Analysis of Turkey's Electric Power Demand Forecast and Generation Models Scenarios for the Next Ten Years

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Abstract: - The Turkish Government makes great efforts to increase the new and renewable energy resources, use new systems with low carbon emission instead of high carbon emission technologies, make energy saving and decrease the emission of Carbon-dioxide (CO_2) and other sera gases by increasing the energy productivity by means of preventing losses in energy distribution systems. In production of electric energy, the high rate of the imported fossil fuel is a significant advantage. With this regard, the investments made to local and especially renewable energy resources must be increased. In this study, the technical and economical parameters such as primary energy resources, demand increases and price fluctuations are examined in detail. In the study legal regulations made for that purpose are also considered. By using the data published by Turkish Electricity Transmission Company (TEIAS), analysis of important parameters such as energy demand increase rates, investment plans, change in emission rates expected to occur until year of 2020 according to two scenarios, in terms of sustainability in energy production, is made. Consequently, within following ten years, a very small development in energy investment policies of Turkey is expected with effect of legal arrangements in favor of renewable energy resources. However, this increase is very low according to the potential usable in the country. This situation decreases the competition power of country with the OECD countries in terms of energy prices. For a sustainable development, the country must make significant changes in the foreign-dependent energy production policies. In the policies to be determined, supplying of continuously increasing demand from local resources must be encouraged. In some regions of the country, measures to decrease the air pollution that causes important social reactions and health problems must be taken and by rapidly completing the privatization studies, the weight of private sector also on installation of new plants must be increased.

Key-Words: - Turkey, sustainable consumption, legal arrangements, energy price, wind, solar, geothermal energy resources, investment plan, greenhouse gases.

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1 Introduction

One of the most important parameters of the developing plans of the world's countries is the energy production planning and meeting of the increasing demand. The World Energy Council (WEC) makes forecasts on various scenarios related to energy amounts in the future and energy production technologies. These scenarios are characteristically divided into two groups. In both scenarios, it is forecast that the population of world will be 10.2 billion in 2050. In the first scenario, it is forecast that the globalization will increase the energy need and economical development in the world and the annual energy consumption of $420EJ$ in 2000 will increase to $1040EJ$ in 2050. Besides, it is mentioned that the fossil and renewable energy resources in the world will continue to be used in high rates and so, annual carbon dioxide emission will increase from $6.4Gt$ to $9-15Gt$. In the second scenario, it is assumed that the international society will extraordinarily focus on protecting the ecological balance and international equity and as a result of this, our energy consumption will decrease. According to this scenario, in 2050, the primary energy consumption will be only $600EJ$. It is forecast that small, powerful and reliable new technology product nuclear reactors and renewable energy systems will be used in energy production and as a result of this, the annual carbon dioxide emission will decrease from $6.4Gt$ to $5Gt$ [1].

2 The Concept of Sustainability Development

According to the definition made by United Nations Environment and Development Commission, the sustainable development is "a development that can meet the needs of today's world without endangering the ability of future generations to provide their own needs" [2]. When we consider this expression, we understand that we must use the consumable resources of world in the lowest possible level.

The EU's Sustainable Development Strategy aims, in tandem with the Lisbon Strategy for growth and jobs, for a more prosperous, cleaner and fairer Europe. Sustainable Development is an overarching concept. The EU Treaty requires the integration of sustainable development into all European policies, so that they contribute in an integrated way to meeting economic, environmental and social objectives. The Renewed EU Sustainable Development Strategy identifies seven key challenges:

i. climate change and clean energy,
ii. sustainable transport,
iii. sustainable consumption and production,
iv. conservation and management of natural resources,
v. public health,
vi. social inclusion, demography and migration, and
vii. Global poverty and sustainable development challenges [3].

2.1 Sustainable Consumption

The term "green belt" tries to cover different ecological practices, meant to make the ecological function of the city more important. These refer to: urban forest, agricultural areas, parks, green spots, different trees, protected natural ecosystems, green houses, nurseries, the natural wet spots. Another important aim is the implementation of strategies for sustainable consumption and zero emissions.

Sustainable consumption targets everyone, across all sectors and all nations, from the individual to governments and multinational conglomerates. Current unsustainable consumption patterns are destroying the environment; depleting stocks of natural resources; distributing resources in an inequitable manner; contributing to social problems such as poverty; and hampering sustainable development efforts. Focusing on the demand side, sustainable consumption compliments sustainable production practices and achievements. Sustainable consumption requires a multidisciplinary and multinational approach. Teams composed from various disciplines are required to create and implement policies. Developed nations need to assist rather than exploit developing nations. The zero emissions concept envisages all industrial inputs being used in final products or converted into value-added inputs for other industries or processes. In this way, industries are reorganized into clusters such that each industry's wastes/by-products are fully matched with the input requirements of another industry, and the integrated whole produces no waste of any kind. This technique is based on the well-established economic nalysis tool known as the input/output approach. From an environmental perspective, the elimination of waste represents the ultimate solution to pollution problems that threaten ecosystems at global, national and local levels [4].

2.2 Sustainable Energy Production

The main disadvantages of using fossil fuels are related to following main features: when they burn they emit pollutants, including green house gases that are causing irreversible modification on the Earth climate; countries without adequate reserves of fossil fuels are facing increasing risks to the security of their energy supplies; their amount on earth is declining, as utilization is accomplished in an incomparable amount as their natural refresh [5].

The coverage of the sustainability concept in respect to electric energy production can be summarized as "to increase the potential of electric energy production continuously, keep the waste materials resulting from that production in a level that can be cleaned in natural ways, keep the risks related to human health in the lowest possible level and to realize the energy production by using raw materials including environmental resources in the lowest possible level [6]. In short, the sustainable energy production that can be defined with the green energy concept aims to reduce to the lowest possible level the usage of natural resources, the harmful gas emission and usage of the electric energy production methods that cause wastes. In this manner, it will be contributed to the process of slowing down the global warming and climate changes as well as new long-term employment opportunities and more balanced economical development in the world will be ensured.

Sustainable development is a complex fact depending on many variables. While some of these indicators are dominant in definite areas, some remain in the background. For instance, energy investments vary depending on various variables such as purchasing power, income distribution, education level, health standards, nutrition, biological variety, literacy rate, average life-span, work power and employment rates of that work power, accessibility opportunities for basic raw materials, credit note etc. Effects of such sub-parameters on investments and their significance order vary depending on countries [7, 8].

The Interstate Natural Gas Association of America Foundation (INGAA) defines Distributed Generation as ``any small scale power generation technology that provides electric power at a site closer to customers than central station generation, and is usually interconnected to the transmission or distribution system". In the future this definition is to change from ``is usually interconnected" to ``which may or may not be interconnected" An energy system based on renewables combines many small-scale renewable energy sources such as solar energy, water and wind power, geothermal and biomass (Fig. 1) [9].

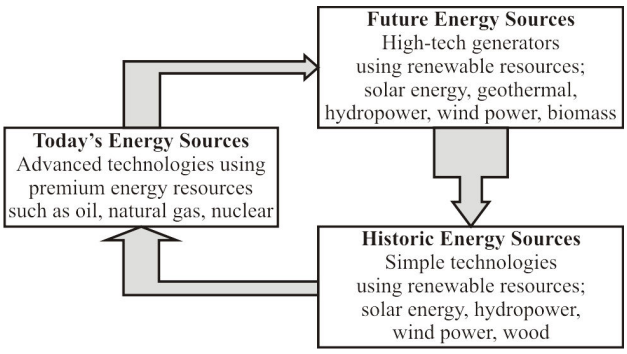

Fig. 1 The cycle of primary energy sources.

3 Features of the Power System in Turkey

As Turkey has a bridge position between three continents because of its geographical situation, it is vitally important for energy transfer between the Asia and Middle East countries having rich fossil fuels and the European Union countries. For this reason, it is expected that Turkey will draw a continuous improvement graphic in political, social and economical terms. Turkey is very behind the OECD countries for energy supply per person. (Fig. 2). While the energy supply per person of the OECD countries in 2009 was $8.65TWh$, this value was $2.58TWh$ in Turkey.

In Turkey that signed the Kyoto protocol at the beginning of 2009 to undertake a decrease in carbon emission, the installed power as end of 2008 was about $41817.2MW$. $27595MW$ part of the installed power was established by thermal plants (66%), $13828MW$ by hydroelectric plants (33%), $376MW$ (0.8%) by wind plants and $17.5MW$ ($\approx 0\%$) by geothermal cycle power systems. [10].

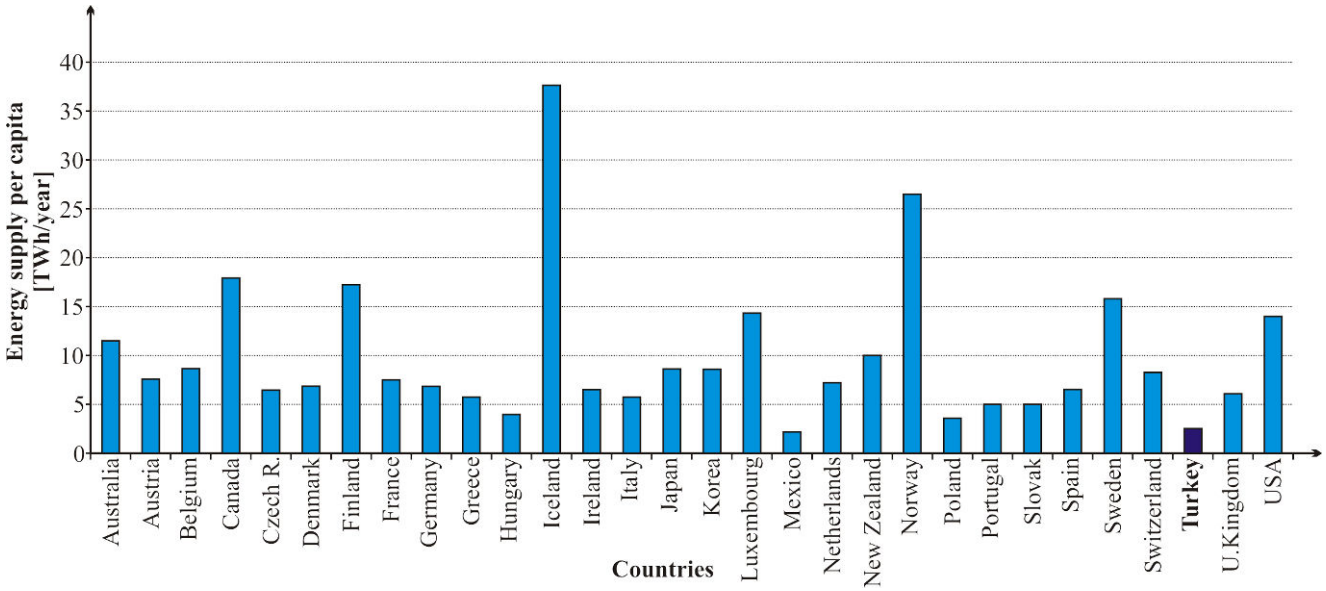

Fig. 2 Energy supply per capita in OECD countries.

By the end of 2008 gross electrical consumption of Turkey was198.4*billionkWh* . 36.1*billionkWh* of this amount was unregistered because of thetechnical loss and illegal consumption, and net consumption was recorded as 161.9*billionkWh* . Acoording to the provisional data, the breakdown of Turkey's certifited electrical energy consumption to major sectors was 47.9% industrial, 23.5% residential, 14.2% commercial, 4.4% government offices, 2.6% public lighting, 7.4% others.

The analysis of the last 15 years period indicates that the increases and the decreases in the annual electrical consumption and gross national product (GNP) are in parallel and there exits a close relation between economic growth and electrical energy consumption. In Fig. 3, the increase/decrease rates of annual net consumption and rate of growth GNP are compared by years [11]. In Fig. 4, historical change of the installed power in the country is given

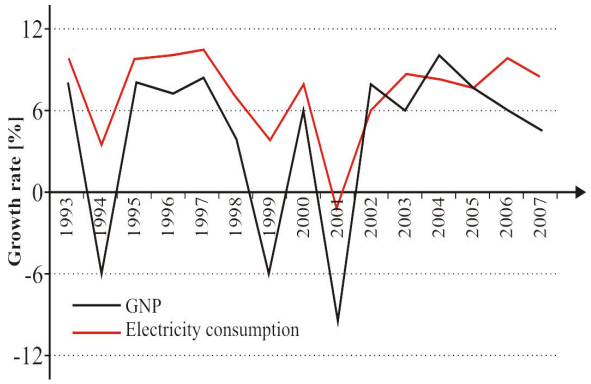

Fig. 3 Growth rates of GNP and net consumption by years

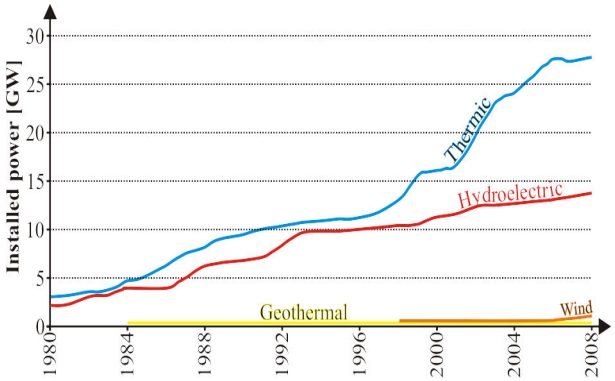

Fig. 4 The historical change of installed power.

Especially in years after 2000, it is observed that the share of thermal plants that use fossil fuels in energy production increases gradually. Besides, the weight of natural gas cycle power plants the country is foreign-dependent in great extent increases gradually among thermal plants. In Fig. 5, the classification of thermal plants depending on fuel kind is given. As year of 2008, the rate of natural gas plants in total installed power was about 25.5%. This rate was 19.6% for the lignite coal.

Dispersion of the European Union (EU) Countries according to the electric energy resources is given in Fig. 6. When the figures are examined, it is seen that though the use of coal decreases as an electric energy resource, it takes place in the first row of the energy market because of the reasons such as it is easily accessible and has low cost. It is seen that the natural gas and coal use is not much different from Turkey in proportionately. It is observed that use of nuclear resources as an electric energy resource has decreased and investments on

renewable energy resources like biomass and geothermal have increased [12].

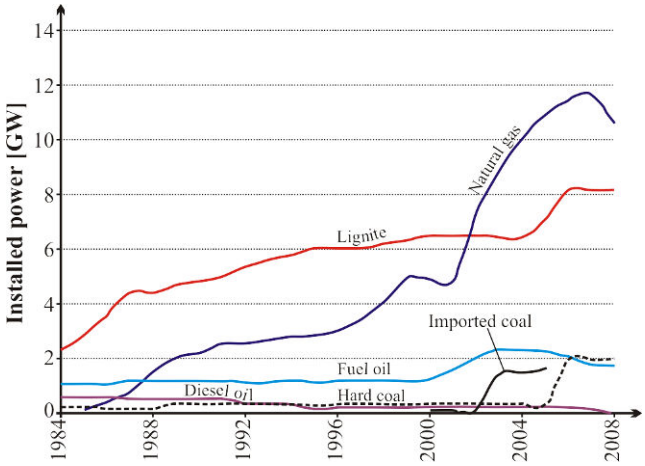

Fig. 5 The classification of thermic power plants according to fuel supply.

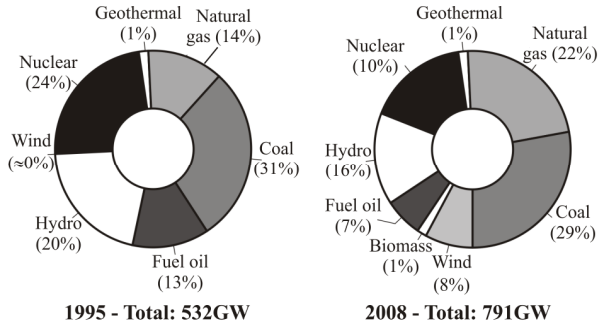

Fig. 6 Electric power generation distributions according to sources in EU countries

Besides, plants having the highest operational period in terms of capacity usage rates are the natural gas cycle power plants. Because the hydroelectric plants in the country are not operated because of various reasons and investments of the private sector are focused on the natural gas plants. These effects make worse the negative installed power table in terms of production rates. As year of 2008, 48.4% of the total electric production was obtained from natural gas, 22.7% from domestic coal, 16.7% from hydraulic resources, 6.3% from imported coal, 5.2% from liquid fuels and 0.4% from wind [13]. As the country is foreign-dependent in great extent in terms of natural gas and petroleum, the share of domestic resources in total electric production was %40 for 2008 year. As a result of the wrong energy policies, Turkey became a country that imported electric energy indirectly. Because of the unstable economical structure of the country and the production policy depended on fossil fuels of which prices continuously change according to the market conditions, continuous fluctuations occur in the electric energy prices. As it is seen in Fig. 7 the energy prices increased greatly especial during 1991 and 2001 economic crises. It is seen that the price fluctuations decreased in last five years.

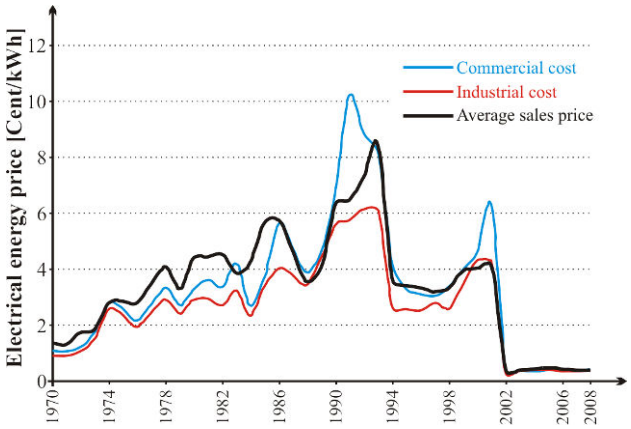

Fig. 7 Changing of energy prices of Turkey by years [6]

3.1 The Local Energy Resources of Turkey

Turkey has rich resources especially for lignite and hard coal. The total lignite reserve of the country is 8075 million tons and hard coal reserve is 1126 million tons. In contrary, the petroleum reserve is calculated as 36 million tons and natural gas reserve as 8 million-m^3 [14]. In thermal plants, hard coal and lignite are used as domestic fuels. Below, the domestic resource potentials of Turkey that can be used in electric energy production are given in abstract.

Lignite and hard coal: The total lignite potential usable in electric energy production is 18790MW and 8205MW of it (43.6%) was in operation until the end of 2008 and 515MW (2.7%) is under construction or are the projects licensed by Republic of Turkey Energy Market Regulatory Authority (EPDK). The remaining 10070MW (53%) potential has not been evaluated yet. The hard coal potential is estimated as 2000MW. Almost the whole part of this potential (1986MW) is under operation as end of 2008 as an installed power.

Hydroelectric: The total hydraulic potential usable in electric energy production under mean rainy conditions is 36355MW and the annual hydroelectric amount that may be produced economically is 433MW. 13829MW of it (38%) was in operation until the end of 2008 and 203MW (6%) is under construction or are the projects licensed by EPDK. The remaining 20523MW (56%) potential has not been evaluated yet [15].

Solar: It has an attractive potential in Turkey. The first studies indicate that our country has annual 2640 hours insolation period with average $3.6 kWh/m^2 - day$ sunlight density, though it is high in some regions. The annual solar energy potential of Turkey technically usable in electric energy production is $6105 TWh$ [16]. In the country, there is not any solar plant that its economical value can be considered though many studies are being made to evaluate the potential. In Turkey, especially in the south and west regions, the solar heated production for the housing and commercial sectors is almost equal to 290000 tons petroleum fuel [17].

Wind: Especially, the Aegean coasts, Marmara Region and East Mediterranean coasts have an attractive potential in terms of wind energy. It is calculated that the technically usable wind potential of the country can produce about $200 TWh$ energy annually [16].

The total wind energy potential of Turkey was tried to be determined with a joint study of the General Directorate of Electric Power Resources Survey and Development Administration (EIE) and Turkish State Meteorological Service (DMI). As a result of this study, it was forecast that the total technical potential was in level of $40-85 GW$ for only the land part. The annual mean of the wind speed in $10m$ height, except the settlement areas, is $4.5-6.5 m/s$ in the Aegean Region and other coast areas and $3.4-4.6 m/s$ in inner sections. Antakya, Bandırma, Bergama, Bodrum, Bozcaada, Çanakkale, Çeşme, Çorlu, Gökçeada, İnebolu, Mardin ve Sinop are rich areas in terms of wind energy. As geographical areas, Marmara, North West Black Sea and Aegean coasts are aligned [10]. The wind energy investment made in Çeşme in 1998 on two wind plants with $8.70 MW$ capacity has reached to $145.95 MW$ through production plants established in Çanakkale-Gelibolu, Çanakkale-İntepe, Manisa-Akhisar and İzmir-Çeşme until the end of 2007 year. In 2008, while in İstanbul-Gaziosmanpaşa and Çatalca, İzmir-Aliağa, Balıkesir-Bandırma, Şamlı, Hatay-Samandağ, Manisa-Sayalar, Muğla-Datça and Çanakkale, production plants in total $287 MW$ capacity were established, until the end of 2009 year, production plants in $403 MW$ capacity were established in Osmaniye-Bahçe, İzmir-Çeşme, Hatay-Samandağ, Manisa-Soma and total capacity reached to $835.95 MW$ [13].

Geothermal: Turkey is the seventh country of the world in terms of geothermal potential. There are 140 geothermal areas of which surface temperature is above 40°C. However, only four of they are suitable for the electric production. In Denizli- Sarayköy, there exists a plant in $20.4 MW$ installed electric power. Besides, for a $34 MW$ plant, a license was taken from the EPDK. The electric energy amount that may be annually produced from geothermal resources is calculated as $1.4 TWh$. This value corresponds to $160 GW$ power plant [16].

Wave energy: The electric energy potential is in level that can provide $18 TWh$ electric energy annually. No investment is made on that energy resource except the research and development studies [16].

4 The Electric Energy Production Plan of Turkey

Today, Turkey's electricity supply industry is dominated by large, publicly-owned companies Directorate-General of Turkish Electricity Transmission (TEIAS), Turkish Electricity Distribution Corporation (TEDAS) and Electricity Production Company (EUAS). Especially, in recent years, the share of the private sector in energy investments increases gradually. While in 1995, 14% of the total production $(86.25 TWh)$ was realized by private sectors, in 2008, 50.6% $(100.37 TWh)$ of the production $(198.42 TWh)$ was realized by the private sector investments and privatized companies [10].

4.1 Legal Arrangements

Energy development in Turkey has been dominated by public investment and management. The current government, however, is keen to complete the process of liberalization, restructuring, and privatization in the energy sector. Turkey has made early and extensive use of financing models such as build-own-operate (BOO) and build-own-transfer (BOT). As yet, however, no decisive breakthrough has been achieved. This does not mean a complete withdrawal of the state from energy development. In fact, state involvement in formulating and implementing favorable policies for renewable energy development remains vital. To ensure timely and effective investment in renewable sources, however, the state needs to mobilize the extensive funds available to the private sector. A number of renewable energy projects, such as certain hydropower and solar thermal applications,

are already commercially attractive to private interests [18].

The government makes great efforts to increase the new and renewable energy resources, use new systems with low carbon emission instead of high carbon emission technologies, make energy saving and decrease the emission of CO_2 and other sera gases by increasing the energy productivity by means of preventing losses in energy distribution systems. In parallel to this energy policy, "**the law on using of renewable energy resources for purpose of electric energy production**" was enforced on May 10, 2005 with number of 5346 and it contains important arrangements related to use of renewable energy resources.According to this law;

- Development plans that effect the usage and productivity of renewable energy resource areas on the Public or treasury lands will not be arranged,
- For the energy to be produced from renewable energy resources by companies that fulfill the conditions given in the regulation, a purchasing guarantee will be ensured.
- In case the natural and judicial persons establish plants with maximum 1MW installed power to meet their own needs, regardless of whether it is a network supported or individual system, for the projects of which definite project, planning, master plan, preliminary survey or first study are prepared by the General Directorate of State Hydraulic Works (DSI) or EIE, no service fee will be charged.
- The necessary plant investments to establish such systems, supplying of electro-mechanic systems domestically as production, research and development (R&D) and production investments to be made under scope of electric production systems that use solar cells and focusing units and R&D plant investments related to electric energy or fuel production by using biomass resources will be benefit from incentives,
- The settlement units within boundaries of municipalities and governorships where sufficient geothermal resources exist will cover their heat energy needs firstly from geothermal and solar thermal resources.
- In case immovable assets under property of the forestry and treasury departments or disposition and jurisdiction of the state are used to make electric energy production from renewable energy resources under scope of law, the required usage permits for such lands will be given and in case of leasing; various tax deductions will be awarded [19].

To increase applicability of that law, on October 04, 2005, "regulation on principles and procedures related to issuance of renewable energy resource certificate" and on October 25, 2008, "regulation on increasing of productivity in energy use and energy resources" was enforced [20, 21]. It has been determined that such regulations had positive effects on renewable energy production.

4.2 Installed Power Planning

In this section, the electric plant investments made by TEIAS and planned or licensed between years of 2010-2020 are examined. As it is seen in previous sections, the energy need of the country increases each passing day. The energy investments must be made continuously to meet the energy demand. In the energy investment planning, two different scenarios are considered.

In scenario 1, it is forecast that in case the energy demand increases in rate of 7.9% in a year, though the licensed projects under construction are completed, no power reserve will remain at the end of 2012 and the installed power demand and puant power demand will be at par point. The existing installed power will not be able to meet the demand at the end of 2009 under the drought climate conditions and at the end of 2010 under normal climate conditions, as there will remain no reliable energy production reserve.

In the second scenario, it is forecasted that the demand increase will be in rate of 6.4% annually. In that case, with operation of the licensed systems under construction, the demand will be able to be met until the end of 2014. It is forecast that the existing installed power will not be able to meet the demand at the end of 2010 under the drought climate conditions and at the end of 2012 under normal climate conditions (

Fig. 8). The increase rate in energy demand of the country was 7.55% between years of 2005-2008 [15]. This value may help in deciding that the first scenario is a more realistic approach. Both scenarios indicate that the energy investments in Turkey must continuously increase and new plant projects must be realized urgently.

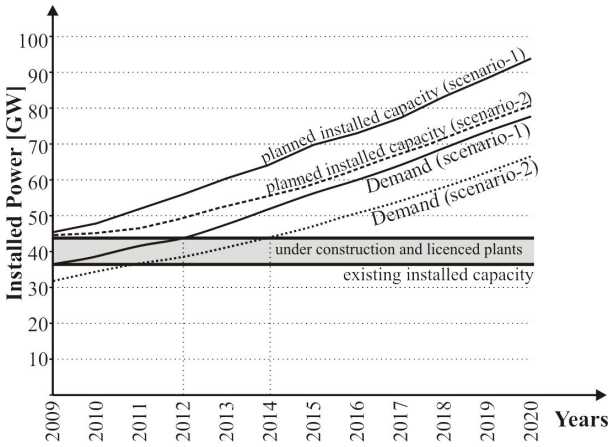

Fig. 8 Increasing demand and capacity forecasts for next ten years

The cycle plants that are planned to add in the system to meet the demand increase in both scenarios are given in Table 1. As it is seen in the Table, the share of renewable energy resources in the total installation is forecasted to be 33% in the first scenario and 34.7% in the second scenario. The share of domestic resources is 54.84% and 46.7% respectively. In case the first scenario is realized, the share of plants (using domestic fuel) in the total installed power, 57% in 2005, will be 55% in 2015 and 57% in 2020. In the second scenario, this value will regress to 55% in 2015 and to 53% in 2020 and demonstrate a 4% decrease [22].

Table 1 Types of planned additional power systems, and application schedule

SOURCES	Additional Power Plants [MW]							
	Scenario-1				Scenario-2			
	2005 - 2010	2011 - 2015	2016 - 2020	Percentage share	2005 - 2010	2011 - 2015	2016 - 2020	Percentage share
Lignite		4520	5520	19.5%		2280	1880	11.9%
Hard Coal			1200	2.34%				
Imported Coal			4500	8.76%				
Natural Gas	2800	6000	5450	27.7%		6150	8100	40.6%
Nuclear		4500		8.76%		1500	3000	12.8%
Hydro	542	6811	7782	29.5%		2752	7644	29.7%
Wind	500	625	625	3.5%	500	625	625	5%
Solar								
Geothermal								
Subtotal	**3842**	**22456**	**25077**	**100%**	**500**	**13307**	**21249**	**100%**
TOTAL	**51375**				**35056**			

4.3 The Investment Plan and Emissions

To meet the installed power need as determined as a result of the analysis made above, detailed investment plans must be prepared and applied carefully. TEDAS prepares these investment plans and publishes the realized investment amounts at the end of each year. The investment amounts suggested to be made every year are given in Fig. 9.

In the investment plans, though the fossil fueled production technologies are higher, very significant increase are expected in sera gas emission amounts. The factors such as weighted natural gas and nuclear plant investments that are more advantageous than the coal plants in terms of emission and using of high technology product filtering systems in plants to be installed newly prevent the emission increase. In Fig. 10-a, the sulphur (SO_X) and carbon dioxide (CO_2) amounts to be emitted in the atmosphere every year are given for both scenarios. Especially, the Sox emission remains fixed during the process. Because of low productivity in filtering systems, the CO_2 emission increases 70% according to the first scenario and 30% according to the second scenario. As a result of this, the SO_X emission per GWh demonstrates decrease in both approaches. The CO_2 emission remains almost fixed (Fig. 10-b) [15, 22].

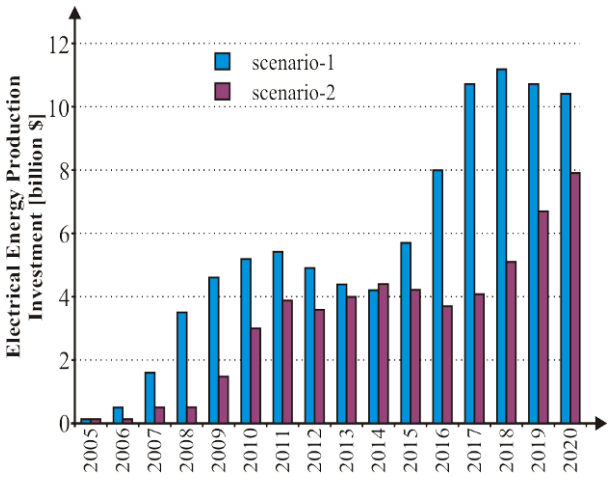

Fig. 9 Annual amounts of investment in energy production system [10]

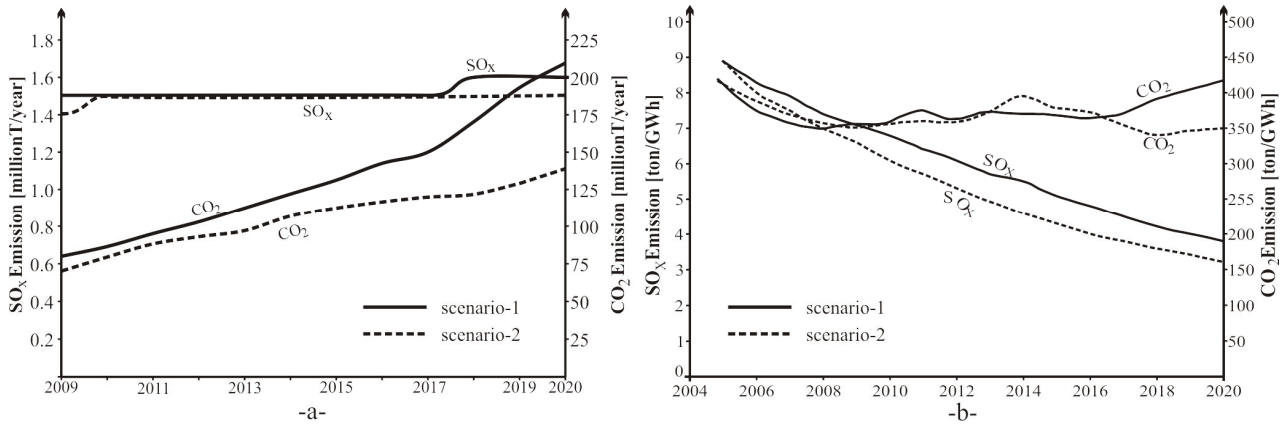

Fig. 10 Changing expectations of a-) annual greenhouse gas emissions b-) the greenhouse gas emissions per GWh

5 Conclusions

One of the most important components of sustainable development is sustainable electricity generation policies. Turkey is largely dependent on outside in terms of fossil fuels especially oil and natural gas and is in critical point with regard to installed power required to meet the energy demand. The imported fuel usage rate of Turkey, especially after 2000, increased in great extent. This situation made the country indirectly foreign-dependent for electric energy production and an importer country. With the effect of legal arrangements made in recent years to change this negative table, especially the wind plant investments increased but have not reached to desired level yet. The solar and geothermal systems have not been used in the electric production.

According to the development scenario considered, within next 10 years, about 45-50GW power must be added in the existing system. Therefore, Turkey has to invest 4 billion dollars annually in electricity generation. The rate of fossil fuel plants in the additional installed power is anticipated as 65% in the investment plans made until 2020. A significant decrease is expected, especially in the SO_X emission, with usage of new technologies. CO_2 emissions are projected to remain constant because of current installed capacity technology. The share of production depended on imported fuels is calculated as 45%. As the prices of these fuels are very variable according to the market conditions, this may cause instability in the energy prices in long-term and decrease the competition power in great extent. In both scenarios taken into account in this study, the level of investment in renewable energy is very low between 2010 in 2020. These investment plans can be considered as negative in terms of sustainable development.

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