# BLACK SEA RESERVES, ENERGY POTENTIAL AND RENEWABLE ALTERNATIVES[1,2]

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## Abstract

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).

**Keywords:** Black Sea Reserves, Energy Poential, Renewable Alternatives

## Introduction

The first exploration well in the Black Sea was drilled on the Golitsyn run high in 1975, almost simultaneously with the start of drilling in the North Sea. Since then, the North Sea passed through all the way to the natural decline in oil and gas production, whereas in relation to the Black Sea there is still no clear answer to the question – does it really contain projected huge reserves of hydrocarbons?

The answer to this question can only be given by drilling ultra-deep offshore wells exceeding 2.000 m deep.

Prior to Russia's annexation of the Crimean autonomy in 2014, Ukraine made some progress in increasing gas production on the shallow northwest shelf. In 2013, it grew up to 1.65 bcm. In 2015, production was to reach 3 bcm due to the completion of the Odeske and Bezimenne fields with

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resource reserves of not less than 35 bcm of natural gas. At that time, Chornomornaftogaz PJSC owned 17 fields, of which 11 gas fields, 4 gas condensate fields and 2 oil fields. The total reserves of these fields were: 58.56 bcm of natural gas, 1,231 thousand tons of gas condensate, 2,530 thousand tons of oil. Ukraine lost the ability to produce hydrocarbons in a number of fields (Bezimenne, Odeske, Arkhangelske, Shtormove, Schmidta), as well as continue exploration work in other promising areas (Zakhidno-Golitsynska, Kulisna and the Dnieper paleochannel) [1], [4].

Georgia, Russia, Türkiye, Bulgaria and Romania have been actively involved in the oil and gas exploration race within their Black Sea economic areas over the past decade.

The flagship of deep-sea exploration of the Black Sea is undoubtedly Türkiye. Since 2006, Türkiye drilled eight prospecting wells in the deep-water Economic Zone, which turned out to be “dry” [13].

However, the Turkish national oil company revealed 13 promising gas structures on the shallow shelf.

Romania made significant progress in studying its shelf. Since the second half of the 2000s, several fields were discovered on the Romanian shelf – Delta – 4 (oil and gas field), East Swan (oil and gas condensate field), West Swan and Pescarus (oil and gas fields), thanks to which annual oil production grew by 7 million tons.

Despite the skepticism about drilling the first Domino-1 deep well in the Romanian sector of the Black Sea (Neptune block, sea depth-930 m), a field with preliminary reserves of 42-84 bcm of gas was discovered in 2011. Two gas fields – Galata (2.5 bcm) and Kaliakra – were discovered in Bulgaria.

The discovery of the Domino-1 field in the Romanian sector of the Black Sea gave an impetus to the start of project on the Khan Asparukh block in Bulgaria, the Scythian area and the Foros section in Ukraine, the 2roje Black Sea section of Russia, and the continuation of work in Türkiye’s deep water. Georgia announced the discovery of three promising sites, the potential of which was estimated at 70 million project to 1.3 billion barrels of oil. However, there is no real confirmation of this yet [5].

All fields of the Black Sea in operation are located on the shallow shelf while promising oil and gas structures are expected to be in the deep-water part of the water area.

During 2010-2013, in the Black Sea economic zones of Türkiye, Bulgaria and Romania, well-known companies (British Petroleum, ExoonMobil, Chevron, Petrobras, Sterling Resources, OMV Petrom and Petro Ventures) drilled 11 exploration wells using modern mobile offshore drilling platforms of the fifth generation (Leiv Eiriksson, GSP Jupiter) and a floating drilling vessel of the sixth generation (Deepwater Champion). The table clearly shows the negative result of extremely expensive wells. For example, the cost of the Surmene-1 well was USD 4 billion (official information by Mehmet Uysal, CEO of the Turkish state-owned company TPAO).

Currently, 21 wells were drilled at sea depths exceeding 500 m: Romania – 10, Türkiye-8, Bulgaria-2 and Russia – 1. So far, not a single well was drilled in the Ukrainian and Georgian deepwater segments. [7]

In December 2017, Rosneft, together with the Italian company Eni, started drilling the first Maria-1 ultradeep exploration well in the Russian Black Sea sector on the Shatsky shaft.

Drilling the Maria-1 prospecting well was carried out using the Scarabeo-9 drilling platform owned by Saipem.

With a sea depth of 2,125 m and a designed depth of 6,126 m, drilling of the well was terminated in March 2018 at a depth of 5,260 m.

The reason project termination of work by the Italian company Eni was anti-Russian sanctions.

The drilling revealed a fractured carbonate reservoir with a capacity of more than 300 meters, which, according to Rosneft's press release, is highly likely to contain hydrocarbons.

The discovery of a number of giant ultradeep oil concentrations at depths exceeding 10 km confirms the possibility of the existence of hydrocarbon deposits at significant depths.

The exact volumes of gas currently lying deep underneath the Black Sea are not yet known. Rough estimates predict that the Ukrainian shelf may contain more than two trillion cubic meters of gas.

Ukraine's state energy company Naftogaz is preparing to explore 32 remaining blocks.

Meanwhile, Türkiye made international headlines in 2020 when it said reserves at its offshore Tuna-1 exploration project be as high as 405 billion cubic meters. Further reserves could be discovered in adjacent blocks.

To the west, Romania is thought to hold anything between 150-200 bcm of offshore reserves, being one of the most advanced littoral countries in terms of developing resources.

Bulgaria's total reserves are unknown but just one of its as-yet unexplored fields, Khan Asparuh, is thought to contain 100 bcm. If this 3rojec proves to be correct, these reserves alone could cover the country's annual demand for more than 30 years.

To the east, Georgia may have overall recoverable gas resources of 266 billion cubic meters, although how much of these reserves lie in its Black Sea economic zone has yet to be determined.

In recent months, Romanian-Austrian integrated oil and gas company, OMV Petrom, which has been developing Romania's Neptun Deep project together with US company ExxonMobil, has been seeking cooperation opportunities with neighboring countries.

In February 2021, it signed a memorandum of understanding with Naftogaz for joint gas exploration projects in Ukraine. Last summer, it increased its share in the Bulgarian Khan Asparuh project to 42.86% following the transfer of Spain Repsol's 30% stake. The company also won a bid for exploration in Georgia's offshore Block II.

## 1.Black Sea Reserves, Energy Potential

### Türkiye's Discovery

Turkish Petroleum Corporation (TPAO)'s FATIH drilling ship discovered 320 billion cubic meters (bcm) i.e. 11 trillion cubic feet (tcf) of natural gas reserves in the Black Sea, within the western part of Türkiye's Exclusive Economic Zone (EEZ). The reserve — identified to be within the Tuna-1

exploration zone — was discovered some 4,525 meters below the sea bottom, at near 2 km depth. News of the discovery has been welcomed in Türkiye as a game-changer with regard to the country's expensive natural gas import bill.

Sakarya is an ultra-deep-water exploration well within block AR/TPO/KD/C26-C27-D26-D27 that is 100 percent TPAO equity which is 7000 square kilometers in all. The formation is located some 150 kilometers off Türkiye's western Black Sea coast and is at the perimeter of Bulgaria's and Romania's maritime borders. Tuna-1 is located around 100 kilometers south of Romania's Neptun Deep block (84 bcm) – the previous largest gas find in the Black Sea discovered eight years ago by Petrom and Exxon. Türkiye has discovered a new 135 billion cubic meter (bcm) natural gas reserve in the Amasra-1 well in the Black Sea off the northern Zonguldak province.

Last year, Türkiye's Fatih drillship discovered 405 bcm of natural gas in the western Black Sea region's Sakarya field, about 100 nautical miles north of the Turkish coast, in the country's biggest discovery.

State energy company Tpao found 135 billion cubic meters of gas at the Amasra-1 offshore well, bringing the total amount of deposits discovered over the past year to 540 billion cubic meters, Erdogan said in televised remarks from the Black Sea coastal city of Zonguldak.

This physical proximity indicates that Türkiye may face production difficulties similar to Neptun's in the extraction of Tuna-1 reserves. The basin center is deep, cold, and highly anoxic (lacking oxygen – A.C.). These harsh, challenging conditions require specialist experience. The Sakarya development will almost be at the deepest limits of the Black Sea. This is an ultra-harsh environment."

Türkiye's Energy Minister Fatih Donmez said that there are still around 1,000 more meters of drilling to be conducted: "Seismic data shows two more layers of similar reservoir structures below currently, we are 3,500 meters deep and have cut [into] second important reserve."

Türkiye currently has four long-term take-or-pay pipeline contracts with Russia (Blue Stream until 2025 and Bati Hatti until 2021), Azerbaijan (until 2021) and Iran (until 2026). Even beyond these dates, Türkiye will continue to import from these suppliers. However, Sakarya can provide bargaining power for Türkiye to renegotiate the pricing in these agreements. If and when Sakarya comes online, energy experts argue that Türkiye can convince Russia to index its current gas prices to spot natural gas price—a proven strategy of European countries.


Figure 1- The Tuna-1 zone is located off the mouth of the Danube block at the crossroads of the Bulgarian and Romanian maritime borders and the inland waters of Türkiye.

### The Economic Value of The Discovery

The discovery can be categorized as a giant field. Türkiye consumes 45-50 bcm of natural gas per annum and the Sakarya field, in an optimum production level, has the potential to supply a quarter of Türkiye's needs for about 25-28 years. The field is planned to pump gas in 2023, but it will take at least 5-6 years to reach its peak production. Thus, the expected contribution will be in the longer run. The gas prices are expected to recover after 2024 and hence Türkiye can take the advantage of its own resources to decrease the cost of its imported energy bill. Considering this potential trend, International Energy Agency (IEA)'s director Fatih Birol says that its value can go up to $80 billion [16], [17].

Government officials say that the current estimated value of the reserve based on the price that Türkiye pays to third countries is around $64 billion. In market terms, this value could go even lower. Considering the downward trend in the spot markets due to the oversupply of Liquefied Natural Gas (LNG) and COVID-19, the LNG prices plunged in 2020 and hit below $1.7 per million British thermal unit (MMbtu) in June. Since then the markets have been recovering and spot LNG prices tend to move above $2 per MMBtu. Thus, the spot LNG price is almost one-third of the gas price that Türkiye receives via pipelines from third parties. Beyond its economic value, the finding is important to foster exploration efforts, which so far had been futile. In this regard, the debate on the value of the Sakarya reserve has secondary importance.

### Implications for Turkish Russian Relations

The finding will definitely give Türkiye an upper hand in its relations with Russia. BOTAŞ and private sector's contracts (in total 8 bcm per annum) with Gazprom will expire in 2021. These are long-term, oil-indexed contracts and have "take or pay" clauses. In 2020, Gazprom has lost its dominant share

in Türkiye's natural gas consumption. Türkiye has recently opted for importing more LNG from the spot markets (particularly from the United States - US) rather than pipeline gas. After the capacity increases in LNG terminals and new Floating Storage Regasification Unit (FSRU) investments, Türkiye's regasification capacity reached 30 bcm per annum. Even though currently Türkiye uses one-third of this capacity, the consumption pattern has changed dramatically. As the LNG imports increased, the share of Russian gas declined from 55 percent in 2015 to 33.6 percent in 2019. Ankara aims for better terms in new contracts as Gazprom's European partners managed to get in the last decade. The new discovery of the offshore gas field has the potential to contribute, along with Russia's multi-billion-dollar investment in the Turkish Stream and recently increasing volume of LNG imports, to Türkiye's position in negotiations. Energy trade is an important area of cooperation between Moscow and Ankara. However, the Turkish side has been complaining about the unbalanced trade for a long time. The discovery has the potential to offer Türkiye advantage. Yet, the room to increase Russian gas supply to Türkiye is getting dimmer in parallel with the new trends in the LNG market and Türkiye's energy consumption pattern. The finding will definitely give Türkiye an upper hand in its relations with Russia. BOTAŞ and private sector's contracts (in total 8 bcm per annum) with Gazprom will expire in 2021. These are long term, oil-indexed contracts and have "take or pay" clauses. In 2020, Gazprom has lost its dominant share in Türkiye's natural gas consumption. Türkiye has recently opted for importing more LNG from the spot markets (particularly from the United States - US) rather than pipeline gas. After the capacity increases in LNG terminals and new Floating Storage Regasification Unit (FSRU) investments, Türkiye's regasification capacity reached to 30 bcm per annum. Even though currently Türkiye uses one-third of this capacity, the consumption pattern has changed dramatically. As the LNG imports increased, the share of Russian gas declined from 55 percent in 2015 to 33.6 percent in 2019. Ankara aims better terms in new contracts as Gazprom's European partners managed to get in the last decade. The new discovery of the offshore gas field has a potential to contribute, along with Russia's multi-billion-dollar investment in Turkish Stream and recently increasing volume of LNG imports, to Türkiye's position in negotiations. Energy trade is an important area of cooperation between Moscow and Ankara. However, the Turkish side has been complaining about the unbalanced trade for a long time. The discovery has the potential to offer Türkiye leverage. Yet, the room to increase Russian gas supply to Türkiye is getting dimmer in parallel with the new trends in the LNG market and Türkiye's energy consumption pattern [8]

## 2. Future Technologies and Renewable Alternatives

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.

## Wind Potential in the Black Sea

The impact of climate change on the future wind power potential is evaluated by comparisons between historical data and 2021-2050, 2071-2100 projections.

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 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. [5] [18]

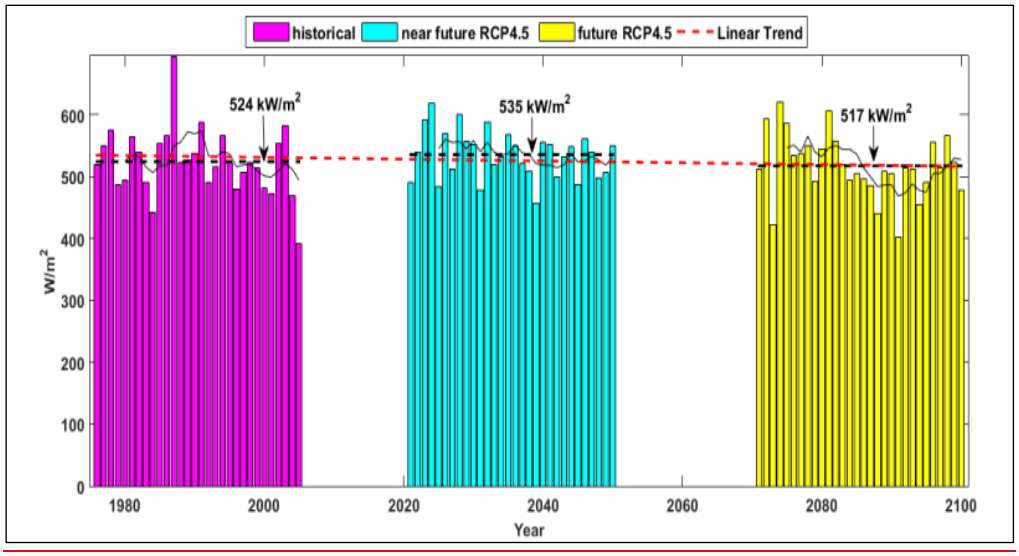


Figure 1- Annual means of the wind power at the height of 80 m above the sea level on Black Sea [2], [5]

## Current Renewable Positions of 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 source [6].

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

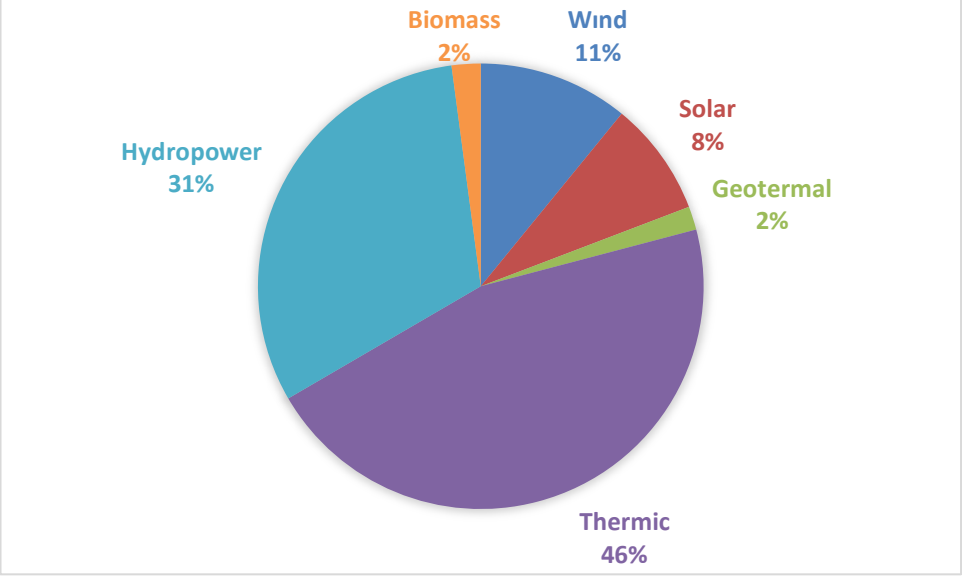


Figure 2- Installed power distribution of Türkiye at 2022 [14], [15]

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%.

**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. [1], [3[4] [4] [4]] Hydrogen has an exergy-based calorific value of almost three times more than natural gas [1] 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. [3]

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[11], 12].

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 [1].

## Conclusion

Offshore hydrocarbon exploration activities carried out by TPAO in the Black Sea have gained momentum since 2004. Between 2004 and 2019, intensive seismic activities were carried out in the Black Sea, 142,000 km two dimensional (2D) seismic data and 37,610 km2 three dimensional (3D) seismic data were collected and interpreted in the fields that TPAO holds license. After the interpretation of the collected data, a total of 6 deep sea and 10 shallow sea exploration wells were drilled. Following the gas discovery in the Akçakoca-3 and Akçakoca-4 wells, number of wells drilled in the Akçakoca production site has reached to 24].

However, more investors are needed to provide technology, financial support, and know-how to help littoral states develop an integrated strategy addressing shared challenges. With the exception of Russia, all other littoral countries of the Black Sea have traditionally been dependent on energy imports. This reality could soon change. Türkiye has estimated that the Black Sea holds recoverable reserves of ten billion barrels of crude oil and two trillion cubic meters of natural gas. As part of exploration plans to confirm the Black Sea's reserves, an ultra-deep water well (one of the first in the region) was recently drilled off the coast of Türkiye.

The Sakarya field is certainly going to change Türkiye's energy security posture. It is highly likely that with further drilling its reserves will be enhanced. Yet, Türkiye needs to analyze its options for this project sensibly – if mismanaged the Tuna-1 field could transform from boon to burden for Ankara [10] https://iset-pi.ge/en/blog/214-georgia-s-energy-security-in-a-nutshell

Türkiye's emerging economy still does not enjoy a strong country risk ranking, and FDI for large hydrocarbon projects does not come easy these days. To attract international majors to Sakarya, Türkiye needs to prove attractive geology and reserve data, and offer an array of economic incentives. Only then can it confidently hail the game-changing prospects of this new find.

## References

[1] Kilkis, B. (2020, August 30). Exergy-based hydrogen economy with 100% on-board renewables, h2s reserves, and coastal hydrogen cities in the Black Sea Region. [Special Report]. Turkish Ministry of Energy and Resources (MENR).

[2] Rusu, L. (2019). A Projection of the Wind Energy in the Black Sea along the 21st Century. In *E3S Web of Conferences* (Vol. 103, p. 01005). EDP Sciences.

[3] Ertan, S. (2020, September 20). Hydrocarbon Reserves in the Seas Surrounding Türkiye. Information Note (In Turkish).

[4] www.atlanticcouncil.org/blogs/ukrainealert/why-the-black-sea-could-emerge-as-the-worlds-next-great-energy-battleground/ (Erişim Tarihi: 12.08.2022)

[5] https://ceenergynews.com/climate/the-untapped-renewable-potential-of-the-black-sea-region/ (Erişim Tarihi: 12.09.2022)

[6] www.tpao.gov.tr (Erişim Tarihi: 22.08.2022)

[7] www.tenaris.com/media/ruddm2jo/1-unlocking-the-black-sea-s-deepwater-potential.pdf (Erişim Tarihi: 02.08.2022)

[8] https://briqjournal.com/en/the-black-sea-sea-energy-prosperity-and-peace (Erişim Tarihi: 19.08.2022)

[9] Unga, R., & Rusu, E. (2016). Study of the Variability of Wind Energy Resources in Romania. *Mechanical Testing and Diagnosis*, *6*(1), 20-28.

[10] https://iset-pi.ge/en/blog/214-georgia-s-energy-security-in-a-nutshell (Erişim Tarihi: 05.08.2022)

[11] https://www.tskb.com.tr/uploads/file/enerji-bulteni-mayis-2022.pdf (Erişim Tarihi: 15.08.2022)

[12]www.ifri.org/en/publications/editoriaux-de-lifri/Türkiyes-new-gas-discovery-black-sea-and-its-potential-implications (Erişim Tarihi: 17.08.2022)

[13] www.forbes.com/sites/arielcohen/2020/09/18/Türkiyes-new-natural-gas-find-in-the-black-sea-exciting-but-tricky-process-ahead/oil-gas.com.ua/news/The-Black-Seas-oil- and-gas-potential-the-reality-and-prospects-of-drilling-a-unique-ultra-deep-well-on-Zmiiny-Island (Erişim Tarihi: 12.05.2022)

[14] https://www.teias.gov.tr (Erişim Tarihi: 13.08.2022)

[15] https://www.tskb.com.tr/hizmetler/danismanlik-hizmetleri/ekonomik-arastirmalar (Erişim Tarihi: 12.07.2022)

[16] https://www.aa.com.tr/tr (Erişim Tarihi: 12.08.2022)

[17] https://www.iea.org (Erişim Tarihi: 22.08.2022)

[18] TESPAM (2019) “Dünya Enerji Görünümü 2100”