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Solar and Wind Energy Potentials and use in Southeastern Anatolia

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Abstract: The potential of solar and wind energy, related studies in Turkey explained. Solar and wind energy potential at Southeastern Anatolia Region is summarized and energy applications are explained with some examples. Expanding the activities and investments with special regulations and government supports on implementation of renewable energy projects, wind and solar energy is emphasized.

Key words: Southestearn Anatolia, solar, wind energy and applications, expanding, wind, supports

INTRODUCTION

Today usage of fossil fuels is insufficient to meet the growing energy needs of Turkey. To meet this need, nuclear power plants are suggested for Turkey. These plants are expensive and dangerous in many ways such as fossil fuels will be damage the environment one day. Turkey is a country rich in renewable energy sources. At certain extend, using more renewable energy sources, it is possible to meet partially daily energy demand (WPP., 2017). Turkey's solar energy potential is equivalent to the sum of the potential of almost all European countries. According to the study by EIE (Electrical Power Resources Survey Administration), the average annual total sunshine duration is 2640 h, the mean total radiation intensity was found to be 1311 kWh/m^2 year. That is to say that, 7.10^6 kcalories of solar energy fallson entire surface of Turkey. Some related data are given at Table 1 and 2 (WPP., 2017).

Wind energy has the highest economic potential as renewable energy sources of Turkey and she has the best wind energy potentials within 19 European countries. It is estimated that Turkey has about 83-88 GWh wind energy latent power. Wind-powered electricity generation projects at economical scale were implemented in coastal regions of Marmara, Aegean and of Mediterranean Seas of Turkey. Total production capacity is reached about 3, 5G Wh at June 2014. The wind energy potential of Turkey would also, positively is affected by global warming and climate changes. Naturally, increase of temperature difference between day and night times will cause additional increase in wind potential of inland region of Anatolia (Kick, 2011)

Table 1: For long term monthly total solar energy and sunshine duration of Turkey

Months	---Total solar energy (kWh/m^2 month)---		Sunshine duration (h/month)
January	4.4500	51.750	103.0
February	5.4400	63.270	115.0
March	8.3100	96.650	165.0
April	10.510	122.23	197.0
May	13.230	153.86	273.0
June	14.510	168.75	325.0
July	15.080	175.38	365.0
August	13.620	158.40	343.0
September	10.600	123.28	280.0
October	7.7300	89.900	214.0
November	5.2300	60.820	157.0
December	4.0300	46.870	103.0
Total	112.74	13110	2640.0

Table 2: Regional long term average values of total solar radiation of Turkey (WPP., 2017)

Region	Total solar radiation (kWh/m^2 year)	Sunshine duration (h/year)
Southeastern Anatolia	1460	2993
Mediterranean	1390	2956
East Anatolia	1365	2664
Central Anatolia	1314	2628
Aegean	1304	2738
Marmara	1168	2409
Black Sea	1120	1971

Due to the global climate changes, the increase in the solar energy potential of Southeastern Anatolia Region (SEAR) must be studied (Kick, 2011) (Fig. 1).

Related studies about solar energy in Turkey: The first time, solar energy studies were started at universities, Technical University of Istanbul, METU (Middle East Technical University), University of Istanbul and of Ankara in 1960. This was the period of water heating systems. Solar energy coordination committee

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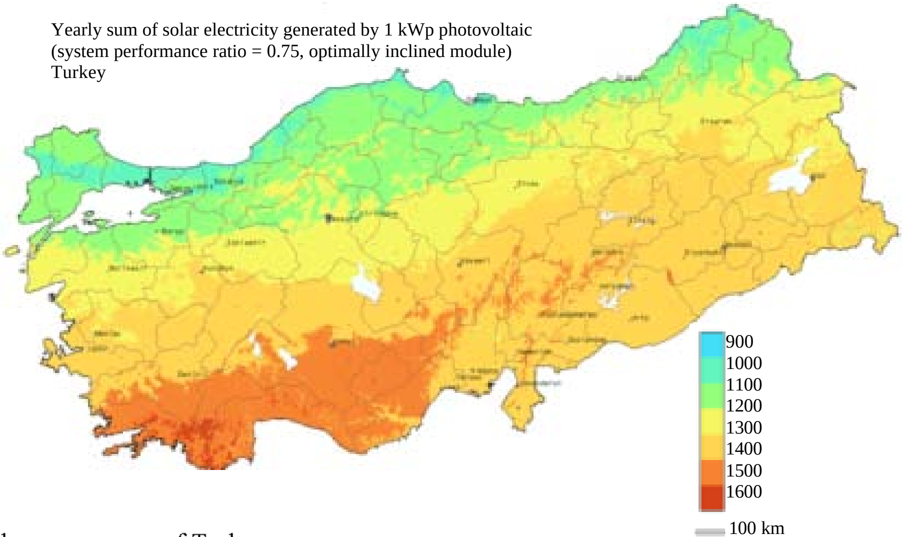

Fig. 1: The solar energy map of Turkey

established in 1973 and worked until 1975. Then, mineral research and exploration institute were commissioned for the study of solar energy in 1975. Marmaris Solar and Wind Energy Research Center was established in 1975 and worked until 1980. However, this center's task is given to EIEI at 1981. Solar pool studies were started at 1976 in Cukurova University. A solar house built at Hacettepe University which started research on solar radiation absorption and heat storage. Plane solar collectors are combined with cylinder parabolic mirrors for production of distilled water system at Dicle University at 1986. Standardization of production of plane collectors was accepted at 1994. As a result of survey which are made on plane solar collectors, 1, 5.10^6 m^2 solar collector was in use at 1994 in Turkey. By the year 2000 with some of the establishment of centers such as the solar energy research institute and at some universities on some renewable energy projects are carried out, Muola University developed lighting system of campus by PV panels (2002-2008). A solar house (greenhouse) is designed and put into operation between 2003 and 2008 in Diyarbakir. Some of the universities, e.g., Ataturk, Batman, Suleyman Demirel and Middle East Technical University reserach on efficiency improvement of solar cells. According to Turkey's 5 years development plan in the next 5 years put forward target for solar energy consumption (hot water utilities are included) must be reached about to 80 at 2020.

MATERIALS AND METHODS

Solar energy in Southeastern Anatolia Region (SEAR) and Diyarbakir: Falling solar energy per square meter is about 1461 kWh/m^2year for SEAR which is much higher than the average value of Turkey. Solar data for Sanliurfa, Diyarbakir and Mardin Provinces are slightly higher than the other provinces as seen in Fig. 2. Solar radiation data for the provinces of the region and Diyarbakir for long term period has been prepared by the General Directorate of Meteorology (MIGM) (Eris, 2003; Gursoy, 2004; YEGM., 2012).

In Diyarbakir as elsewhere, natural sunlight has been used at indoor and outdoor for several needs. For example, sunlight had been in use for lighting and heating of Turkish baths and mosques, madrasas and of public activity halls. As used many years, the Sun's rays are still in use for natural drying of timber, wheat, tomato paste, vegetables, fruit, sausage washed-carpet, dress. For cooling purposes in volcanic stones which erupted from Karacadag are used at Diyarbakir. When these stones are soaked by water it holds the water inside then gradually takes the heat from environment, the water evaporates and house gets cool. By this way, most of the house of Diyarbakyr was kept cool during the summer period for many years. Since, 1980 passive and active solar energy systems are in use for solar energy utilization in Diyarbakir. Hot water demands at homes and at businesses are easily overcome by this solar energy utilization system. Many traditional or ever ready (frost-selective glass and antifreeze, vacuum) solar collector have been installed on top of roof of any kind of buildings (public or private houses) for to meet the daily hot water requirements. The plane collector and cylinder parabolic concentrators are installed and tested together in a water distillation system and productivity accounts were published between 1986 and 1989 at University of Dicle-Diyarbakir. This system is seen in Fig. 3. But

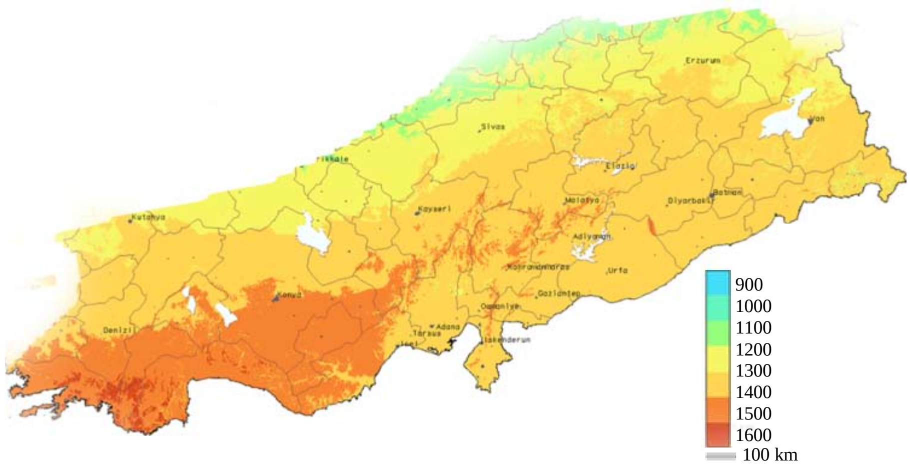

Fig. 2: The solar energy map of Southeastern Anatolia Region (SEAR)

Fig. 3: The plane collector and cylinder parabolic concentrators together with heat exchanger in a water distillation system (Arslan and Aydinol, 2011)

later Photo Voltaic (PV) panels and wind-powered electricity generation projects were implemented in many parts of Turkey and in the world.

PV panels and plate thermal collectors which they were placed to the southern side roof of the house were used for electricity and hot water production. This house project has been supported by Diyarbakir municipality, together with 20 scientists and 20 sponsoring companies DNV GL, 2016. The house is also in use for training purposes of renewable energy. Southern facing roof of this house is shown in Fig. 4. The electrical energy generated from PV panels stored in the batteries. Again, the water fall has an implementation that uses the energy obtained from PV panels. Solar cooker and furnace applications and are also exhibited. Sun powered waste water treatment system also runs at this house.

Use of PV panels for garden lighting, irrigation pumping, traffic lighting and preparation research for solar chimney system (model study) are shown in Fig. 5 (Arslan and Aydinol, 2011; Geo Trust, 2017). After the encouragement of 4628 law, several companies start competing on marketing of thermal solar collectors, PV panels, home heating systems and solar power generation businesses in SEAR. A significant contributions and leading role has been taken by Diyarbakir Metropolitan municipality on expansion of electricity production using PV solar panels (DNV GL, 2016). Indoor/outdoor applications of PV panels in the region can be summarised as follows by expanding the use of PV panels, produced and stored electricity used for radio and telephone systems, air observation stations, lighting inside or outside the building, away from residential areas in homes, TV, refrigerator such as the operation of electrical equipment for water pumping for agricultural irrigation and for domestic use at forest lookout towers, first aid, alarms and security systems, seismic stations, tunnels, road markings and lighting, security and billboards lighting. Still price of PV panels puts a limitation on its use.

Fig. 4: Southern facing roof of the solar house in Diyarbakyr (DNV GL, 2016)

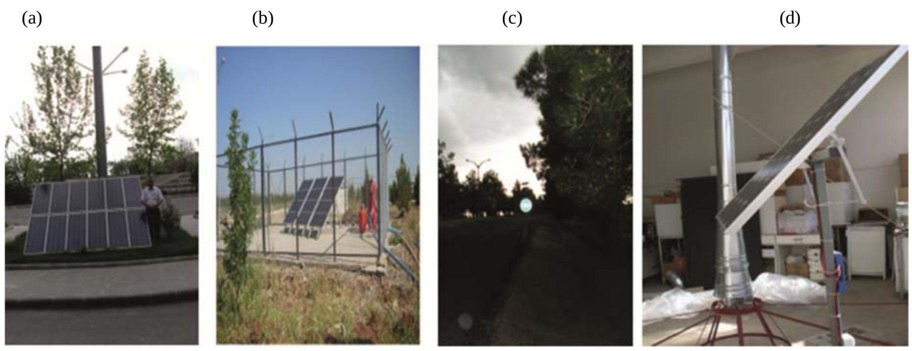

Fig. 5: From left to right: a) Lighting; b) Irrigation; c)Traffic Lighting and d) Solar chimney system (Arslan and Aydinol, 2011; GeoTrust, 2017)

A private firm is developing a grid connected flagship solar project named “Edessa Project” at Sanliurfa with a capacity of 12 MWp. Another issue, the efficiencies of PV panels are in the range of 5-25%. The cost of electricity generated by PV panels compare to the cost of electricity generated by hydroelectric power plants is very high. The other disadvanteges is that when there is no sun radiation, you can not get electricity from PV panels. As the hottest region of Turkey, SEAR could might be act as an energy bridge for neigbouring regions. Private sector or government need to evaluate the best strategic locations of SEAR for to produce electricity from solar energy. The 4628 law “Electricity generation from renewable energy sources and to support production from solar energy law” does not contain a big drawback. By expanding the scope of this law, many investors might be encourages and promotes for the production of electrical energy from solar energy. To support the expansion of this issue is a constitutional obligation to provide equal opportunities for citizens to invest. Broadening the scope of this law is also suitable by the contents of the Kyoto protocol. Diyarbakir has a great potential for solar energy. By placing PV panels on 40% of the roof of houses in Diyarbakir, electrical energy needs of all the SEAR could be met. In addition this by using produced winds from solar chimneys and towers it is also possible to produce additional electricity. Taking these into account, it would be possible to sell electricity to the national grid and the energy transfer and sale to the surrounding countries. Strong dependency on foreign natural gas network and foreign currency could be reduced by this way. Since, 1969 the world believe in the necessity of diversifying energy sources and methods of utilization of solar energy, passive systems are used for heating and hot water needscan be made available forevery family. With the availlable collector technology with an annual rate of conversion efficiency of 30-60% collectors are in use. According to these assumptions, the sun radiation falling on Turkey, 36 million TET low temperature heat energy possible to produce in a year solar energy data and meteorological measurements are maintained by MIGM in Turkey (Gursoy, 2004). With total collector area of 10 m^2 and with different PV panels, different amounts of energy produced for 9 provinces of SEAR are given in terms of kWh/m^2 year in Table 3 (WPP., 2017; Eris, 2003).

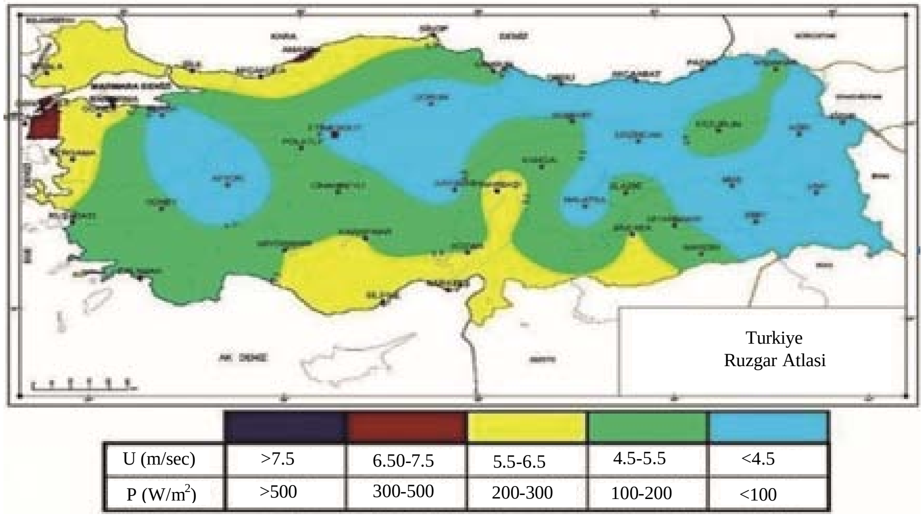

Fig. 6: Turkey wind energy potential map of Turkey by EIE

Table 3: With collector area of 10 m^2 with different PV panels, produced different amounts of energy for 9 provinces of SEAR are given in kWh/m^2 year (WPP., 2017)

Province	Mono crystallin	Poly crystallin	Thin Cu film	Cd-Te	Amorph Silis
Batman	2700	2300	1400	1200	1050
Diyarbakir	2500	2200	1300	1100	1000
Mardin	2600	2300	1400	1200	1500
Siirt	2700	2400	1400	1200	1050
Sirnak	2700	2400	1400	1200	1050
Adiyaman	2700	2400	1400	1200	1050
Gaziantep	2600	2300	1400	1200	1000
Kilis	2600	2300	1300	1200	1000
Sanliurfa	2600	2300	1400	1200	1000
Means of SEAR	2500	2200	1300	1100	1000
Means of Turkey	2500	2200	1300	1100	1000

According to Table 3 the best region of Turkey is SEAR in terms of annual solar energy potential. For Diyarbakir, values of solar radiation falling on horizontal plane, before entering the atmosphere are given for each month as the monthly average solar radiation and the average sunshine duration of many years, wind speed in m/sec terms, measured the soil temperature values at one meter below the soil surface are also relevant datas could be obtained from (Arslan and Aydinol, 2011; WPP., 2017) (Fig. 6).

RESULTS AND DISCUSSION

Wind energy in the Southestaern Anatolia: The annual average wind speed in the region and around Diyarbakir is about 5 m/sec and there is no particular seasonal prevailing specific wind direction. Wind energy potential for electricity generation SEAR of the economic scale are considered inadequate. For this reason, if we want to use wind power for electricity generation first we have to produce a regular and controllable wind then we can able to produce electricity by using suitable wind turbines. If anyone planning to setup an economical wind farm anywhere, one of the necessary conditions is that wind speed must be 7 m/sec or greater at 50 m height. Capacity factor should be 35% or more for each turbine. New wind farms must be close to national wind power plants or substations to be installed close to the national grid are also preferred. It is almost necessary to evaluate the site datas by “Wind farmer V4 software programme” before make final decision. This programme is available at www gl-garradhassan.com. Turkey wind energy potential map prepared by EIE and is given in Fig. 6 (GeoTrust, 2017). For SEAR average wind speeds fall between 4.5-6.5 m/sec at 50 m above the land. It seems to be not much economical for electricity production with large scale wind turbines.

Temperature difference between the ends of the along pipe (called solar chimney) could easily controllable. Due to the air flow from hot to cold end of solar chimney system with a controllable speed, wind can be obtained. Chimney reserach like a wind tunnel and help to turn several funs, namely provides mechanical energy. By converting mechanical energy into the electrical energy by wind turbines it is able to meet the some parts of electricity demand (Geo Trust, 2017). This method could be implemented on unused land and rural areas for required electricity production from solar energy. Global warming and climate change, land and seas of our country by increasing the temperature difference is expected to positively affect the potential for wind energy. The related research on global warming affect has already started. In addition, during the planning of policies and amending the related laws of electricity generation from solar and wind energy, this type of changes should be considered. Naturally, the further increase of day-night temperature differences in SEAR is also affects the wind power potential (Gursoy, 2004).

In terms of annual solar energy potential of Turkey is the best region SEAR. In this region, irrigation pumps in farms, critical institutions in rural areas gets required electricity needs from PV panels (signal transmission, seismic records and observer locations). Traffic lights and garden, interior or exterior windows and building lighting electrical energy obtained from photovoltaic systems for use in urban centers and rural areas initiated. This is further supported by the laws of any special incentive. Thermal SPA waters of the region with the application of solar energy and solar chimney systems could be much economically used. For instance as such site can be established which might be simultanously serves as holiday camp and as an electric power production facility. The hot water vapors produced by solar energy could contribute to removal of oil by pumping into the oil wells at raman region. The wind energy potential of SEAR is below the average of Turkey and noted that production capacity is not economical. However by using existing technologies in addition to the potential of the solar energy for example using solar chimney (and combination of PV panels) with yielded winds which has constant speed, it would be possible to produce at some scale of electricity at SEAR (Arslan and Aydinol, 2011; Karahocagil, 2012). Even, if climate changes occur this sort of applications still will be remain an applicable way to produc eelectricity in this region. If we all use electricity which produced from renewable energy sources then we can live in much cleaner surrounding. For the future following recommendations would be considered. For green energy opportunities, launching a study to implement a coordinated and multi-faceted projects. With a rapid transfer of information about renewable energy and of its advantageous must be presented to public. Government should have provide all the support for wind or solar power generation projects in the region. Strengthening of the existing electricity transmission infrastructure, transmission and distribution lines and adopt them to green energy electricity. Electricity usage must be controlled locally. Preparation of a site-specific wind and solar atlas data for this region must be prepared, analyzed and made accessible to everyone.

CONCLUSION

The wind and solar energy power generation technologies must be taught formally with other, engineering and related science subjects at all levels. For staff training at all levels cooperatation with other countries such as EU Asia-Pacific countries must be considered.

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