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The Role of Renewable Energy Resources on Regional Development at the Thrace Region in Turkey

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Abstract: Countries try to increase their economic growth and development levels effectively by using their production factors. The main purpose of the local and regional development is to enhance underdeveloped and developing regions' limited income level and increase the business opportunities when compared with the developed regions. One of the most significant factors in the local and regional development is definitely energy. Especially, recently, the demand for the renewable energy sources usage has been increasing. Renewable energy sources are evaluated according to their potentials. When a region has a renewable energy potential, establishing and operating renewable energy sources-based power plants will have positive effects on regional development. In this study, energy concept, which is one of the most important inputs of regional development, is discussed. The potential of the Thrace Region's current energy sources is presented and the effects of renewable energy sources on regional development are studied.

Keywords: Regional development, Renewable energy, Thrace region, Turkey

1. Introduction

Due to its location, Turkey is one of the developing countries and it is always open to development since its geopolitical significance and dynamic economy. In the recent years, factors such as increase in urbanization rate, the growth in construction and industry owing to the new investment support, use of technology in order to make life easier affect the economy directly. Apart from these parameters, the other crucial factor is population growth. Population growth affects the value of growth in gross national product (GNP) directly. In case of the population growth is a parallel to the country's economic growth, progress and development could be mentioned. The combination of all of these parameters which are mentioned creates regional development. In order to eliminate the disparity as a result of a collection in a certain region industrialization, regional development is a fair distribution of wealth in the country by improving the industry of disadvantaged regions[1].

In order to ensure progress and development in disadvantaged regions, disparities between regions could be removed by improving regional development policies. Regional development policies could be listed as following:

- Making investments that will allow the use of its own regional resources.
- Providing state-owned enterprises' investment primarily in these regions
- Preparing the regional development plans in order to give priority to activities in this direction by selecting appropriate technologies according to the degree of labor intensity and capital in regions
- Implementing various measures such as tax incentives and credits in order to draw the private sector investment to the regions
- Supporting the business to be established in this region by making up organized industrial zones.
- Giving priority to the infrastructure of disadvantaged regions as to the state investment and ensuring that the national economy is in the integrative direction.

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- Organizing training activities which eliminate the deficit of technical personnel and skilled workers in these regions.

- In the realization of the regional development, synchronized regional development level has achieved and demand for energy has increased[1].

Therefore, one of the most important factors in local and regional development is energy. Especially in recent times demand for the use of renewable energy sources has been increasing. Renewable energy sources are the energy sources that are evaluated by means of their potential in the region. If the region has renewable energy potential, establishing and operating the power plants based on renewable energy sources will provide a positive contribution to regional development. This article deals with the concept of energy, which is one of the most significant input in development. The potential use of available energy resources in Thrace region will be revealed and the role of these sources on the regional development will be examined with, especially, the use of renewable energy sources.

2. The role of energy on the regional development

Due to urbanization that shows development with population growth, industrialization, and the spread of technology, energy consumption has increased inevitably. Despite this situation, the energy consumption should be kept as low as possible and energy should be used effectively and efficiently. Because in the energy sector:

- Production, transmission and distribution costs of energy resources are high.

- Energy projects are investments requiring long planning, development and investment periods, advanced technology and high finance

- With the decrease in qualified fossil fuels such as oil and natural gas, the strategic importance of this resource will increase and prices will enter into an upward trend unless new or alternative energy sources don't take place of these resources.

- In Turkey, where energy resources are not relatively rich, still 62% level is in dependence on external in this area. This external dependence will increase in response to increasing consumption depending on this value

- Energy resources have negative characteristics by affecting the environment at production and consumption phases. Eliminating environmental problems is an important factor of cost[2-3].

Those reasons mentioned above in items show importance of energy concept and use the available resources in the most efficient and economical way[2-7].

3. Current situation of energy and energy diversity in Turkey

Turkey's demand for energy and natural resources has been increasing due to growth in economy and population. In recent years, Turkey has recorded the fastest growth in electricity demand among OECD members, with an annual growth rate of 5.5% since 2002. Turkey's energy use is expected to increase by 50% over the next decade. Turkey's installed capacity exceeded 88GW as of January 2019, which represents a threefold increase in 15 years. When viewed cumulatively between 2000-2018 years. Turkey's energy consumption increased by 50% despite the significant decline in the crisis period. The total energy consumption in the EU increased by 3.6% in the same period. Energy consumption growth is regarded as a development indicator. However, energy consumption is the most important factor in triggering its external dependence at the same time. Another problem is inability to use the energy efficiently. Energy intensity in economy is considered as an indicator of energy efficiency. **Figure 1** shows the development and growth of the energy consumption shown in Turkey[8].

World population growth, urbanization and industrialization cases and growing trade opportunities as result of globalization, increase the demand for natural resources and energy gradually. The gross electricity consumption in Turkey in 2017 was 296,7 billion kWh. Also, it was 147.2 billion kWh by the end of June 2018. In 2023 it is estimated at 450 billion kWh. As of the end of the first half of 2018, EUAS had a share of 22.8% in installed capacity of Turkey, 62.9% of the private sector, 7.0% of build-operate plants, 1.6% of build-operate-transfer plants and 5.7% of unlicensed power plants. In addition, as of the end of the first half of 2018, number of electricity energy production plants in our country have been 6886. According to energy sources, number of existing plants is as follows [9]:

- 636 hydroelectric Power Plant
- 63 Coal Power Plant
- 232 Wind Power Plant
- 40 Geothermal Powe Plant
- 303 Natural gas Combine Power Plant
- 5.422 Solar Power Plant
- 190 Other Power Plants

Turkey is a country that fossil-based sources are widely used. Especially dependence on fossil fuels to natural gas has increased, in order to meet the rapid increase in demand over the years. 87% of primary energy demand is met by fossil fuels[10] which took place in 2010 according to data from the Ministry of Energy and Natural Resources. By the end of the first half of 2018, the distribution of Turkey's installed power by resources are demonstrated in **Figure 2**.

According to **Figure 2**, Turkey provides 32% from hydroelectric installation, 22.2% from coal, 26.4% from natural gas 7.7% from wind 5.4% from solar 1.3% from geothermal and 5.0% from other sources of electric power[9]. The fact that domestic and renewable resources will not be sufficient to meet Turkey's energy demand and dependence on imported sources is expected to continue in the coming years is under consideration. It should be given to indigenous fossil resources exploration and energy efficiency efforts in order to reduce dependence on external sources to get a little bit. Energy efficiency studies in especially industry associations and housing will provide significant time savings from energy consumption when executed in order to achieve planned goals[10,12]. Energy consumption forecasts for the sector in 2023 are given in **Figure 3**.

Considering the diversity of Turkey's energy coal is first place in terms of importance. By the end of 2016, Turkey possessed 136.2 million tons of equivalent petrol, with the share of coal in the total primary energy consumption being 28%. As of the end of June 2018, the power plant installed capacity dependent on coal in our country was 18,666 MW, and this is equal to 22% of the total installed capacity. The installed capacity using domestic coal is 10,570 MW (12.1%) and using imported coal is 8,794 MW (10.1%)[13]. Coal is used primarily for energy production, steel production and cement production. In addtion it is used for heating in settlements. The state has the largest share in Turkey's coal industry. Turkey Coal Enterprises, a state owner an economic enterprise (TKI) is the only coal producer in the country. Coal consumption has been increasing continuously since 1998. In Turkey the most important domestic resource of coal is lignite. Large and extensive brown coal mining are available in the country. Lignite rezerve was in a continuous incline from 8.3 billion tons to 17.3 billion tons in 2005-2018[12,14-15]. Considered oil from the perspective of energy diversity Turkey is a poor country in terms of oil compared with its neighbors. Crude oil that was processed in 2016 and 2017 in Turkey occured at 30.35 and 31.57 million tons respectively. **Figure 4** shows Turkey refining capacity between 2013 and 2017[16].

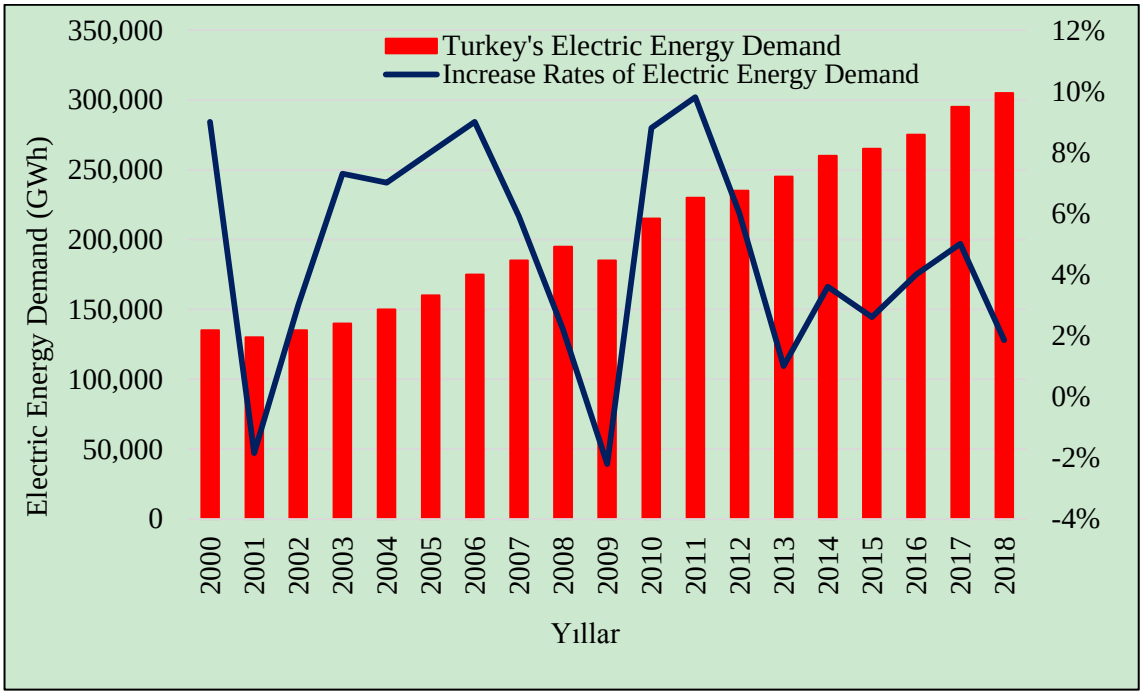

Figure 1. Development of energy consumption in Turkey

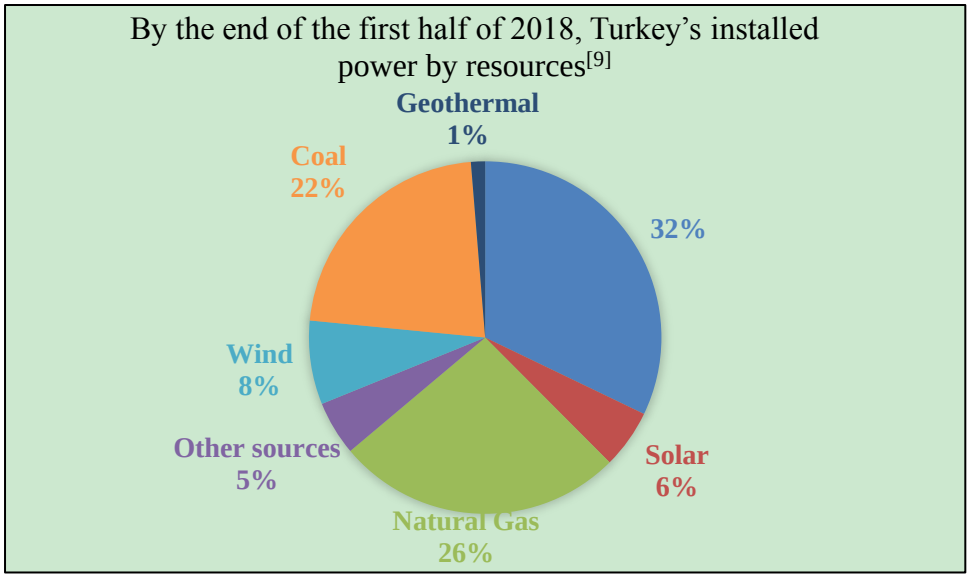

Figure 2. By the end of the first half of 2018, Turkey's installed power by resources

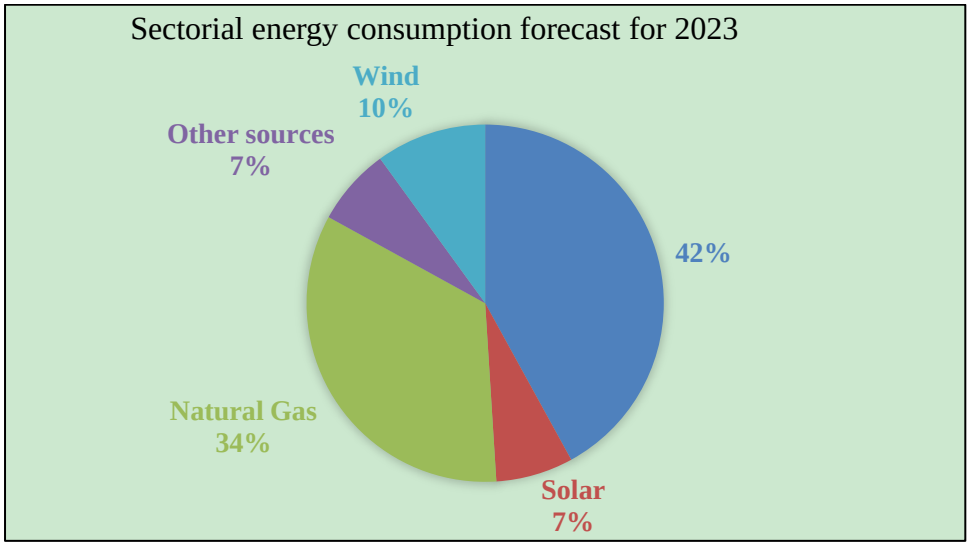

Figure 3. Sectorial energy consumption forecast for 2023

The share of natural gas and its importance is increasing to meet the rapidly growing demand for energy in Turkey. The natural gas increases the share as energy inputs in industry, housing industry and electricity production gradually and it has become the preferred fuel type in three sectors of Turkey.

Since 1987, the use of natural gas in Turkey has been increasing. The share of natural gas in total primary energy supply, leaving the oil, by the year 2018 was 26%. Turkey with 51.7 billion cubic meters of natural gas consumption in 2018 became a full market with the opportunities for investors and gas exporting countries[11]. Turkey is largely dependent on outside for natural gas and imports natural gas from Russia, Iran and Azerbaijan with the channel pipelines and from Nigeria and Algeria in the form of LNG[16]. Turkey's natural gas consumption values in 2005-2017 are given in **Figure 5**. In particular electricity generation, represents an important place in the market of natural gas.

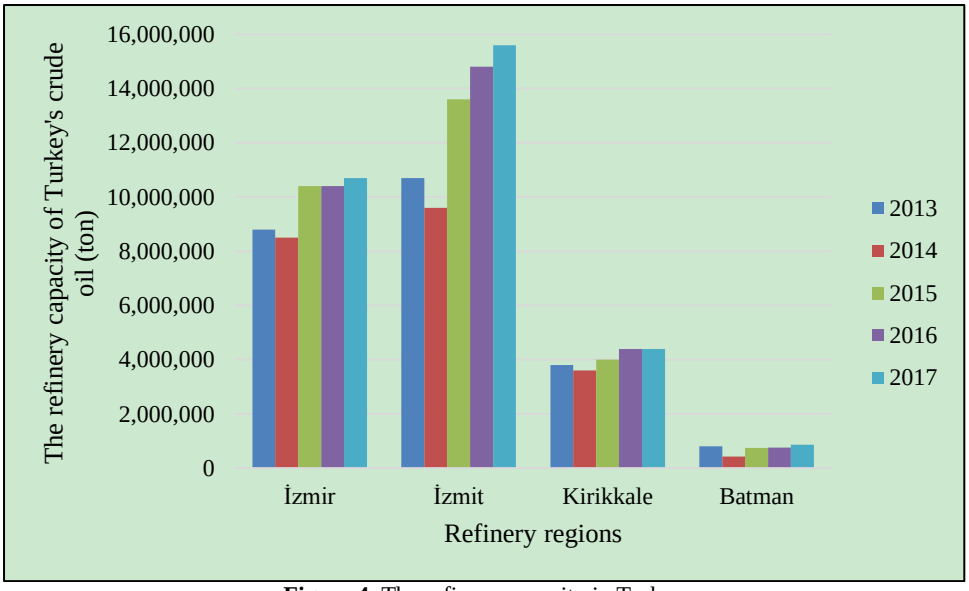

Figure 4. The refinery capacity in Turkey

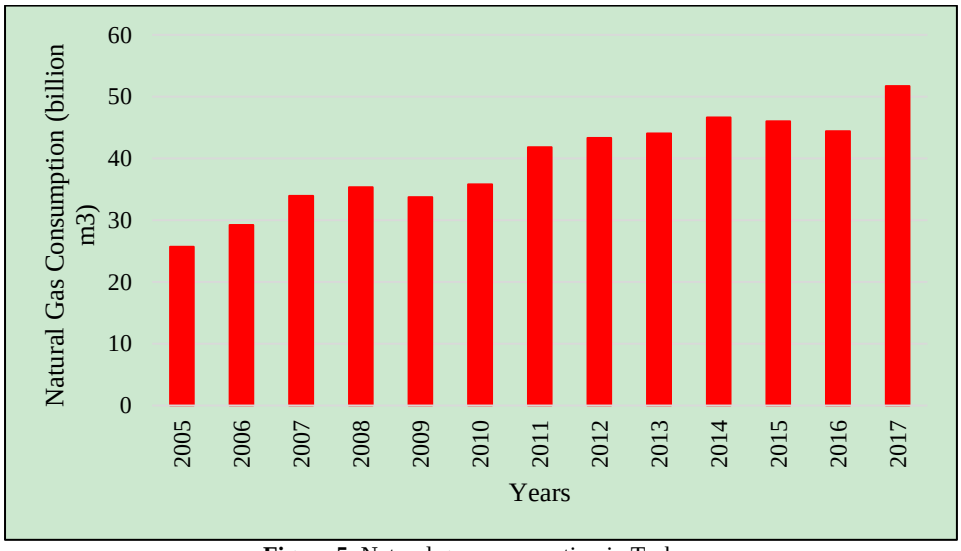

Figure 5. Natural gas consumption in Turkey

Turkey has an important place in the provision of energy diversification with renewable energy sources. Despite the rich potential of renewable energy sources, it has not yet implemented a significant part of this potential. In the mid-1990s, total primary energy supply of renewable energy was about 17%. By the year 2009 the amount decreased to 9.4%. By the end of the year 2010 was 9.6%[17]. Nowadays, this rate is reached to 25% in 2018. Biomass and hydroelectric power are the main types of renewable energy sources in Turkey. Geothermal, wind and solar energy are renewable forms of energy utilized in low rate currently[12,14-17]. Both the share of renewable energies in primary energy supply decreased, and the share of renewable energy sources in electricity production declined to 26.3% from 40% level in 2010. Despite the increase recorded in the generation of electricity based on wind energy, the share of renewable energy in total electricity generation occured as 25.7% for the year 2018. Power generation obtained from water source is shown in **Figure 5**[12]. Turkey gradually aims to increase the use of renewable energy sources with declining trend, such as geothermal, wind and solar energy, and also plans to enhance the use of hydropower instead of traditionally used biomass.

Hydropower is considered to be the most reliable and economically feasible energy source among the renewable energy sources, available for Turkey. Furthermore, hydropower is the main domestic energy source for Turkey and has the highest potential for electricity generation in Europe[19-21]. Turkey's hydroelectric resources, which hold the most important position in the renewable energy potential of our country, possess a hydroelectricity potential of 433 billion kWh, while the technically usable potential is 216kWh, and the economic hydroelectricity potential is 140 billion kWh/year. As of the end

of June 2018, there were 636 hydropower plants, with a total installed capacity of 27,912 MW. This is the equivalent of 32% of the total potential. By the end of June 2018, hydroelectricity production was realized about 33 billion kWh and 22.4% of our electricity production was obtained from hydropower[18].

Wind energy development based on the installed capacity in Turkey is presented as of years in **Figure 6**[22]. Approximately, wind-energy-generating capacity was installed in Turkey in 2016, 2017, and 2018 6106.05, 7369.35 and 6872.1MW, respectively[23]. Theoretically, Turkey has 160 TWh a year of wind potential, which is about twice as much as the current electricity consumption of Turkey[24]. The usage of wind energy in Europe is a remarkable industrial success for Europe. Between 2006 and 2016, 106 GW of power capacity were installed. In the same period the US installed 71 GW, China 156 GW and the rest of the world 80 GW. 31% of the global installed capacity is in Europe and 46% was manufactured by European companies.

On 30 November 2016 the EU presented the Clean Energy for All Europeans legislative package outlining the post-2020 EU regulatory framework for renewable energy, the internal energy market, security of supply and energy efficiency[25].

4. Potential of renewable energy sources and regional development in Thrace region

4.1 Wind Energy Potential

Wind energy installed capacity has increased substantially in the last 5 years in our country and worldwide and continues to increase. There are areas suitable for wind power plants on the south of Edirne, the east and south of Tekirdağ and the south of Kırklareli in Thrace region in the studies carried out by Renewable Energy General Directorate (YEGM). According to wind values set by YEGM wind speed in Edirne and Kırklareli 5.5 to 7 m/s, while in Tekirdag 6.5 -7m/s levels[12,14-17]. A total of 584 MW of wind capacity has been licensed according to the data by Energy Market Regulatory Authority (EPDK) in Thrace. Only 44MW of capacity is in operation, and the rest is either under construction or hasn't started for construction yet. With the completion of construction of the existing specified license, a significant proportion of wind potential will be evaluated in Thrace region. It is possible to evaluate the potential of wind power in the region of Edirne, Kırklareli and Tekirdağ in the context of unlicensed production. There is significant potential scope of unlicensed production of electricity from wind in Thrace region where there are a number of private industrial facilities[26]. Wind power potential is especially higher in the southern provinces of Edirne, such as Kesan and Enez districts, according to the YEGM data. An area which is about 694 km^2 in Edirne, is suitable for wind farm construction according to the studies conducted by YEGM. In the region, the substation connecting the power stations, is located in Keşan. Wind power potential is high in southeast districts of Kırklareli such as Pınarhisar, Vize and also high in north districts like Kofçaz. An area which is 615 km^2 in Kırklareli is suitable for wind farm construction according to the studies conducted by YEGM. A total of 3079 MW of wind power can be installed. Substation to connect the power stations in the region is concentrated in Lüleburgaz where wind speed is relatively low. There is one substation which belongs to TEIAS in Vize. Similarly, wind power potential is higher in eastern and western parts of Malkara, Şarköy Saray and Corlu in Tekirdağ according to the data YEGM. An area which is 925 km^2 in Tekirdağ is suitable for wind farm construction according to the studies conducted by YEGM. A total of 4,626 MW of wind power can be installed. In order to have an increase in investment of RES and connection of more wind power plant to the system investment of substation by TEIAS is necessary in the districts, Malkara and Sarköy[27]. **Figure 7** shows the existing wind farms in Thrace[28].

4.2 Biomass energy potential

Firewood obtained by forest waste, turd obtained from animal waste, garbage in city, the waste from agriculture, plants grown specifically for energy such as canola, corn, sugarcane are used for energy production from biomass. Energy is obtained by burning solid, liquid and gaseous form of agriculture, livestock waste, urban waste and waste obtained from forest. Biomass which is converted into the forms of bioethanol, biodiesel and biogas could be burnt as liquid and gas. Methane and wood briquettes that are obtained by using biomass are also used in especially power generation plants.

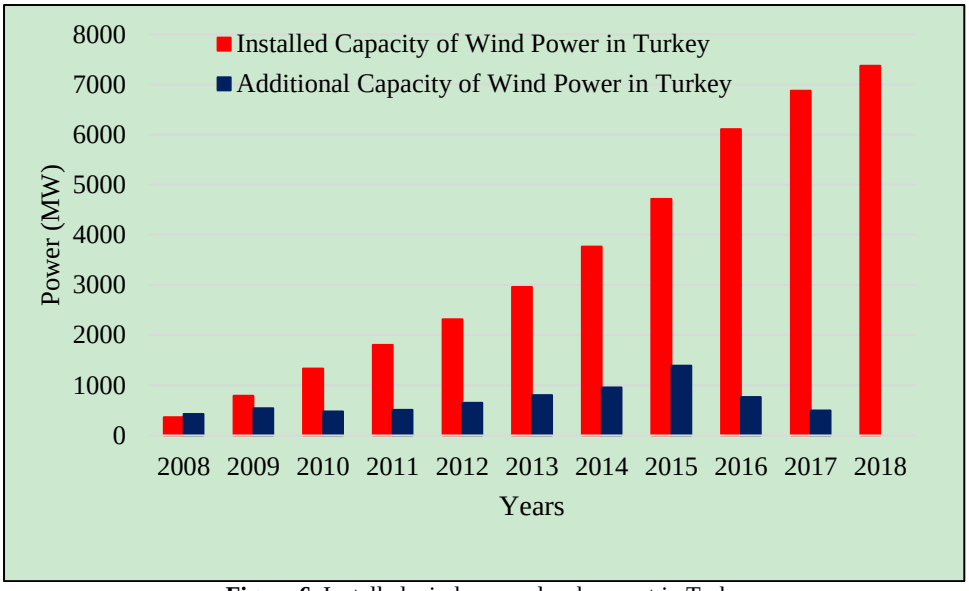

Figure 6. Installed wind power development in Turkey

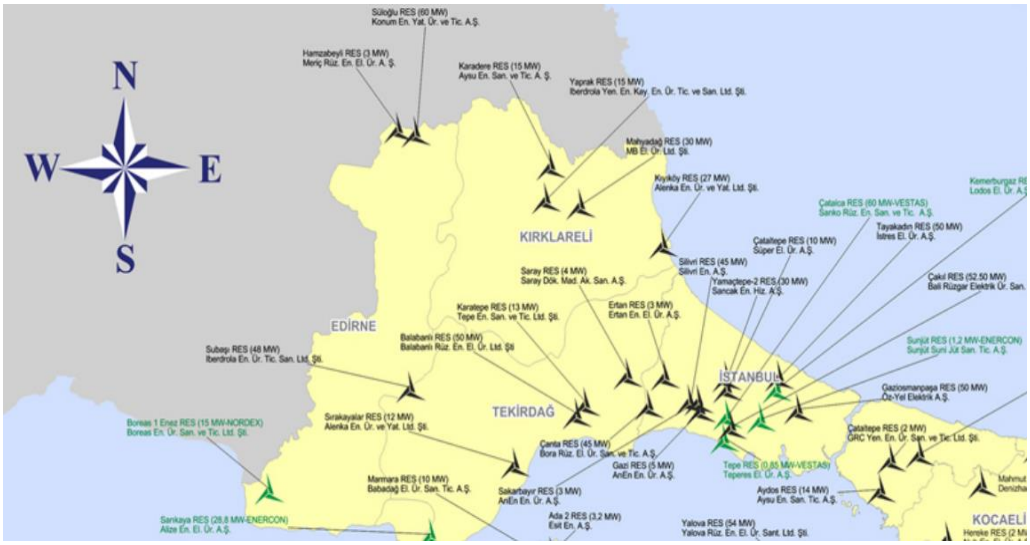

Figure 7. Existing wind farms in Thrace region

Biomass	Cycle Method	Fuels	Application areas
Forest Waste	Anaerobic Digester	Biogas	Electricity Generation, Heating
Agricultural Waste	Pyrolysis	Ethanol	Heating, Transportation
Energy Crops	Direct Burning	Hydrogen	Heating
Animal waste	Fermentation, anaero-bic digester	Methane	Transportation, Heating
Garbage (organic)	Gasification	Methanol	Aircrafts
Algae	Hydrolysis		Syntheticoil, Rockets
Energy forests	Biophotolysis	Diesel	Product Drying
Vegetable and Animal oils	Esterification Reaction	Diesel	Transportation, Heating, Greenhouse

Table 1. Biomass species[29,30]

Electricity production potential from forestry, animal and agricultural waste and organic waste from urban will be evaluated in Thrace region in this study. First of all, it is necessary to determine the potential waste in this region. According to the data conducted by General Directorate of Forestry the amount of forested land in Thrace region is given in **Table 2**[31].

Average 10-15% of the biomass derived from forest areas is left in the forest during harvest. Specifically, improved logistics techniques are used, for collecting waste biomass left in the forest is a costly and difficult process. It is possible to produce electricity in cogeneration plants when agricultural waste is collected and burnt by reducing humidity in it. Agricultural waste is widely used in all energy production in the world. According to data in 2010 Thrace region meets 9.3% of the wheat production, 62.5% of sunflower production and also the 44.5% of paddy production of Turkey. Sunflower, rice and wheat production quantities are given in the table below according to the TUIK data in 2011[32,33].

Provinces	Normal Forest (ha)	Degraded Forest (ha)	Total forest (ha)
Edirne	65,465	40,315.5	105,780.5
Kirklareli	221,889.5	36,806.4	258,695.9
Tekirdag	66,010.5	38,075.5	104,086
Total	353,365	115,197	468,562

Table 2. Thrace region total forest assets [31]

Provinces	Sunflower (tons)	Wheat (tons)	Rice (tons)
Edirne	240,417	451,743	379,182
Kirklareli	130,889	365,081	18,473
Tekirdag	253,471	592,982	22,103
Total	624,777	1,409,806	419,758

Table 3. The harvest number of agricultural products in Thrace region

	Edirne	Kirklareli	Tekirdag	Total
Total Paddy handle (tons / year)	568,773	27,710	33,155	629,637
Paddy Shell (tons / year)	75,836	3,695	4,421	83,952
Paddy handle for energy production (tons / year)	341,264	16,626	19,893	377,782
Paddy shell for energy production (tons / year)	45,502	2,217	2,652	50,371
Total corn stalk (tons/year)	451,743	365,081	592,982	1,409,806
Corn stalk for energy production	271,046	219,049	355,789	845,884
Total sunflower stalk (tons/year)	120,209	65,445	126,736	312,389
Sunflower for energy production (tons/year)	72,125	39,267	76,041	187,433
The total annual amount of energy (Gcal)	1,944,900	758,257	1,262,517	3,965,675
About cycle efficiency	40%	40%	40%	
The total annual working hours	6,500	6,500	6,500	
About theoretical installed capacity (MW	139	54	90	284
The amount of annual electricity production (GWh)	905	353	587	1,844

Table 4. Thrace region electricity production potential of the agricultural waste

Evaluating sunflower, wheat, and rice husk of the rice stalks obtained post-harvest as agricultural waste is possible for generation of electricity. It is possible to burn this waste as solid (biomass) in the form of biooil at the result of pyrolysis and in the form of the synthesis biogas obtained after fermentation by gasification. The capacity to be specified for power generation differs according to the selected combustion techniques. As a result of the detailed calculations the extent of potential power generation potential in Edirne, Kırklarel and Tekirdağ is shown in **Table 4** by using rice straw and rice husk, wheat straw and sunflower stalks.

Electricity and heat production could be done by burning waste obtained from poultry and livestock as methane or liquid forms in cogeneration plants. Electricity production potential in the region that could be obtained from livestock waste has been calculated below by starting from advanced livestock activities in Thrace region. Primarily the number of animals in Edirne, Kırklareli and Tekirdağ was obtained from the TUIK data[32].

The approximate amount of manure that could be obtained according to animals species annually are given in **Table 6**[32,33]

From Total number of animals in Thrace region, biogas amount and about fertilizer value given in **Table 6** the potential of biogas plants which are fed by total animal waste and could be established in Edirne, Kirklareli and Tekirdag was obtained.

According to the calculation electric power plant that can be obtained from biogas with a total of approximately 41MW of power could be made up by using animal waste in the region. Although 41MW isn't a large capacity on behalf of Turkey's total energy balance, evaluating waste as biogas is crucial for regional development. An annual budget of 38.5 million USD only in electricity generation for the region is created when $13.3/kWh calculation, the incentives given by the government for biogas today is made. The waste heat obtained from the plant is possible to evaluate the warming and greenhouse operations[1]. In Turkey, one of the first plants where urban waste was converted into electrical energy is in Ankara. In the plant where licenses are received for electricity generation, electricity and heat production are made by burning landfill gas product derived from waste collected in Mamak distrit of Ankara in 2006. By comparing the data related to amount of urban waste in Ankara and Thrace region, the potential for electricity generation from urban waste has been determined for Edirne, Kırklareli and Tekirdağ.

Provinces	The cattle	Small cattle	Poultry
Edirne	156,460	251,048	265,783
Kirklareli	132,922	213,591	352,788
Tekirdag	153,162	307,684	904,020
Total	442,544	772,323	1,522,591

Table 5. Number of animals in Thrace

Animals	Fertilizer amount (tons / year)	Biogas amount (m^3/day)	Energy value (MJ / day)
Cattle Farming	6	0.42-0.60	12.96
Sheep & goat Farming	0.7	0.37-0.61	7.4
Poultry Raising	0.013	0.05	0.22

Table 6. Approximately manure value obtained from animal

Provinces	Total fertilizer (tons / year)	Total biogas quantity (m3 / year)	Biogas AID (kcal / m3)	Total Energy Value (MWh / year)	Combustion efficiency	Annual Working Hours Of Plant	Installed Capacity (MW	Annual electricity production (GWh)
Edirne	1,117,949	29,261,332	5,000	170,124	60%	7,000	15	102
Kirklareli	951,632	24,865,729	5,000	144,568	60%	7,000	12	87
Tekirdağ	1,146,103	28,707,072	5,000	166,902	60%	7,000	14	100
Total	3,215,684	82,834,133		481,594			41	289

Table 7. Thrace animal waste biogas potential

Provinces	The collected waste (tons / year)	Installed Capacity (MW)	Estimated annual production (GWh)
Edirne	329,929	6	52.5
Kirklareli	202,145	4	35
Tekirdağ	451,567	9	78.8
Total	983,641	19	165.3

Table 8. Electricity production potential of urban waste in Thrace region

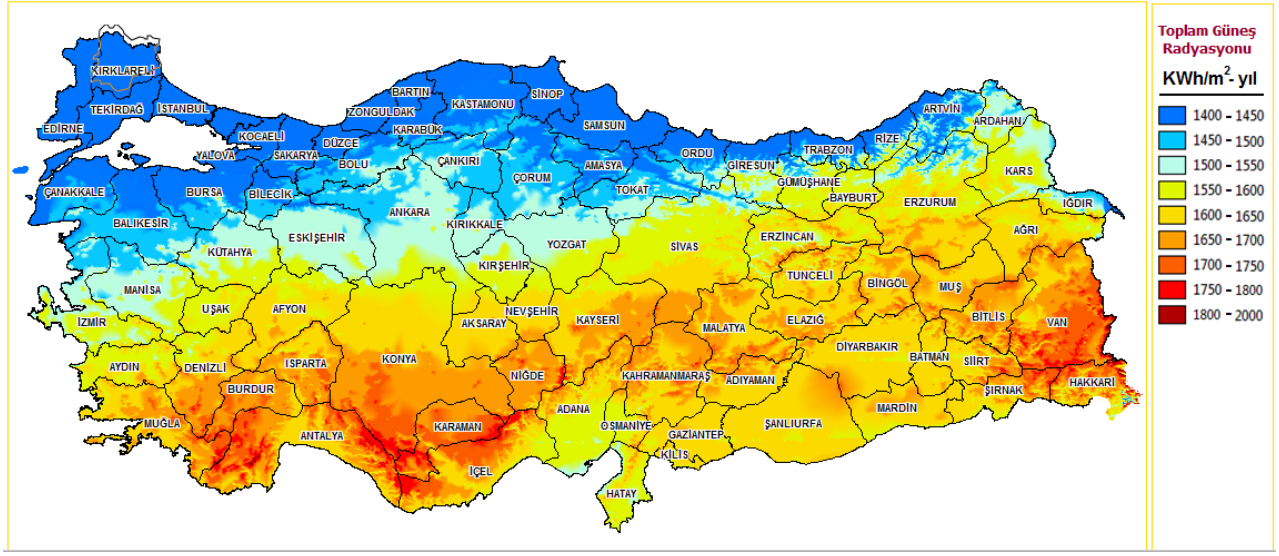

Figure 8. Solar energy potential atlas in Turkey

The values in the **Table 8** were obtained from Turkish Statistical Institute municipal waste statistics in 2018. The installed capacity of the existing plant installation in Ankara was proportioned to some provinces in Thrace in terms of collected waste. In this context the 19MW power plant using municipal waste could be established in the region.

4.3 Solar energy potential

Thrace region isn't considered as efficient in terms of generating electricity from solar energy and a capacity isn't allocated in any substation. Licensed solar power plant will not be made possible in the first place in Thrace region according to an announcement made by the MENR. On the other hand, investors who want to install solar energy as an unlicensed facility do not have an obstacle in the region.

When the solar energy potential atlas in the **Figure 8** is investigated Thrace Region is observed that in the blue zone. That the average radiation in Edirne, Kırklareli and Tekirdağ is 1400-1450m^2/kWh /year has been identified by YEGM[4,12,34].

The fact that the average radiation rate in Thrace Region is lower than the average of Turkey is the biggest obstacle to solar energy investment in the region. Renewable energy incentives granted under the laws are insufficient for assessment of potential solar energy in Thrace Region[4,12].

4.4 Geothermal energy potential

In Turkey geothermal energy research and development work has been carried out by the Mineral Research and Exploration General Directorate (MTA) since 1962. As a result of geological, geophysical, geochemical and drilling performed for geothermal by MTA from that date until today there is no temperature geothermal field with over 35^{0}C in Kırklareli. This situation is evident on the map of geothermal resources and applications prepared by MTA[4].

5. Conclusions

The role ofrenewable energy for Thrace region on regional development in terms of renewable energy sources are the ingredients below:

- According to the data of Electrical Power Resources Survey and Development Administration with regard to wind energy, Thrace region has a significant potential in terms of energy production. In these districts production of energy is provided by establishing wind power generating plants and offering employment opportunities to people in these plants. It prevents migration out of the region.

- Thrace Region is unfavorable in terms of solar ener-

gy. Therefore, it doesn't have an important role in a regional development.

- Thrace region has a significant potential in terms of biomass energy.

- The fact that the vast majority of people deal with farming, agriculture will give a special importance on this energy source for the people.

- Supporting energy forestry in the region could contribute to the promotion of the welfare of the people. The fact that the people of the region are familiar with the process of cultivation of oilseed crops and encouraging the cultivation of the crops, agriculture for energy (sorghum, miscanthus, canola, C_4 plants, such as planting) instead of the crops removed from the scope quato (such as sugar beets) will provide guidance to the agricultural sector, create jobs and increase national income.

- The establishment of a facility to carry out the energy production can be achieved with the assessment of village forest waste in areas where the forest is dense.

- Finally there aren't any hydropower and geothermal resources in Kırklareli. Therefore an effect to regional development isn't concerned.

Abbreviations

EU : European Union

EUAS : Electricity Generation Coorparation

EPDK : Energy Market Regulatory Authority

GNP : Gross National Product

MENR : Ministry of Energy and Natural Resources

MTA : Mineral Research and Exploration General Directorate

OECD : Organization for Economic Cooperation and Development

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