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# Assessment of renewable energy potential and policy in Turkey – Toward the acquisition period in European Union

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## ABSTRACT

This paper aims to assess the renewable energy capacity of Turkey in order to consider main priorities in the energy policy of Turkey. In this paper, renewable energy potential and regulatory conditions are discussed in Turkey in comparison with European Union. The results of the study implemented within the framework of EnviroGRIDS project indicated a promising yet very susceptible future for the implementation of renewable energy power plants in Turkey. The forecasts have shown that the solar power potential utilization is becoming more significant after 2020. The projections for 2050 indicate that electricity consumption from small and medium renewable energy sources including solar and wind will constitute 15% of the total, whereas the solar thermal will constitute around 16%. Geothermal and other renewables will remain around 3%. According to the high demand scenario, in 2050 the share of hydropower in overall electricity generation will be 12%, followed by solar power at 7% and wind power at 3%. Additionally, renewable energy policy and regulations in Turkey and in EU are overviewed in this study. On the contrary to EU, the constant feed-in tariff amount does not consider capital investments of specific energy sources in Turkey that brings disadvantage to the implementation. However, new regulations published and currently applied should be accepted as milestones in acquisition period of Turkey in EU.

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## 1. Introduction

Renewable energy sources enable countries both meeting domestic energy requirements and protecting the environment with zero or almost zero emissions of both air pollutants

and greenhouse gases. Turkey has a favorable geographical position which results in having a good renewable energy. Turkey with totally 1778 km of border to Black Sea is divided in to 81 administrative provinces in seven geographical regions. Since the Black Sea Catchment was selected as the study area of the EnviroGRIDS project, only 41 provinces of Turkey were

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completely or partially covered in this study. Provinces completely covered are mostly located in Black Sea and Marmara Regions along the Black Sea Coast of Turkey whereas partially covered provinces are located in Marmara, Aegean, Central Anatolia and Eastern Anatolia Regions.

Turkey lies in a sunny belt between 36N and 42N latitudes. The yearly average solar radiation is 3.6 kWh/m<sup>2</sup> day and average sunshine duration is 2640 h, corresponding to around 30% of the year. Theoretical technical solar potential, unconstrained by technical, economic or environmental requirements of Turkey was cited in official publications to be not more than 1% or 88 Mtoe/year, 40% of which was considered economically usable. Three-fourths (24.4 Mtoe/year) of the economically usable potential is considered suitable for thermal use, with the remaining (8.8 Mtoe/year) for electricity production (Ertekin et al., 2008). Solar power potential assessment for the national “solar atlas” was produced with the “ESRI Solar Radiation Model” used in GIS. The solar atlas presents the solar radiation and sunshine hours are calculated for 57 cities of Turkey.

It is estimated that Turkey’s technical wind energy potential is 88 GW and economical potential is approximately 10 GW depending on the technical condition. The wind atlas prepared by the General Directorate of Renewable Energies reported that, Turkey’s technical wind energy potential was 83 GW and production potential was 166 TWh/year. However, Turkey’s total installed wind capacity was only 2800 MW in 2010.

The potential energy output from biomass accounts to approximately 32 million tons oil equivalent per year Mtoe/y, whereas the total recoverable bioenergy potential is estimated to be about 16.92 Mtoe (Balat et al., 2006). Turkey has the highest gross and technical hydropower potential in Europe which is estimated around 216 TWh/year while the economic potential for hydropower capacity and electricity output have been estimated as 45 GW and 140 TWh/year, respectively (Erdogdu, 2011; Kucukali and Baris, 2009; Kose, 2007). The current utilization of geothermal energy in Turkey is very limited, of which 105 GWh/year is used for electricity generation and 4465 GWh/year is used directly, all of which contributes to only 3% of the total geothermal potential of Turkey (Yarbay et al., 2011; Kose, 2007).

On the other side, in Europe, World Energy Assessment (WEA) estimates the technical renewable energy potential at the European regional scale around 40,000 PJ/year which is almost twice the present electricity consumption and 75% of the current heat consumption. This potential is able to supply 62% of the current primary energy consumption in Europe. The distribution of renewable energy potential and use differs widely such that approximately 80% of the existing hydropower potential and 50% of the biomass potential is already used-up while the remaining available resources are hardly exploited.

This paper will assess the renewable energy capacity of Turkey in order to consider main priorities in the energy policy of Turkey. In this paper, renewable energy potential and regulatory conditions are discussed in Turkey in comparison with European Union. Based on the given data in enviroGRIDS project, the projection of the renewable energy potential in

Turkey, the analysis will be carried out in the scope of the result of projections in the project.

## 2. Evaluation of the renewable energy capacity for Turkey

Total electricity generation in Turkey was 229,395 GWh in 2011. Hydropower (as renewable) is the main indigenous source for electricity production and represented 23% (52,339 GWh) of total generation in 2011. Geothermal capacity of Turkey is considered as 31.500 MWt and 78% of this capacity is in Western Anatolia which results in an electricity potential of 1500 MWe. Additionally, biodiesel production capacity in current facilities is 561.217 ton/year. As it is estimated, this production capacity is going to be increased to 1.2 million ton/year biodiesel and 0.7 million ton/year bioethanol based on 2.7 million hectare agricultural land (Öz, 2013).

Renewable energy generation except for hydropower constituted only 2.6% of the total generation, wind power constituting the 2% while geothermal and renewable waste constituted less than 1%. The total installed capacity reached 52,911 MW, of which 19,106 MW is the renewable capacity hydropower constituting 32% of the total capacity. The share of renewables (hydro included) in the energy generation was 25%. The energy generation projection by primary sources according to the “Turkish Electrical Energy 10-Year Generation Capacity Projection Plan (2011–2020)” published by the Turkish Electricity Transmission Company is given in Fig. 1.

The solar and wind atlases prepared for Turkey are shown in Fig. 2. Fig. 2a indicates the map of total solar radiation in Turkey (URL 1) where Fig. 2b indicates wind map of Turkey. Table 1 also indicates the potential amounts of energy related to Turkish wind map as the legend of the map presented in Fig. 2b (WES, 2003). To identify the promising areas, the regions more than 1620 kWh/m<sup>2</sup>.year radiation have been identified to sustain a potential of solar energy.

After the Renewable Energy law came into force in 2005, 80 new wind power projects with 2887 MW installed power have been given license. After the completion of construction of those wind energy power plants, total installed capacity is estimated to be 1000 MW (Tükenmez and Demireli, 2012).

On the other hand, the total potential of approximately 5738 TWh/year is larger than the current and future electricity demand of around 3500–4000 TWh/year of the EU countries (URL 2). The potential is calculated by taking into account different renewable energy resources for power generation, i.e. – Concentrating Solar Thermal Power Plants in Southern Europe and MENA, Photovoltaic Power (PV), Wind Speed (Onshore and Offshore Wind Power Plants), Hydropower Potentials from Dams and River-Run-Off Plants, Heat from Deep Hot Dry Rocks (Geothermal Power), Biomass from Municipal and Agricultural Waste and Wood, Wave and Tidal Power.

The share of renewable energy in EU is shown in Table 2 (URL 3). In the renewable energy mix of Europe, biomass and waste, accounted for just over two thirds (65.5%) of primary renewables production in 2012. Hydropower was the following contributor to the renewable energy mix by a 16.2% of the total and output of wind energy accounted for 10.0% of the EU-28’s renewable energy produced in 2012.

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