COST ACTION ES 1002: WORKSHOP 22-23 March 2011, Nice France.

This website is hosted by

METEOTEST

"State-of-the-Art" Workshop 22-23 March 2011

- Agenda
- Workshop Report
- List of presentations & extended abstracts

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Memorandum of Understanding

COST Action ES1002

An Overview of Wind and Solar Energies Usage in Turkey

Selahattin İncecik, Ceyhan Kahya, Erhan Çalışkan and Hüseyin Toros
Istanbul Technical University, Department of Meteorology, Postal Code: 34469, Maslak Istanbul, Turkey, incecik@itu.edu.tr

1.Introduction

Turkey is situated at the Southeastern Europe and Eastern Mediterranean region with a population of about 73 million. Turkey has experienced rapid economic growth since 1980s and today Turkey ranks among the fastest growing energy markets in the world. Turkey's total national installed capacity is about 45.000 MW by the end of 2009, while it was 16.318 MW in 1990 with the average annual growth rate of 5%. Total power generation of the country rose from 57.543 GWh in 1990 to 194.813 GWh in 2009, with an average growth rate of 6,7% [1]. Hence, energy-related CO_2 emissions have more than doubled since 1990 in Turkey. Turkey has ratified Kyoto Protocol in 2009. There are several efforts to control and mitigate GHG emissions in the country. In this regard, the utilization of renewable energy resources, such as solar, geothermal, and wind energy, appears to be one of the most efficient and effective ways in achieving the Kyoto Protocol's requirements.

Turkey does not have enough primary energy sources such as petroleum and natural gas. Turkey's second largest energy source after coal and natural gas is hydro. The Turkish government hopes that hydro capacity will expand to 35,000 MW by the year 2020. Furthermore, geothermal energy is the only renewable energy source not originating from solar energy which includes direct use of heat, electricity production and geothermal heat pump. Turkey is the seventh richest country in the world in geothermal potential for its direct use and for electricity generation. It is located on the Alpine–Himalayan organic belt, having one-eighth of the world's geothermal potential [2]. Turkey has 170 geothermal fields over 400 ^oC temperature and they are located at Western and Central parts of the country [3]. To realize Turkey's sustainable development, the national energy development strategy includes an energy conservation priority policy, and at the same time is vigorously developing renewable energy and new energy in Turkey. Renewable energy technologies produce marketable energy by converting natural phenomena/resources into useful energy form. In Turkey, such as wind and solar these resources represent a massive energy potential, which greatly exceeds that of fossil fuel resources. The usage of renewable energy resources such as wind and solar in Turkey is a promising prospect for the future as an alternative to conventional energy.

This study presents an overview on the production of wind and solar energy in Turkey.

2.Turkey's renewable energy potential

Turkey's energy policy target is planned to reach a 20% renewable energy share by the year of 2020, and 30% in 2050, respectively [4]. The instruments to reach this goal range from the 'Law of the Turkish Policies on Renewable Energies' to the political and financial support of research and development of renewable energy sources. The Ministry of Energy and Natural Resources of the Turkey has listed CSP (concentrating solar power) as an important research issue in the 'Summary of National mid & long-Term Science and Energy Technology Development Plan' (2006–2020) [4]. On the other hand, up to now, no commercial solar thermal power plant is in operation in Turkey.

Turkey's renewable energy potential is given in Table I [4]. Renewable energy production makes up approximately 14.4% of the total primary energy supply (TPES), i.e. 10.30 Mtoe in 2007, and renewable sources represent the second-largest domestic energy source after coal. Table III shows solar energy potential in Turkey [5]-[11]. In spite of this high potential, solar energy is not now widely used, except for flat plate solar collectors. They are only used for domestic hot water production, mostly in the sunny coastal regions. In 2007, about 8.0 million m^2 solar collectors were produced and it is predicted that total solar energy production is about 0.390 Mtoe [6]-[12].

TABLE I: Turkey's renewable energy potential

Energy Type	Usage Purpose	Naturel Capacity	Technical	Economical
Solar energy	Electric (billion kWh)	977,000	6105	305
	Thermal (Mtoe)	80,000	500	25
Hydropower	Electric (billion kWh)	430	215	124.5
Wind energy (land)	Electric (billion kWh)	400	110	50
Wind energy (off shore)	Electric (billion kWh)	-	180	-
Wave energy	Electric (billion kWh)	150	18	-
Geothermal energy	Electric (109 kWh)	-	-	14
	Thermal (Mtoe)	31,500	7500	2.843
Biomass energy	Total (Mtoe)	120	50	32

Since mid-2000's as a result of applied important structural changes and increased investment incentives in renewable energy, investment demands above the potential on wind energy has arisen in Turkey. In the near future there will be an overloaded demand to solar energy like wind energy. In this context the possible usage areas and rate effects of renewable energies replaced with fossil fuels to the economical benefit of the country can be examined.

3.Wind energy

Wind energy is the fastest growing energy source and technology in the world and wind power is one of the most widely used alternative sources of energy today. In most of the some countries wind power in share of gross electric consumption is continuously increasing. As an example, in Germany its share has reached to 6.4% in 2010. The west parts of Anatolia have been identified as very favorable locations for wind power generation in Turkey [7]. As for the background in Turkey, wind energy has always played an important role in the historical and economical development of Anatolia. The people used wind energy for hundreds of years for pumping water and grinding grain in Anatolia. Then, they must have been dominant landmarks already in the 14th century in Anatolia and the wind mills were built mainly in the 19th century. Recently, wind power as a potential renewable energy source has grown in Turkey. Today, it is estimated that Turkey has 160 TWh a year of wind potential, which is about twice as much as the current electricity consumption of Turkey.

According to Ministry of Energy and Natural Resources, the wind potential of Turkey is given as 88,000 GW and the economic potential is estimated as 10,000 MW or higher [8]. Although, wind energy has a significant contribution to the energy system, for effective energy planning in the grid systems, prediction of wind energy production should be accurately up to 48-72 hours. Today, the majority of wind energy projects in Turkey are concentrated in the west with and Mediterranean regions with a total 25 projects. The installed capacity of wind energy is expected to reach 20,000 MW by 2023.

4.Solar Energy

Solar radiation arriving on earth surface is the most fundamental renewable energy source. In recent years, solar energy utilization in various applications has increased significantly. Turkey is promising country for solar energy potential. Turkey's geographical location is highly favorable for the utilization of solar energy. Turkey is geographically located (36-42°N latitudes) in a useful position for the solar power in the South Eastern of Europe and the Mediterranean. Solar radiation incident on a horizontal surface and sunshine duration are measured in the meteorological stations by Turkish State Meteorological Service (TSMS) (Figure 1) in Turkey.

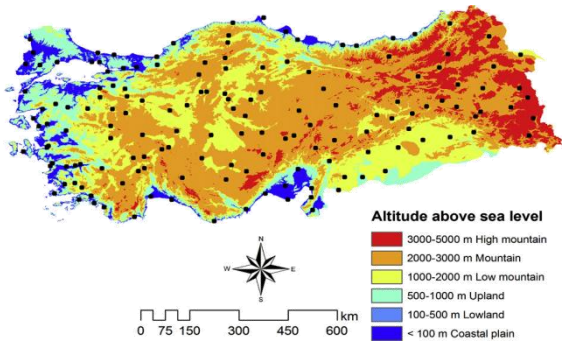

Fig.1. Solar radiation measurement stations by TSMS in Turkey

The country has an average 3.6 kWh/m2-day irradiation and 7.2 hours insolation time per day (Table II). In the southern parts of Turkey, there are about 3000 sunshine hours per year (Table III). The insolation values are higher and conditions for solar power generation are comparable to Spain. Table II indicates that the yearly total solar radiation is 1311 kWh/m²-year, and the average total yearly irradiation duration period is 2640 h [9]. Figure 2 shows the solar map of Turkey. The solar resource greatly changes in various areas. Southeastern Anatolia and

Mediterranean regions of Turkey are in the highest levels with closing to 1500 kWh/m²-year.
Solar energy is widely used in Turkey. The main solar energy utilizations in Turkey are the flat-plate collectors in domestic hot water systems. The hot water heating system installations exceeds 10 million m2 area having with a total installed capacity of 7.8 GW_{th} in 2008. Turkey is in the 2nd rank of the top countries using solar thermal power in worldwide following China. In China, this figure exceeds 100 GW_{th}[10]

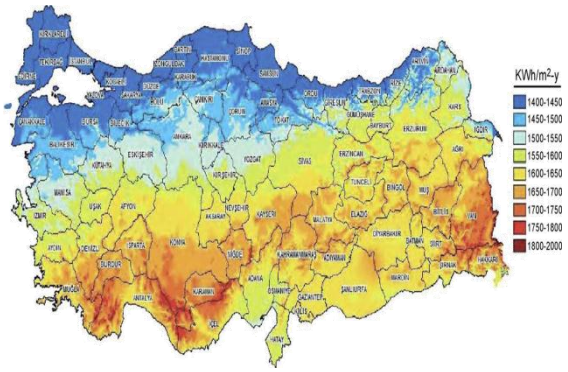

Fig.2. Solar map of Turkey

Furthermore, utilization of photovoltaic systems is very limited with the usage of some governmental organizations in remote service areas such as telecom stations, forest fire observation towers and highway emergency only. However, it is hoping that the photovoltaic system will play an important role in the future energy planning in Turkey.

Table II. The monthly average solar potential in Turkey

Months	**Monthly Total Solar Energy (kWh/m²-month)**	**Sunshine Duration (hours /month)**
January	51.75	103
February	63.27	115
March	96.65	165
April	122.23	197
May	153.86	273
June	168.75	325
July	175.38	365
August	158.4	343
September	123.28	280
October	89.9	214
November	60.82	157
December	46.87	103
Total	1311	2640
Average	3.6 kWh/m2-day	7.2 hours/day

TABLE III: Regional distribution of solar energy potential in Turkey

Region of Turkey	**Total solar energy (kWh/m²-year)**	**Annual irradiation duration (hr)**
Marmara	1168	2409
Black Sea	1120	1971
Aegean	1304	2738
Central Anatolia	1314	2628
Mediterranean	1390	2956
East Anatolia	1365	2664
Southeast Anatolia	1460	2993

The research and development of photovoltaic in Turkey is very new. It has not commercialized yet. The installed capacity of solar energy in Turkey is very small. Short-term forecasts are important tasks with potential, leading to improved energy forecasts and helping to increase the efficiency of the renewable energy productions for photovoltaic solutions as well contributing to improve the management and presumably the design of the energy grids in the future. Short-term forecasts are important tasks with potential, leading to improved energy forecasts and helping to increase the efficiency of the renewable energy productions as well contributing to improve the management and presumably the design of the energy grids in the future.

5. A National Proposal: Short term forecasting of solar radiation using WRF model

Variations of solar irradiance are known to have a significant influence on electric power generation by solar energy systems. Forecast of solar power is a key point for integration of the solar power production into the electricity grid systems. For this purpose, we have just submitted a proposal to the Turkish Scientific and Technical Research Council. In this project it is aimed to forecast the solar radiation for a short time over Turkey by using previously measured solar radiation data and a meso-scale numerical weather prediction model globally and widely used by academicals institutes and weather services. The suggested study which entitled "Short term forecasting of solar radiation using WRF model" is planned to be carried on under **COST Action ES 1002 WIRE** - Weather Intelligence for Renewable Energies. Numerical weather predictions of global radiation from the WRF Model (Weather Research and Forecasting) will be used. As a non-hydrostatic atmospheric model; WRF helps the users to bring the regional resolution to a few kilometers. A spatial resolution of 5km x5km will be applied. Global radiation, cloud cover, temperature

and wind speeds will be predicted by the WRF model. The model simulations will be obtained for January, March, July and September. The results obtained from the model will be compared with ground based data of the same period and evaluated considering cloud effects. A Benchmarking process has been described to to evaluate the performance of the developed models and to compare the current atmospheric conditions with several different atmospheric conditions. Model Output Statistics (MOS) will be applied to the output of WRF Model for improving the forecasting. Thus the research has to include post-processing algorithms coupled with weather prediction models and past and online measurement of ground based observations. The research will contribute to investigate the relationship between the weather dependent energy production and concurrent capacities like transport and distribution of the energy to the end users.

6.Conclusions:

The usage of renewable energy resources shows a promising prospect in Turkey in the future as an alternative to the conventional energy. In the past decade, wind energy has become a valuable and dependable source of electricity worldwide. There is a promising potential in Turkey for both wind and solar energy. In Turkey, several research institutions have initiated research at various stages on the applications of solar energy. The estimated wind and solar energy potentials: 48,000 MW for wind and 80Mtep for solar. Turkey has a considerably high level of renewable energy resources that can be utilized to satisfy a part of the total energy demand in the country. Present applications have shown that renewable energy sources in Turkey are a promising alternative.

In a recent project proposal, short term forecasting of solar power production into the electricity grid system has been submitted to the Turkish Scientific and Technical Research Council of Turkey.

References

[1] B. Ozer, E.Gorgun, S. Incecik. An analysis of the CO_2 emission mitigation potential from electricity production industry in Turkey. SET2011, 10th International Conference on Sustainable Energy Technologies, Istanbul Turkey, 2011

[2] N. Cicek, M. Ozturk, N. Ozek, Renewable energy market conditions and barriers in Turkey, Renewable and Sustainable Energy Reviews, 2009, Volume 13; 1428-1436

[3] EIE, Electrical Power Resources Survey and Development Administration. Potential of Turkish wind and solar power. Available from http://www.eie.gov.tr [accessed 20.06.09].

[4] MENR, Ministry of Energy and Natural Resources. Energy report of Turkey in 2007. Turkey, Ankara; available from http://www.enerji.gov.tr [accessed 10.06.09].

[5] WECTNC, World Energy Council Turkish National Committee. Energy report of Turkey for 2007–2008. Ankara, Turkey: WECTNC.

[6] Toklu, E., M.S. Guney, M. Isık, O. Comaklı, K. Kaygusuz. Energy production, consumption, policies

[7] Incecik S, Erdogmus¸ F. An investigation of the wind power potential on the western coast of Anatolia. Renewable Energy 1995;6(7):863-865

[8] MENR, Ministry of Energy and Natural Resources. Energy report of Turkey in 2008. Available from http://www.enerji.gov.tr [accessed 04.06.10].

[9] SWEPS, Short term wind energy prediction system, TUBITAK Project, 2010.

[10] Solar thermal energy barometer, EurObserVer, 2010.