potential; in fact, it is estimated that the country has almost 90,000 MW of theoretical wind energy potential and about 10,000 MW of economical potential (Gencer, 2009). Turkey started exploiting their wind energy potential in the late 1990's and has continued development into the present.

Wind power engineering development began in Turkey in 1998. The first build-operate-transfer model power plant in Turkey was established in November 1998 in Cesme. The total installed power of the plant is 7.2 MW, with 12 operating turbines (Gencer, 2009).

The most attractive sites for wind power are Marmara Sea region, Mediterranean Coast, Aegean Sea Coast, and the Anatolia inland. The wind power densities for the best potential regions in Turkey are displayed in the table below.

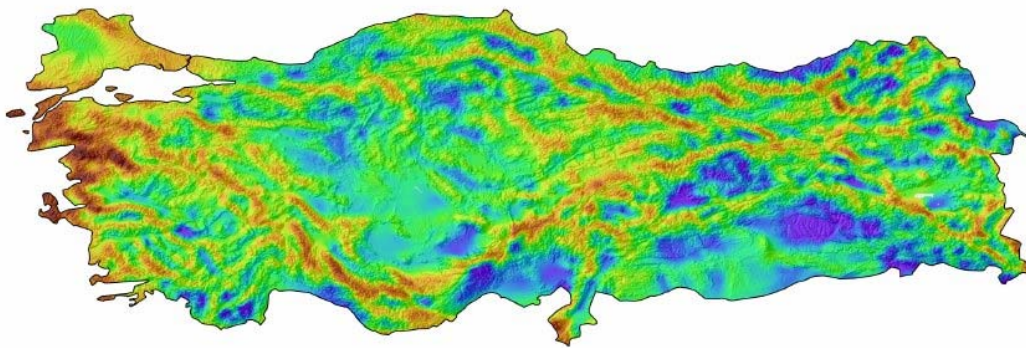
Region	Annual average wind power density (W/m <sup>2</sup> )
Mediterranean region	21.4
Middle Anatolia region	20.1
Aegean region	23.5
Black Sea region	21.3
Eastern Anatolia region	13.2
South-Eastern Anatolia region	29.3
Marmara region	51.9

*Source: Gencer, Advanced Technologies Symposium, 2009*

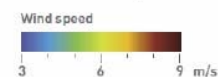
#### **Wind Energy Potential for Various Regions in Turkey**

Government incentives passed in 2006 yielded a large increase in wind energy in Turkey. The wind power capacity grew from 50 MW in 2006 to 270 MW in 2009 (UDI, 2009). Another 450 MW should be completed by the end of 2009 (Bas, 2009). One of the projects to be completed is a 135 MW on-shore wind farm, consisting of 54 wind turbines. This wind farm will be Turkey's largest wind farm; it is located in Osmaniye, in southern Turkey (EBRD, 2009).

## Turkey Wind Map at 80m



5km Wind Map at 80m



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### 4. Biomass

Biomass is a major source of energy for rural Turkey; fuel wood is the most widely used biomass resource. Over 5 million cubic meters of fuel wood is produced in Turkey each year. The total biomass potential for Turkey is approximately 370,000 GWh, and the technical potential is approximately 198,000 GWh (Balat).

Turkey produced 167 million kWh of electricity using biomass and waste resources in 2007. Approximately 5 percent of energy consumed and 0.1 percent of electricity consumed in Turkey is from biomass and waste resources (EIA, 2007).

Most of the biomass energy produced in Turkey is in the form of biofuels. Turkey has an installed biodiesel production capacity of 1 M tonne/year, and the annual bioethanol production is over 20,000 tonne/year (REEE).

The table below displays selected biomass resource data from 2006-2007.

<b>Biomass resource type</b>	<b>Total production</b>	<b>Production density</b>
<b>Total land area covered by</b>	(avg. 2006–2007, km <sup>2</sup> )	(avg. 2006–2007, %)
Arable Land	224,565	29
Permanent Crops	29,015	4
Permanent Meadows and Pastures	146,170	19
Forest Area	102,119	13
Other Land	267,761	34
Inland Water	13,930	2
<b>Primary crop production</b>	(avg. 2006–2007, tonne)	(tonne / 100 km <sup>2</sup> )
Total primary crops (rank among COO)	96,693,524 (24)	12,405 (15)
<b>Top 10 primary crops</b>		
Wheat	18,844,000	2,417
Sugar beet	14,626,081	1,876
Tomatoes	9,887,275	1,268
Barley	8,487,000	1,089
Potatoes	4,339,003	557
Grapes	3,961,552	508
Maize	3,843,000	493
Watermelons	362,537	465
Seed cotton	2,527,500	324
Apples	2,134,235	274
<b>Animal units, number</b>	(avg. 2006–2007, number)	(number / 100 km <sup>2</sup> )
Cattle	10,698,902	1,373
Poultry	336,497,000	43,168
Pigs	1,648	0.2
Equivalent animal units	14,064,531	1,804
<b>Annual roundwood production</b>	(2006–2007, m <sup>3</sup> )	(m <sup>3</sup> / 100 km <sup>2</sup> )
Total	17,874,000	2,293
Fuel	5,238,000	672
Industrial	12,636,000	1,621
Wood-based panels	5,224,000	670
	(2006–2007, tonne)	(tonne / 100 km <sup>2</sup> )
Paper and paperboard	1,643,000	211
Recovered paper	1,016,000	130

*Source: Food and Agriculture Organization of the United Nations*

## Biomass Resource Data

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## 5. Solar

Turkey's geographical location is highly favorable for the utilization of solar energy. The country has approximately 2,460 days of sunshine with an average solar radiation of 3.6

kWh/m<sup>2</sup> per day or 1,311 kWh/m<sup>2</sup> per year. Solar energy consumption in the country has grown drastically from 58 GWh in 1986 to 3,900 GWh in 2003. Currently, Turkey mostly uses solar energy for heating purposes. Rooftop flat plate collectors used for water heating produce energy equivalent to nearly 4,800 GWh annually (Bas, 2009).

Turkey's solar market is extremely large, with approximately 10 million square meters of installed solar panels. Their solar industry is well developed with high quality manufacturing and export capacity; the annual manufacturing capacity is approximately 750,000 m<sup>2</sup>. The number of solar companies in Turkey is around 100 (EIE, 2001).

Solar energy potential in Turkey has been measured by the States Meteorological Services during 1966-1982; the annual solar radiation based on that dataset is displayed below for different regions. Since 1992, new measurements have been taken that have not been completed; however, estimates from the new data indicate that the actual solar radiation values are 20-25 percent higher than the values included in the original dataset.

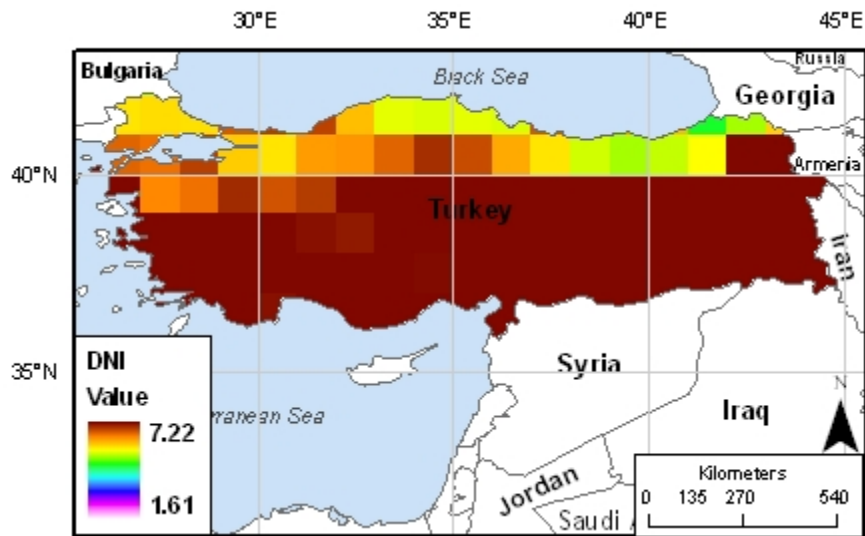
Region	Total Annual Solar Radiation (kWh/m <sup>2</sup> )	Sunshine Duration (hour/year)
Southeastern Anatolia	1,460	2,993
Mediterranean	1,390	2,956
East Anatolia	1,365	2,664
Central Anatolia	1,314	2,628
Aegean	1,304	2,738
Marmara	1,168	2,409
Black Sea	1,120	1,971
<i>Source: General Directorate of EIE</i>		

**Regional Distribution of Solar Energy Potential in Turkey**

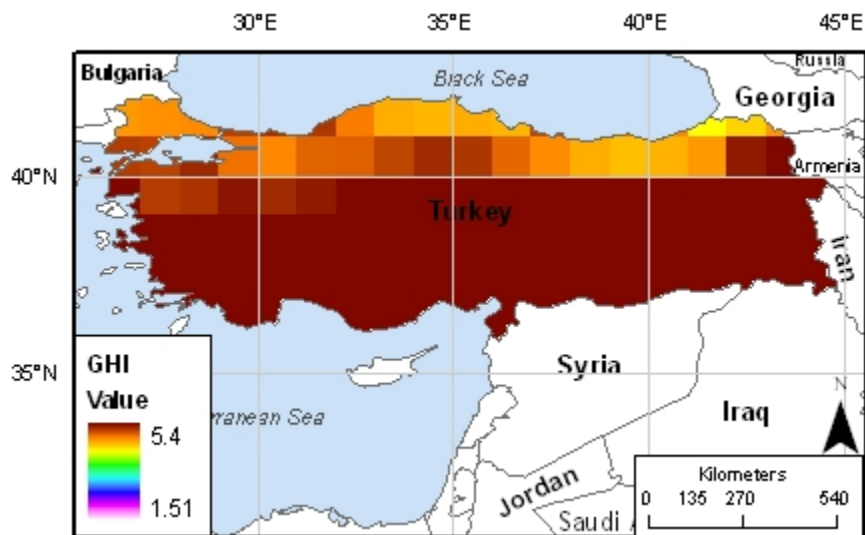
The use of solar PV systems in Turkey is limited. Some governmental organizations use PV in remote services areas such as telecom stations, forest fire observation towers and highway emergency. The estimated installed capacity is 300 kWp (EIE, 2001). Also, at this point, no large scale solar power plants exist in Turkey (UDI, 2009).

The maps below display the direct normal insolation and global horizontal irradiation values for Turkey. As shown Turkey has significant potential in the central and southern portion of the country.

Turkey Solar Direct Normal Insolation (Source: NASA)



Turkey Solar Global Horizontal Irradiance (Source: NASA)



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## 6. Geothermal

Turkey is considered to be the seventh most promising country in the world in terms of geothermal potential. Turkey's great potential is thanks to its location in the Alpine-Himalayan Orogenic Belt. Although research is still ongoing, it is estimated that Turkey has 35,600 MW of geothermal potential. About 4,500 MW of capacity could be used for electricity production and the rest for thermal applications. A majority of the geothermal potential is located in west Turkey in the Aegean and Marmara regions (Oğulata, 2007).

Turkey uses direct heat for many different applications including residential heating (65,000 residences), greenhouse heating (635,000 m<sup>2</sup>), thermal tourism (heated baths), and various industrial applications.

Turkey has a total thermal installed capacity of 1,177 MWt producing 19,623 TJ of energy per year. Most of Turkey's geothermal sites are in the low-to-medium enthalpy range. Turkey has drilled hundreds of wells with intentions of taking on more high-temperature projects, exploring hot dry rock possibilities, and further developing low-temperature applications (IGA, 2005). Temperatures ranging from 20 degrees Celsius to 242 degrees Celsius have been determined throughout wells in Turkey (Oğulata, 2007).

Turkey generates some electricity from geothermal energy. Their only active power production field in Turkey is Kizildere (20 MW installed capacity), started in 1968. Kizildere began generating power in 1984, and the plant produces 12-15 MW electricity annually. The power plant also produces 120,000 tonnes of liquid carbon dioxide and dry ice each year (IGA, 2005).

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## 7. *Hydroelectric*

Turkey's hydropower potential is among the highest in Europe. In fact, Turkey has about 1.2 percent of the total hydropower potential in the world. Most of the water resources in Turkey are located in the Southeast and Eastern Black Sea region. Turkey's technically feasible hydroelectric potential is about 216 TWh per year. The economically feasible potential is around 125 TWh per year (Oğulata, 2007).

Turkey has numerous rivers and lakes. The rivers are usually relatively short and swift flowing. The Kizilirmak is the longest river flowing entirely through Turkey (1,150 km / 715 miles). It empties into the Black Sea along with another major river, the Sakarya. The Gediz and Büyükmenderes are chief rivers that flow into the Aegean Sea, and in south central Turkey, the Ceyhan and Seyhan rivers flow from the Taurus Mountains to the Mediterranean. Lastly, the Tigris and Euphrates rivers have their headwaters in the mountains of eastern Turkey and eventually empty into the Persian Gulf (Encarta, 2009). Turkey has many large rivers, which in enable the country to have its large hydropower potential.

Currently Turkey has approximately 13,580 MW of operating capacity with another 5,390 MW under construction. The total combined capacity will be 18,970 MW, which is approximately 15 percent of Turkey's economically feasible potential. Thus, Turkey has the opportunity to exploit much more hydropower. They currently have almost 9,100 MW of new plants planned. A majority of Turkey's hydroelectric capacity is in the form of large hydroelectric power plants (UDI, 2009).

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## 8. *Relevant Links*

Please see webpage for relevant links.

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## *10. Country Contacts*

Contacts made in the preparation of this assessment are gratefully thanked for their contribution to this report. Please see webpage for contacts listing.

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