

ASSESSMENT OF THE TURKEY'S ELECTRIC POWER POLICIES IN TERMS OF SUSTAINABILITY

by

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This study, using statistical data published by the Turkish Electricity Transmission Company, analyzes key parameters such as installed capacity and energy demand growth rates, investment plans and emission rates, taking into consideration the expected increase in use through the year 2023. The results of the analyses were compared to relevant data from around the world. The weight of domestic – and especially renewable – resources in investment plans for the next 10 years was discussed. Recommendations for an investment plan to support sustainable development in Turkey are listed. Consequently, the lack of investment in domestic and renewable energy projects decreases the competitive power of Turkey vis-à-vis Organisation for Economic Co-Operation and Development countries in terms of many parameters. For a sustainable development, the country must make significant changes in its foreign-dependent energy production policies. Any future policies must encourage supplying local resources to meet the continuously increasing demand. Qualifications for incentive mechanisms applied to investments in renewable energy should be developed. The impact of the private sector on the installation of new plants must also be increased by quickly completing the privatization process

Key words: sustainability development, energy, Turkey, foreign dependency, planning, privatization, electricity theft

Introduction

Energy is a concept that can be influenced by large integer variables that are not directly related technically. For example, the Fukushima nuclear power plant accident that occurred in 2011, the financial crises in 2008, 2009, and partly 2010, political uncertainty and regime change in Arab countries, and rising unemployment rates are developments that will affect all countries' energy policies for the next 10 years. One of the most influential parameters in the development plans of the world's countries is the energy production planning and gathering of increasing demand.

Turkey, located at the intersection of three continents in terms of its geographical position, is of vital importance for the transfer of energy from Central Asia and the Middle Eastern countries with their reserves of deep fossil fuels on the one end and European Union countries on the other. This is why Turkey is expected to continue to develop in political, social and economic terms. Turkey is far behind the OECD countries in terms of energy supply per person. In 2011, while the annual power supply per person of the OECD countries was 9.65 MWh, this figure was 3.017 MWh in Turkey [1]. However, in the following 10-year

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period, a significant number of electrical energy generation transmission and distribution plants are included in the investment plans of Turkey.

Legislation enacted and support provided to the private sector on this issue led to significant developments, especially over the last two years. Turkey, one of the countries that signed the Kyoto protocol, also aims to use sustainable energy production models. This study researches the energy profile of Turkey and the features of its investment policies in terms of sustainable development. The first section briefly introduces the concept of sustainability, its indicators and power systems deemed sustainable. The second section examines the current state of Turkey's energy infrastructure. Its delicate and powerful sides in terms of sustainable development are analyzed. The final section analyzes, in the context of the data obtained, whether the developments expected by 2020 and beyond are consistent with sustainable energy production policies.

The sustainability concept

Sustainable development is defined as a situation with which the next generation can meet the needs of today's world without jeopardizing their ability to meet their own needs [2]. All the activities related to production order use the world's consumable resources at the lowest possible level. The life cycle cost analysis is an international, standard and acceptable tool to evaluate the impact of a production or service with respect to determining sustainability indicators. Furthermore, methods such as input-output analysis, matter and energy balances, and positive power accountings are being used [3]. Its scope in terms of electrical power production can be summarized as follows: keeping waste materials produced while meeting the requirements of today's increasing demand for energy at a level that may be eliminated by natural ways, keeping human health-related risks at the lowest possible level, and generating electricity using the lowest possible amount of raw materials [4]. In short, the sustainable energy production that may be defined under the "green energy" concept aims for the reduction of natural resource utilization, sera gas emission and production methods resulting in the least possible level of waste. This manner hopes to achieve a slowdown of global warming and climate changes as well as to establish new and long-term employment opportunities and economic development distributed in a more realistic way around the world [5-8].

Sustainability indicators

Publications of international energy organizations use the 3A principle (Accessibility, Availability, Acceptability) for power generation technologies as an indicator of sustainability. Based on this basic approach, many indicators such as unit energy cost, sera gas emission, resource availability, efficiency, freshwater consumption, land use, positive public perception and new work power potential can be examined. In terms of public opinion awareness, it can be said that renewable, clean energy resources are sustainable. However, when a comparison is made by considering the indicators listed above, nuclear technologies have also a decisive advantage despite negative public opinion awareness [7-10].

Sustainable energy technologies in 21st century

Organizations such as the World Energy Council (WEC) and the International Energy Agency (IEA) make forecasts about different scenarios related to future energy consumption and power generation technologies. The primary energy resource consumption expectations suggested by the IEA for 2035 are given in fig. 1. According to the current policies sce-

nario, the annual energy demand growth in the world will be 1.6%. The energy demand, 12.1 billion tons of oil equivalents (TOE) in 2009, will rise to 18.3 billion TOE, a 51% increase. The world will continue with policies dependent on fossil fuels such as coal, petroleum and natural gas, and the percentage of such fuels in total consumption will remain at around 80%. Renewable sources will be used in the production of 14% and nuclear systems in the production of 6% of total power supply.

According to the different legislative approaches scenario dependent on energy efficiency, as a result of an annual 1.3% and a total 40% increase, energy demand will arise to 16.9 billion TOE. The share of fossil fuels in the entire production will regress to 75%, with a decline in coal. On the other hand, renewable energy production will be 18% and nuclear systems 7%. The most optimistic scenario suggested by the IEA is 450 ppm sera gas. This target is called the "450 ppm scenario." Accordingly, world power generation systems will make progress in terms of using renewable energy sources. Furthermore, creative energy use and saving policies will continue to be used effectively. In this situation, the annual growth demand will be 0.8%, with an overall increase of 23%. Energy demand will rise to the level of 14.85 billion TOE. In addition to this confident expectation related to the increase, the share of renewable sources in production will attain a highly competitive level such as 27%. It is estimated that the shares of nuclear energy and fossil fuels will be 11% and 62%, respectively [11, 12].

Electric energy profile of Turkey

Turkey has made valuable economic progress, especially within the last 10 years. Gross national product (GNP) and income per capita continue to increase. The country has to implement an energy policy based on the reliability of the supply of power. The primary purpose is to give priority to local sources, increase production source diversity and minimize risks resulting from import. Maintaining environment-friendly energy policies, increasing energy efficiency and improving the investment environment with fully operated free market conditions are among the goals of basic policies [13]. In parallel to these political approaches, especially in recent years, hydroelectric, wind and geothermal system investments have increased. The total installed capacity has increased by 101.4% over the last decade to reach 57 GW (in 2001 it was 28.3 GW). In particular, combined heat power plants that have significant advantages for private companies increased about five fold from early 1990 to 2004, rising from 2.82 GW to 10.97 GW. At the end of 2012, the installed capacity of natural gas stood at 14.1 GW. Because the combustion efficiency of lignite is low, using hard coal in the country has increased in recent years.

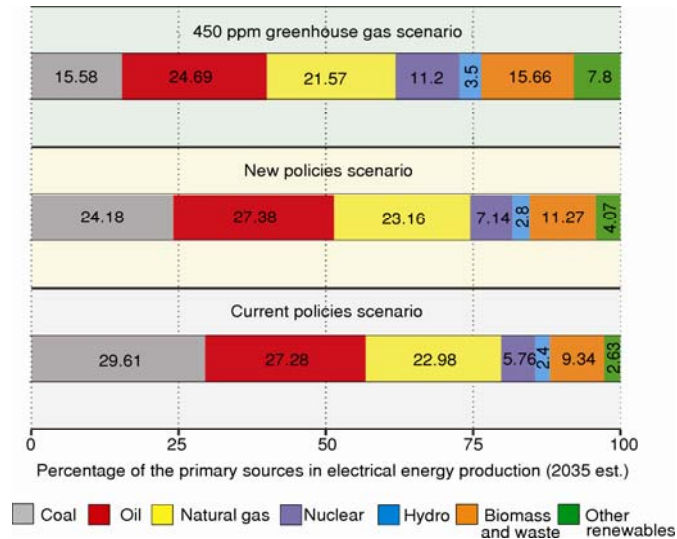


Figure 1. Expectations for the distribution of primary energy consumption [12]

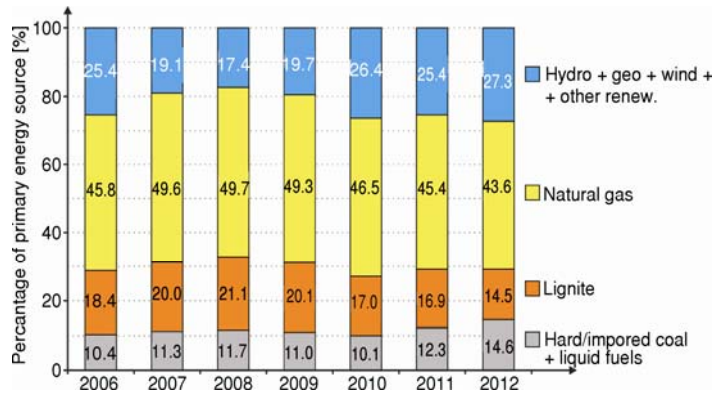


Figure 2. Turkey's gross electricity generation by primary energy resources [1, 17]

TWh. Especially in recent years, the amount of production from lignite decreased significantly. A full 21.1% of total energy produced (41.85 TWh) in 2008 was covered by lignite. In spite of the increase in total energy supply, electric generation from lignite has continued to decrease and regressed to 34.8 TWh at the end of 2012, with its total energy share coming out to 14.5%. In contrast, using higher quality coal fuels increased significantly. Imported coal and hard coal base generation, which produced 14.2 TWh in 2006, increased twofold by the end of 2012 to yield 33.32 TWh. Its share in total energy reached a significant figure of 14%.

Sustainable energy production handicaps

A 2012 energy report prepared by the IEA summarizes the parameters expected to be largely affected globally as follows:

- the shares of countries with developed economies in global energy demand and directional effects on the energy markets will increase parallel to the improvement in the personal life standards in such countries,
- the growth expectations in unconventional petroleum and gas production in the USA will reshape the energy balance and trade outside of the country,
- turning the marketing route from the Middle East to Asia as the demand for petroleum in growing Asian economies has increased, and protection of points along this route is becoming strategically vital,
- with Iraqi petroleum production having increased rapidly, increasing the total petroleum export of the country to about \$5 trillion by the summer of 2035 and its positive impact on the welfare of the country and global energy trade,
- the use of renewable sources in electrical power production will increase but depending on incentives and subventions given by governments,
- despite their popularity with governments, subvention mechanisms directed at fossil fuels have adverse effects on market operations and global warming,
- countries around the world use only one-third of the energy efficiency applications and benefit potential that may be ensured on the global scale. Using this potential fully is important in terms of energy security and economic benefits as well as keeping global warming below 2 °C, and
- Increasing demand for power production from water sources, pressure created by this situation on water sources and measures to be used to reduce that stress [14].

The distribution of electric energy production in the country according to source is given in fig. 2. Hydroelectric power plants that have the biggest installed capacity fall terribly behind the natural gas power plants in terms of the amount of energy generated. While 43.6% (104.5 TWh) of 239.5 TWh of energy generated in 2012 was obtained from natural gas, hydroelectric power plants produced about 57.8

Almost all of the variables listed above are closely related to Turkey. The country continuously increases its personal comfort level with its developing economic form. Because Turkey has close relations with the US and is a neighbor of Iraq, it is directly affected by economic and political developments in these countries. Being in the geographical location to serve as a bridge between Asia and Europe presents significant advantages, especially in terms of energy transportation projects. However, the obstacles that stand in front of Turkey to establish sustainable development-purpose policies for the energy sector are explained below.

Foreign dependence

Despite the positive developments stated in previous sections, Turkey is highly dependent on foreign countries, especially in primary energy sources. Because Turkey could not use its native sources efficiently and due to other factors, such as not finding any petroleum and natural gas reserves in drills it undertook, its foreign dependence ratio in 2011 was unusually high (73%). Figure 3 shows the country's change in foreign dependence in terms of primary energy sources. In 2011, 22% of total imports (\$240 billion) comprised energy imports (\$54 billion). A full 38% of energy imports (\$20.5 billion) facilitated electrical energy generation. This figure corresponds to 8.5% of total imports [12]. Foreign dependence in terms of electrical power is extremely dangerous. As seen in fig. 2, the country obtained 43.6% of 2012 power production from imported natural gas and 6.2% from imported coal. This situation indicates that foreign dependence in electrical power production is at 50% [15-17].

The source diversity comparison of the country against average world power production can be seen in fig. 4. The demand for natural gas is about two times the world average. The import of natural gas wholly negatively affects competitive power and energy expenditure policies. Furthermore, the share of renewable energy sources in production is 25%, significantly above the world average (18%). Coal use has a competitive value of 29%, compared with the world average of 41%. In this regard, it can be said that the country's existing energy profile possesses a sustainable structure. However, technical and financial risks to be listed in the following sections require the taking of significant political and economic measures [17]. Figure 4 also suggests the necessity of diversification of production sources in the country. In particular, with the correct use of internal source potential, risks resulting from generation dependent on some sources must be reduced. No use of nuclear technology in the country and keeping renewable energy systems at relatively low levels establishes a framework dependent on fossil fuels and hydroelectric systems. This is why it is inevitable for this power system, one which depends on climatic changes, energy balance policies between countries, energy prices and international agreements like the Kyoto protocol, to have a supply risk.

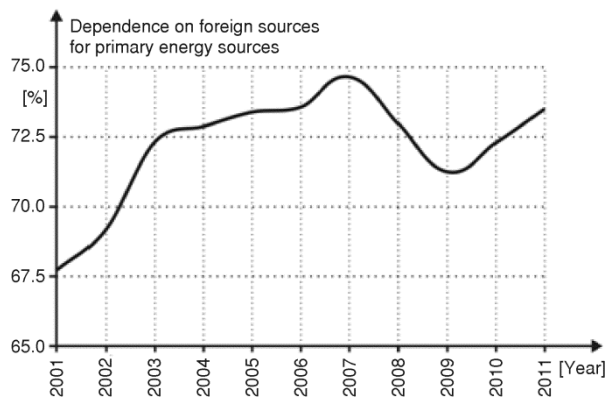


Figure 3. Foreign dependency in terms of primary energy sources [18]

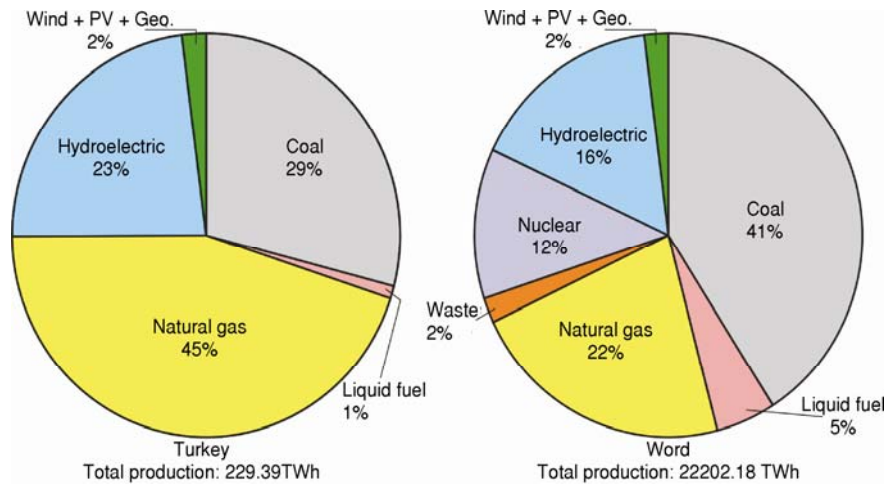


Figure 4. Electrical energy generation sources [1]

Illegal energy usage (electricity theft)

Turkey faces illegal electrical consumption above the world and OECD average. The total rate of transmission and distribution (T&D) losses in 2012 stood at around 15.3%. The rate of technical losses resulting from features of the system is accepted as 6%. In this case, about 10% of total production was not invoiced as a result of usage. This rate corresponds to 22.8 TWh annually. Its monetary value is about \$2.2 billion. Furthermore, depending on the country's demand for energy, it tends to grow from year to year. For instance, although the demand rate was comparable between 2011 and 2012, the power lost increased by 4.7% [17]. Turkey is among the five OECD countries that remain above the 15% illegal/lost rate. In recent years, significant steps have been taken in privatization to decrease lost/illegal usage rates in some regions. However, the lost/illegal utilization rate is a key reason for the slowing down of privatization activities and for distribution companies not finding buyers at desired values.

Troubles in privatization sector

Turkey continues its policies focused on privatization in power production and distribution. As part of the first phase of privatization applications, the most effective way to eliminate public ownership in the electric sector, some of the 20 electric distribution companies were transferred to private companies and some of them are in the process of being transferred. However, this process advances extremely slowly in regions with infrastructure problems that have high illegal electric usage rates. For instance, the distribution system privatization in southeast Anatolia, the most problematic part of the country in terms of lost illegal electric consumption charge, was carried out in March 2013. For the Istanbul-Anatolia and Istanbul-Europe regions, where the most valuable material losses have been seen in terms of lost/illegal electrical use size and infrastructure problems, the privatization process has continued for a long time. With the privatization of such regions, technical and economic gains in the middle and long term may be expected. By providing an immediate private sector contribution, especially after 2010, in energy generation, the share of private companies in installed capacity was raised to 56.6% and the rate in generated energy amount to 62% by the end of

2012. The country's energy investor companies do not include structures to meet billions of dollars in cost of power plants such as nuclear, coal or large hydroelectric plants. They tend to invest in solar, wind, small hydroelectric power plants or natural gas cycle power plants. In this situation, supply reliability must be ensured by means of the government [18].

High energy prices

An important result of external dependence is the high prices of energy in the country. Though Turkey has ensured a definite growth in electric power price stability, it applies electrical power prices above the OECD average. Energy pricing applied in 2012 for the industry is 13.4% above the OECD average. The power unit cost of 0.185 \$/kWh for housings is 6% above that of the OECD (0.174 \$/kWh). That same year, the figure was 0.119 \$/kWh in the US. The important factor for the energy price differences is tax policies that differ from country to country.

Rapidly increasing energy demand

Estimates were made in the electric energy market according to two different scenarios. The first suggested that if the energy market develops at the rate of 7.9% per year on average, in 2012 there would remain power to spare, and the installed power supply and peak power demand would come to a breakeven point. According to this scenario, in 2020, peak energy demand would be 79.35 GW and annual energy demand 500 TWh. This scenario did not play out because of the 2009 economic crisis. 2009 and 2010 saw decreases in energy demand. The second scenario envisages annual energy demand growth at a rate of 6.4% on average. Accordingly, an energy reserve would remain in the year 2014, and installed energy supply and peak power demand would come to a breakeven point. According to this scenario, in 2020, the peak power demand would come out to 66.6 GW and energy demand to 407 TWh. The estimates of change in energy demand made by TEIAS using MAED (Model for Assessment of Energy Demand) are given in fig. 5 as a graphic. The crisis experienced in 2009 forced some small flexible changes to these estimates. For instance, the

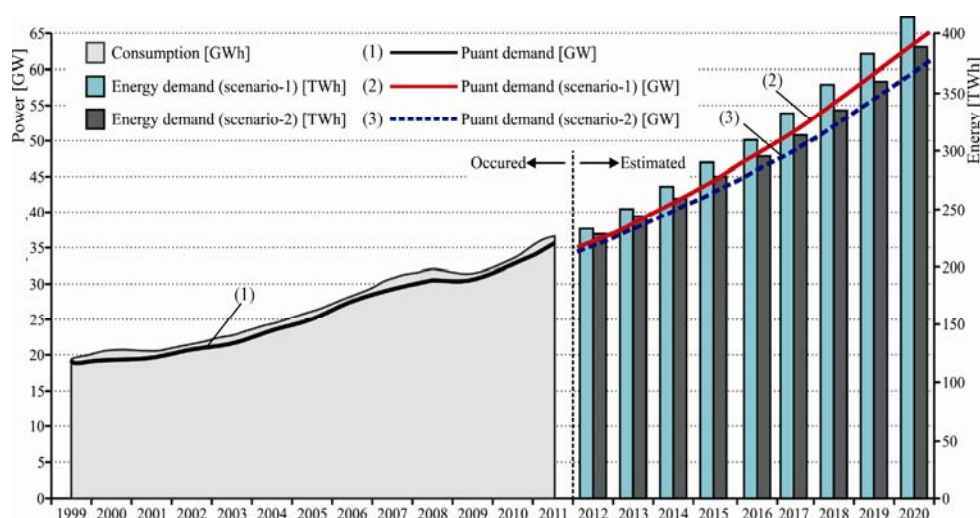


Figure 5. Peak load and energy demand of Turkey between 1999-2020 years [17, 20]

500 TWh value estimated by TEIAS for 2020 was revised to 400 TWh. If these scenarios play out, the rate between demand growth and economic growth (flexibility coefficient) is expected to decline to a value of 1.0 by the end of 2020, down from 1.6 in 2004. This prediction of regression clearly indicates that the chance of being pushed into an energy blockage is relatively high [19, 20].

According to both scenarios, the installed capacity additions planned to be made by the country in the system and distribution of sources are given in tab. 1. The investment density is typically distributed between 2011 and 2020. Among the country's most valuable investment plans is the construction of a four-reactor nuclear plant (VVER-1200), with nuclear power producing a total of 4,800 MW within the next 10 years. To this end, the necessary legal procedures and ground studies were completed with the agreement signed with Russian capital Akkuyu Nuclear Power Plant Power Generation Inc. on Dec. 27, 2010, and at present this plant is in the installation phase. To meet the rapidly increasing demand for electricity and minimize the risks resulting from import dependency, nuclear energy is planned to be included in the electrical power installed capacity structure at the rate of 10% through the year 2023. Attempts to install nuclear reactors planned for Sinop continue. The targeted nuclear installed capacity for 2023 is 10 GW, and the planned investment amounts to \$40 billion [16].

Table 1. Types of planned additional power systems, and application schedule [20]

Sources	Additional power plants [MW]					
	Scenario-1			Scenario-2		
	2011-2015	2016-2020	Percentage share	2011-2015	2016-2020	Percentage share
Lignite	4,520	5,520	15%	2,280	1,880	9%
Hard coal		1,200	2%			
Imported coal		4,500	7%			
Natural gas	6,000	5,450	18%	6,150	8,100	30%
Nuclear	4,500	4,500	14%	1,500	3,000	9%
Hydro	6,811	7,782	22%	2,752	7,644	22%
Wind	3,000	7,000	15%	3,000	7,000	21%
Solar	600	3,000	6%	600	3,000	8%
Geothermal	244	600	1%	244	600	2%
Subtotal	25,675	39,552	100%	16,526	31,224	100%
TOTAL	65,227			47,750		

High sera gas emission

Turkey has carbon density values slightly above those of developed countries. The main disadvantages in particular are limited government control of non-productive processes related to solid energy applied in the industry and the slow development of effective mechanisms that would prevent uncontrollable energy use. As seen in tab. 1, though fossil-fuelled generation technologies are given importance in funding plans made through the year 2020 (total of coal and natural gas 54%), most significant increases are being expected in sera gas emission amounts.

Factors such as investing more in natural gas and nuclear power plants that are more powerful than coal plants and using advanced technology filtering systems in plants to be newly installed prevent an increase in emissions. In particular, the SO_x swing will remain

constant during the process. Because of the low yield in filtering systems, CO₂ emissions will increase by 70% according to the first scenario and by 30% according to the second scenario. Consequently, SO_x oscillation per GWh demonstrates a reduction in both approaches. CO₂ oscillation remains almost constant [20-23].

In order to decrease emission rates in Turkey, the basic necessities are the privatization of distribution and production systems, increasing the percentage of natural gas among fossil fuels, and operating mechanisms that promote energy reserves. Furthermore, additional processes such as prevention of electricity theft, expanding the renewable energy systems market and increasing research on different resources – mainly the sea – must continue.

Insufficient and unproductive use of domestic sources

The strategic plans prepared by the Ministry of Energy see boosting energy efficiency and increasing the renewable energy share in consumption as necessary for the objective of minimizing effects on the environment. The ministry targeted reducing the amount of power consumed per GNP at the rate of 20% through the year 2013 when compared to 2011. Increasing foreign dependence to 73% in primary energy consumption will result in using all coal and hydro resources for the purpose of electrical energy generation through the year 2023. While domestic generation met 48% of the energy demand in 1990, this rate regressed to 29.7% in 2010 [24]. Table 2 gives the primary energy sources potential of Turkey, assessable economically, determined at the end of 2010 and their utilization rates. Furthermore, calculations show that the country can generate 18 TWh of energy annually from waves [24]. In recent years, a few scientific research projects have been realized on this subject. However, no power production plant has yet been installed.

Table 2. Domestic primary energy capacity of Turkey [13, 25, 26]

Source	Amount		Capacity can be installed [MW]	Energy can be generated [billion kWh/year]	Installed capacity [MW]	Benefit ratio [%]
Lignite	11.40	billion tons	18,000	120	8,199.30	45.55
Hard coal	1.30	billion tons	6,000	6.50	4,351	72.52
Hydro	129.40	billion kWh/year	46,700	170	17,137.10	36.70
Wind	48,000	MWh/year	40,000	60	1,728.70	4.32
Geothermal	32,100	MWh/year	2,000	16	114.20	5.71
Biomass	8.60	MTEP	5,000	30	30.00	0.60
Solar	32.60	MTEP	20,000	380	0.20	0.00
Natural Uranium	9.13	ton	1,000	7	0.00	0.00
TOTAL			138,700	789.50	31,560.50	22.75

Lack of incentive mechanisms for renewable energy investment

Incentive mechanisms applied globally for renewable energy can be summarized as follows: (1) Fixed feed-in tariffs, (2) premium, (3) quota-based green certificates, (4) tender incentives, (5) investment incentives, and (6) tax exemptions and reductions. The milestone of

renewable energy policies in Turkey is the Law No. 5346 on the use of renewable energy resources for the purpose of electrical energy production, enacted on May 10, 2005. According to this law, Turkey applies the fixed-price guarantee as a method of promoting the use of renewable energy. Furthermore, the law also introduces direct incentive mechanisms for plant investments supplying electro-mechanic systems domestically as production, research and development and land allocation [27].

The effects of these incentive mechanisms were observed in a short time and installed wind power increased from 50 MW (in 2005) to 2,300 MW (in 2012). Similarly, hydroelectric power increased from 12,906 MW to 19,606.4 MW. Geothermal and solar power plant investments have also started to improve, especially in terms of the very broad potential investment opportunities in solar energy. The goal of disseminating and encouraging the use of solar energy was put in the Strategy Document to form the basis of these studies [28]. Moreover, with the Renewable Energy Law, dated Jan. 8, 2011, the highest unit price guarantee is provided to energy produced by solar power plants. However, the world's most successful countries in renewable energy investments such as Germany, Spain, Denmark, and Netherlands utilize more than one incentive mechanism simultaneously, and especially tax exemptions, a quota system, fixed feed-in tariffs and investment promotion.

Results and discussion

Turkey has a sufficient and abundant amount of resources and economic potential for electric power generation policies to ensure sustainable development. The most significant disadvantage of the country's existing installed capacity and power generation systems are their foreign-dependent form. The gigantic hydroelectric potential of the country in assessable structure presents a valuable opportunity for sustainable development [29]. Negative impacts of large hydroelectric plants on key parameters such as climate, social life, and historical and cultural matters have been seriously discussed. For this reason, investing in small hydroelectric plants is inevitable. In 2010, the utilization percentage of the country's hydro resources in total was 36.7%. The aim is to increase that percentage to above 80% by 2023. So the installed hydraulic capacity will be about 40 GW. A very significant domestic resource rate will be obtained within the targeted 100 GW installed capacity.

An important contribution to the sustainable growth model will be made by completing the nuclear power plant projects. The nuclear energy market, first put into operation in 1954 and developed progressively until 1986, took a prominent below following the Chernobyl and 2009 Fukushima-Daichi disasters. The other reasons for regression are the entrance of natural gas to the energy market and the decrease of interest in this sector, which requires significant investment as a result of the recession in the global economy. The share of nuclear power plants in the world's power production increased above 17% at the end of the 1980s. As of the end of 2012, this rate was 13%. However, extremely strong economies will benefit from that energy in high rates. Mean nuclear energy utilization in the US, Germany and the OECD is at about 20%.

Nuclear is believed to be the cleanest, safest and cheapest energy, but this perception has changed enormously over the last 30 years. Security related anxieties have caused many countries to tend in the direction of giving up this energy. On the other hand, though, it is also interesting to see nuclear energy put forth in constantly optimistic scenarios that predict limiting the increase in the emissions of greenhouse gases. As can be seen in fig. 1, the IEA's assessment for 2035 puts it at about 10%. Turkey aims to increase the percentage of nuclear energy to 10% by the end of 2023, as a country with a total 10 GW nuclear installed capacity.

This policy contains an important attack in terms of sustainable development. Nuclear power has significant scientific, economic and environmental advantages in highly valuable parameters such as greenhouse gas emission, unit energy cost, energy quality, foreign dependence and resistance to economic fluctuations.

The expectations reflected in investment plans with respect to the utilization of other renewable resources except hydroelectric resources are not at the desired level. As concerns these resources, the biggest investment will be made in wind systems. Wind plant investments are carried out by means of the private sector. In recent years, incentives given for the installation of renewable energy systems and improvements made to the purchase of generated energy have increased the investments made in this area [30, 31]. To increase diversity in generation, using these resources efficiently is extremely crucial. Energy efficiency is the main heading included in sustainable energy models of all countries. If Turkey realizes the targets in the 2011-2023 Energy Efficiency Strategy Document, there will be significant development in this area. However, reducing lost/unauthorized use rates below 10% and decreasing carbon emissions must be considered under this subject title [32].

Conclusions

Energy investments planned to be made by Turkey within the next 10 years were assessed in terms of sustainable development. The most obvious targets of the country are to minimize the environmental pollution resulting from power generation, to use energy efficiently, to invest in clean and renewable energy sources as a priority and to implement incentives [31]. The most significant disadvantages of the sustainable energy model are foreign dependence, the private sector's tendency to invest in small hydroelectric power plants, wind and natural gas sources and the lack of a powerful legal infrastructure related to energy efficiency.

Table 3 compares the compatibility of the country's policies with accepted degrees of sustainability. Developments related to each generation source are scored starting from 1. Values in the second column of tab. 3 are taken from [7, 8]. Calculations of the sum of scores given to each source are listed in the last column in a way so that the source with the smallest total is equal to 1. As can be seen, hydro, nuclear and wind source investments top the list. This result is compatible with the accepted sustainability degrees in the world with a small change. The sustainability degree of coal is relatively high. It may be concluded that the country must reduce its investments in coal. Though foreign dependence brings the natural gas alternative to the most disadvantageous circumstances, risks of the country's tendency to invest in this area must be analyzed. The situation may be reassessed in the future in accordance with any positive results obtained from natural gas explorations in the country.

Though Turkey has significant solar and geothermal sources, poor investments made in this area are an invaluable deficiency of the country. That said, the largest share of investment activities is planned for renewables. By 2023, the total capacity planned to be built in hydro, wind, solar and geothermal is 70 GW. The total rate of increase is around 73%. Similarly, the share of renewable sources in total production is targeted to increase to 37%. The results are given only in terms of electrical power generation systems. To achieve the strategic targets determined to increase energy efficiency, the effects of studies such as the creation of determinant policies, decreasing lost/illegal use rates, and reducing energy density consumed per GNP are extremely beneficial.

In recent years, Turkey has taken decisive steps to ensure energy investment policies handle native resource potential efficiently and sufficiently. The sustainability of the existing

energy policy for 2023 – the centennial of the establishment of the Republic of Turkey – will prevent a power bottleneck. However, legislation and incentive mechanisms put into play to ensure the reliability of the power supply must be maintained.

Table 3. Degree of sustainability of Turkey's electric energy production systems, 2011-2023

Sources	Overall rating [8]	In terms of Turkey												
		Expected increase in installed capacity				Expected increase in total energy production				Sharing in installed capacity		Foreign dependency	Total of indices	Order*
		2011 [GW]	2023 [GW]	Increase [%]	Rank	2011 [%]	2023 [%]	Increase [%]	Rank	2023 [%]	Rank			
Wind	1	1,7	20	1156	1	2	6	300	2	6	4	5	2	2
Hydro	3	17,1	40	233	5	23	30	130	3	0	1	1	0	1
Solar	4	0,0	5	500	3	0	0,5	50	6	0,5	5	4	8	6
Geothermal	5	0,1	5	439	4	0	0,5	50	6	0,5	5	2	7	5
Nuclear	2	0,0	10	1,000	2	0	10	1,000	1	10	3	6	12	3
Natural gas	6	13,1	25	190	6	45	30	67	5	30	1	7	9	7
Coal	7	15,6	23	148	7	29	23	79	4	23	2	1	14	4

*The rank of the total of renewables is "1" (wind + hydro + solar + geothermal)

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