

# Promising Energy Sources within the Framework of 2023 Energy Targets in Turkey: Solar and Wind

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**Abstract**—Signing of Kyoto Protocol in 2009 can be accepted as a milestone for revision of energy policy in Turkey. 2010-2014 Strategic Paper prepared by Ministry of Energy and Natural Resources (MENR) are published by Turkish Government. Energy targets are explained in this strategic paper. Main point of this strategic paper is to increase the share of renewable energy sources in electricity generation by 30% rate in 2023. Since geographical location of Turkey is suitable for renewable energy, photovoltaic and wind energy have gained importance in recent years. According to the Vision 2023, Turkey aims to reach to 5GW PV and 20GW wind energy capacities by 2023. Since the beginning of 21st century, Turkey has accelerated renewable energy integration into the grid applications. Legal regulations have been finalized and regions with high potential have been identified for photovoltaic application. As of February of 2016, wind and photovoltaic capacities are 4533.6 MW and 290 MW, respectively. Furthermore, West and North West side of Turkey is more convenient for wind applications. North side of Turkey is convenient for photovoltaic applications. With these advantages, it can be commented that solar and wind energy is promising energy sources for Turkey.

**Index Terms**—vision 2023, energy, Turkey, solar, wind

## I. INTRODUCTION

Electricity demands increase continuously in Turkey. In order to meet these demands, sustainable and reliable precautions have to be taken. The most important of these precautions are to provide sustainable and reliable energy and independence of energy. However, it is clear that large part of consumed energy is based on imported sources which causes to additional burden on Turkey's economy and decrease the independency of energy. For example, according to the MENR, Turkey spent US\$20.0 billion to natural gas imported in 2011 and this was equal to more than 20% of Turkey's annual trade deficit for this year [1]. When all imported sources are included, this rate reaches to undesirable levels.

Signing of Kyoto Protocol in 2009 can be accepted as a milestone in terms of determination of new energy policies. As a present Turkish Government's term, Vision 2023 has been defined by important issues related to

different areas. In this context, energy is one of the prominent agenda [1]-[9]. Considering the geographical location of Turkey, renewable energy based potential is clearly promising for meeting growing energy demand. Hydropower based renewable energy plants are the most chosen up to present in parallel to the potential of the country's streaming. As of February of 2016, total installed capacity of hydropower plants is 25.92 GW in Turkey [10]. On the other hand, solar and wind based plants are seen as an alternative to hydropower plants. However, wind energy plants have 4533.6 MW installed capacity [10]. When it comes to solar, Turkey has completed legal regulations and determined the regions for photovoltaic power plants (PPS) with connection points. First photovoltaic projects were received in June of 2013 and 600 MW photovoltaic projects approval process were completed. Furthermore, investors are encouraged by local equipments incentives with different bonus payment for solar and wind energy utilization [11].

This study aims to show current status of wind and solar energy in Turkey. Electrical power statistics of Turkey is explained in Section 2. Current status of wind and solar energy and energy targets of Turkey are given in Section 3. In the last section, Turkey's energy policy and 2023 Vision are discussed.

## II. ELECTRICAL POWER STATISTICS IN TURKEY

Electricity is one of the energy form used in various applications which can be generated by different ways. Conventional power plants use fossil based resources which are pollutant and limited in nature. Since these plants are dominant in electricity generation sector, some issues, such as global warming and CO<sub>2</sub> emissions, have become important. In order to avoid deterioration of the balance of nature, renewable energy based regulations have been made up to present with contributions of nations. Considering the fossil based resources reserves and their harming effect, renewable and unlimited energy resources are the critical agenda for countries [1]-[9].

Increase of electrical power needs is related to industrial and technological developments. These developments are among the factors that affect economic growth in Turkey. Turkey is a member of G20 major economies with 4.2% and 2.9% annual growths in 2013 and 2014, respectively [12]. In order to realize

sustainable growing, energy independence should be provided. Today, Turkey is energy imported country and this reality may cause to growing blockages and problems related to welfare of people in the long term. As shown in Fig. 1, electricity consumption has positive trend.

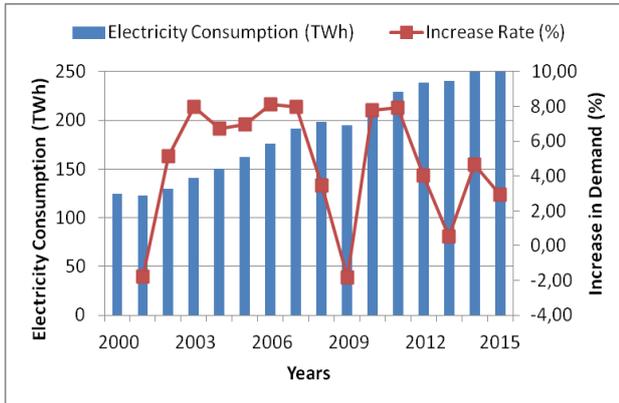


Figure 1. Electricity consumption and increase rate by years.

When amount of consumed electricity is evaluated between 2000 and 2013, it is clear that electricity demand decreased in 2009 because of the economic crisis. Except for the year 2009, electricity demand increases by average 7-8% per year. According to the Turkish Electricity Transmission Company (TEIAS) projections, annual average increase in electrical power demand will be 6.4% and 7.9% for the low and high scenario in the next five years, respectively [13]. In order to meet this increased demand, new power plants have to be utilized. As of September of 2014, shares of resources in installed capacity are shown in Table I. It is clear that renewable energy based electricity power plants are limited apart from hydro.

TABLE I. SHARE OF SOURCES IN INSTALLED CAPACITY [10]

Source	Power (MW)
Natural Gas + LNG	21.227
Coal	15.212
Thermal (Other)	5603
Hydropower	25.918
Wind	4533
Geothermal	635
Solar	290

### III. OVERVIEW OF SOLAR AND WIND ENERGY USAGE IN THE WORLD

Significant population growth, increasing energy needs, concerns over energy security and global warming have begun a new period in renewable energy and environmental technologies in the world [14]. Domination of conventional power plants in electricity generation may increase the risks of global warming if significant measures are taken in the long term. Thus, renewable energy based electricity generation has been prevailing option in recent years. In this context, countries have changed energy policy and tendency to renewable energy sources have been popular.

#### A. Solar Energy Status

Depletion of fossil resources, effects of global warming and increased environmental sensitivity have led to the new energy resources. Thus, solar power generation systems have been attracted worldwide attention in recent years. Thanks to abundant energy capable of solar, PPS can generate excessively electricity by using photovoltaic modules. Besides, cost of utilization PPSs are reduced with the increase in efficiency of solar panels and inverters. Today, large scale projects can be utilized without government incentives [15]. In 2015, total power capacity of PPSs increased by 32% and reached to 233 GW as shown in Fig. 2. China adding 10.6 GW PPS in 2014 accounted for almost one-third of global utilizations. Investments of Japan and United States were nearly up to their available power capacity. On the other hand, with 1.7 GW solar power installed in 2013, Germany experienced a 42% PV market steep decrease compared to 2013 due to the decrement of feed in tariffs by the end of 2012. In 2014, Italy added up 0.4 GW PPS [15]. Countries in the Middle East changed their energy plan in order to reduce oil importation expenditure. During 2013 and 2014, large plants were commissioned in several countries including Jordan, Kuwait, Saudi Arabia and the United Arab Emirates [15]. Geographical location of these countries is suitable for use of solar energy. However, lack of solar technologies information and qualified staff have prevented to development of this technology.

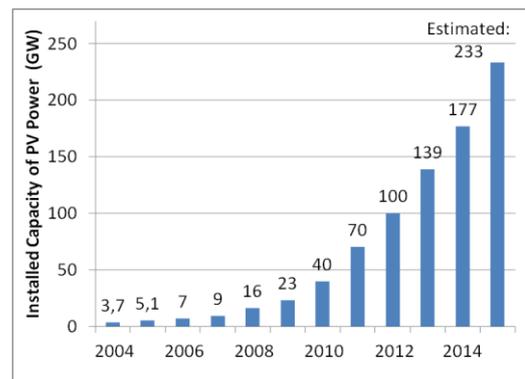


Figure 2. Cumulative total installed PV capacity in the world [15]

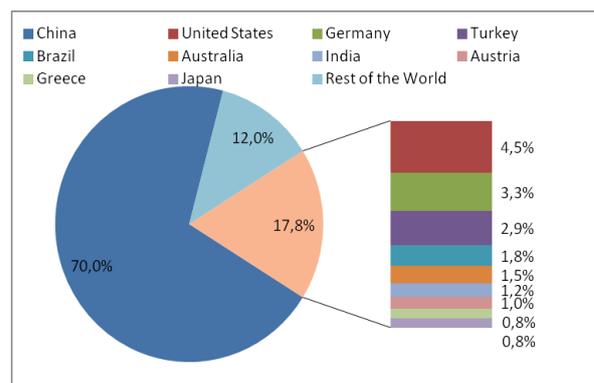


Figure 3. Shares of solar water heating collectors global capacity in 2012 [15]

Solar thermal technologies contribute significantly to hot water production in many countries, and increasingly to space heating and cooling as well as industrial processes. Solar water and air collector capacity exceeded 330 GW<sub>th</sub> in 2013 and reached an estimated 406 GW<sub>th</sub> by the end of 2014 [15]. Fig. 3 shows the distribution of total installed solar thermal capacity in the World. It is clear that the vast majority of solar heat capacity in China, which accounts for 70% of the World market as shown in Fig. 3.

#### B. Wind Energy Status

Wind energy as a renewable energy source is the second renewable energy sources in terms of utilized power plants after hydropower based electricity generation systems in the world. In 2015, total installed capacity reached to 432 GW as shown in Fig. 4. 35 GW of this power was added in 2013. China is the leader country in terms of utilized wind energy power plants. China added an estimated 30.5 GW of new capacity in 2015, increasing total installed capacity by 26.7% to 145 GW [15]. In European countries, with 44.95 GW utilized wind energy based power plants Germany is the leader country [15].

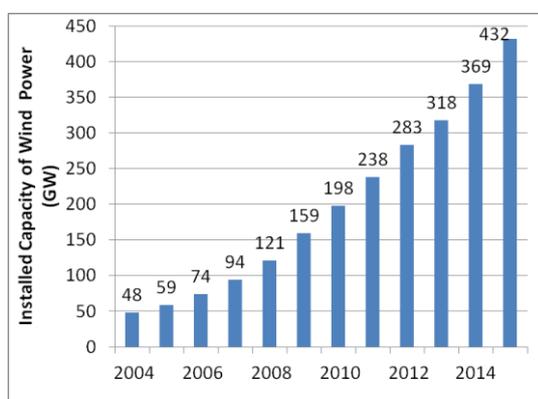


Figure 4. Cumulative installed wind power capacity in the world [15]

### IV. PROMISING ENERGY SOURCES IN TURKEY: SOLAR AND WIND

As a fast growing country, energy consumption in Turkey is on the rise. The Turkish electricity market is one of the fastest growing in the world, with approximately 4% annual growth on average between 2011 and 2015 [13]. Since Turkey has not rich fossil based resource reserves and 80% of total electricity generation is based on these resources, Turkey has to develop new energy policies. In other words, Turkey should increase diversifications of energy in the short term. In this context, renewable energy has been one of the hot topics on Turkey's energy agenda.

#### A. An Important Agenda for Turkey: 2023 Energy Vision

Energy has been an important agenda for Turkey since the beginning of the twenty-first century. When Turkey's renewable energy based electricity market is evaluated, in 2005, the law on utilization of renewable energy

resources of the purpose of generating electrical energy was amended. This amendment can be accepted as the beginning of energy revolution in Turkey. Besides, approval of Kyoto Protocol as Annex I country is assumed as a milestone for Turkey. After Turkey had signed the Kyoto Protocol, MENR announced the Electrical Energy Market and Supply Security Strategy Paper (2010-2014 Strategic Paper) Investments in renewable energy technologies remained limited between 2005 and 2010 due to the lack of secondary legislation and relatively low feed-in tariff prices [14]. In 2011, renewable energy sources support mechanism was enabled and regulation of unlicensed electricity generation was made. Since this year, investments have shown significant rise in several areas such as wind, solar, geothermal and biomass.

Strategic Paper of Turkey consists of different issues related to Turkey's energy supply and security. With this strategic paper, Turkey's energy targets by 2023 have been determined. These targets can be analyzed as follows: First issue is to increase energy diversification by increasing share of local sources in meeting energy demand. Renewable energy based energy consumption should be increased. Energy importation costs are aimed to reduce. Besides, in order to reduce dependency of petroleum and natural gas as well as to reduce importation, petroleum and natural gas drilling operations should be made to obtain local resources. Renewable energy based electrical power supply should be increased. Turkey aims to increase renewable energy shares in electricity generation by 30% rate of total electricity generation by 2023.

#### B. Current Status of Solar Energy

Although large part of Turkey is suitable for utilization of solar power generation system, Turkey has not utilized these systems efficiently until recently and requires significant investment to tap its full potential [14]. Countries are divided into six regions in terms of solar energy potential. Turkey is in the fourth region countries. According to the General Directorate of Renewable Energy (GDRE), the average annual radiation in Turkey is 2.640 hours per year and the yearly average solar radiation received is 1.311 kWh/m<sup>2</sup> [3], [16].

Although Turkey's solar energy potential is quite tremendous, investments in this area have been limited up to 2011. In 2010, MENR unveiled the 2010-2014 Strategic Paper consisted of renewable energy based targets. In January, 2011, new feed in tariffs were introduced and electricity from solar power plants are remunerated at about 0,133\$/kWh and locally manufactured equipments used in these plants are also remunerated by different bonus payment. Turkey aims to reach to 5 GW PPSs in 2023 [17]. In order to encourage the small investors, Turkish governments exempted from electricity generation license, if installed capacity of electricity generation plant is lower than 1 MW. Furthermore, in 2013, investors showed keen interest in solar power generation systems. Even if 8.9 GW photovoltaic power projects have been proposed, 600 MW of this received projects are approved for utilization

due to the lack of capacities in transformer stations and necessity of use of natural financial sources [18].

PPSs should be utilized in most convenient region in terms of solar radiation, sunshine duration and temperature values. In order to increase the available power, temperature of regions has to be small and solar radiation and sunshine durations have to be high. In this context, MENR determined the convenient areas for PPSs

utilization. Fig. 5 shows these regions. According to the TEIAS's analysis, 121 substations and twenty seven cities were determined for PPSs integration [19]. TEIAS also determined the transformer station and transformer capacities. In this capacity analysis, with 92 MW total capacities, Konya is the leader city in terms of utilizing PPSs [20].

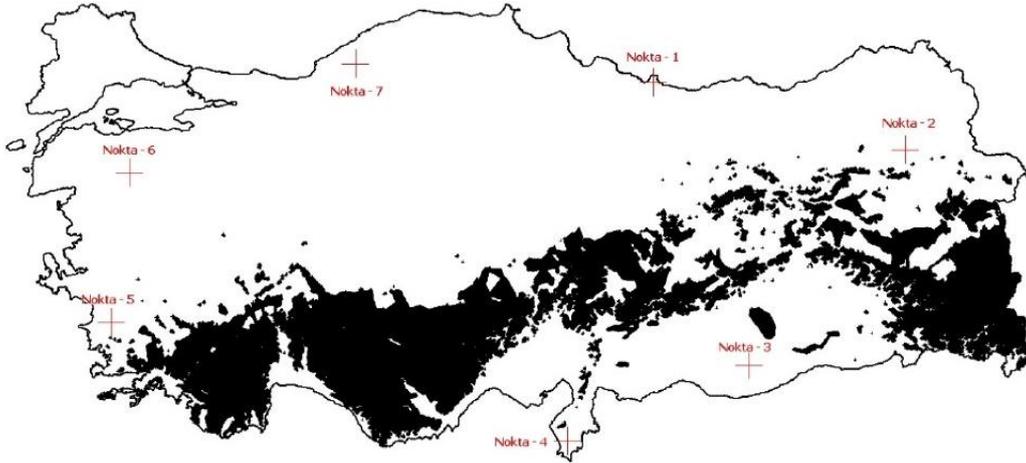


Figure 5. Determined areas for photovoltaic power generation power plants.

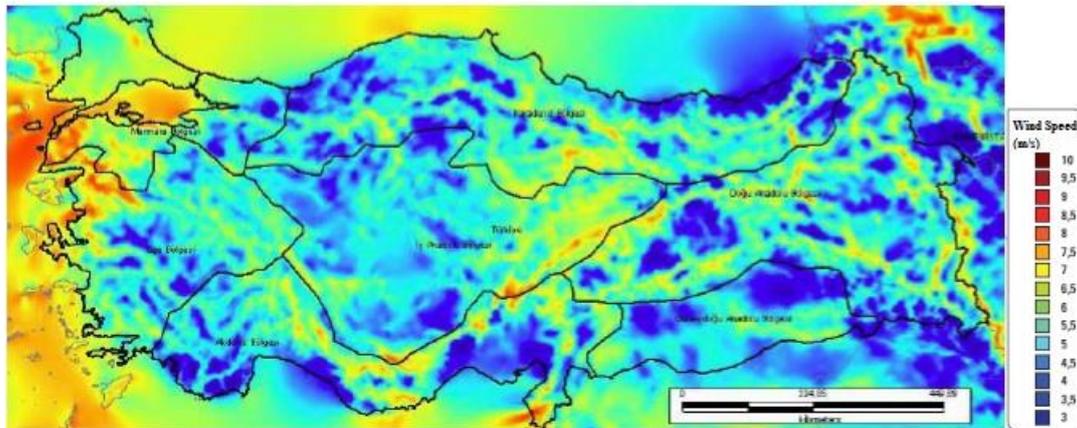


Figure 6. Wind speed distribution of Turkey at 50m height [18]

C. Current Status of Wind Energy

Use of wind energy in electricity generation has been growing in the world due to the depletion of fossil sources, environmental pollution and global warming [5]. Since Turkey is surrounded by three seas, it has significant wind energy potential. According to the General Directorate of State Meteorological (GDMS) studies, Turkey's annual mean wind speed is 2.58 m/s and wind power density is 25.82 W/m<sup>2</sup> [5], [6], [21]. According to the GDRE, Turkey's wind energy potential is estimated at 48 GW. Distribution of this potential is summarized according to the wind speed and wind power density in Table II. While this potential is determined, measurements of wind speed which is at least 7 m/s and height of 50m above from ground level are considered. [17]. Fig. 6 shows wind speed distribution of Turkey and wind energy potential atlas. It is clear that west and

northwest regions of Turkey is more suitable than the other regions for wind power applications.

TABLE II. WIND POWER POTENTIAL OF TURKEY WHERE WIND SPEED IS HIGHER THAN 7 M/S AT 50M HEIGHT [18]

Wind Speed (m/s)	Average wind power density (W/m <sup>2</sup> )	Potential Power (MW)
7 - 7,5	400-500	29.259,36
7,5 - 8	500-600	12.994,32
8 - 9	600-800	5.399,92
>9	>800	195,84

In 2007, utilized wind energy plants (WPP) capacity was 146 MW as shown in Fig. 7. With announcement of the tenders for WPPs at the same year accelerated the wind energy sector. After this year, use of wind power in electricity generation increased significantly. With 2023 energy targets, Turkey aims to increase its wind power plants capacity to 20 GW in 2023. As of beginning of

2016, according to the Turkish Wind Energy Association's data, utilized wind power plants have 4503.2 MW [13] total capacity and power plants under construction have 1.87 GW capacities [22].

Aegean and Marmara are the prevailing regions in terms of utilized WPPs with rate of 37.72% and 36.95% respectively [22]. These regions are tremendous for wind energy potential. Besides, these regions are the most populated regions and centre of tourism which need more energy than the other regions.

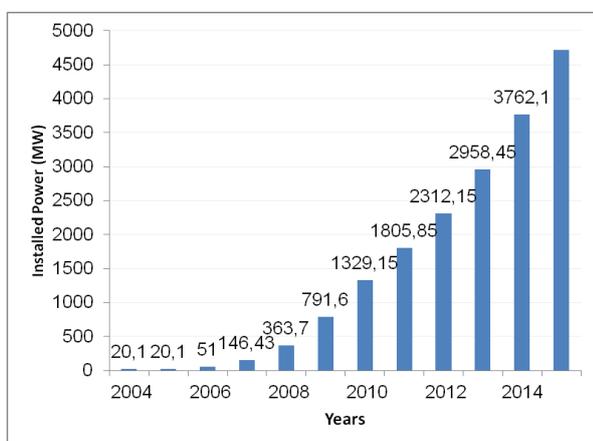


Figure 7. Installed wind energy power plants in Turkey by years [22]

## V. DISCUSSION AND CONCLUSION

Due to the depletion of fossil resources and increase in environmentalist concerns over the world, energy has been an important agenda for countries. Therefore, new and indigenous energy sources have gained priorities in terms of economical and strategic reasons for countries. On the other hand, effects of global warming cause to climate change and increase the CO<sub>2</sub> emissions. That is, temperature of earth increase continuously which affect adversely the environment and human health. Thus, countries change their energy policy. One of the common changes is the increase the share of renewable energy source for energy usage. Diversification of energy sources are the another important issue due to the World Energy Forum's and International Energy Agency's estimation related to expiring of fossil resources.

As an Annex I country in Kyoto Protocol, Turkey has some obligations related to greenhouse gas emissions. Furthermore, with growing population and industrial development, energy demands in Turkey increase continuously by average 7-8% per year and TEIAS's projections are verified this trend with rate of 6.4% and 7.9% for low and high scenario, respectively. In this context, in 2009, 2010-2014 Strategic Paper was published by MENR and main energy agendas as 2023 Vision of Turkey were emphasized. In the 100th anniversary of foundation of Republic of Turkey, there are some critical energy targets determined that Turkey are willing to achieve by 2023.

Solar and wind energy are the promising energy sources within the framework of 2023 Vision of Turkey. With huge wind and solar energy potential, Turkey aims

to have 20 GW WPPs and 5 GW PPSs by 2023. With contribution of the other renewable energy sources, renewable energy shares in energy production are 30% of total energy demand by 2023. Current capacities of these sources are 4503.2 GW and 290 MW for wind and solar, respectively. Although, Turkey, with these values, seems to be quite far from the targets, Turkey aims to develop unique and indigenous equipments for using in these plants. In this context, On the one hand, MILRES project is developed by universities and official institutions to promote local technology. In addition, TÜBİTAK encourages the domestic production and urges the priority areas such as energy included solar and wind energy with high project budget. On the other hand, Turkey, as a new country in photovoltaic energy needs local technology as well as wind does. However, Turkey does not have a natural solar energy projects. Feed in tariff (FIT) mechanism is also designed to promote investment in renewable energy technologies with attractive incentives for investors. Incentives of solar and wind energy with local technology bonus are 0.2\$ and 0.11\$ per kWh.

Geographical location of Turkey, with high solar and wind energy potential, is suitable for WPPs and PPSs utilization. With these advantages and large scale natural projects, Turkey will reach 2023 energy targets by utilizing approximately 2.2 GW WPPs and 600 MW PPSs per year.

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