FUTURE TECHNOLOGIES AND RENEWABLE ALTERNATIVES[1]

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The Black Sea region has always been considered a bridge between Europe and Asia. When it comes to the energy sector, the status of all these countries might be different, as some are producers, some rely heavily on imports and some others just serve as corridors. However, the future is one and only and over the last years all these countries have started working in the same direction.

The urgency of the fight against climate change has been acknowledged almost by every country. So far well-known for its role in the gas industry, the Black Sea region is now emerging as a potential renewables hub.

In particular, concerning renewable energy sources, significant advantages have been introduced across the countries, such as feed-in tariffs, renewable energy zones, green certificates, and other attractive incentives.

Today, the local energy demand in the countries of the region is forecast to grow in line with the GDP, with Türkiye alone registering a 5.1 percent electricity demand growth since 2002.

The Black Sea presents strong resources of renewable energy in each of the six surrounding countries (Romania, Bulgaria, Georgia, Ukraine, Türkiye, and Russia).

Thanks to the hinterland of this region, the demand will absolutely help to design such a good scenario to shift to 100 percent renewable energy.

Achieving energy security is at the top of the authorities' agenda for many countries in the region. By the end of 2020, Romania plans to meet the obligations set by the EU in terms of greenhouse gas emissions through its legislative package Climate changes – Renewable Energy. Bulgaria adopted the Renewable Sources Act already in 2011, regulating the generation and consumption of energy from renewable sources. The wind potential is limited in all countries but Romania and Serbia have good water potential.

The Black Sea is one sea-basin stirring new interest. The World Bank estimates it has 453 GW of technical offshore wind potential – 269 GW for bottom-fixed and 166 GW for floating offshore wind. The Romanian Parliament is debating a draft Offshore Wind Bill. And Bulgaria is starting to look into offshore wind deployment as well.

How much solar do we need to electrify the energy system in the Black Sea and how can we scale the industry up to meet that demand? What are the most promising utility-scale projects in the region?

•Romania plans to add around 3.7 GW of solar by 2030;

•Türkiye plans to commission 10 GW of solar by 2027;

•Bulgaria envisages the installation of 1600 MW of solar between 2020 and 2024.

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Wind Potential in the Black Sea

The recent wind power conditions for a 30-year period (1976-2005) are assessed based on the results provided by the same RCM (Regional Climate Model) used to generate the future climate projections of the wind fields. The impact of climate change on the future wind power potential is evaluated by comparisons between historical data and near-future (2021-2050) and more distant future (2071-2100) projections. Under the scenario considered, an increase in the mean wind power was observed until the middle of the 21 st century, followed by a small decrease.

Annual means of the wind power at the height of 80 m above the sea level for the point M3 computed for historical data and, near future and distant future projections under the RCP4.5 scenario. The linear trend is indicated by the red dashed line. (Rusu, 2019)

The highest mean values of wind power there are in all deep water points, for all time periods considered, with values ranging between 500-550 W/m2.

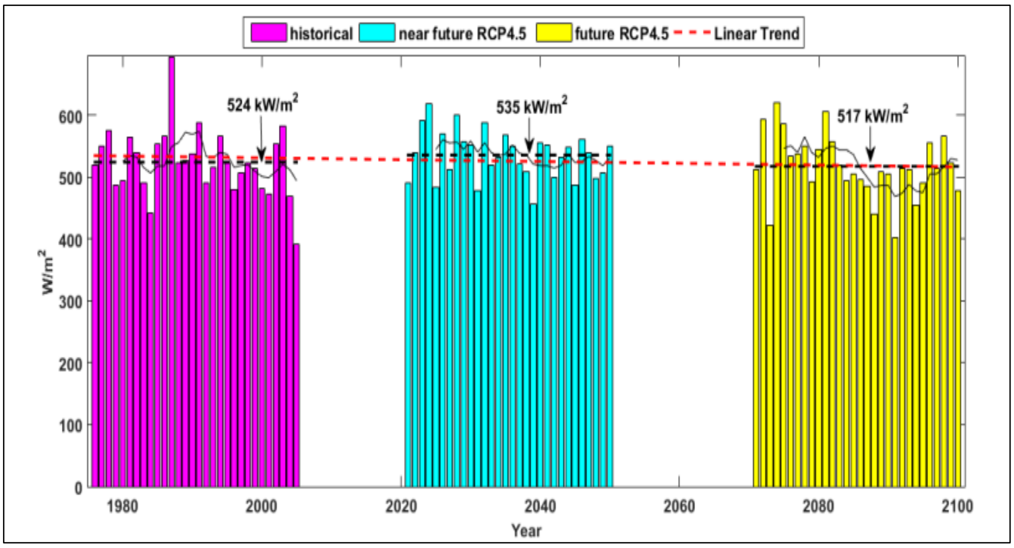

Figure 1- Annual means of the wind power at the height of 80 m above the sea level on Black Sea

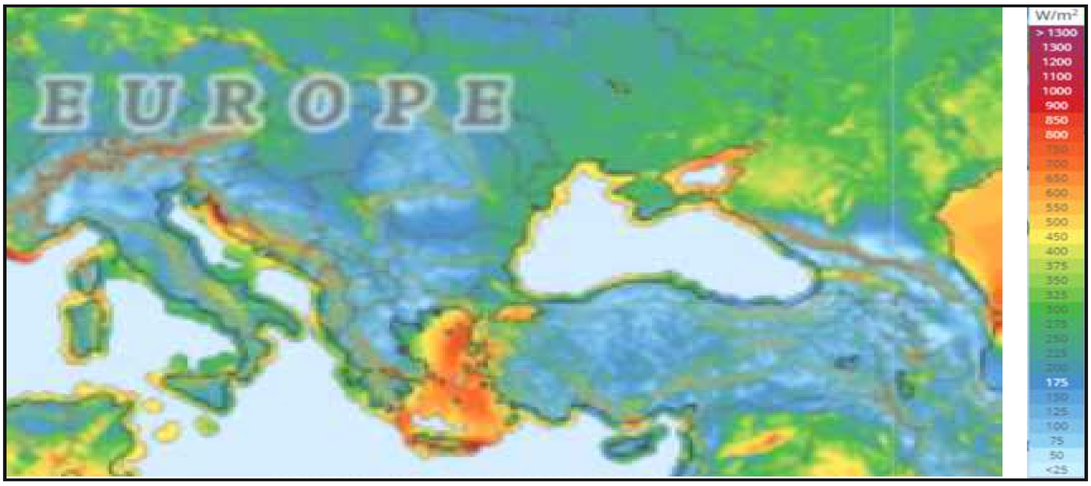

Figure 2- Average wind values of Europe and Black Sea

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Current Renewable Positions of the Black Sea Countries

Türkiye

The wounds by the end of July 2022 can be experienced according to current sources; 31% hydraulic energy, 24.8% natural gas, 20.7% coal, 10.9%, 8.5% solar, 1.7% geothermal and .4% ü are other sources.

Türkiye has an important solar energy potential due to its geographical location. According to the Türkiye Solar Energy Potential Atlas (GEPA) prepared by our Ministry, the average annual total sunshine duration is 2.741 hours and the average annual total radiation value is calculated as 1.527.46 kWh/m2.

Our onshore wind potential stands strong and as most of the Turkish sites are still young, re-powering them in the next decade may again boost the installed wind fleet, by better using existing resources, About offshore, we consider that the potential is remarkable and together with the improvement of technology and amelioration of the economic aspects, Türkiye would be on a competitive edge.

According to the data of the Turkish Wind Energy Potential Atlas (REPA-V1) prepared in 2006 with a horizontal resolution of 200 m using a medium-scale numerical weather forecast model and a micro-scale wind flow model, the annual average wind speed of 50 meters above ground level and over 7.5 m/s It has been accepted that 5 MW wind power plants per square kilometer can be established in usable areas with high speed and the total capacity of wind power plants that can be established in Türkiye is determined to be 47,849.44 MW. As of the end of June 2022, our installed power based on wind energy is 10,976 MW, and its ratio to the total installed power is 10,81%.

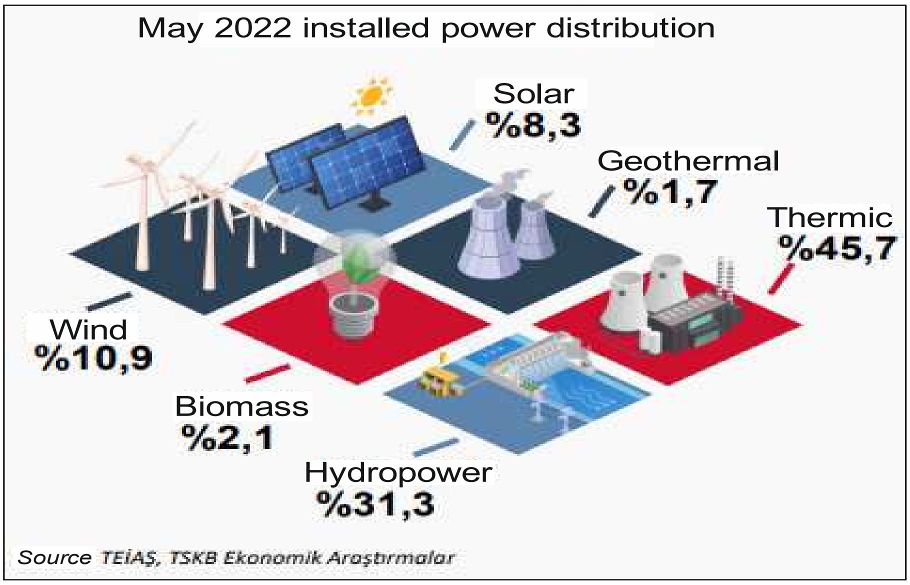

Figure 3- Installed power distribution of Türkiye at 2022.

As it is known, geothermal energy is a domestic underground resource that is renewable, clean, cheap and environmentally friendly. Since our country is located on an active tectonic belt due to its geological and geographical location, it is in a rich position among the world countries in terms of

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geothermal. There are geothermal resources at different temperatures in the form of approximately 1,000 natural outlets spread all over our country.

Türkiye is the 1st country in Europe in terms of geothermal potential and the 4th country in the world in terms of installed power.

The geothermal energy installed power, which is widely used in electricity generation as well as district heating, is 1686 MW as of the end of June 2022, and its ratio to the total installed power is 1.66%.

Georgia

Georgia also could reach a 100 percent renewable future, thanks to its tremendous resources in hydro, wind, and solar. It will depend on the pace of technological development. Forty percent of the electricity comes from the energy produced in summer. However, for the cold season, the country needs storage.

There are no plans to produce green hydrogen locally so far, but they are actively engaged in this sense and there are many international players like the European Bank for Reconstruction and Development (EBRD), the Asian Development Bank, and the World Bank which is ready to support them.

Technology is quite expensive for now, so in the short term, Georgia will exploit its natural resources as much as possible.

Indeed, if rightfully exploited, the Black Sea's untapped energy potential could actually serve as a bridge between today’s use of resources and a future based on renewables.

Bulgaria

Bulgaria started renewable energy promotion, including the establishment and implementation of the institutional and legal framework only in 2007, which is far later than the other old EU member states. The state experienced strong RES development in two periods (2007-2012 and 2012-2016) and increased its share dramatically. Currently, the installed output of RES plants in Bulgaria stands at well over 1700 MW (mostly wind and photovoltaic). Bulgaria is among the 11 EU member states that have already hit their 2020 renewable energy target. According to the National Statistic Institute, the share of renewable energy in gross final energy consumption in 2018 was 20.5%

At the end of 2019, Bulgaria pledged to update its national target for renewable energy and raised the share of wind, solar and other renewables to 27% of their energy consumption respectively by 2030. Hydropower plays an important role in the energy production of Bulgaria with a share of approximately 14% of the total installed capacity. Electricity generation from hydropower makes a substantial contribution to meeting the increased electricity demand and is currently the most used resource which is not fossil fuel or nuclear-based electricity generation technology. Bulgaria has a total installed generation capacity of 12.6 GW (2017), including 4.5 GW lignite and hard coal, 2.0 GW nuclear, 0.6 GW natural gas, 3.2 GW hydropower including pumped storage, and 1.8 GW of other renewables.

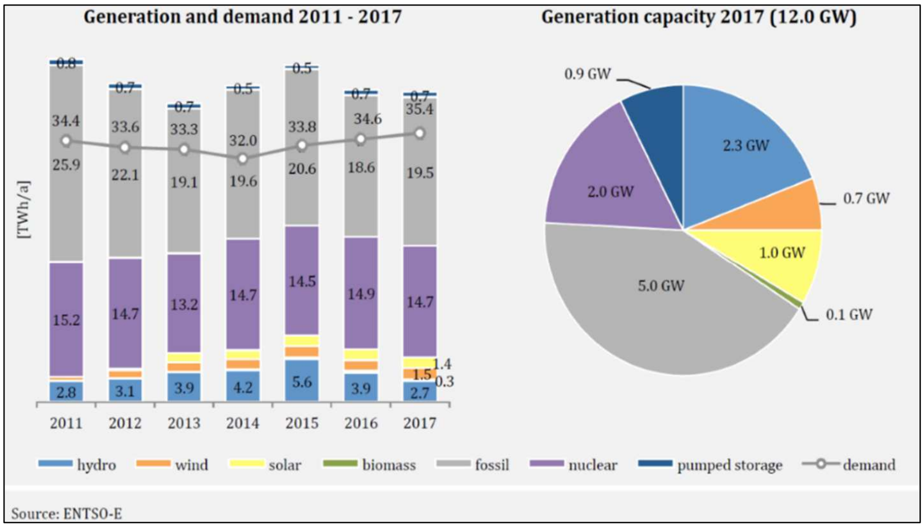

Figure 5- Installed power distribution of Bulgaria

In Bulgaria, there are 242 hydropower plants in operation. In total, the National Electric Company (NEK) owns 30 conventional hydro and pumped storage plants with a total installed capacity of 2,713 MW in generating mode and 937 MW in pumping mode. Hydropower contributes to an annual avoidance of 491,690 tons of CO2 emissions, which translates into an annual CO2 cost avoidance of $3,5 million.

Romania

According to the data displayed by Electrica Furnizare SA in August 2020 (source www.electricafurnizare.ro), the structure of electricity production in Romania in 2019 was provided by:

1. High-carbon energy sources: 38.85%,

•22.89% – coal
•13.95% – natural gas
•0.01% – naphtha
•2.00% – other conventional sources

2*. Low-carbon sources: 61.13%,*

•26.75% – hydro-energy
•18.98% – nuclear
•12.09% – wind power
•0.68% – biomass
•2.62% – solar energy
•0.01% – other renewable sources

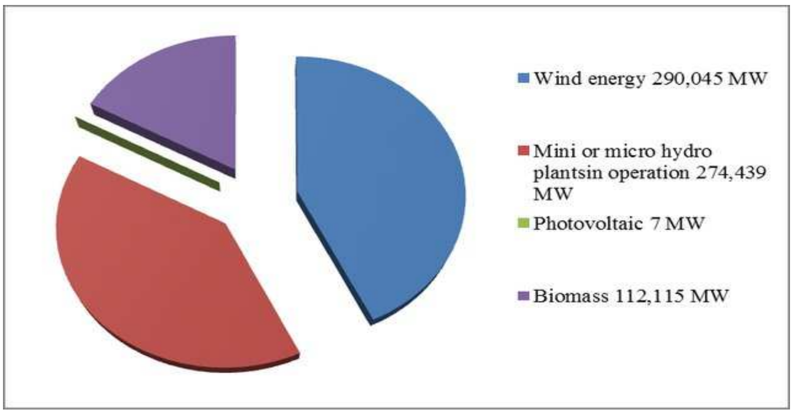

Figure 6- Capacity of renewable energy facilities in Romania

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Russia

Renewable energy in Russia mainly consists of hydroelectric energy. In 2010, the country was the sixth largest producer of renewable energy in the world, although it was 56th when hydroelectric energy was not taken into account. Some 179 TWh of Russia's energy production came from renewable energy sources, out of a total economically feasible potential of 1823 TWh. 16% of Russia's electricity was generated from hydropower, and less than 1% was generated from all other renewable energy sources combined. Roughly 68% of Russia's electricity was generated from thermal power and 16% from nuclear power.

While most of the large hydropower plants in Russia date from the Soviet era, the abundance of fossil fuels in the Soviet Union and the Russian Federation has resulted in little need for the development of other renewable energy sources. In the early 21st century Russian Prime Minister Dmitry Medvedev called for renewable energy to have a larger share of Russia's energy output, and took steps to promote the development of renewable energy. But by 2020, wind and solar only amounted to 0.2% of electricity generation, compared to the world average of 10%.

Russia is one of the world's largest producers of energy, most of which it obtains from oil, natural gas, and coal. The country's focus on those resources for production and export, which constitute 80% of foreign trade earnings, means it has paid little attention to renewable energy. Out of the 203 GW of electric generation capacity that Russia has, 44 GW comes from hydroelectricity, 307 MW from geothermal, 15 MW from wind and negligible amounts from other renewable sources.

Ukraine

In Ukraine, the share of renewables within the total energy mix is less than 5%. In 2020, 10% of electricity was generated from renewables; made up of 5% hydro, 4% wind, and 1% solar. Biomass provides renewable heat.

Methane Hydrate (Natural Gas Hydrate)

Gas hydrates are ice-like crystalline solids that can form under low temperature and high pressure (thermo-baric) conditions. These structures are formed when water molecules trap low molecular weight gas molecules when suitable thermo-baric conditions are provided. Gas hydrates were discovered accidentally in the laboratory in the first quarter of the 18th century. The fact that gas hydrates can occur spontaneously in nature was understood by the extraction of gas hydrates from permafrost areas in the Messoyakha region of Russia in the 1960s, and it has been known that gas hydrates can also occur in marine sediments for more than 30 years. Gas hydrates in nature are also called “Methane Hydrate” or “Natural Gas Hydrate” because they contain predominantly methane gas. Studies have shown that 1 m3 of gas hydrate can contain 164 m3 of natural gas. Gas hydrates are considered the energy source of the near future due to their ability to trap a gas 164 times larger than its own volume.

Gas hydrates, like shale gas, were not considered commercially in terms of hydrocarbon production in the years when they were first discovered in nature. To explain through two similar examples; the USA. Commercial natural gas has been produced from shale gas in Louisiana since 1905 and from gas hydrates in the Messoyakha region of Russia since 1970. On the other hand, the possibility that both shale gas and gas hydrates may offer potential in terms of natural gas production in other fields has been neglected for many years by the oil industry. On the other hand, due to the increasing energy need of the world and the depletion of traditional hydrocarbon resources on a global scale, shale gas from these two non-traditional energy sources has been investigated in detail and appropriate production technologies have been developed over time. As a result of this situation, shale gas has taken its current place in the oil industry since the 2000s, and today it has been described as a "game changer" in terms of the policies of countries toward energy resources.

In terms of gas hydrates, the Turkish Seas offer quite a high potential, except for the Aegean Sea. On the other hand, the Eastern Mediterranean and the Marmara Sea, especially the Black Sea, are among the important areas in the world in terms of gas hydrate formation. In particular, the fact that the Black Sea is an anoxic basin and there is no oxygen below 150 m of water depth brings along very good protection of the organic material required for hydrocarbon production and the gases derived from organic materials. Although the Turkish coasts of the Eastern Mediterranean are still untouched areas in terms of gas hydrate research, the continental edges of this area are also very suitable for gas hydrate formation.

Researches are concentrated in the Black Sea Basin, the world's largest intercontinental anoxic basin. In contrast, the amount of data in the studied areas is insufficient for a detailed gas hydrate survey. In addition, there are areas of the Black Sea Basin that have not yet been studied on the continental margins of our country.

As a result, gas hydrate researches carried out in Turkish seas have focused mainly on the first phase of gas hydrate researches carried out around the world, and studies on the determination of potential areas as an inventory are continuing.

Hydrogen

Using lower-quality renewables like solar energy to generate hydrogen from the water provides a zero-carbon fuel, which has higher quality than natural gas. Black Sea countries are very fortunate in this respect because the seawater is exceptionally rich in H2S gas that may be split into hydrogen and sulfur using abundantly available off-shore renewable energy sources like wind, wave, and solar. The Black Sea has alarmingly high levels of H2S awaiting useful applications to reduce simultaneously environmental and human risks.

The Black Sea is one of the world's largest H2S reservoirs. The total reserves are estimated at between 28-63 billion tons (between 41x1012 and 92x1012 m3) (Ertan, 2020; Kılkış, 2020). Assuming a retrieval ratio of just 50% and considering that there are six countries with continental shelves, the Turkish share is estimated between 7 and 15x1012 m3 of hydrogen. (Ertan, 2020; Kılkış, 2020). Hydrogen has an exergy-based calorific value of almost three times more than natural gas (Kılkış, 2020). Therefore, on a natural gas equivalence comparison, the natural gas-equivalent net reserve for Türkiye will be about 21 to 45x1012 m3 of equivalent natural gas. This is almost 65 times more than the recently discovered Tuna-1 (Sakarya) natural gas reserve (Kılkış, 2020).

Furthermore, the yearly increase of H2S gas reserves in the Black Sea is annually increasing by a rate between 4-9 million tons/annum (Ertan, 2020). Again, taking the lower estimate, this annual H2S gas increase in the Black Sea is about nine times more than the Tuna-1 reserve. In other words, if H2S gas is not used by renewables to produce hydrogen, Türkiye will be missing nine natural gas reserve-equivalent energy reserves every year, which is a much cheaper-to-produce zero-carbon fuel.

Because of the historic energy generation capacities of those countries, such a transformation will not only be a strong step to reach climate neutrality but also may create a transformation within the industrial development, by enhancing engineering skills, manufacturing chains and smart distribution solutions.

The Black Sea Region need an energy transition, the solution is provided by governments, which, with their policies, can really get everybody on board and stimulate investments in the region. Every country and every region must do its part in the de-carbonization and cooperation is crucial.

Now, among the priorities, Black Sea Region countries need to increase the share of renewables, untapping the potential of offshore wind, storage, and hydrogen, so to make them innovative hubs for new technologies. For countries, a realistic path includes improving energy efficiency, increasing renewable and nuclear energy and using natural gas as a transition fuel.

The number of auctions, support schemes, acquisitions and investments in the renewable energy field shows that not only companies are ready but also consumers (and prosumers) are aware of the important role they can play in the energy transition. After all, is not only about renewables but also about a change of mindset and the Black Sea region is fully embracing that.

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