



RENEWABLE ENERGY SOLUTIONS

Lifelong Learning Programme

Leonardo da Vinci Partnership Project

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CHAPTER 5

IMPORTANCE OF RENEWABLE ENERGY SOURCES IN THE 6 PARTNER COUNTRIES

5.1. Turkey

Turkey's population of more than 70 million is growing at an annual rate of 1.7% and expected to grow to 83.4 million in 2022. In response to the growth rates of population, Turkey's total final consumption (TFC) grew at an annual rate of 9.6% over the last three decades. This average annual growth rate of TFC is projected to increase by 5.4% between 2005 and 2010, and 7% between 2010 and 2020 [1].

Turkey is at an energy crossroad both in time and geographically. Three fourths of the world's proven oil and gas resources are located in regions neighboring Turkey. And with the increasing dependence of OECD and developing Asian countries on Middle Eastern and Greater Caspian oil Turkey's role as an important energy player has emerged. This energy dependency is likely to have further major geopolitical implications. Given its unique geographical location between the Middle East and the Caspian regions on the one hand and the energy consuming markets on the other, Turkey stands as a key country in ensuring energy security. Latest developments have shown once again the fragility and vulnerability of the energy markets which brought to the fore the issue of energy security of supply. In this context, diversification of energy sources and routes has become one of the key priorities for Europe and other energy consuming markets. The common challenge today is to guarantee affordable, secure and uninterrupted flow of hydrocarbon resources from the Greater Caspian Region and the Middle East to Europe and beyond. Caspian crude oil will provide Europe with an alternative source, independent from the Middle East region, furthering the efforts of the EU member states to diversify energy sources and routes [2].

Energy is considered to be a key factor in the generation of wealth and also a significant component in economic development in Turkey as in other countries. This makes energy sources extremely significant for energy countries in the world. Because of social and economic development of Turkey, the demand for energy and particularly for electricity is growing rapidly. The main indigenous energy sources are hydro and lignite. Turkey has no big oil and gas reserves. Almost all oil and natural gas is imported, as is high quality coal. As we move into the 21st century, Turkish economic prosperity is driving the consumption of energy to record levels, with electricity consumption anticipated to increase at rates faster than overall energy supply (Figure 5.1.) [3].

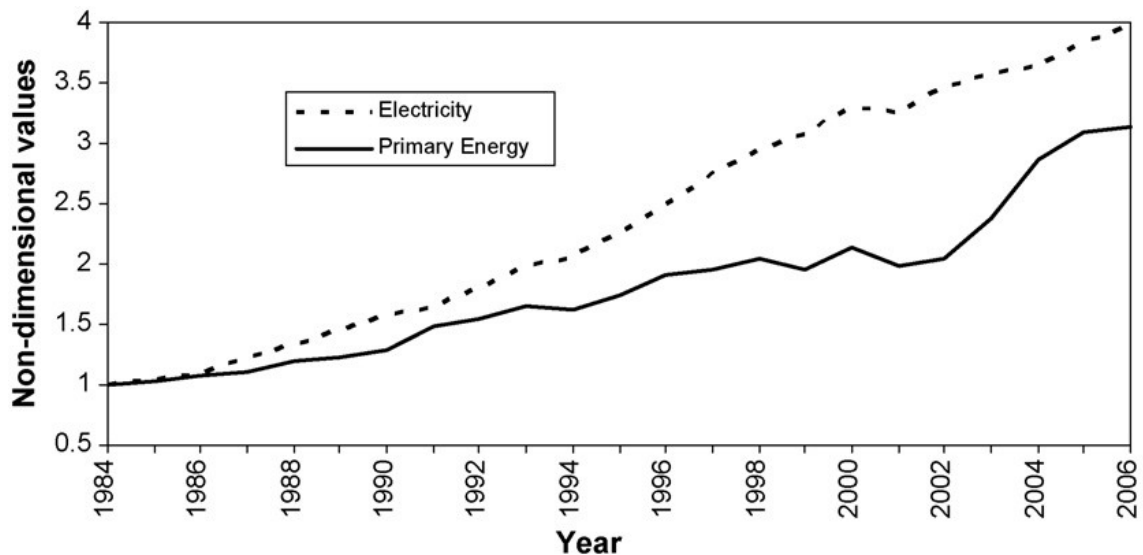


Figure 5.1. Time-evolution of primary energy and electricity consumption of Turkey [3].

Turkey's energy policy is based on the following items:

- Meeting long-term demand using public, private, and foreign capital.
- Accelerating privatization activities in the energy sector.
- Taking into consideration supply costs of energy imports.
- Meeting demand as much as possible through indigenous resources.
- Diversifying energy supplies and avoiding dependence on a single source or country.
- Adding new and renewable sources (geothermal heat, solar, wind, etc.) as soon as possible to the energy supply system.
- Ensuring sufficient, reliable and economic energy supplies on time.
- Ensuring energy security of supply.
- Implementing measures for energy efficiency.
- Planning energy research and development activities to meet requirements.
- Minimizing losses in energy production, transmission, distribution and consumption.
- Protecting the environment and public health in the production of energy.

As basic strategy, improvement of domestic production by increasing efficiency of plants by rehabilitation, diversification of energy sources to secure fuel supply, accelerating the existing construction programs, initiation of new investments are chosen to achieve these

energy policies. As Government's financial resources are not enough to achieve these objectives, acceleration of private investments is essential.

Turkey's energy supply is based on a balanced mixture of energy sources, in which renewable sources in 2006 represented 31% of the primary energy share and primary energy production and consumption have reached 34 and 135 MTOE, respectively. Turkey is an energy importing country, more than half of the energy requirements have been supplied by imports. Natural gas has the biggest share in total primary energy consumption. Renewable except hydraulic and waste, have only very minor shares in power generation in Turkey. Total share of renewable in total primary energy supply has declined, owing to the declining use of non-commercial biomass and the growing role of natural gas in the system. The other important factor of renewable resources is to create new employment opportunities [3].

Utilization of renewable energy sources in order to reduce the energy import dependency and to foster greenhouse gas abatement is another. In this context, Renewable Energy Law was enacted in 2005 in order to encourage renewables based generation in competitive market conditions. Supporting mechanisms such as feed-in tariffs and purchase obligation are defined in the law, in conformity with the EU legislation and practice. These mechanisms are envisaged to facilitate the development of power plants based on renewable energy sources.

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CHAPTER 6

CURRENT STATUS OF RENEWABLE ENERGY IN THE 6 PARTNER COUNTRIES

6.1. TURKEY

Turkey has substantial renewable energy resources. Renewable energy potential of Turkey is shown in Figure 6.1.

Table 6.1. Renewable energy potential of Turkey

Energy Source		Usage Area	Natural Capacity	Technical	Economical
Solar Energy		Electricity (Billion kWh)	977.000	6.105	305
		Thermal (mtoe)	80.000	500	25
Hydro Power		Electricity (Billion kWh)	430	215	124.5
Wind	Directly to Energy (land)	Electricity (Billion kWh)	400	110	50
	Directly to Energy (offshore)	Electricity (Billion kWh)	—	180	—
	Wave Energy	(Billion kWh)	150	18	—
Geothermal Energy		Electricity (10 ⁹ kWh)	—	—	1.4
		Thermal (mtoe)	31.500	7.500	2.843
Bio Mass Energy		Total (mtoe)	120	50	32

Renewables make the second-largest contribution to domestic energy production after coal. In 2003, energy from renewable sources amounted to 10 Mtoe (12% of TPES). This shows very little increase from 1990 when 9.7 Mtoe renewables were used (18% of the TPES). More than half of renewables used in Turkey are composed of combustible renewables and waste, the rest being mainly hydro and geothermal (see Table 6.2.). Combustible renewables and waste used in Turkey are almost exclusively non-commercial fuels, typically wood and animal products, used in the residential sector for heating. The use of biomass for residential heating, however, has declined owing to replacement of non-commercial fuels by commercial fuels. The contribution of wind and solar is still small but is expected to increase.

Turkey's use of hydropower, geothermal and solar thermal energy has increased since 1990. However, the total share of renewables in TPES has declined, owing to the declining use of non-commercial biomass and the growing role of natural gas in the system. The fixed feed-in tariffs and purchase obligation for distribution companies under the proposed new Renewable Energy Law can encourage investments. The maximum level, 6 eurocents per

kWh, is moderate as compared to the levels given, for example, to wind power in some other IEA member countries. While the scheme may not become excessively expensive for consumers, which is a common risk in feed-in tariffs, careful monitoring and adjustment of the cost of the scheme will be necessary until it is fully replaced by the purchase obligation in 2011. Given the diverse availability of resources among different distribution areas, it needs to be ensured that distribution companies can buy renewable electricity from certified producers located in other distribution regions to be able to fulfil their obligation at minimum cost. Despite a large potential for use of heat from renewables (geothermal, solar thermal and biomass), there are no specific policies in place for heat production from renewables.

Table 6.2. Renewable Energy Supply in Turkey, 1990 to 2003

	1990	1995	2000	2001	2002	2003
Primary energy supply						
Hydro (ktoe)	1 991	3 057	2 656	2 065	2 897	3 038
Geothermal, solar and wind (ktoe)	461	654	978	1 056	1 142	1 215
Biomass and waste (ktoe)	7 208	7 068	6 457	6 211	5 974	5 748
Renewable energy production (ktoe)	9 660	10 779	10 091	9 332	10 013	10 001
Share of total domestic production (%)	38	40	38	37	40	42
Share of TPES (%)	18	17	12	12	13	12
Generation						
Hydro (GWh)	23 148	35 541	30 879	24 010	33 684	35 330
Geothermal, solar and wind (GWh)	80	86	109	152	153	150
Renewable energy generation (GWh)	23 228	35 627	30 988	24 162	33 837	35 480
Share of total generation (%)	40	41	25	20	26	25
Total final consumption						
Geothermal, solar and wind (ktoe)	392	580	910	974	1 048	1 134
Biomass and waste (ktoe)	7 208	7 068	6 457	6 211	5 974	5 748
Renewable energy TFC (ktoe)	7 600	7 648	7 367	7 185	7 022	6 882
Share of TFC (%)	18	15	12	13	12	11

Gas accounted for 40% of total electricity generation in 2001, coal 31% and oil at about 9%. Hydropower is the main indigenous source for electricity production and represented 20% of total generation in 2001. Hydropower declined significantly relative to 2000 due to lower electricity demand and to take-or-pay contracts in the natural gas market. According to Turkish statistics, the share of hydropower in electricity generation increased to 26% in 2002.

Renewable energy supply in Turkey is dominated by hydropower and biomass, but environmental and scarcity-of-supply concerns have led to a decline in biomass use, mainly for residential heating. Total renewable energy supply declined from 1990 to 2001, due to a decrease in biomass supply. As a result, the composition of renewable energy supply has changed and wind power is beginning to claim market share.

As a contributor of air pollution and deforestation, the share of biomass in the renewable energy share is expected to decrease with the expansion of other renewables. On the whole, Turkey has substantial reserves of renewable energy sources, including approximately 1% of the total world hydropower potential. There is also significant potential for wind power development. Turkey's geothermal potential ranks seventh worldwide, but only a small portion is considered to be economically feasible.

Natural gas and coal are currently the primary fuels for electricity generation. Hydro accounted for 26% of total electricity generation in 2002. The government is pursuing hydropower expansion, particularly in the south-east where less than 40% of hydropower potential currently is being used. The government expects that in 2020 hydropower generation will reach 97.5 TWh (or 8.4 Mtoe).

Electricity generation from renewables totalled 35.5 TWh and contributed 25% to total generation in 2003. In 1990, generation from renewables was 23.2 TWh and their share in power generation was higher, representing 40%. Hydro is the dominant source of renewable electricity, with only 0.15 TWh derived from other sources. Hydro production fluctuates annually depending on the weather.

6.1.1. Solar Energy

According to a solar estimate made in 1983, there are on average 2640 sunshine hours per year in Turkey and the average solar intensity is 3.6 kWh per square metre per day (see Table 6.3., 6.4. and Figure 6.1.). However, because these historical estimates are not sufficiently accurate for electricity generation projects, new solar potential measurement projects are under way and data will be collected in selected sites in different parts of the country over a five year period. At the moment, measures are being conducted in the cities of Ankara, Adana, Isparta, Kayseri and Balıkesir. The measurements in the cities of Antalya, Izmir and Aydın cities have been completed. Flat-plate solar collectors used for domestic water heating are widely used and commercially available in Turkey.

Table 6.3. Regional solar energy potential of Turkey

Region	Total solar energy (kWh/m² per year)	Sunshine duration(hours per year)
South-eastern Anatolia	1 460	2 993
Mediterranean	1 390	2 956
Eastern Anatolia	1 365	2 664
Central Anatolia	1 314	2 628
Aegean Region	1 304	2 738
Marmara Region	1 168	2 409
Black Sea	1 120	1 971

Source: MENR.

Table 6.4. Monthly average solar potential of turkey

Month	Monthly Total Solar Energy		Sunshine duration (Hours/Month)
	(kcal/cm²-month)	(kWh/m²- 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
Avarage	308,0 cal/cm ² -day	3,6 kWh/m ² -day	7,2 hours/day

Source: EIE

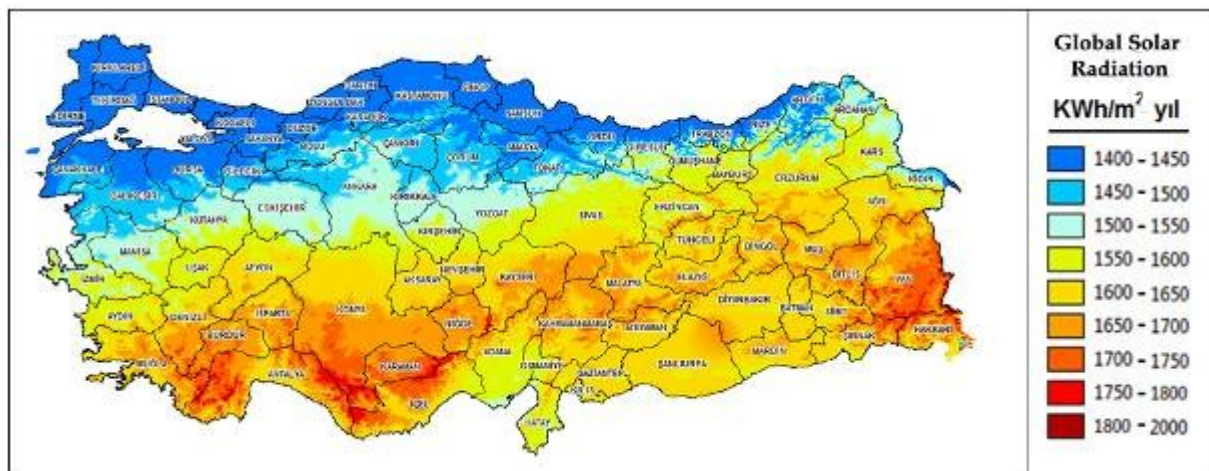


Figure 6.1. Solar energy potential of Turkey

In 2003, the collector surface area installed in Turkey was 10 million m², including both household systems and large-scale use in hotels, industrial activities, etc. Using these collectors for heating contributed 0.35 Mtoe to energy production. Annual collector manufacturing capacity is 1 million m². The EIE installed a computer-aided test stand in order to enable the manufacturers to improve the quality and efficiency of the collectors. It used the test stand to help the Turkish Standard Institute to develop new standards for collectors.

6.1.2. Wind Energy

According to Turkey Wind Atlas, Turkey's technical wind energy technical potential is 88000 MW and its economic potential is 10000 MW (see Figure 6.2.). The Aegean coast, Marmara and the East Mediterranean regions are very favorable locations for wind power generation. In recent years, interest in wind energy has greatly increased in Turkey with many studies on the resources and private sector investing in wind power plants.

In Turkey, wind energy use has been focusing on grid-connected systems. At present, total installed wind power capacity is about 200 MW. Furthermore, licence applications for a total capacity of 85000 MW have been applied (Table 6.5.).

Wind measuring stations have been installed in many parts of the country to enable the evaluation of the wind potential. This has not been done solely by the public sector as wind measurements have been carried out at nearly 500 different sites by private enterprises as part of feasibility studies for wind power plants.

Wind measurement data from the past ten years (1989-1998) were processed in 2002 into a Wind Atlas, which gives a general idea about Turkey's wind potential. This study was carried out by the EIE and the State Meteorological Organisation. In the study, data for 45 selected meteorological stations were processed. Long-term planning studies project that wind energy capacity could reach 1769 MW by 2010 and 3019 MW by 2020.

Wind capacity was 19 MW in 2001 and its contribution to total renewable energy supply was a mere 0.06%. The first wind turbine was installed in 1986 at Çesme Altın Yunus with a nominal capacity of 55 kW. In 1998, two wind power plants were constructed through the BOT financing scheme, the first in Germiyan Village in Çesme in Turkey, with an installed capacity of 1.7 MW, and the second, the ARES wind farm in Alaçati, with twelve wind turbines and an installed capacity of 7.2 MW. ARES is to be transferred to the state after investment costs have been recovered and some profits have been made. ARES is expected to

repay its investment cost in two and a half years. BORES, the newest and largest wind development, is 10.2 MW installed capacity and will be sold after investment costs of US\$ 13 million have been recovered, which is expected to take six years.

The western coast and south-eastern Anatolia have been identified as very favourable locations for wind power generation, with annual average wind speeds of around 2.5 m per s and annual wind power densities of 2.4 W per m². Progress in wind energy technology in recent years has drawn much private-sector attention.

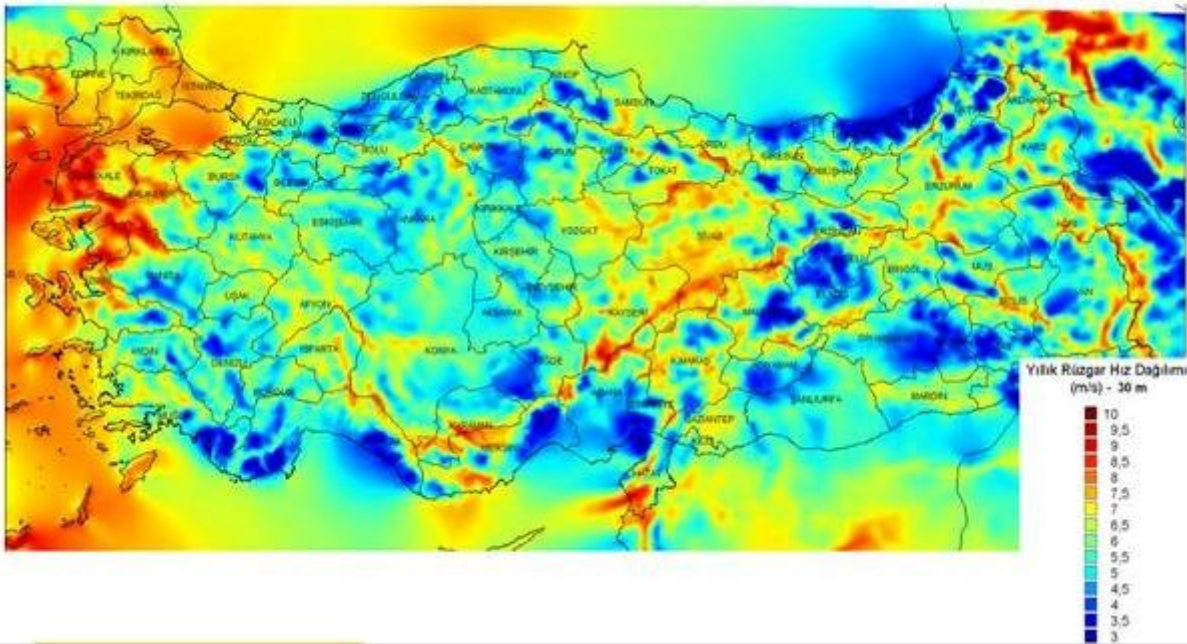


Figure 6.2. Wind atlas of Turkey

Table 6.5. Hydraulic and Wind Energy Power Stations

	Hydraulic Energy Power Station	Wind Energy Power Station
	MW	MW
Constructed	12 819	200
Under construction	4 397	601
Licence	8423	2 500
Applied for Licence	11 238	85 000

Three plants have been commissioned. There are contracts in place for wind power projects through the BOT financing approach. In response to both the BOT approach and the advantages put in place by the Electricity Market Law, numerous companies have submitted applications to the authorities for the construction of new wind turbines. In 2001, 72 new

projects totalling about 2000 MW were under evaluation. Total capacity of all wind projects underway in Turkey was about 800 MW in early 2004. The goal is for wind power to represent about 2% of installed power capacity in 2005. Long-term planning studies project that wind energy capacity could reach 2100 MW by 2010 and 5000 MW by 2020. Given Turkey's wind potential and private investor interest, these goals could be achieved given the market incentives in place.

6.1.3. Hydropower

Hydropower generation climbed from 2 Mtoe (23.1 TWh) in 1990 to 3.0 Mtoe (35.3 TWh) in 2003, growing on average by 3.8% per year. Figure 6.3. shows the development of hydropower and Table 20 indicates the 2004 status of hydropower projects in Turkey.

Hydropower installed capacity increased by 5.1% per year from 1990 to 2001. Hydropower contributed 22.1% of total renewable energy supply and 2.8% of TPES in 2001. According to Turkish statistics, there were 130 hydroelectric power plants, with capacity of 12 500 MW, operating in 2002. Currently, some thirty hydro plants are under construction. Hydropower has to some extent been stimulated by the BOT financing scheme.

DSI and EIEI estimate that only 35% of the economic potential for hydropower has been exploited. The Turkish government has a strategy for developing this potential and expects that 332 additional hydro plants will be constructed over the long term, adding more than 19 GW of capacity. Construction costs would be on the order of US\$ 30 billion.



Figure 6.3. Hydropower potential in Turkey

Table 6.6. Hydropower in Turkey, 2004

Status	Installed capacity	Average Annual Generation (TWh)	Number of Project
In operation	12 618	45.21	135
Under construction	3 219	10.7	41
Final design completed	3 585	10.9	15
Feasibility study completed	6 918	25.1	143
Master plan completed	5 161	17.9	89
Reconnaissance completed	4 759	17.5	255
Total	36 260	127.4	678

The Turkish government would like to expand hydropower capacity to 35 000 MW by 2020, and plans to encourage this outcome through favourable licensing conditions established by the Electricity Market Licensing Regulation. Hydropower is included in the loans available through the Renewable Energy Program.

The economic hydropower potential has been estimated at 128 TWh per year, of which 35% has been exploited. The government has a strategy for developing the hydropower potential and expects a few hundred plants to be constructed over the long term adding more than 19 GW of capacity. Construction costs would be approximately US\$ 30 billion. The government expects hydropower capacity to reach about 31000 MW in 2020. Some 500 projects (with a total installed capacity over 20400 MW), which are in different phases of the project cycle, are awaiting realisation. Turkey's hydro generating capacity includes the huge South-East Anatolia Project (GAP) which is one of the most ambitious water development projects ever undertaken. GAP is an integrated hydroelectric and irrigation project and its objectives are the reduction of Turkey's regional disparity in economic prosperity, employment and infrastructure. The GAP project is situated in the lower reaches of the Euphrates and Tigris rivers and in the plains between them. The project covers an area of almost 74 000 km², equalling one-tenth of Turkey's total land surface. Upon completion, GAP will include 21 dams, 19 hydropower plants and a network of tunnels and irrigation canals. The hydropower plants will have an installed capacity of 7.5 GW producing 27 TWh of hydroelectricity annually. Major hydro dams of the GAP include: Atatürk (2400 MW of capacity), Karakaya (1800 MW), Ilisu (1200 MW – highly controversial owing to environmental concerns), Cizre and Silvan/Kayseri (240 MW each), Batman (198 MW), and Konaktepe and Karkamis (180 MW each); 12% of the irrigation projects and 72% of the hydropower projects have been completed, including the Karakaya, Atatürk, Birecik, Karkamis, Dicle, Kralkızı and Batman power plant projects. The completion of the whole

project is expected in 2014. The total cost of the project has been estimated at US\$ 32 billion of which investments of US\$ 16 billion have already been made.

Turkey and its downstream neighbours Syria and Iraq are located in one of the driest regions of the world. Their combined water needs exceed the capacity of the Euphrates and Tigris rivers. Turkey maintains that the dam system will stabilise water supplies as it will help regulate the highly erratic water flow in the Tigris.

Turkey has a lot of potential for small hydropower (< 10 MW), particularly in the eastern part of the country. At present the total installed capacity of small hydropower is 176 MW in 70 locations, with annual generation of 260 GWh. Ten units are under construction with a total installed capacity of 53 MW and estimated annual production of 133 GWh. Furthermore, 210 projects are under planning with a total capacity of 844 MW and annual production of about 3.6 TWh.

6.1.4. Geothermal Production

The contribution of geothermal to TPES was 0.86 Mtoe in 2003, including 89 GWh of electricity generation. Turkey has significant potential for geothermal energy production, enjoying one-eighth of the world's total geothermal potential. This potential has been estimated at 4.5 GW of electric capacity (GWe) and 31.1 GW of thermal capacity (GWth); most of this is of relatively low enthalpy making it unsuitable for electricity generation but can still be used for direct heating applications. By the end of 2003, Turkey's total direct geothermal heating capacity was 1 077 MWth, of which 6 19 MWth provided heat for 71 000 residences, 131 MWth for 63.5 hectares of greenhouses and 327 MWth was used to provide hot water to about 200 spas. Geothermal sources and their application areas have been given in Figure 6.4. and Figure 6.5.

The government estimates that 500 000 residences could be heated by geothermal power by 2010, representing heat use of 2 190 MWth. Despite having already announced the first geothermal energy programme in 1972, Turkey has four operating geothermal power plants (see Table 6.7.). The facility includes nine production wells and has an integrated liquefied CO₂ and dry ice production factory. Another geothermal power station (49 MWe) and five heat plants (73 MWth) will be added. Two geothermal electricity generation projects with a capacity of 13.45 MW and a slightly smaller one have been licensed. The cost of electricity from geothermal resources is between €0.03 and €0.10 per kWh; the bottom end of this range is competitive with conventional systems.

There are 11 other geothermal fields, all in far south-west Turkey, which may be suitable for geothermal power production. The Germencik-Aydın field in the Aydın Province is the most promising one. Power generation potential in this field has been estimated to exceed 100 MWe.

Table 6.7. Geothermal Power Plant in Turkey (May 2009)

Geothermal Area	Installed Power	Temperature	Situation	Name of Company
Denizli-Kızıldere	15 MWe	242	Constructed	Zorlu Enerji A.Ş.
Aydın-Sultanhisar (Dora-1)	7.95 MWe	162	Constructed	Menderes Jeotermal Elektrik Üretim A.Ş.
Aydın-Sultanhisar (Dora-2)	9.5 MWe	162	Under construction	Menderes Jeotermal Elektrik Üretim A.Ş.
Aydın-Germencik	47.4 MWe	232	Constructed	Gürmat Elektrik Üretim A.Ş.
Çanakkale-Tuzla	7.5 MWe	174	Under construction	Tuzla Üretim A.Ş.
Denizli-Kızıldere (Binary Cycle)	6.85 MWe	140	Constructed	Bereket Jeotermal Enerji Üretim A.Ş.

Geothermal production was 7.4% of total renewable energy supply in 2001. Installed capacity has remained unchanged but production increased by 4.4% per year on average between 1990 and 2001. Estimated potential of geothermal electricity generation capacity is 35 GW. The cost of electricity generated from geothermal resources is between € 0.03 and € 0.10/kWh. The bottom end of this range is competitive with conventional systems.

The Turkish government started a geothermal construction programme in 1972 that predicted an installed capacity level of nearly 710 MW by 2004. However, the programme was not fully implemented and the geothermal potential remains largely unexploited. The geothermal market has seen no growth in installed capacity between 1990 and 2001. The geothermal market has received some stimulation from the BOT financing scheme, where at least one geothermal project contract was put in place, although it may still be too early to see the effects on the geothermal market due to rather long lead times for geothermal power developments.

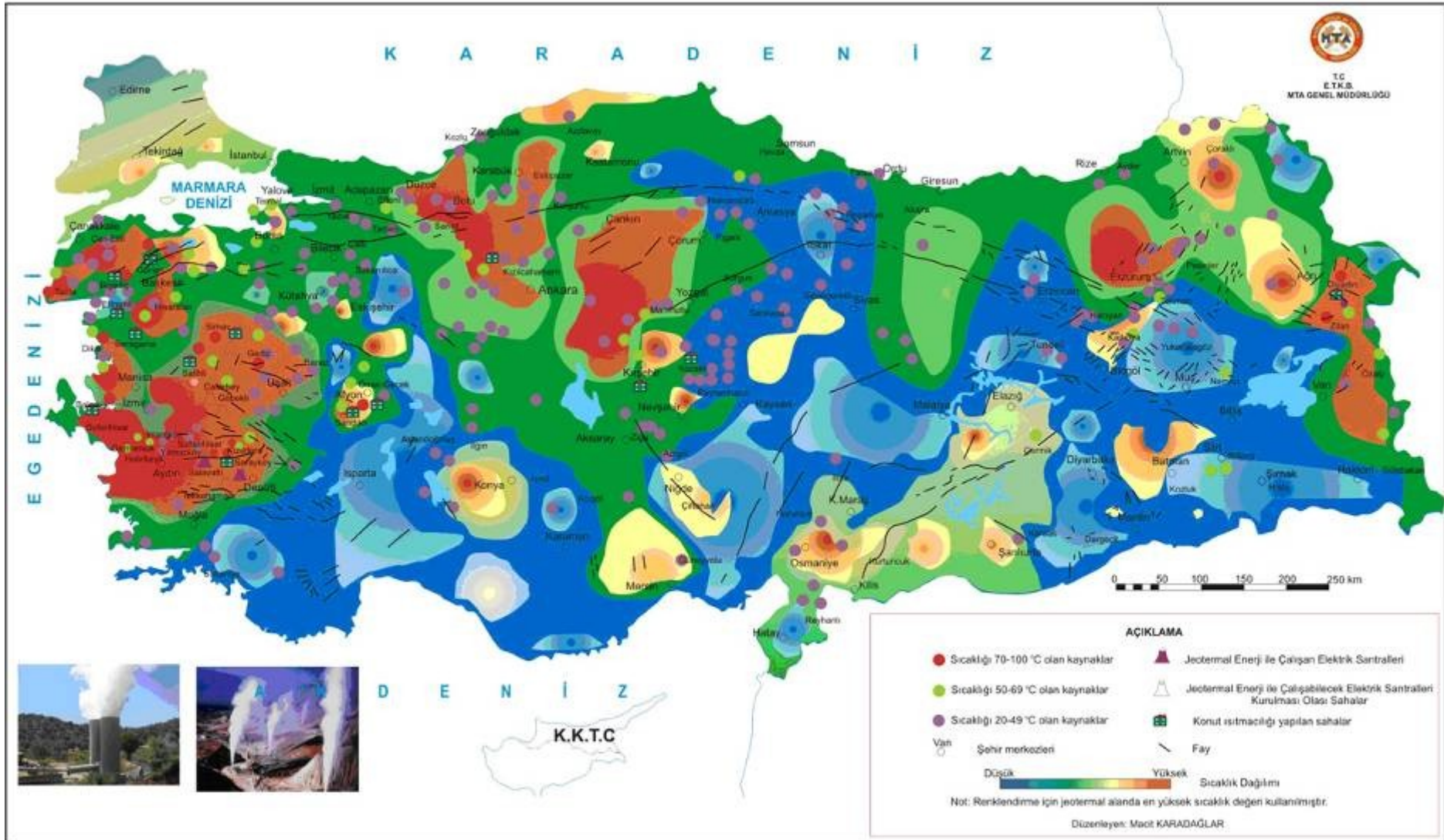


Figure 6.4. Map of geothermal sources and their application areas in Turkey

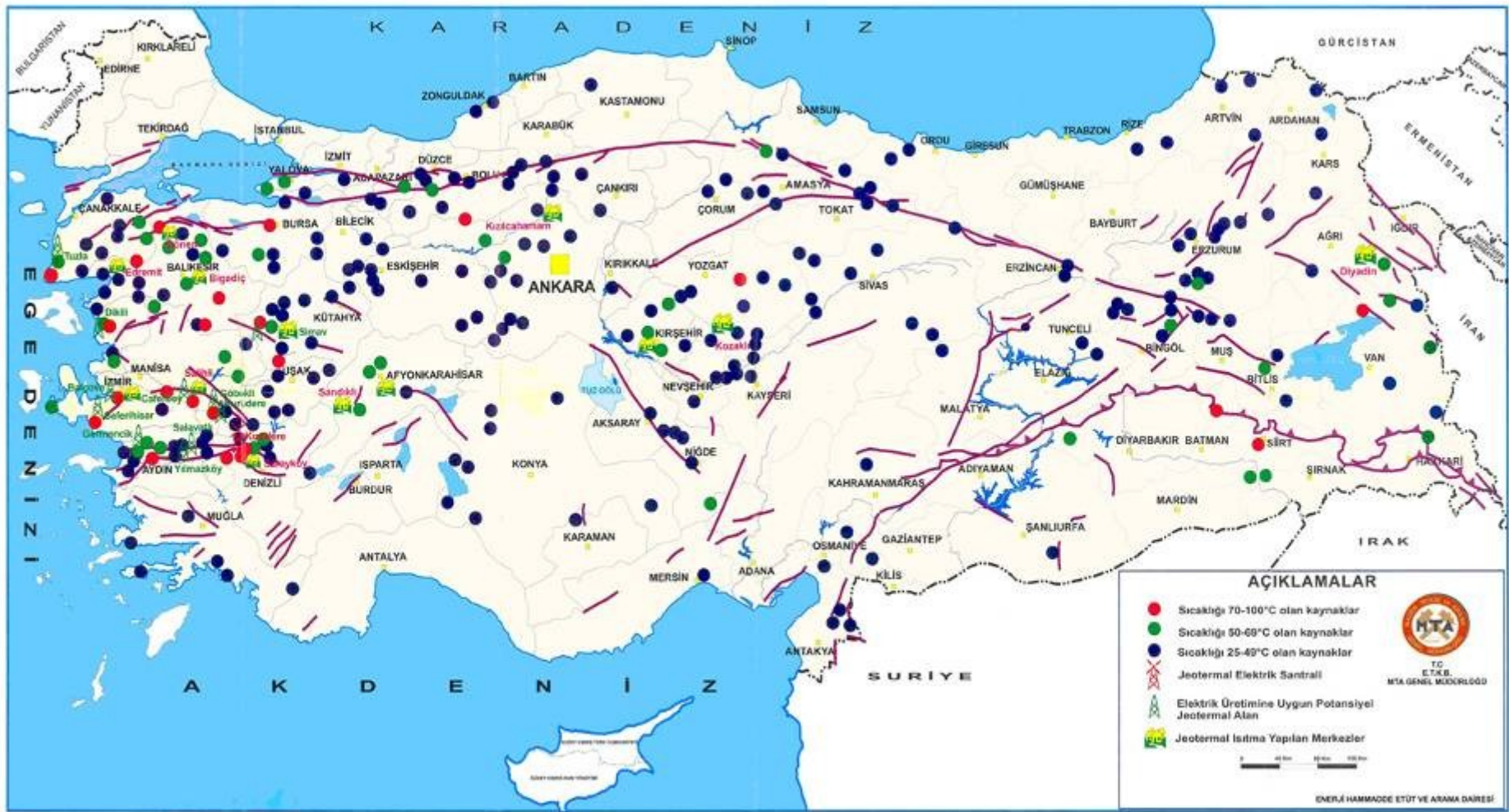


Figure 6.5. Map of geothermal sources and their application areas in Turkey

6.1.5. Bioenergy (Commercial Biomass Biogas and Waste)

Biogas production potential has been estimated at 1.5 to 2 Mtoe but only two small units (in total 5 MW) are in operation and one new facility (1 MW) has been licensed. There are, however, R&D activities in the area.

At the end of 2003, the total installed capacity of waste-fired power plants was 27.6 MW, all of which was in the industrial sector. One waste-fired power plant with 11.5 MW of installed capacity was commissioned in 2004. There are no power plants in operation using biomass. Biofuels are discussed in Chapter 4 together with other alternative transport fuels.

Turkey's substantial renewable energy resources make a sizeable contribution to its energy mix. However, the contribution has grown very little and its share has declined rapidly since 1990 because, while the use of hydropower and to some extent geothermal and solar thermal energy has increased, the use of noncommercial biomass has declined. Commercial use of renewable energy in Turkey, excluding large-scale hydropower, has not developed in proportion to the large resource base and the trends seen in many other IEA member countries.

The principal reason appears to have been that there were few promotional measures and large-scale power generation projects to meet the growing electricity demand that dominated the policy. The recently introduced licensing regulation and associate promotional provisions are positive developments. It is commendable that the government has decided to step up these activities and is drafting new Renewable Energy and Geothermal Energy Laws.

As for the use of commercial renewables, hydropower has the largest contribution followed by geothermal. Only about 35% of the potential hydro resources have been exploited and the government intends to utilise the remaining potential by 2020. Some of these projects are, however, challenging to implement because of various environmental, economic, social and international considerations. Another way to increase hydropower capacity could be the refurbishment of existing power plants. The economic lives of existing power plants are estimated to be 50 years. The actual potential for refurbishment is studied by EÜAS.

The government has proposed the Renewable Energy Law to exploit indigenous and environmentally sustainable energy resources, which are not, or are not fully, competitive. However, the introduction of the law has been delayed repeatedly after it was announced in July 2003 to be introduced in the first quarter of 2004. This is hampering investor confidence. To date, 1 366 MW of generation licences have been granted but implementation of the projects, some of them licensed more than a year ago, has not started as the investors are

waiting for the introduction of the law. The law should be introduced as soon as possible because it can contribute to the development of power plants based on renewable energy sources, thus increasing the use of domestic energy resources and bringing environmental advantages, which are positive externalities currently not captured by the market. It should be noted, however, that other policies, such as increased investments in energy efficiency, carry similar benefits and can have a lower cost than renewables; there appears to be abundant potential to improve energy efficiency in cost effective ways in Turkey.

The new Renewable Energy Law will introduce a feed-in tariff scheme and a purchase obligation for renewables for a transition period up to 2011. Thereafter the feed-in tariffs for new projects will be abolished and renewable will be promoted solely by the purchase obligation and possibly a certificate trading mechanism. The tariffs can give incentives for potential investors, particularly for projects in good locations. The maximum level, 6 eurocents per kWh, is moderate as compared to the levels given, for example, to wind power in some other IEA member countries¹⁸, meaning that the scheme may not become excessively expensive for consumers, which is a common risk in feed-in tariffs. Careful monitoring and adjustment of the cost of the scheme will, however, be necessary to assure maximum effectiveness.

The purchase obligation for the distribution companies is likely to be a strong incentive for the development of renewables, particularly once it reaches the level of 8%. However, available resources and the cost of developing them can vary substantially among the different distribution areas in the country. Therefore, it needs to be ensured that distribution companies can buy renewable electricity from certified producers located in other distribution regions to fulfil their obligation and at minimum cost. It will be very important to develop a sound certification and accreditation system possibly in the form of certificate trading. The certificate trading system is relatively new and its real effectiveness remains to be demonstrated. Several IEA member countries, including Australia, Austria, Japan, Italy, Sweden and the United Kingdom, as well as the Flemish region of Belgium, have already introduced portfolio standards (quota obligations) together with tradable green electricity certificates or a similar scheme, and Norway and Sweden are preparing a joint scheme. Turkey would benefit from studying and learning from those programmes and exchanging experiences with these countries.

The licence applications for wind power, for 4 000 to 5 000 MW, already reach the government's projections for 2020. It is not clear what the policy will be for licensing wind power given that the industry has rapidly filed applications, i.e. will all applications be

approved without any cap? Licence fees are reduced or exempted for renewable energy projects in order to promote them. However, given the small licence fee, the impact is limited. Licensing procedures, which have very often become a bottleneck in developing renewable energy projects in many IEA member countries, appear to work well in Turkey. There is also currently not much public opposition to wind power, which is a growing hurdle for wind power development in many other IEA member countries.

The introduction of intermittent renewable energy sources, principally large quantities of wind power, can affect optimal grid performance. Problems could occur either when wind capacities are providing too little or too much power. Technical solutions and business and regulatory practices are being developed in other countries to help the integration of large wind capacities, and could provide lessons for Turkey. The grid's continuous modernisation may reduce the investment required to accommodate added wind capacity. This would reduce the financial burden on wind power companies and, finally, on consumers.

The EIE is conducting research on wind power's impact on the grid system reliability and possible combination of a wind and small hydro pumping system to minimise such an impact. Turkey has the advantage of having significant hydropower resources making this a seemingly sensible approach in Turkey. Despite that about two-thirds of renewable energy is used in Turkey for heat, there are no specific targets and policies in place to promote heat production from renewables. While at present non-commercial biomass dominates the use of renewables for heat production, there is also a large potential for the use of geothermal and solar thermal applications in Turkey. Solar collectors are already a significant, completely market-driven business in the country. The government expects the use of geothermal and solar thermal energy to double between 2003 and 2010. The planned tax incentives for households for the installation of solar collectors can help and further growth could be sought by trying to find new applications, such as increasing the use of solar collectors in non-residential buildings. The Geothermal Energy Law is planned to have provisions which could provide a significant boost for the use of this resource for residential heating. The organic component of waste incineration should be considered as a renewable option in the future, but this should be done using the appropriate technology to ensure high health and environmental standards, in particular with respect to airborne emissions.

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CHAPTER 7

FUTURE PROJECTIONS OF RENEWABLE ENERGY

7.1. Turkey's future projections of RES

Turkey, with a population of 70 million which is increasing by 1.7% yearly, can be assumed as one of the biggest countries in Europe. Because of its increasing population and growing economy, Turkey's energy demand has increased in the last decade significantly. Table 7.1. shows the energy consumption met by primary sources in year terms [1].

Table 7.1. Annual general energy consumption in Turkey met by primary sources [1].

Sources	1990	1995	2000	2001	2002	2003	2004	2005
Hard coal (kton)	8191	8548	15,393	11,039	13,756	17,535	18,904	23,116
Lignite (kton)	45,891	52,405	64,384	61,010	52,039	46,051	44,823	60,941
Asphalt (kton)	287	66	22	31	5	336	722	700
Petroleum (kton)	22,700	27,918	31,072	29,661	29,776	30,669	31,729	33,595
Natural gas (million m ³)	3418	6937	15,086	16,339	17,694	21,374	22,446	27,167
Hydraulic (GWh)	23,148	35,541	30,879	24,010	33,684	35,330	46,084	41,889
Geothermal electric (GWh)	80	86	76	90	105	89	93	122
Geothermal heat (ktoe)	364	437	648	687	730	784	811	976
Wind (GWh)	–	–	33	62	48	61	58	56
Solar (ktoe)	28	143	262	287	318	350	375	409
Wood (kton)	17,870	18,374	16,938	16,263	15,614	14,991	14,393	13,819
Waste of animal and agricultural plant (kton)	8030	6765	5981	5790	5609	5439	5278	5127

The total amount of generated electricity reached 161,504.8GWh in 2005. The total installed capacity of 38,819.9 MW divides at the end of 2005 by shares into 66.6%, 33.2% and 0.1% (Table 7.2) for thermal, hydro and geothermal/wind power plants, respectively [2] [3]. At least these parameters do show that renewables such as wind, geothermal and solar energy do not have a reasonable demand in Turkey, as far as they require investment in specific energy transformation technologies. Annual development of installed capacity and electricity generation in Turkey are shown in Table 7.3.

Table 7.2. Renewable energy potential of Turkey [4]

Renewable energy source	Usage kind of energy	Natural potential	Technical potential	Economic potential
Solar energy	Electrical energy (TWh/year)	977,000	6105	305
	Heat (mtoe/year)	80,000	500	25
Hydraulic energy	Electrical energy (TWh/year) 433	433	216	127.4
Wind energy				
Direct terrestrial	Electrical energy (TWh/year)	400	110	50
Direct maritime	Electrical energy (TWh/year)	–	180	–
Sea wave energy	Electrical energy (TWh/year)	150	18	–
Geothermal energy	Electrical energy (TWh/year)	–	–	1.4
	Heat (MWth)	31,500	7500	2843
Biomass energy	Fuel (classic) (mtoe/year)	30	10	7
	Fuel (modern) (mtoe/year)	90	40	25

Table 7.3. Annual development of installed capacity and electricity generation in Turkey [5]

Years	Installed capacity (MW)				Production (GWh)			
	Thermal	Hydraulic	Geothermal +wind	Total	Thermal	Hydraulic	Geothermal +wind	Total
1970	1509.5	725.4	–	2234.9	5590.2	3032.8	–	8623
1975	2407	1779.6	–	4186.6	9719.2	5903.6	–	15,622.80
1980	2987.9	2130.8	–	5118.7	11,927.20	11,348.20	–	23,275.40
1984	4569.3	3874.8	20.4	8464.5	17,165.10	13,426.30	22.1	30,613.50
1985	5229.3	3874.8	20.4	9124.5	22,168.00	12,044.90	6	34,218.90
1990	9535.8	6764.3	20.4	16,320.50	34,314.90	23,148.00	80.1	57,543.00
1995	11,074.00	9862.8	20.4	20,957.20	50,620.50	35,540.90	86	86,247.40
2000	16,052.50	11,175.20	39.3	27,267.00	93,934.20	30,878.50	108.9	124,921.60
2001	16,623.10	11,672.90	39.3	28,335.30	98,562.80	24,009.90	152	122,724.70
2002	19,568.50	12,240.90	39.3	31,848.70	95,563.10	33,683.80	152.6	129,399.50
2003	22,974.40	12,578.70	40.5	35,593.60	105,101.00	35,329.50	150	140,580.50
2004	24,144.70	12,645.40	40.5	36,830.60	103,518.60	46,034.80	148.1	149,608.30
2005	25,873.40	12,906.00	40.5	38,819.90	121,787.50	39,572.00	145.3	161,504.80

Green power products may be seen as a means of fostering renewable energy sources (RES) because they create and channel consumer demand for environmentally sound power generation. Turkey also has a large potential for renewable energy exploitation in a number of areas. Clean, domestic and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world. The renewable energy contribution in the total primary energy production is insignificant. The alternative and renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs. In this context, Renewable Energy Law was enacted in 2005 in order to encourage renewable-based generation in competitive market conditions. Supporting mechanisms such as feed-in tariffs and purchase obligation are defined in the law, in conformity with the EU legislation

and practice. These mechanisms are envisaged to facilitate the development of power plants based on RES. [6]

RES are becoming attractive solutions for clean and sustainable energy needs of Turkey. This is primarily because RES have some advantages when compared to fossil fuels. Turkey has to adopt new long-term energy strategies to reduce the share of fossil fuels in the primary energy consumption. A major dilemma now faced by Turkey is how to invest in new electric power capacity while at the same time adhering to foreign debt ceilings under lending rules set by the International Monetary Fund [7].

The alternative and renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs [8]. According to the estimates of the Turkish Ministry of Energy and National Sources, an increase in the production of renewable energy is expected, while a decrease is predicted in total energy requirements [9]. In this context, the Renewable Energy Law was enacted in 2005 in order to encourage renewable-based generation in competitive market conditions. Supporting mechanisms such as feed-in tariffs and purchase obligation are defined in the law, in conformity with the EU legislation and practice. These mechanisms are envisaged to facilitate the development of power plants based on RES [10]. Furthermore, the Law gives the Council of Ministers the authority to increase the price applicable to RES by a maximum of 20% at the beginning of each year. The Renewable Energy Law is a first step towards implementation of the renewables acquis. However, the Law does not set a target for electricity generated from RES by 2010, as foreseen by the relevant directive. Given Turkey's significant untapped potential for RES, it should set itself an ambitious target for their further development, including geothermal energy. Turkey would be recommended to develop an overall strategy for RES [11].

7.1.1. Hydropower

The water in rivers and streams can be captured and turned into hydropower, also called hydroelectric power. Hydropower is also inexpensive, and like many other RES, it does not produce air pollution. Hydroelectric power and especially small hydroelectric power are emphasized as Turkey's renewable energy sources [12]. In recent decades, Turkey has made great strides in water resource development for irrigation, power generation, flood control and other purposes. The creation of dams and reservoirs has enabled Turkey to save the water from its brief seasons of rainfall to use throughout the year for irrigation, energy, drinking and sanitation. The objective of this activity is to check dam, hydroelectric power plant (HEPP)

and related power generation facilities projects which will be implemented under the State Hydraulic Works (DSI in Turkish initials) control, to check the construction stages of the dam and hydroelectric power plants, and to examine and approve dam projects designed by other public and private organizations and required to be approved by DSI. Annual rainfall varies from 220 to 2500 mm in Turkey with an average of 643 mm, which means total volume km³. Turkey's water and land sources at the base of river zone are given in Table 7.4. The most important rivers are the Firat River (Euphrates) and Dicle River (Tigris), both of which are transboundary rivers originating in Turkey and discharging into the Persian (Arabian). The Euphrates and Tigris rivers represent over 28% of the nation's water supply by rivers, and the economically irrigable areas in the region make up 20% of those for the whole country [13]. In 1977, these two basin projects were given the single title of the Southeastern Anatolia Project (GAP in Turkish initials). Thirteen projects were prepared to develop the rich water resources (the rivers of Euphrates and Tigris) of the region for irrigation and power generation purposes. Seven of these projects are in the basin of the Euphrates and six in that of the Tigris. These projects envisage the construction of 22 dams and 19 power plants, generation of 27 billion kWh of energy a year over an installed capacity of 7485 megawatts (MW), and irrigation that will cover 1.7 million hectares of land [14]. Major Turkish hydro dams as part of the GAP include: Ataturk (2400MW capacity); Karakaya (1800MW); Ilisu (1200MW); the largest hydro project on the Tigris River, but highly controversial due to environmental concerns; Cizre (240MW); Silvan/Kayseri (240 MW); Hakkari (208 MW); Alpaslan II (200MW); Batman (198 MW); Konaktepe (180 MW); and Karkamis (180MW) [6].

Table 7.4. Water and energy potential of selected river basins in Turkey [6]

Name of basin	Land Area (km ²)	Average rainfall (mm/yr)	Number of dam	Stored Water (hm ³)	Installed Capacity (MW)	Average generation (GWh)
Susurluk	22,399	712	25	3509	537	1697
Gediz	18,000	603	14	3369	250	425
B.Menderes	24,976	664	19	2722	215	848
B.Akdeniz	20,953	876	24	1837	675	2495
Antalya	19,577	1000	15	2885	1252	4411
Sakarya	58,160	525	45	6920	1063	2362
B.Karadeniz	29,598	811	24	2519	593	2110
Yes-ilirmak	36,114	497	45	6302	1658	6468
Kızılırmak	78,180	446	82	21,260	2007	6512
D.Akdeniz	22,048	745	11	9122	1496	5176
Seyhan	20,450	624	18	6125	1886	7117
Ceyhan	21,982	732	25	7720	1409	4634
Euphrates	127,304	540	83	112,792	9845	38,939
D.Karadeniz	24,077	1198	43	1523	3323	10,927

Coruh	19,872	692	20	7544	3227	10,614
Aras	27,548	432	20	4085	585	2291
Tigris	57,614	807	36	30,295	5082	16,876

An overview about the situation of hydraulic energy potential in Turkey, which is the most important one amongst the renewables, has been given in Table 7.5. According to this table, there are a number of 544 dams constructed by General Directorate of State Hydraulic Works (DSI) and another 11 dams built by other companies. In 2005, 141 hydroelectric power plants (HEPP) were under operation for the electricity generation [15]. The hydroelectric power will continue to be the a very important source, if the HEPP projects by private sector move forward and the rainfalls will retain at normal seasonal levels. As Table 9 shows the gross hydroelectric potential of Turkey is about 433 billionkWh, while it is 216 billion kWh in technical potential point of view [16]. According to this data, the theoretical potential of Turkey is only about 1% of world potential, while it is 16% of European potential. At the end of 2005, the total installed capacity of HEPPs was 12,906MW and the electricity generation was 39,572GWh (see Table 7.3).

The studies on 12 of totally 26 river basins are still in progress. Fourteen river basins are planned to be completed step by step by General Directorate of Electrical Power Resources Survey and Development Administration (EIE). If the HEPPs, which provided 24.5% of the total energy generation of Turkey in 2005, is compared with those of the world, Ataturk HEPP with its installed capacity of 2400MW is 23rd and Karakaya HEPP with its installed capacity of 1800MW is 37th [17].

Table 7.5. Dams in Turkey which are in operation and under construction [15]

	In operation			Under construction/in schedule		
	DSI	Other	Total	DSI	Other	Total
Large dams	201	11	212	85	1	86
Small dams	343	–	343	124	–	124
Hydro power plant	53	82	135	53	17	70
Pond	47	617	664	1	43	44
Irrigation (million ha)	2.77	2.12	4.89	0.8	–	0.8
Water supply (billionm ³)	2.5	0.46	2.96	1.09	–	1.09
Flood control area (million ha)	1	–	1	0.5	–	0.5

7.1.2. Geothermal energy

Turkey has significant potential for geothermal power production, possessing one-eighth of the world's total geothermal potential. The main utilization of geothermal energy in Turkey is

in domestic heating, greenhouses, and spas and thermal resorts installed for balneological purposes. The overall geothermal potential in Turkey is about 38,000MW (electric and thermal). Of this potential, around 88% is appropriate for thermal use (temperature less than 423 K) and the remainder for electricity production (temperature more than 423 K).

Geothermal energy is clean, cheap and renewable, and can be utilized in various forms and electricity generation. Geothermal energy is being used for electricity production and it has direct usage in Turkey, which is among the first five countries in the world for the geothermal direct usage applications. The first geothermal researches and investigations in Turkey started by Turkey Mineral Research and Exploration Institute (MTA in Turkish initials) in 1960s. Upon this, 170 geothermal fields have been discovered by MTA, where 95% of them are low–medium enthalpy fields, which are suitable mostly for direct-use applications [18]. As seen in Table 7.6., high-temperature geothermal fields suitable for conventional electricity generation are Aydin–Germencik (473–505 K), Denizli–Kizildere (463–485K), Canakkale–Tuzla (413–473K), Aydin–Salavatli (435–444 K), Kutahya–Simav (426–435 K) and Izmir–Seferihisar (410–426 K) [19].

This means that considerable studies on geothermal energy could be conducted in order to increase the energy supply and to reduce atmospheric pollution in Turkey. Although Turkey is among the countries which have a high potential of geothermal energy in the world, the use of this energy for electricity generation is rather low.

Table 7.6. Turkey’s hot field resources [19].

Field	Temperature range (K)
Izmir–Balcova	353–399
Izmir–Seferihisar	410–426
Kutahya–Simav	426–435
Aydin–Salavatli	435–444
Canakkale–Tuzla	413–473
Denizli–Kizildere	463–485
Aydin–Germencik	473–505

Geothermal energy use is based on hydrothermal circulation. Although the use of the geothermal energy lays out to old ages, the use in electricity generation has started in 1904. Today, the electricity generation from geothermal energy in 24 countries has reached 8912MW [20]. Although Turkey is among the first seven countries with its potential, it is in

the last rank with its installed capacity of 28.3MWe (20.4MWe in Denizli–Kizildere and 7.9MWe in Aydin–Salavatli). The first geothermal researches and investigations in Turkey started by Turkish Mineral Research and Exploration Institute (MTA in Turkish initials) in 1960s. Since then, about 170 geothermal fields have been discovered by MTA, where 95% of them are low-medium enthalpy fields, which are suitable mostly for direct-use applications. However, only 7% of these fields have high enthalpy and are adequate for electricity generation. Turkey’s first commercial geothermal power plant is located at Denizli–Kizildere field. It was discovered by the MTA in 1968 and a power plant was installed there in 1984 with a capacity of 20.4 MW. Apart from power production capacity, Turkey has 827 MW district heating and 402MW balneological utilization capacities together with a carbon dioxide production capacity of 120,000 tonnes per year. If she fully utilizes its geothermal potential, Turkey is capable of meeting 5% of her electricity need and 30% of heat requirement from geothermal sources, which corresponds to 14% of her total energy need [21]. As listed in Table 7.7., there are 11 known geothermal fields which are adequate for electricity generation with Rankine and flash cycles in Turkey [22]. Although it is aimed to achieve an amount of 500MWe by 2010 and 1000MWe by 2020 from geothermal power plants, which are considered to be installed on these fields, the level of implementation is quite far away from achieving these goals [23].

Turkey’s geothermal gross theoretical, technical and available heat potentials are, respectively, 31,500, 7500 and 2843MWth (see Table 7.2.). The amount of proofed geothermal theoretical and available electricity potential is, respectively, 500 and 350MWe. The obtainable electricity generation from the available potential is about 1400 GWh/year [23] [24].

Table 7.7. Geothermal fields suitable for conventional electricity generation in Turkey

Site	Temperature (°C)	Potential (MW_e)
Denizli–Kizildere	242	120
Aydin–Germencik–Omerbeyli	232	150
Manisa–Salihli–Gobekli	182	30
Canakkale–Tuzla	174	50
Aydin–Salavatli	171	50
Kutahya–Simav	162	30
Izmir–Seferihisar	153	10
Manisa–Salihli–Caferbey	150	30

Aydin–Yilmazkoy	142	20
Izmir–Balcova	136	10
Izmir–Dikili	130	10
Total		510

Over the next three decades, it is expected that many foreign investors and financiers will be interested in the Turkish hydropower market [Geothermal electricity generation has a minor role in Turkey’s electricity capacity, as low as 0.09%, but the projections foresee an improvement to 0.32% by the year 2020 [19].

Geothermal electricity production for the year 2005 is only 94GWh [1]. It is planned to generate 500MWe geothermal energy by 2010 and 1000MWe energy by 2020 in the plants to be set up in the fields that are suitable for electricity generation [24]. Turkey has extended its involvement in geothermal energy projects, supported by loans from the Ministry of Environment, and geothermal energy is expected to increase substantially in the coming years.

Out of Turkey’s total geothermal potential, around 94% is appropriate for thermal use (temperature less than 150°C) and the remainder for electricity production (temperature more than 150°C). The geothermal electricity generation capacity potential of Turkey is estimated at 2000 MW (16 TW h/year) and a generation capacity of 550 MW that utilizes geothermal sources is expected by the year 2013. The main utilization of geothermal energy in Turkey, however, is in domestic heating, greenhouses, spas and thermal resorts. The overall geothermal heat generation potential of Turkey is about 31,500 MW. It is projected that, by the years 2010 and 2020, the total installed capacity will increase to 3500MW (500,000 residence equivalent, which is about 30% of the total residences in the country) and 8300 MW (1,250,000 residence equivalent) for space heating, respectively [21].

There exist some barriers in Turkey for the exploitation of geothermal energy. These can be listed as follows:

- establishment of a structure at the institutional level, which requires a higher level of coordination and cooperation within and between institutions, agencies, institutes, and other stakeholders,
- insufficient available information about existing and possible future costs of geothermal energy utilization,
- insufficient detailed geothermal energy resource assessments and data banks pertaining to Turkey,

- insufficient credit facilities, particularly for small-scale projects,
- administrative and time-consuming obstacles for foreign investors,
- need for support for infrastructure and management know-how at a local level,
- insufficient participation by the private sector,
- need for staff with sufficient technical information,
- difficulties possibly encountered in planning, project feasibility, and project control activities,
- insufficient policy instruments in the sector,
- need for public acceptance and willingness, [25]

Although Turkey has no specific laws for development of geothermal energy yet and the lack of governmental support, direct use applications have been growing Table 7.8. [25].

Table 7.8. Present and future geothermal heat and electricity generation projections in Turkey [25]

Years	Total capacity (MW_e)	Electricity generation (GW_h)	Thermal generation (MW_t)	TOE (x1000) (thermal)
2002	20	90	965	430,721
2003	45	202.5	1187	511,462
2004	60	202.5	2122	914,341
2005	100	360	2926	1,260,774
2010	300	1250	3765	1,622,288
2015	400	2150	4670	2,145,410
2020	600	3500	6365	2,742,610
2025	1250	4625	8182	3,225,660
2030	1500	5625	10,150	3,890,545

7.1.3. Wind energy

Wind energy is the fastest growing energy source in the world and wind power is one of the most widely used alternative sources of energy today. It is a clean and renewable source of electricity. In Turkey, wind energy has great potential. Turkey's total theoretically available potential for wind power may be around 88,000MW annually, with particularly attractive areas for wind located along Turkey's west coast and in southeastern Anatolia. Table 7.9. shows Turkey's wind energy potential over various regions. Turkey's wind energy potential

could not be definitely calculated due to the insufficiency of available data. There are a number of regions with relatively high wind speeds in Turkey. The most attractive regions for wind energy utilization are the Marmara, Southeast Anatolian and Aegean. The highest wind speed is 6.36 m/s and the highest wind density is 319.5W/m² s in Bozcaada. However, the highest wind speed values given in the literature are 6.4 m/s in Karaburun and Karabiga, 7 m/s in Senkoy and 7.1 m/s in Nurdagi. The highest wind density recorded is 152.6W/m² in Bandırma [26].

The first wind power plant (wind farm), located in Cesme, Izmir, was commissioned in February 2001 in accordance with the auto production scheme. This plant has a total installed capacity of 1.5MW and provides 2.5–3 million kWh of electricity annually. The second Build–operate–transfer (BOT)-modeled windmill park, located in Alacati, Izmir, has been operating since November 1998. This wind power plant had 12 wind turbines with a total installed capacity of 7.2MW. On the island of Bozcaada, the third wind power plant (called BORES) was connected to the grid in July 2000. The plant is currently the biggest one in the country and has a total installed capacity of 10.2MW. Currently, wind energy projects are concentrated in the Aegean region (16 projects) and the Marmara region (nine projects) [19].

Table 7.9. Turkey’s wind energy potential over various regions

Region	Annual average wind speed (m/s)	Annual average wind density (W/m²)
Southern Anatolia	2.69	29.3
Mediterranean	2.45	21.4
Aegean	2.65	23.5
CentralAnatolia	2.46	20.1
East Anatolia	2.12	13.2
The Marmara	3.29	51.9
Black Sea	2.38	21.3
Mean of Turkey	2.58	25.8

In Turkey, wind energy measurements are being performed by DMI for climatic purposes. Since the DMI’s measurement stations are located mainly within central living areas, these measurements are quite far from representing correct and authentic values. For this reason, the wind speed and wind direction have begun to be measured by EIE in the areas having high potential and on which it is considered to install wind power plants in 1990. If the shore-line and mountain-valley formations of Turkey are taken into consideration, Turkey has a rich

potential in terms of wind energy. In 1983, EIE started a study to perform R&D (Research and Development) projects in the field of wind energy. In order to determine the available potential as a first step of this purpose, the data of wind speed and direction for a 10-year-period (between 1970 and 1980) obtained by DMI has been evaluated as average wind power density and wind speed for seven geographical regions of Turkey, as shown in Table 7.10. These values show that the region with the highest density, having a value of 51.91W/m^2 , is the Marmara region and the one with the lowest density is Eastern Anatolia with a value of 13.19W/m^2 .

Turkey initially had started to generate electricity with a plant at Altinyunus Hotel in Izmir–Cesme in the Aegean region with a capacity of 55kW in 1986 [14]. Later, between 1986 and 1996, a few attempts were made in this field, but unfortunately they failed. In 1994, the first wind power project in a type of Built–Operate–Transfer (BOT) was submitted to the Ministry of Energy and Natural Resources (MENR). So, the first plant has been taken into operation in Izmir–Cesme–Germiyan with a capacity of 1.5MW in 1998 [27]. By September 2006, Turkey’s installed capacity has reached 50.1MW accompanied by starting operation of the Bandirma Wind Energy Plant (BARES) with an installed capacity of 30MW, as seen in Table 7.11.

Although the objected development level has not been achieved yet, it is foreseen that wind energy will have a share of 2.02% (4890 GWh) of Turkey’s total energy generation by the year 2010 (see Table 7.12.), as mentioned in energy generation projection prepared by TEIAS. However, in spite of Turkey’s technical wind energy potential of 88 GW and economical potential of 10 GW, current studies show that it would not be possible to achieve these goals [29].

Table 7.10. Average wind power densities and speeds on a regional basis [28]

Region	Average wind power density (W/m ²)	Average wind speed (m/s)
Marmara	51.91	3.29
Southeast Anatolia	29.33	2.69
Aegean	23.47	2.65
Mediterranean	21.36	2.45
Black Sea	21.31	2.38
Central Anatolia	21.14	2.46
East Anatolia	13.19	2.12

Table 7.11. Installed wind power capacity of Turkey [28]

Plant name	Installation year	Capacity (MW)	Site
Delta Plastik—Autoproduction	1998	1.5	Izmir—Cesme—Germiyan
ARES Gucbirligi Company—BOT	1998	7.2	Izmir—Cesme—Alacati
BORES Demirer Company—BOT	2000	10.2	Canakkale—Bozcaada
Sunjut Industry—Autoproduction	2003	1.2	Istanbul—Catalca
BARES Bilgin Energy—Autoproduction	2006	30	Balikesir—Bandirma
Total		50.1	

Although there are an appreciable number of windy days in many parts of Turkey, the possibility of wind energy generation assessment has not been completed yet and, therefore, local research is on-going [30]. Electricity produced from wind energy between 1998 and 2005 in Turkey amounts to 345 GWh. The installed capacity of wind energy is expected to reach 51 MW by 2005 and 11,200 MW by 2025 [19], where the share of wind energy for generating electricity would increase from 0.04% to 3.6%. Table 7.13. shows the estimated wind energy capacities of Turkey between 2005 and 2025. Considering the development of wind energy in the country, it may be concluded that the number of the wind power plant installations will considerably increase in the future [30]. Turkish Wind Energy Association plans a new project on preparation of wind atlas of Turkey. This project will be carried out jointly by state meteorological service (DMI), General Directorate of Electrical Power Resources Survey and Development Administration (EIE) and Bilkent University Communication and Spectrum Management Research centre (ISYAM).

Table 7.13. Estimated wind energy capacities of Turkey between 2005 and 2025 [31]

Years	Installed Wind Energy Energy (MW)	Electricity Generation through Wind Energy (GWh)
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2005	365	1189
2010	3292	6524
2015	5853	12012
2020	8475	18109
2025	11219	25000

7.1.4. Solar energy

Among the alternative clean energy sources in Turkey, the most important one is the solar energy. Turkey has a more chance than the other countries in terms of solar energy potential due to its geographical situation. Turkey's gross solar potential is calculated as 88 billion tons of oil equivalents (toe) per year, of which 40% can be, used economically. Three-fourths of the economically usable potential is efficient for thermal use and the remainder for electricity production. Solar radiation and sunshine duration in various regions of Turkey are given in Table 7.14. The average solar radiation is 309.6 cal/m²day and the average sunshine duration is 7.2 h/day. In particular, the southeast Anatolia and the Mediterranean regions are favorable for solar energy use. Generally, solar energy is used for heating and the consumption of solar energy has increased from 5 ktoe in 1986 to 375 ktoe in 2004 [1].

Table 7.14. Solar radiation and sunshine duration in various regions of Turkey [32]

Region	Solar radiation (cal/cm ² day)	Sunshine duration (h/day)
Southeast Anatolia	344.8	8.2
Mediterranean	328.3	8.1
East Anatolia	322.4	7.3
Central Anatolia	310.3	7.2
Aegean	308	7.5
Marmara	275.9	6.6
Black Sea	264.5	5.4
Average	309.6	7.2

Due to its location, Turkey has virtually rich solar potential as shown in Table 7.14. The most common field of use is hot water systems. The installed solar collector area was recorded as 7.5 million m² in 2001 and 10 millionm² in 2004. From these collectors, commonly used in Mediterranean and Aegean regions, heat energy about 290 and 375 ktoe/year was provided in 2001 and 2004, respectively [33] [21]. Because of the rich potential, it is possible to benefit from solar energy in the other regions of Turkey, too. The

electricity generation from the solar is realized by PV and solar collectors. Unfortunately, PVs have high installing costs; hence, an economical usage of them is not available today. In Turkey, the Ministry of Environment and Forestry (forestry observation towers), Turkish Telecommunication Companies (transfer stations), the Highway Board Department (emergency calling, traffic management systems), EIE (demonstration applications) and various research associations (most of them are off-grid) have a common installed PV capacity of 300kW.

The mentioned EIE study derived benefit from Turkish State Meteorological Service's (DMI) data of solar energy and radiation periods between 1966 and 1982, which determines the total radiation period as 2640 h and total solar energy as 1311kWh/m² year. [21].

In the result of the technical calculations, solar technical potential has been determined as 6105 TWh/year as seen in Table 7.14. Only 5% of this technical potential (equal to 305 TWh/year) is economically available for electricity generation [4].

7.1.5. Bioenergy

Due to the prevailing geographical and meteorological conditions, Turkey is very suitable for forestry and agriculture. The sum of the agricultural areas, grasslands and forests constitute 93.6% of the total area of Turkey. The annual average biomass yield of forests is estimated to be 188 million tons (Mt), followed by agricultural areas at 180 Mt and grasslands at 174 Mt. This represents a total dry biomass of 542 Mt annually [30]. The annual biomass potential of Turkey is approximately 32 million tons oil equivalents (Mtoe).

The total recoverable bioenergy potential is estimated to be about 16.92 Mtoe. In recent years, Turkey's main renewable source is biomass and animal waste (67.4% of thermal electrical power stations), but expected to decline in share and absolute terms in the future as the convenience and options of oil, natural gas and liquefied petroleum gas, coal or electrical heating and cooking become available

The technical potential of conventional biomass is about 10 mtoe while the currently available potential is about 7mtoe/year in Turkey. However, it would be more agreeable to use the technical potential of modern biomass instead of conventional biomass. In this regard, the technical potential of Turkey is about 40mtoe and the currently available potential is about 25mtoe/year (see Table 7.2.). The amount of vegetable waste (in dry form) from grain plants in Turkey is about 55–70 Mt. The available part of this waste, which could be used in several

areas including power plants, is about 37–48Mt. As it is seen in Table 7.15., the available energy generation in 1998 was 653–839PJ/year (14–19mtoe/year) [33].

The available amount of animal waste (in dry form) is about 10.8Mt while the available biogas from the manner is about 200m³/ton what equals to an energy potential of 49 PJ/year assuming an average heating value of 22.7 MJ/kg (1117 ktoe/year). Further the total amount of municipal waste is about 21Mt/year. Assuming that these wastes have an average heating value of 15 MJ/kg, the energy potential calculates to 315 PJ (7150 ktoe/year). In 2007, electricity generation with an installed capacity of 13.8MW was available from bio-potential. This amount divides into 9674kW achieved from waste-to-energy power plants and 4127kW achieved from biogas power plants [34]. In Turkey, there is a use of conventional biomass in form of wood and dried dung; however, modern biomass use is limited related to energy crops [35].

Table 7.15. Turkey’s biomass energy potential

	Agricultural waste	Animal waste	Municipal waste
Quantity (Mt/year)	37–48	10.8	21
Lower heating value (MJ/kg)	17.5	22.7	15
Achieved energy (PJ/year)	653–839	49	315

7.1.6. Contribution of renewable sources to electrical energy production of Turkey

Total installed capacity reached to 38,820MW by the end of 2005 [36]. If forecasts prove correct, Turkey may need to triple its total installed capacity, to around 109 giga-watt-hours (GWh), by 2020. [36]. Turkey’s electric capacity development in the near future is given in Table 7.16. Over the next three decades, it is expected that many foreign investors and financiers will be interested in the Turkish hydropower market. Geothermal energy should be available in Turkey since it lies astride deep geological faults, and could be utilized, in selected locations, to cover a share of electricity demand.

Table 7.16. Turkey’s electric capacity development in the near future [19]

Energy source	2010		2020	
	Installed capacity (MW)	Generation (GWh)	Installed capacity (MW)	Generation (GWh)

Hydro and other renewables	24,982	85,719	30,031	104,043
Natural gas	18,856	125,548	34,256	225,648
Coal	16,106	104,035	26,906	14,235
Fuel oil and diesel	3125	17,993	8025	49,842
Nuclear	2000	14,000	10,000	70,000
Total	65,069	347,925	109,218	463,768

According to maximum-case-projection for electricity generation for the period 2006–2020, drawn by the Turkish Electricity Transmission Company (TEIAS), the share of renewable power plants in total electricity generation is estimated as 29.63% while the use of natural gas is estimated as 45% with a value of 79,355GWh for year 2006 as shown in Table 7.17. In the mentioned projection aiming an annual growth of 8% in the electricity generation, it is expected that natural gas will have a share about 33.38% and renewables about 23.68% for the year 2020 [5] [28]. Also nuclear power plants which are considered for coming in service after 2012 will take a place in energy sector according to this plan. It is foreseen that nuclear plants will deliver 10,527GWh in 2012, which will increase up to 31,579GWh in 2015. The Turkish Nuclear Energy Institution (TAEK) has specified following regions for the installation of nuclear power plants: Beysehir–Seydisehir (Konya), Nallihan–Beypazari, Akcakoca–Eregli, Sinop (Black Sea shore-line), Akkuyu (Mersin), Igneada (Kirklareli), Kirikkale–Nevsehir (throughout Kizilirmak River). The studies on this subject are still in progress [28].

Table 7.17. Turkish electricity generation projection by sources (GWh)

Years	Lignite	Hard coal	Petroleum	Natural gas	Imported coal	Wind	Hydraulic	Nuclear	Import	Renewable	Total
2006	26,157	1802	8873	79,355	7937	2402	49,874	0	0	29.63	176,400
2007	49,986	1042	260	72,040	9954	3841	53,579	0	0	30.11	190,702
2008	51,117	1627	2055	82,654	9975	4192	54,779	0	0	28.56	206,399
2009	54,171	1667	5741	92,461	9978	4541	54,941	0	0	26.61	223,500
2010	54,328	1691	6949	106,789	9980	4890	57,393	0	0	25.73	242,020
2011	61,056	1672	6610	116,863	9981	5238	60,580	0	0	25.13	262,000
2012	64,120	1634	6392	119,227	9978	5587	66,035	10,527	0	25.26	283,500
2013	70,737	1609	6792	128,364	9978	5938	72,154	10,527	0	25.51	306,099
2014	76,310	1591	6665	130,446	9975	6287	77,974	21,052	0	25.51	330,300
2015	82,867	1613	6856	134,200	9970	6636	82,479	31,579	0	25.02	356,200
2016	89,400	1555	5510	140,778	9956	6985	87,486	31,579	9750	24.66	383,001
2017	97,010	1549	5882	145,134	13,163	7334	92,799	31,579	16,250	24.39	410,700

2018	106,932	1548	6015	151,739	19,553	7684	98,300	31,579	16,250	24.11	439,600
2019	113,555	2296	6172	161,398	25,968	8033	104,249	31,579	16,250	23.91	469,500
2020	117,980	3561	6317	166,738	38,774	8382	109,909	31,579	16,250	23.68	499,490

Turkey's renewable energy potential is very important. But, the renewable energy contribution in the total primary energy production is insignificant. Presently, Turkey does not have any demonstrated success in renewable energy except hydroelectric energy. The renewable energy systems have been neglected so far in Turkey but must be included in the new energy programs. Over the next three decades, it is expected that many foreign investors and financiers will be interested in the Turkish hydropower market. Turkey has extended its involvement in geothermal energy projects, supported by loans from the Ministry of Environment, and geothermal energy is expected to increase substantially in the coming years. Considering the development of wind energy in the country, it may be concluded that the number of the wind power plant installations will considerably increase in the future. The installed capacity of wind energy is expected to reach 51MW by 2005 and 11,200MW by 2025, where the share of wind energy for generating electricity would increase from 0.04% to 3.6.

The use of renewable energy has a long history. Biomass, for instance, has been used for heating and cooking, while wind has been used in the irrigation of fields and to drive windmills for centuries. Although Turkey has many energy resources, all of these with the exception of coal and hydropower, cannot meet the total energy demand. Turkey has been importing resources to meet this deficit. These resources have become increasingly expensive and also have undesirably high emissions ratings. Turkey has an extensive shoreline and mountains and is rich in renewable energy potential. The share of renewables on total electricity generation is 29.63% while that of natural gas is 45% for the year 2006. The projection prepared for the period between 2006 and 2020 aims an annual growth of 8% for the total electricity generation. According to this projection, it is expected that renewables will have a share about 23.68% with a decrease of 5.95% while natural gas will have a share about 33.38% for 2020. This paper presents the present state of world renewable energy sources and then looks in detail at the potential resources available in Turkey. Energy politics are also considered. [Ozgur, 2008]

The energy supply and demand should be closely monitored and revised the forecasts to take account of the progress of liberalization, energy efficiency improvements, structural

changes in industry and other major factors. Medium and long-term forecasting of energy demand, which is based on realistic indicators, is a prerequisite to become an industrialized country and to have high living standards. Energy planning is not possible without a reasonable knowledge of past and present energy consumption and likely future demands. Energy demand management activities should bring the demand and supply closer to a perceived optimum. Turkey's energy demand has grown rapidly almost every year and is expected to continue growing. [38]

Energy transitions are the driving force for economical and technological development. Understanding long-term energy transitions and development trajectories is a great challenge in moving towards sustainable development in a globalizing world, especially for developing countries, like Turkey. Energy transitions are defined as; investments in possibly cleaner technologies to replace and expand the depreciating capital stock to meet growing energy demand. When considered a longer time horizon, significant changes in energy technologies and consumption could be observed. Energy is generally expected to play a major role in achieving economic, social, and technological progress and to complement labor and capital in production. Energy use increases as more economic sectors develop and more channels of flow are opened. Global energy demand will increase 60% more from 2002 to 2030—with yearly average 1.7% (if no action is taken) [39]. Development trajectories of energy can be characterized by sectoral changes in the economy [40], population, import and export of the country. Turkey has dynamic economic development and rapid population growth. As the Turkish economy grows, so does demand for energy. In practical terms, it means we are using energy more widely through increasingly efficient homes, cars, appliances and businesses. Therefore to develop and adopt efficient energy practices and technologies, is extremely important and prudent. The government should be advised to secure primary energy supplies and conversion capacity to enable the country to industrialize. The rapid growth from a low base suggests that Turkey still has to catch up with the industrialized nations in terms of economic development and industrialization.

With the beginning of planned development period in 1963, the combined demands of industrialization and urbanization in Turkey nearly tripled energy consumption in the 1960s and 1970s. The growth rate of primary energy consumption is greater than the growth rate of primary energy production. The gap between production and consumption of primary energy gets larger for Turkey and consequently the development gap between Turkey and the industrialized nations is not closed yet. It is obvious that, the economic growth in the future will be matched by strong growth in energy demand [38].

Turkey is highly dependent to imports to satisfy its energy needs. Due to lack of fossil resources, Turkey's dependency level is around 70%, which may rise over 80% by 2030. By 2010, Turkey's oil demand will increase by 96%. Currently Turkey satisfies 40% of its energy needs by oil. 90% of its oil supplies are imported from the Middle East (Saudi Arabia, Iran, Iraq and Syria) and the Russian Federation. When it is compared to the European Union, Turkey depends on import more and the volatilities in the Middle East may affect Turkey more, therefore Turkey has to diversify its energy sources. In 2001, natural gas was constituting 19% of its energy needs. It will rise to 32% by 2010 while oil will be 33%. This makes Turkey highly dependent, since Turkey imports almost all of its gas supplies. Turkey's electricity demand has been growing very rapidly. It has increased from 56.8TWh in 1990, to 118.5TWh in 2000, with an annual average growth rate of 8.1%. The growth in electricity generation in recent years was below growth in electricity demand. Therefore, Turkey has become a certain importer of electricity since 1997. The electricity demand of Turkey is expected to increase 555.7TWh in 2020. The installed electricity capacity has reached from 16.3GW in 1990, to 26.1GW in 1999, and is projected to increase to 104.9GW in 2020 [38].

Medium and long-term forecasting of energy demand based on realistic indicators is a prerequisite to become an industrialized country and thus to have high living standards. Overestimating the energy demand may cause redundancy in resources, while underestimating may cause series energy crises.

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CHAPTER 8

POLICIES AND LAWS SUPPORTING RENEWABLE ENERGY

8.1. Introduction

The EU member and candidate states apply a wide range of policy instruments in order to promote the use of renewable energy sources. Policy instruments include green certificates, investment aid, tax exemptions or reductions, tax refunds and direct price support present different options, which includes feed-in tariff, quota obligation, tenders, exemption from energy taxes and earmarking, where part of the revenue from energy taxes is used to finance renewable energy sources in a way or another [1].

In general, measures taken to promote RES fall into eight categories [2]:

- *Economic and fiscal incentives* through subsidies, grants or tax breaks (or, conversely, disincentives such as a carbon tax competing fuels or full cost pricing),
- *Guaranteed markets and/or favorable prices* for RES,
- *Government-funded R&D* on RES
- *Information and education campaigns* to increase awareness of RES performance, availability and incentives,
- *Regulations and standards* on energy use and its environmental effect,
- *National targets*: i.e. quantified plans for renewable energy development either by source or by sector,
- *Voluntary actions (VAs)*, generally between governments and industries/utilities,
- *Green pricing*, whereby customers choose to pay more green energy.

8.2. Turkey

The Ministry of Energy and Natural Resources is the main body for the formation and implementation of energy policy in general and renewable energy in particular. The Electric Power Resources Survey and Development Administration (EIEI) carries out investigations and surveys to identify the energy potential of water, wind, and solar energy resources. If large hydropower generation potential is located and considered for realization in the renewable energy group, the Directorate General of State Hydraulic Works (DSI) is the main implementing organization. The main state organizations having responsibility for planning the energy policy in Turkey are given in Table 8.1. [3].

Table 8.1. Main state organizations having responsibility for planning Turkish energy policy [3]

Organization Name	Under the Responsibility of:
DPT, State Planning Organization	Prime Minister
TUBITAK, Scientific and Technical Research Council of Turkey	Prime Minister
Research, Planning and Co-ordination Board	Ministry of Energy and Natural Resources
Directorate General for Energy Affairs	Ministry of Energy and Natural Resources
Directorate General of Mining Affairs	Ministry of Energy and Natural Resources
Directorate General of Petroleum Affairs	Ministry of Energy and Natural Resources
TEUAS, Turkish Electricity Generation Company	Ministry of Energy and Natural Resources
TEIAS, Turkish Electricity Transmission Company	Ministry of Energy and Natural Resources
TEDAS, Turkish Electricity Distribution Company	Ministry of Energy and Natural Resources
TETTAS, Turkish Electricity Trading and Contractor Company	Ministry of Energy and Natural Resources
DSI, Directorate General of State Hydraulic Works	Ministry of Energy and Natural Resources
TPAO, Turkish Petroleum Company	Ministry of Energy and Natural Resources
EIEI, Electric Power Resources Survey and Development Administration	Ministry of Energy and Natural Resources
BOTAS, Turkish Pipeline Corporation	Ministry of Energy and Natural Resources
TKI, Turkish Coal Enterprises	Ministry of Energy and Natural Resources
Turkish Hard Coal Enterprises (TTK)	Ministry of Energy and Natural Resources

The above directorate generals are operating under the Energy and Natural Resource Minister and his Undersecretary. Therefore, the main body responsible for energy policy is the Ministry of Energy and Natural Resources. All groups receive directives from the Ministry and implement the policy accordingly. As indicated above, there is a separate Department of Energy Directorate General, which reports to the Minister and his Undersecretary. The Energy and Natural Resource Minister reports their works to the Prime Minister. There are also some non-Ministerial agencies with responsibilities for various aspects of energy policy [4].

Large hydropower provides around 20-25% of Turkish power requirements. Until very recently this has been the only non-fossil power production in the country. The EU accession process has produced several results on the policy side. The three important contributions of EU harmonisation have been:

1. The Renewable Electricity Law;
2. The Energy Efficiency Law which was passed by the parliament and will be effective after relevant directives have been published;
3. The amendments to the Petroleum Market Law (Biofuels Petroleum Market Law (Law No. 5015)) exempting biofuels from fossil taxes and stipulating 2% ethanol in automotive fuel.

Despite favourable statements from the government regarding RES, Turkey has set no targets on the proportions of RES in the energy matrix. Despite heavy dependence on foreign import of primary fuels for heat as well as power and transportation, a plan to decrease this dependence has not been announced either.

Turkey is a large agricultural producer and has significant biofuels potential. Oil seed cultivation potential is estimated to be 2-2.5 million tonnes per year. Currently 7% of cultivable land area is used for oil seed agriculture and the target is 15%. An estimated 2,000,000 hectares could be used to grow energy crops.

The RES-Electricity law, basically modeled after Germany's Renewable Energy Act [5], passed by the Turkish Grand National Assembly (TBMM) in May 2005 has allowed increased penetration of the power grid, formerly completely dominated by natural gas power production, by wind and hydro. Singular examples of electricity production via geothermal and biomass fuels exist.

Turkish market in RES-Heating has been traditionally strong with total solar collector area reaching 12 million m² in 2007. Some district heating applications have been done using geothermal energy in the Aegean region. The tax waiver on biofuels suddenly exploded biodiesel capacity but also put pressure on vegetable oil production in the country. The situation became unsustainable with the large imports of oil seeds and the law was amended to only give tax exemptions to biofuels production originating from the use of local agricultural oil seed production.

Turkish Law no: 5346 pertaining to RES-Electricity came into force on 10 May 2005. This law and its secondary legislation built on previous laws in the energy sector, particularly Law No: 4628, deregulating the power sector, and its secondary legislation, and other laws (such as environment law, law on appropriation of public-private land etc.). The support system can be summarised as:

- Feed-in tariff (FIT) for all technologies is determined by the EPDK (Electricity Market Regulation Authority) and is the previous year's average wholesale price
- The price cannot be below 50 €/MWh and cannot be above 55 €/MWh
- The rate is valid for 10 years for plants starting up before 31.12.2011

The renewable electricity law with its feed-in tariff has increased investment activity in Turkey in both the wind and hydro power sectors. Despite the fact that the FIT rates are very low, the investors have been able to use the lower price guarantee and duration as a leverage for borrowing money for their investments and actually call the law an 'insurance' law rather than a 'support' law.

Grid-connected solar electricity does not exist in Turkey due to very low, across the board FIT support for RES-Electricity. The only positive development regarding solar electricity has been the few articles in the energy efficiency law that removed some of the non-technical

barriers to gridconnected solar electricity. The most relevant of these is the licence-waiver for roof-produced electricity up to a power of 200 kW. It is calculated that grid-connected solar electricity would be feasible in southern Turkey with a FIT rate of 200-250 €/MWh.

There is no supportive legislation regarding solar hot water systems in Turkey. The widespread use is totally due to the economics of the situation and the presence of low-cost producers. Biodiesel and bioethanol produced from domestic agricultural produce are exempt from the tax regime applied to transport fuels up to 2%. Up to 5% addition of bioethanol to benzene allowed, according to standard TS EN 228. Farmers Cooperatives can enter into biofuel purchase agreements with biofuel producers (tax exempt), the amounts of which should be equivalent to the agricultural products their shareholders have produced. Firms with annual production capacity of > 30,000 tonnes can apply for a production licence [6,7].

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