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Importance of Turkey as an Energy Corridor and Supplier for European Union.

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Abstract

Global warming due to the greenhouse gas emissions threatens the nature and human life. The studies, action plans and measures to take targeting the arresting of climate change address energy transition from high carbon emitting sources to low / zero carbon sources. Natural gas as a low carbon fossil fuel is becoming critical in this transition period. The EU in the presence of Russia's threat of cutting gas supply should rely on alternative suppliers outside Europe. Besides, the EU should also boost the investments in renewable energy in the transition period. The foremost energy source among the renewables appears to be the solar power as a none carbon and uniform source especially with its incorporated energy storage facility. In this period and onward, Turkey can be the strategic partner of the EU on both transmission of natural gas from the alternative suppliers and provision of renewable energy particularly solar energy considering its geopolitical status and immense source of solar power.

1. Introduction

The world is getting more populous and more demanding every day. The demand on; food , water (basically for agriculture, drink and sanitary purposes), sheltering, dressing, health care issues, energy need in all areas (e.g. heating, cooling, industry, transport), are all increasing and combining those demands with the strategies of growing economy and of rising living standards, Earth's resources are harnessed more and more to meet the needs of the whole world. In this case, more areas to cultivate and to reside, more water sources to drain, more mine to exploit, more sea food to fish, more energy to produce and so on are needed. Besides, these increasing demands, degrade the environment in terms of such as; global warming, deforestation, drying water basins, pollution, lesser lands and less suitable conditions for the living species. The earth, however, is a finite peace of rock where all resources exist with limited amount. Therefore in order to place the resources at the future generations' disposition without a compromise, the resources should be used much more efficiently, through minimizing the waste at all and optimizing the needs. Optimizing the energy use and phasing out the high carbon emitting fuels are of great importance for a healed nature and enough resources for the next generations.

Due to the continuous increase in energy consumption and rise in the above mentioned demands globally, rapid change in global climate resulted from global warming has been being witnessed for decades. Greenhouse gases are emitted mostly by usage of fossil based fuels in human activities such as; heating, electricity generation, manufacturing, transport, agricultural activities and are released as a by - product from the industrial activities (e.g., cement production). Destruction of the carbon sinks by humans for several reasons such as; developing fields for agriculture, mining, urbanization, deterioration of the marine ecosystem are also contributing to the net increase in greenhouse gas content in the atmosphere. Observations on Earth's warming dates back to pre-industrial period (19^{th} century). The Earth is now approximately 1.1-1.2 ^{0}C warmer than it was in the 19th century. Human - activity based global warming is currently increasing at a rate of 0.2°C per decade That means, only in 15 years Earth will be ever warmer

than pre-industrial period by 1,5 ^{0}C. According to scientists, increase of 2°C would have serious negative impacts onto the natural environment and human health and wellbeing, it would also create high risk increasing the possibility of catastrophic changes in the global environment. (IPCC 6th Assessment Report on Climate Change, 2022). For this reason, in order to avoid further and harsher changes in global climate the international community has recognised the need to keep warming well below 2°C and even to limit it with all their might to an ambitious value of 1.5°C.

The climate change and saving the environment is of utmost importance concerning the sustainability of our world. Taking into account the environmental concerns together with energy safety, its supply and the cost, it is really difficult to decide on which one of those three is to be given priority. Here, the transition from fossil fuels to renewables should be conducted in such a way that, the rich countries should put their skates on for completing the transition, but as for the poor countries they should be allowed to use cheap fossil fuels for some time more until the international finance associations such as World Bank or EBRD (European Bank of Reconstruction and Development) compensate the extra cost of renewable investments on behalf of them through giving cheap credit or granting equity as well as incentives. Energy transition to 100% renewable is a must and urgent globally to save the earth, otherwise there would be no home for the living things as well as mankind.

As stated, in order to save the environment and allow it to recover, it is so urgent that world has to change its use of energy resources from fossils based fuels to renewables. However this is not an easy task. Unfortunately, the cheapest accessible energy in majority of the world is still only from the fossil sources since the technology is not sufficiently developed for harnessing the renewables at a cost as cheap as fossils. With regard to usage of fossil fuels and renewables there are some extreme cases like China and Iceland. China uses almost the half of the world's coal in addition to its tremendous use of oil, whereas Iceland consumes renewable energy at an extent of 95% of its total energy use. If the country is rich in renewable sources then it is cheaper to make the transformation from fossil to renewable, but if not, shifting is again possible but more costly. To

give an example; comparing two regions, first of which outweighs the second two times in terms of solar radiation, we see that the investment cost of a solar power plant constructed in the second region will be twice as much as that of solar power plant with the same installed capacity constructed in the first region.

Europe has been trying to decrease its fossil fuel consumption and replace it by renewables for over 30 years ever since the indications of the green housing effect of the carbon based emissions was first revealed. According to the EU's set of action plans so called Fit For 55 Package, net zero carbon emission is targeted by 2050. One of the key actions to take in the Package as explained in the coming sections is transition to low carbon even non carbon energy sources in all areas of energy use. Non carbon energy sources are generally named as renewables such as solar, wind, hydro, geothermal, biomass, tide, wave in which biomass and geothermal still have some carbon content to emit during the energy producing process.

It is easily revealed that natural gas despite its carbon emitting characteristics plays one of the key roles in this transition to first a low carbon and then a zero carbon energy as natural has h much lower carbon content as compared to solid fossil fuels and petroleum. The role assigned to natural gas is to make up the short fall of the higher carbon emitting fuels of coal and petroleum to be phased out in the transition stage and give a room to the renewable investments to flourish and deploy without suffering from serious energy cuts. Therefore natural gas usage should increase to a level targeting 100% replacement of the energy from coal and petroleum. Thus its supply has to be by all means secured. Taking into account the current status between the EU and Russia which is the major gas supplier country to the EU and has been taking actions on either curtailing the gas supply to the EU or threatening the EU on cutting off the gas supply especially after the Russia - Ukraine War broke out, there exist the necessity of seeking for alternative natural gas providers. Liquefied Natural Gas (LNG) shipped by vessels to the ports where LNG facilities are available can be an alternative natural gas provision. However considering the amount of natural gas to be procured, it appears that LNG can only meet the need partially and does not look fairly sustainable which weakens the reliability of the supply. Instead,

pipeline delivery of the natural gas from the resources to Europe seems more reliable and attainable in the medium run, say, 10 years.

In the energy transition period as it is underlined in the Fit For 55 Package, the main target regarding the energy use is to phase out all fossil based fuels in due time and substitute those for renewable energy sources. Among the main non carbon renewables (excluding geothermal and biomass energy sources as they emit carbon) solar is the only source giving stable energy during the day time and it has potential to become stable base load supplier to the grid over 24 hours a day with a proper storage facility. As for the wind, another non carbon energy source, it can produce energy provided that the wind velocity is uniform and suitable in magnitude (no more or no less than a certain interval). This characteristics causes a fluctuation on the grid during the energy production which is not favourable concerning the grid base load phenomena as it runs or stops as per the wind velocity. . With regard to hydro, the situation is similar to the wind particularly during the climate change as the precipitation changes and becomes less foreseeable as compared to the past which does not allow a uniform energy production to be possible.

In the EU' s journey of phasing down and then out high carbon fossil fuels by replacing them with natural gas, and seeking out alternative natural gas suppliers other than Russia, Turkey can be a key partner for the EU. Turkey thanks to its geographical location is situated in such a region that it is neighbouring majority of the world's largest natural gas reserves in the middle east. Turkey can be a safe natural gas corridor bridging Europe and the suppliers in the case of obtaining the natural gas through pipelines from Middle East countries to Europe. The safest and most sustainable way for the EU to obtain the natural gas for sure to be piping it from the resource. Again with regard to the EU's mobilization on the transition to greener energy the final achievement of which is reaching to 100 % renewables, Turkey' s renewable energy sources can feed Turkey as well as EU to the extents as meets the whole needs of Turkey and considerable volume of the EU's demand in the form of electricity.

In the coming chapters and sections, importance of natural gas in the transition to low / zero carbon emitting energy sources, Turkey's energy corridor

characteristics, Turkey's potential in renewable energy sources and capacity of feeding the EU will be discussed in detail. Turkey's wind, solar, hydropower, geothermal and biomass resource capacity will be argued out. Especially the solar power of Turkey will be delved into as it has vast lands with high degree of insolation.

2. Climate Change, Green Deal And Status Of The EU Emissions

The "Climate Change" refers to considerable, long-term changes in the "Global Climate". The global climate is the connected system of, earth and oceans, rain and snow, wind, forests, deserts and savannahs as well as the sun. The climate of a region can be simply described as its rainfall / snowfall, changing temperatures during the year and wind conditions. However, the global climate is not simply the average of the climates of the places. It can be described for example as the impact of the heated pacific ocean on typhoons' power, capacity of dropping rain and of causing damage, or on shifting global ocean currents that are to melt Antarctica ice which slowly makes sea level rise until for example New York will be under water. Climate change in global scale is creating severe risks for ecosystems and human health. It is a great threat for the life on the earth including mankind. The main reason for the climate change is due to the increase in world's greenhouse gas emissions the great majority of which comprised by carbon based compounds such as Carbon Dioxide and Methane coming from fossil fuels. Emission of the gases in large amounts as a result of combustion of fossil fuels and of some other processes brings about the "Global Warming" which is the basic reason for the climate change. That' s why the emitted gases are called as "greenhouse".

Much of the world is covered with ocean which warms. When the ocean warms, more water evaporates into clouds, storms like hurricanes and typhoons are formed with greater energy. A warming atmosphere makes the polar ice cap, glaciers, mountain snow packs, ice shield in Antarctica melt, causing a rise in sea levels. Temperature change alters the winds' patterns that bring the monsoons in

Asia and rain and snow around the world, making drought and unpredictable weather more common.

Any one on earth regardless of his/her region of living can easily realise most of those drastic changes mentioned above in the climate comparing its status just a decade ago. Rising temperature, rising sea levels resulting from the gradual melting of the glaciers, more extreme weathers, flooding, drought and storms. These changes occur because, large amounts of greenhouse gases are released into the atmosphere as a result of many human activities, worldwide. These activities can mainly be listed as electricity generation, heating, transport, agricultural activities and industrial processes. In 2021, around 80 % of the worlds total consumed energy was generated from fossil fuels. Only 12 % of the total energy was from renewables like hydro, wind, solar, geothermal, biomass where there is almost no greenhouse gas emission. (Emission Gap Report, 2021)

Energy use from combustion of fossil fuels dates back to the beginning of the human civilization. However it has started to be used increasingly especially after the industrial revolution. Therefore this warming trend on the earth has accelerated as we have increased our use of fossil fuels including; gasoline, diesel, kerosene and natural gas, as well as the petrochemicals (plastics, pharmaceuticals, fertilizers) we now produce from oil. In fact, within this period the usage of fossil fuels which has increased exponentially has not slowed down considerably yet.

EU started to fight with global warming some three decades ago. In recent years, especially after the Paris Agreement in 2015, EU developed some action plans first scheduling phasing down and then phasing out the fossil fuels till the carbon neutrality has been assured. The EU as being the leading Union in the World in struggling against global warming, prepared and then revised a set of documents through mass of studies and drastic discussions so-called "Green Deal" which contains actions to take to arrest the climate change. However first thing first, arresting the climate change is not only EU's vitally important problem, it is of utmost importance globally instead. China, for example, as the biggest coal consumer has not paid enough attention to the climate change yet. It plans to start with phasing down the coal by 2030 and phase it out in 2060. We

do not know how the fossil fuel based economies will make the transition in Arabic peninsula, gulf region, or the countries like Russia, India or other lock-in countries who are almost no alternative other than fossil fuels in Africa. But leaving aside what other consumers/producers plan against climate change, let's have a look at what EU does.

Prepared and implemented by the EU, Green Deal is the key agreement with its medium and long term targets (2030, 2050 and beyond) within the EU to arrest the climate change.

Green Deal has four basic action plans;

- European Climate Law to enshrine the 2050 climate-neutrality objective into EU law
- European Climate Pact to engage citizens and all parts of society in climate action
- 2030 Climate Target Plan to further reduce net greenhouse gas emissions by at least 55% by 2030
- New EU Strategy on Climate Adaptation to make Europe a climate-resilient society by 2050, fully adapted to the unavoidable impacts of climate change.

According to the latest version of the EU Green Deal the strategy in reaching to above mentioned ambitious targets has three major steps linked to the greenhouse emissions:

1. Making an immediate and rapid reduction in the rate of increase of the global heat targeting to reduce the net greenhouse gas emissions by 2030 to a level 55% lower than the emissions in 1990
2. Stopping the global warming by reaching to a net zero emission by 2050
3. Negative emissions to retrieve the proper climate beyond 2050

Sufficiency of the determined targets for emissions by 2030, carbon neutrality by 2050 and negative emission beyond 2050 in connection with limiting the temperature increase to 1,5-2,0 ^{0}C is of scientists business and expertise to judge although some scholars emphasise the necessity of revising 55% reduction with

65 % for 2030 reporting that as per the simulations with alternative approach, 55% can not catch the global warming targets (https://www.greenpeace.org/eu-unit/issues/climate-energy/2517/european-green-deal-misses-the-mark).

Leaving aside those group of scientists and supposing that 55% reduction is enough by 2030 let's have a look at the European Green Deal's policy reforms focusing on energy related issues so called "Fit For 55 Package" for clean energy supply, concerning; production and consumption, industry, large-scale infrastructure, transport, food and agriculture, construction, taxation and social benefits as well as the economy. The policies which can be said to be the measures against global warming are briefly listed below (CIFE Course Text, 2022, pp. 78)

- Maximizing the energy efficiency in all areas including insulated and energy-self sufficient buildings producing its own electricity and heat by direct use of sunshine.
- Transition to fully decarbonised energy through maximizing renewables with energy in electricity generation with storage facilities and deployment electricity based energy uses in all areas and transition to hydrogen and Power-to-X Technologies
- Maximizing electric vehicles in road transport as well as in railways including fraught carrying and extra pricing for fossil-run vehicles and putting forward strict CO_2 standards.
- Decarbonized industry including carbon capture and utilisation
- Maximizing circular economy
- Developing adequate and smart network infrastructure and inter-connections for direct use of the energy in order to avoid the energy losses.
- Create essential carbon sinks (e.g. re forestation of deforested lands)
- Carbon capture and storage
- Revising Emission Trade System (ETS) and harsher taxation against carbon emissions applicable also for road transport, aviation and maritime.
- Revising Effort Share Mechanism and Carbon Border Mechanism
- Necessary Financing (Green Finance, "Just Transition Funds")

In order to make the ambitious 2030 and 2050 targets within reach, it seems not to be sufficient to make just transition from fossils to non carbon emitting energy and industry. In fact not all emissions - for example, those caused by agriculture, heavy industry or shipping can be completely eliminated. Some way of compensation for these therefore must be found. Achieving climate neutrality by 2050 and negative emission onward in order for the environment to heal , preserving and expanding CO_2 sinks are of vitally important.; in other words, capturing of CO_2 from the atmosphere and storing it permanently. Because fully decarbonized emission by 2050 appears to be not possible concerning the technology. Therefore, EU have to build its carbon sink capacity in order to remove CO_2 from the atmosphere.

How much sink capacity do we need to become climate neutral by 2050? In the EU, there is a lot of experience with net CO_2 removal through land use, land-use change and forestry (LULUCF) which is essential for climate neutrality. Therefore current EU legislation for LULUCF should be revised in a way to provide with the following

- Regulation should set a binding commitment for each Member States to ensure that accounted greenhouse gas emissions from LULUCF are balanced by at least an equivalent accounted removal of CO_2 from the atmosphere in the period until 2030, in other words “no debit” rule should be enshrined.

- The scope should be extended from only forests today to all land uses (including wetlands).

- The new rule of LULUCF should provide Member States with a framework to encourage more climate friendly land use through incentives, which will help farmers to develop climate-smart agriculture practices and support foresters.

- A new EU governance process for monitoring how Member States calculate emissions and removals should be established

CO_2 removals via LULUCF is expected to work efficiently but it contains some uncertainty since the forests that have formed the most important sinks to date are vulnerable to disturbances like heat stress or fires. Thus, there is a real danger that the CO_2 bound in trees and soils might escape into the atmosphere again later on. Therefore , relying only on proper implementation of LULUCF may not bring the success. Together with the above mentioned actions, some considerable development should be pursued in the technological methods of capturing CO_2 from the atmosphere like; direct air carbon capture and storage through filtering CO_2 out of ambient air and combining it with geological storage.

On the way to 2030, beside the above mentioned main elements, there are other tangible and quantitative targets in the Package as well. Some of them are; at least 30 million zero-emission cars , 100 climate neutral European cities, doubled high-speed rail traffic across Europe, large scaled automated mobility and so on (CIFE Course Text, 2022, pp.99). However, the last but not the least item of the action plan in the Package is promoting the green deal with its targets and enhancing the mindfulness all over the World including its member states, non-EU European countries in order for them to get involved in the campaign in a collective and rigorous manner.

2.1. Current Status Of The Emissions In The EU And Quick Look To The Strategy

The main "Kyoto" greenhouse gases are CO_2, CH_4, and N_2O which emanate from both energy and non-energy sources. Also included are hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, which have relatively high global warming potentials but are emitted in small volumes and are for the most part not energy-related. The "greenhouse effect" of the different gases is expressed as CO_2 equivalent, (Steen, 1997)

Up to now the EU's performance on reduction of emission is not outstanding except for 2023 the yearly emission of which was 8% less than that of year 2022. At the end of 2023 the annual emission dropped down to 2,85 billion tonnes of carbon dioxide equivalent. Based on 1990 emissions of 4,7 billion tonnes of

carbon dioxide equivalent, total reduction at the end of 2023 reached to 40%. (Eurostat Statistics, 2023). It is crystal clear that there is still a distance to cover that cannot be said to be not substantial. Considering the 2030 target of 55% reduction, annual reduction should not be less than 2.2% until the end of 2030. In order to keep the pace with 2030 targets it is obvious that EU should rapidly decrease the share of fossil fuels especially the high carbon fossil fuels and increase the share of renewable sources in the total energy use.

Given the emission rates and targets, some remarks concerning the emission reducing strategy would be as follows;

- In fact, this is not an easy task to make this substantial transition in a period less than a decade. As it is discussed in the coming sections, natural gas as being relatively lower carbon energy source should be increasingly used instead of high carbon fossil fuels in order to decrease the total carbon emissions. Namely, the carbon emission per unit energy produced by natural gas is around 50 % lower than that produced by coal and 20-25 % lower than that produced by petroleum. See Table 1.

Table 1. CO_2 emission per million BTU of energy for various fuels

Fossil Fuel Type	Amount of Emission per Million BTU (Pound)
Coal (anthracite)	228.6
Coal (bituminous)	205.7
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel and heating oil	161.3
Gasoline (without ethanol)	157.2
Propane	139.0
Natural gas	117.0

(American Geoscience Institute)

- To say the truth, even currently, Europe is highly dependent on natural gas in heating and industry. However either direct use of natural gas or usage of decarbonized version should be by far increased and be deployed on to the electricity production. Because, it is of a big question mark if renewables can easily and rapidly compensate the large demand of

energy supplied by fossil fuels as the renewables can rarely be used unless transforming the produced energy to electricity. Thus, in the transition period alternative non carbon non renewable sources like Nuclear Power should be brought onto the table and somehow get integrated to the green finance mechanism at least for a limited period of time together with natural gas.

- As given in the Fit For 55 Package, Emission Trade System, Carbon Border Mechanism and High Taxation against fossil fuel usage are effective mechanism to reduce the emissions but to meet the needs of the Europeans, there is still a risk of production transfer from the EU to high carbon emitter countries even to non EU countries in Europe despite the additional carbon pricing and taxes.

- Coming back to renewables, solar power as being one of the key branches of the renewables and most reliable one occupy large pieces of lands. Therefore boosting the solar power in the EU by a full mobilization may have negative impacts on the proper afforestation as well as on the agricultural activities as it may occupy agriculturally low quality but still productive lands. In that case the EU as a large food importing Union could increase the food import to meet the needs which might cause carbon leakage from fossil fuel user countries and less forestation in those countries to meet the demands leading to net increase in the green house gases. Solar Power should be treated very carefully and technology upon it and storage capacity issues should be standardized. Otherwise overall cost from solar may exceed the benefit. Moreover decentralized renewable energy power plants only serve to its location and the region nearby but in order to speed up the transition and use the renewable sources effectively (e.g. larger Solar PPs in regions having longer shining period) renewable energy power plants should be centralized besides their decentralized usage (Bailey and Wilson, 2009)

- Additionally, in the EU with its common and liberal market conditions, where only profitability is of great concern, the private sector is expected to make this transition through some funding and incentive supports. But,

it is not sufficient to rely only on private sector's go- no go decisions or cost-benefit analysis or member states' domestic implementations in order to go on a rapid and mass transition.

- Finally, European Environment Agency (EEA) stated that, the EU could not achieve sustainability by continuing to promote economic growth and seeking to manage the environmental and social impacts. (European Environment Agency, 2020). Regarding the measures to take for carbon neutrality, it is not sufficient to consider only production processes, technologies, or the replacement of fossil fuels by renewables, but consumption patterns and ways of living should also be taken into account. Having gone through the measures it appears to me that circular economy or improvement in energy efficiency is not enough to consume less energy and to assure less industrial emission, there should be a new philosophy focusing on less consumption, minimum waste as a new style of life. It does not mean to be a kind of minimalism but it refers to somehow generousness instead of greed against nature. In the EU Green Deal strategy there is very limited focus on this issue.

2.2 Dynamics Of Energy Provision

When it comes to provision of energy, the most important issues are; security of supply, sustainability, as well as the cost. Therefore the countries / regions / settlements prefer first the energy sources available in their home soils which are supposed to be cheaper, more secure and sustainable. For example if a country is rich in coal then it develops its know how, infrastructure and energy related issues based on harnessing and burning coal. It develops new techniques to mine the coal in a more efficient and cheaper way and through less risky processes, it prefers to construct coal combustion power plants, coal powered factories etc. China as the largest coal producer and consumer in the world is responsible for almost half of the total amount of coal production and consumption worldwide (Emission Gap Report, 2021, page 33). It uses coal as its basic energy source in almost all areas except for the transportation. Likewise, Russia relies on its gargantuan sources of natural gas, petroleum and coal for its energy use. It has been establishing its whole system including infrastructure, pipelines, energy

generation and consumption facilities mostly suitable to these fossil fuels. In Russia again as an example, especially in the forested regions wood is still highly used for heating as being the most secure, sustainable and cheap source of energy. Most of the Arabic countries are rich in petroleum and has been using fuel oil in order to meet their energy needs for decades. They use fuel oil not only for transportation but also for their electricity generation and for powering their industry. They either developed or adapted their infrastructure as per the use of fuel oil in every aspect from extraction (exploration and drilling methods, purifying techniques) to pipeline, network, combustion technology and so on. Although the extraction methods of fuel oil and natural gas are rather expensive and risky tasks as compared to coal, once explored, these sources give so enormous energy that all investment cost returns in a considerable short period of time, which could make them cheaper besides their supply security and sustainability.

- Iceland on the other hand, as situated in the roof of the earth on the very north in the middle of the ocean relies mostly on its domestic hot water resources (geothermal energy) for heating and generating electricity. In Iceland everything has been evolving in a manner to use the hot water as efficient as possible including, district heating, greenhouse, electricity generation, since there is no any kind of fossil fuel available in the island. Besides, in Iceland there are lots of water falls and rivers available for electricity generation from hydropower. In brief, Iceland is dependent on these two domestic energy sources for almost all its energy need except for the transportation (Little, 2010). In the near future when the electricity cars become prevalent, it will be such an island where 100 % of the energy is to be supplied by the renewables.
- The above mentioned examples are very typical “lock – in” cases where the domestic resources are chosen because of their supply security, sustainability and cost effective nature disregarding the carbon emission, or environmental issues. Even Iceland in spite of its high renewable energy use can not be said to have been motivated by targeting low carbon emission, just because it has no local alternative source more secure and sustainable other than renewables.

- Coming to the position of the EU, member states and the EU itself should aim at managing transition to low/zero carbon energy as well as securing the supply of energy/energy sources at reasonable prices in a sustainable manner. This trio of energy cost, security of energy supply and sustainability are so important that as Russia curtailed the supply of natural gas to the EU during the raging Russia Ukraine War some big EU Countries like Germany started to use coal in big masses again in order to compensate the natural gas.

2.3 Current Status Of Energy Use In The EU

Considering the available energy in the EU, according to 2021 statistics the energy mix in the EU consists of ; crude oil and petroleum products that comprise to 35 %, natural gas holding a share of 23 %, renewable energy occupying 17%, nuclear energy which corresponds to 13 % and solid fossil fuels representing 12 %. See Figure 1. (Eurostat Statistics Explained, 2021)

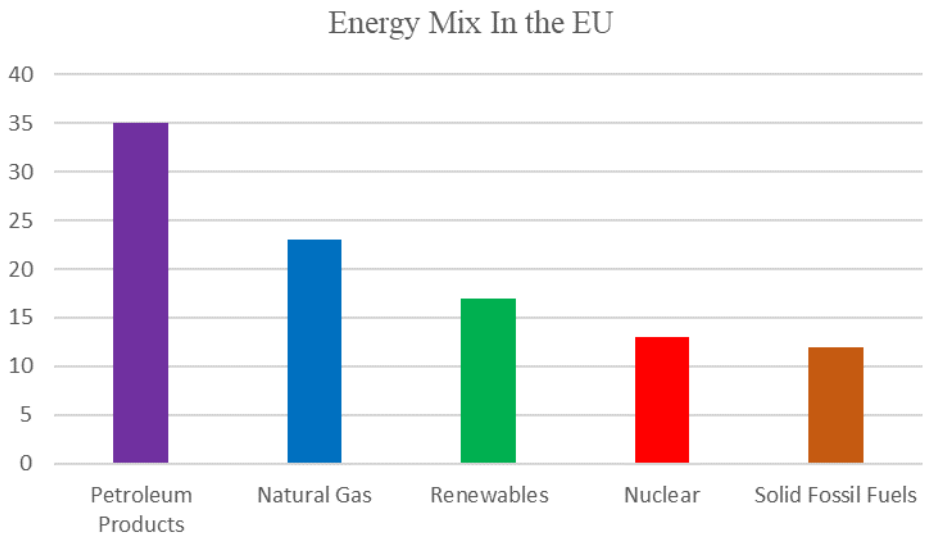

Figure 1. Energy mix in the EU as of 2021

As for the final energy consumption again as per the 2021 data, petroleum products representing 35% is the most consumed energy source. Electricity and gas (including natural and manufacturing gas) rank second with 23% each, and then direct use of renewables (not transformed into electricity) in the forms of such as wood, solar thermal, geothermal and biogas for space heating or hot water production represent 11% , derived heat (district heating) with a share of 5% and solid fossil fuels (mostly coal) comprising to 3%. See Figure 2.

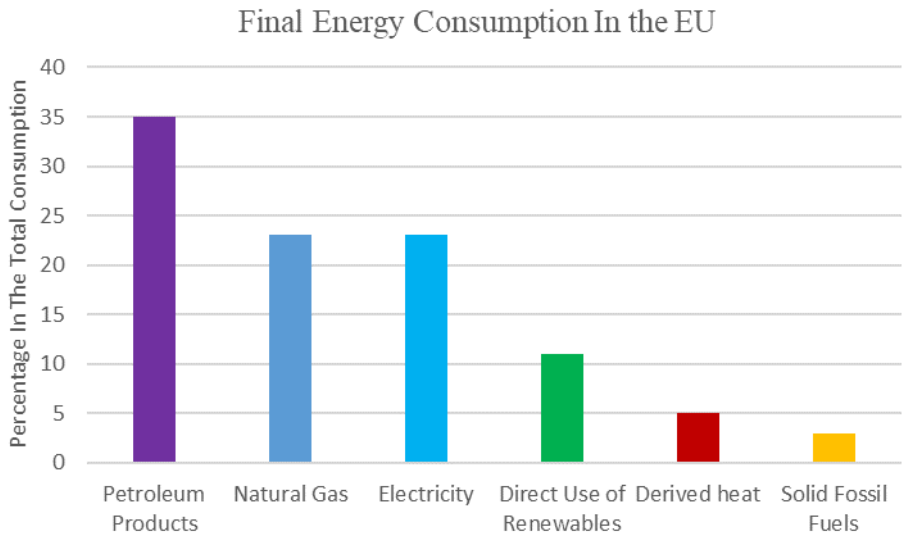

Figure 2. Final energy consumption in the EU as of 2021

The real consumption of renewable energy including electricity rises up to almost 17 %. What is more, considering only the electricity production of the primary energy sources, renewables occupy in total 41 % of the energy used for electricity generation. (Eurostat Statistics Explained, 2021)

When it comes to distribution of energy consumptions with respect to main sectors; the transportation shares the 29 % of final energy consumption being the most energy consuming sector in 2021, it is followed by households with 28 %, industry with 26 % and then services sector holds 14 % and finally agriculture and forestry sector is responsible for 3 %. (Eurostat Statistics Explained, 2021). See Figure 3.

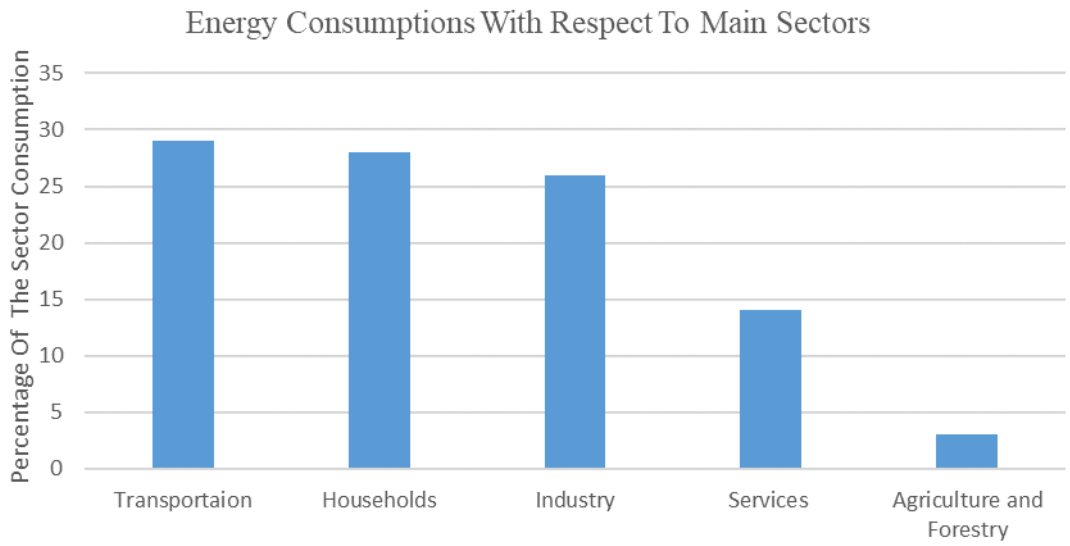

Figure 3. Energy consumptions with respect to main sectors in the EU As per 2021 data

2.4 Amount Of Gas Usage In Place Of High Carbon Fossil Fuels To Achieve The Targeted Emissions

The EU as stated in the previous section still obtains over 45 % of its total energy from high carbon fossil fuels petroleum products and solid fuels. As per the green deal, EU has to phase out those fossil fuels as soon as possible and should substitute them with firstly natural gas as a low carbon emitting source and then secondly by renewables through complete transition in order to achieve targeted values designated in the Fit For 55 Package stated above. In this respect, the EU should increase the proportion of the natural gas usage of 23 % up to almost 70% through replacing petroleum products (35%) and solid fuels (12 %).

Hypothetically speaking, phasing in natural gas to the level meeting the 70% of the total energy need of the EU would decrease the total CO_2 equivalent emissions down to 25% lower than the 2021 emissions. Based on the data given in table 1, where the CO_2 emissions of the different fossil fuels for a produced unit energy are presented, in the case of an exchange of whole high carbon fossil fuels with natural gas supposing that other energy sources keep the same percentages of 17% for renewables and 12% for nuclear the emissions would

drop down to 2, 65 billion tonnes of CO_2 equivalent which does matter for an aim of cutting down of emitted carbon but is still greater than the targeted 2030 value of 2,12 billion tonnes. Therefore, transition to natural gas has to go on hand in hand with the transition to renewables. Here one issue to note that, transition to natural gas from high carbon containing fossil fuels will give a room for in other words free up the renewables to be constructed in mass volumes without derogating from energy supply to the EU.

In the light of above mentioned issues we may refer to again 2021 statistics to delve into what volume of natural gas is needed for a transition to low carbon fuels. According to collected data in 2021, EU' s natural gas consumption was 14 Billion Gigajoules which comprises to 23 % of the total energy consumption of the EU (Eurostat Statistics Explained, 2021). If natural gas use is targeted to be 70 % of the total energy use as stated before then total energy needed annually will be some 42 billion Gigajoule. Keeping in mind that 1 gigajoule energy is produced by 27 cubic meters (cm) of natural gas then energy need of 42 Billion gigajoule corresponds to almost 1135 billion cubic meters (bcm) of natural gas annually. If we assume that the energy from renewables will also increase in the low carbon transition period, the annual need / supply of natural gas is expected to go down to some extent as well.

3. Supply Safety Of Natural Gas And Alternative Gas Suppliers

The EU launched a policy of diversifying natural gas suppliers beside Russia especially after the Russia - Ukraine – Europe crisis that took place in 2006 due to Russia's cutting off natural gas supply to Ukraine for a few days after a long lasting disputes between Russia and the European purchasers upon the pricing of the natural gas. Having been deprived of the natural gas because of this crisis, EU member states and the EU itself decided to enhance natural gas supply security. The implementation of this strategy was speeded up following the second crisis between Russia and Ukraine upon which many eastern and central European countries ended up losers as they become empty of natural gas for fortnight. (Tagliapietra and Fandozione, 2014). Although EU endeavoured to multiply the

alternative gas suppliers from that time on through increasing the LNG demand and number of LNG receiving terminals across the EU, more tangible progress was made after the Russia Ukraine War.

As mentioned above, referring to the 2021 statistics 23% of the total energy consumed in the EU produced by natural gas. Being the main natural gas supplier to the EU, Russia had been provided the EU with 45 % of the total natural gas supplied to the EU until March 2022. However, after the Russia – Ukraine war broke out, upon the European Commission decision in 2022, through certain actions taken, total gas imported from Russia dropped down to 15% of total gas consumed in the EU by the end of 2023. The targeted achievement decided by the EU commission is to end dependence on Russia's gas by 2030. The shortfall of Russian gas has been being made up by LNG imported from all over the world. Main LNG suppliers to the EU are the United States, Norway, Qatar, UK and North African countries. According to 2023 statistics , United States the largest LNG supplier to the EU tripled the LNG supply to the EU in 2023 as compared to 2021 statistics. United States provides 50% of the total LNG imported by the EU. The second largest LNG provider is Norway holding the share of 30^%. (Council Of The European Union, 2023). Although, Russian gas is now being mostly replaced by LNG, it is not as sustainable to import LNG overseas by ships as to obtain it through pipelines from alternative gas supplier countries.

In particular, considering the further natural gas need of the EU within the context of replacing high carbon fossil fuels with the natural gas comprising to 1135 bcm/year at maximum and knowing that the current LNG capacity (capacity of the LNG terminals and related facilities of the EU is some 150 bcm / year (Council Of The European Union, 2023) and supposing that the EU will get the natural gas completely in LNG form, we may come up with a result that the EU should increase its LNG capacity 7,5 times the current one. Moreover one vessel in average size in today's world can carry about 50,000 cubic meters of LNG that almost equals to 0,032 bcm of natural gas on average. In this respect, total need of 1135 bcm per year can only be carried by some 36,000 vessels in a year, that is quite a lot.

It is obvious that particularly the level of increase in the capacity of the LNG facilities are so enormous in number that it is too hard to realize. Therefore LNG as an alternative energy supplier look like it can only be an alternative for needs in smaller scales and be used as an complementary. However, considering whole EU the absolute solution will only be carrying the natural gas via pipelines from the natural gas resources.

3.1 Evaluation OF Alternative Natural Gas Supplier Countries For The EU

Contemplating the possible natural gas resource regions suitable to the EU there are certain criterions we should to be taken into account as follows:

- The resource should be as near to the EU as possible so that the provision of the natural gas is to be at a reasonable price and project is to be not complicated.
- The resource should be within reach to the EU via pipelines with land delivery. If there is inevitable sea cross then it should be an achievable one (Mediterranean cross is acceptable to some extent but crossing ocean is not in consideration as it is unattainable)
- Resource should have an enough reserve capacity to assure a long term and sustainable supply

Now let' s have a look at the possible suppliers that EU can obtain natural gas from.

a) Russia

Russia is having the largest natural gas reserve globally. It is proved reserve capacity is about 50 trillion cubic meters (50,000 bcm). Its proved reserve corresponds to 1,85 trillion gigajoules and is 102 times its annual consumption, meaning that it can make its own living for over 102 years with its readily proved reserve. If we assume that Russia's proved reserves are completely dedicated to

the EU than it can feed the Union for 45 years considering the EU's annual need of 42 Billion gigajoules as previously stated. Russia is still exploring new reserves, thus these reserves are likely to be multiplied over the years. Russia was the main gas supplier of the EU until Russia Ukraine War. Europe had been importing and relying on Russian natural gas since 1980s. (Worldometer Energy Statistics, 2023)

In the mean time, Russia is exporting its natural gas to the numbers of countries. Some EU countries such as Italy,, Hungary, Austria and Slovakia together with Turkey, China, Japan and South Korea are the main customers buying the Russian natural gas in high volumes either through pipelines or in the form of LNG. As stated before, although the current amount of Russian gas received by the EU has decreased to one third of its volume as of 2021 , its portion of 15% within the total natural gas provision of the EU still matters. Degradation in the volume of the Russian gas annually bought by the EU has caused the EU to expand LNG procurement with an equal amount of curtailed natural gas from Russia by the EU.

Looking back to the history of EU-Russia partnership on natural gas, it is crystal clear that the ties between two partners were so strong that allowed them to make long term plans of their cooperation and investments. Russia increased its natural gas production rate and the EU enhanced its infrastructure including cross border huge pipelines allowing it to receive and use the natural gas. Soyuz with a length of 2,700 km and a capacity of 25 bcm / year is the pipeline carrying the natural gas from Russia through Ukraine to mid Europe. Moreover, Nord Steam 1 and Nord Stream 2 are the pipe lines extending from Russia near Finland border to Europe and transmitting the natural gas to Germany via passing under Baltic Sea with the lengths of 1200 km each. They can convey in total 110 bcm / year of natural gas in a year (each carries 55bcm / year). Additionally, Yamal-Europe is another pipe line running from Russia to Poland and passing through Belarus with a total natural gas transmittal capacity of 33 bcm yearly and a total length of 4,100 km. Turk Stream , again a pipe line starting from Russian cost of the Black Sea and having a Black Sea cross with a length of around 900 km

and going into Bulgaria and North Macedonia holds a natural gas capacity of 31,5 bcm / year (Planete Energies, 2022)

In spite of the fact that those huge projects and investments were carried out in the past among Russia and the EU and despite the gargantuan amount of Russian natural gas reserves located in the vicinity of the EU territory which had seemed to be irreplaceable, nowadays it is noticeable that Russian gas has been moving away from the EU. Because, especially after the ongoing war between Ukraine and Russia that broke out at the beginning of 2022 and due to the tension between the EU and Russia based on the status of Ukraine, Russia's reacted in such a way that ended up cutting off the gas supply to the EU after uttering so many blackmails and threats. Then EU seriously considered to curtail the gas procurement from Russia and rolled up its sleeves to seek for alternative gas suppliers. In fact, the first unrest of the recent history between Russia and Ukraine that took place in 2014 had threatened the security of the natural gas supply to the EU seriously for the first time. That tension become a wake up call for some of the EU countries but given the fact that majority of the member states sit on a lid and turned blind to that threat in that period of time, far reaching actions could not be taken against Russian gas.

Briefly speaking, given the above mentioned issues and concerns about the supply security of Russian gas, Russia should not be in the scope of the EU's potential natural gas suppliers, on the contrary, it should be discarded.

b) Iran

Iran is the World's second prosperous country in proved natural gas reserve. Iran's proved reserve amounts to around 35 trillion cubic meters (35,000 bcm) . This amount of reserve is 162 times the annual consumption of Iran, that is, Iran could consume its natural gas resource for over 162 years if it did not export even 1 cubic meter of it. Energy equivalent of its proved reserve is around 1,3 trillion gigajoules. With the supposition of dedicating the Iran's whole proved reserves to the EU, Iran can provide the Union with the natural gas for over 30 years.

Besides, Iran is conducting new exploration studies that may result in substantial increase in proved reserves. (Worldometer Energy Statistics, 2023)

Iran is currently selling its natural gas mainly to Turkey, Armenia, Azerbaijan and Iraq via pipelines. Iran, due to the fact that United States apply sanctions is not in a position to send its natural gas to the EU. Therefore there seems to be no short-term potential for Europe to directly import Iranian natural gas. Apparently, sanctions are the main obstacles that hinders Iran in investing in projects based on LNG production and export as well as piping the gas to the EU. As a result, it focuses only on exporting its gas to the neighbours and utilizing it for domestic needs.

However, if the sanctions are lifted then it is feasible for the EU to go into a natural gas trade cooperation with Iran in the short term. The cooperation may commence with importing LNG. In the medium term, EU can invest in capacity building of the LNG production. In the long run, the role of Iran as a gas supplier to the EU shall be driven by high volume of investments in increasing the amount of source exploitation, pipeline capacity and infrastructure. There is also a possibility that it paves the way for greater energy cooperation in the future. Nonetheless, even after the lifting of sanctions, oil and gas majors of the EU would be reluctant to invest in Iran due to the risk of future sanctions to be applied by US governments again. Therefore, utilizing the long-term strategic step in diversifying European gas imports will heavily depend on permanent positive relation between United States and Iran and a sanctions-free environment for international investment in Iran. (Khajehpour, 2022)

Frankly speaking, Iran and Russia are such countries having many in common. Both are short of democracy, not liberal and are not willing to keep their paces with the West. Politically they are not either stable or foreseeable . Thus, relying mainly on Iranian natural gas contains the great risks of creating similar problems that the EU has currently with Russia. As a matter of fact there is a little possibility that Iran can be an alternative natural gas supplier of the EU.

c) Qatar

Qatar is ranking 3rd in the World with regard to natural gas proved reserves. Its total proved reserves add up to some 25 trillion cubic meters (25,000 bcm). Concerning the current consumption rates Qatar's proved reserve is 609 times its annual usage. As the country sits on a region where there is almost no use of natural gas for heating Qatar has incomparably lower consumption than either Russia or Iran. Energy equivalent of its proved reserve is around 920 billion gigajoules. If Qatar's whole proved reserve were to be put at the disposition of the EU's use than it could meet the Union's natural gas need for over 20 years. Again the proved reserves can enlarge through some exploratory studies. (Worldometer Energy Statistics, 2023)

According to the statistical data of 2022, Qatar is the third largest natural gas exporter country beside its number 3 position in terms of its proved natural gas reserve capacity. Qatar's main customers are China, India, South Korea, United Kingdom and Belgium, other EU member states are also among the Qatar' s natural gas customers. It exports its natural gas mostly in LNG form, it is again the third largest LNG producer and provider after United States and Australia but it also pipes some of its natural gas to Oman and United Arab Emirates through a cross border pipeline called Dolphin with a capacity of 55 bcm/year. (OEC World Data, 2022)

Qatar holds an immense proved reserve of natural gas and geographical advantage that allows the country to send its gas to the EU through pipelines. Therefore, being a strong alternative natural gas supplier, Qatar is a high potential country for the EU to be able replace Russia on its own. At least it could be a reasonable player for the EU in diversifying its natural gas providers. Qatar is strengthening its relation with the EU through cooperation agreements like the one signed in 2018 between the European External Action Service (EEAS) and the Qatari Ministry of Foreign Affairs that is supposed to serve as the basis fro enhanced political dialogue and strengthened cooperation on sectorial areas of mutual interest. More recently, bilateral cooperation between Qatar and the EU has been boosted significantly, leading to the conclusion of an Agreement on the Establishment of a new EU Delegation to the State of Qatari in September

2022. (EU Website). It is notable that unlike Russia and Iran, Qatar is pursuing a cooperative policy in its relation with the western world, which is another but very important positive aspect from the natural gas's supply safety and sustainability point of view.

d) Saudi Arabia

Saudi Arabia is the 5th richest country in terms of natural gas with total proved reserve capacity of almost 8,5 trillion cubic meters (8,500 bcm). At the current consumption rates Saudi Arabia's proved reserve can meet the need of the country 79 years. Similar to Qatar , due to the geographical position of Saudi Arabia there is almost no use of natural gas for heating. Energy equivalent of its proved reserve is around 320 billion gigajoules that can provide the natural gas for the EU for about 8 years long on its own if Saudi Arabia's whole proved reserve imaginarily allocated to the EU, keeping in mind that through new exploration studies the reserve can grow. (Worldometer Energy Statistics, 2023)

Both the EU and Saudi Arabia are part of the G20 forum for international economic cooperation. While the forums are typically attended by finance ministers and central bank governors, there are also dedicated energy ministerial forums in which the EU and Saudi Arabia promote their energy priorities and cooperate. These priorities currently include the clean energy transition, technological innovation and access to sustainable modern energy, and open, transparent and flexible energy markets. The EU is Saudi Arabia's second trading partner, whereas Saudi Arabia is the EU's 17th trading partner. As a result, Saudi Arabia would be a reasonable partner supplying natural gas to the EU. (Delivorias, De Martini, 2023)

e) Turkmenistan

Turkmenistan is the 6th richest country in terms of natural gas with total proved reserve capacity of almost 7,6 trillion cubic meters (7,600 bcm). At the current consumption rates Turkmenistan's proved reserve can last for about 191 years. Energy equivalent of its proved reserve is around 290 billion gigajoules and can provide the natural gas for the EU for about 7 years long if the country's whole proved reserve is set aside for the EU.

Turkmenistan is currently exporting its natural gas mainly to China, Uzbekistan, Azerbaijan and Russia. Its high amount of production appeases the China' s thirst for natural gas to some extent. In the mean time construction of pipelines to India and Pakistan are going on with full force. Although Turkmenistan has a great amount of natural gas reserve and capacity to feed the EU , it is not a good candidate for the EU as an alternative gas supplier since it is totally under the influence of Russia and choosing Russia-China block politically. (Worldometer Energy Statistics, 2023)

f) United Arab Emirates

United Arab Emirates is ranking 7th globally with respect to proved natural gas reserve capacity. Its proved reserve reaches to 6 trillion cubic meters (6,000 bcm). United Arab Emirates can use its reserve for its own need for 82 years as per to current consumption rate. Similar to Qatar and Saudi Arabia due to its geographical location United Arab Emirates consume tiny portion of its reserve annually. Proved reserve can last 6 years with an energy equivalent of 235 billion gigajoules if its total reserve is appropriated for the EU.

The country looks to be a suitable gas supplier for the EU since it has close relations with the western world. (Worldometer Energy Statistics, 2023)

g) Iraq

Iraq holds 3,1 trillion cubic meters (3,100 bcm) of natural gas proved reserve that makes it rank 11th worldwide. Its proved reserve can feed the country for over a thousand years since the internal usage of the natural gas across the country is negligible. Proved reserve can last 3 years with an energy equivalent of 120 billion gigajoules if its total reserve is dedicated to the EU. (Worldometer Energy Statistics)

It is noticeable that Iraq has the potential to become one of the main gas suppliers to Europe considering the EU' s necessity of diversifying and its natural gas providers, particularly after the beginning of the Russia Ukraine conflict.

If Iraq somehow become one of the main natural gas trading partner of the EU, it would be bale to get benefit from improved economy and socioeconomic conditions. Yet, Iraqi natural gas market might face potential risks such as; political instability, Erbil-Baghdad confrontation over natural gas revenues or foreign actors' interests which might harm Iraq's operations of exploiting and exporting its natural gas negatively. (Boltuc, 2022)

h) Azerbaijan

Azerbaijan is the 17th richest country in terms of natural gas reserve with total proved capacity of almost 2,5 trillion cubic meters (2,500 bcm). At the current consumption rates Azerbaijan proved reserve can meet the need of the country for 175 years. Energy equivalent of its proved reserve is around 100 billion gigajoules that has the capacity to feed solely the EU for about 2,5 years long by harnessing the current proved reserve. (Worldometer Energy Statistics, 2023)

Azerbaijan currently sells its natural gas to the EU. The natural gas is piped from Caspian Sea to Italy through Turkey, Greece, Albania and Adriatic Sea. The pipeline has 3 sections, first section extends from the coast on Caspian Sea to Turkish border, then the gas is conveyed to Trans Anatolian Pipeline (TANAP) runs all the way from very east of Turkey to the west until Greece. Then TANAP meets Trans Adriatic Pipeline (TAP) on the border of Greece that lays between

Greece and Italy passing across Greece, Albania, crossing Adriatic Sea to Italy. It is a European section of the Southern Gas Corridor. As of 2022 capacity is 10 bcm per year.

More natural gas from Azerbaijan can be safely transported through additional pipelines to be constructed on the same route. The only matter is to develop the reserve capacity through drilling numbers of wells, constructing pumping facilities and stations.

i) Egypt

Egypt is currently a LNG provider for the EU with its proved resource capacity of 2,2 Trillion cubic meters (2150 bcm). It holds the number 19 according to the current global ranking in terms of proved natural gas reserve capacity . With regard to current internal consumption rates Egypt can harness its natural gas reserves for its own needs for 38 years. Energy equivalent of its proved reserve is around 85 billion gigajoules that can meet the EU's natural gas single-handedly for 2 years excluding the unproved reserves. (Worldometer Energy Statistics)

Egypt can provide high volume of natural gas for the EU if new reserves are explored. Developing new reserves should be funded by the EU through bilateral win/win agreements. However although Egypt is politically stable standing safe and sound, the location can not be said to be suitable for laying pipe. There are two alternatives for the alignment of the pipeline, one crosses the Mediterranean sea through Crete to Greece, the other crosses several problematic countries such as ; Israel, Lebanon, Syria and finally reaches to Turkey and then the EU countries. First alternative is by far eligible than the second one. However, it is of great concern if laying a sea crossing pipeline for a source at this scale is feasible and to what extent the current reserve capacity can be developed.

To summarize, Egypt can be a better LNG provider for the EU if it increases its production capacity with the help of some allocated funds but, the country does not look promising in terns of being a large natural gas supplier in the short or medium run.

Table 2. Summary Of The Alternative Gas Suppliers' Positions

Country	Proved Reserve Capacity (bcm)	The Reserve's Lasting Period As Per The EU Consumption Rate of 1135 bcm/year (Years)	Supply Security (Yes/No/Abstention)
Russia	50,000	45	No
Iran	35,000	30	No
Qatar	25,000	20	Yes
Saudi Arabia	8,500	8	Yes
Turkmenistan	7,600	7	No
UAE	6,000	6	Yes
Iraq	3,100	3	Abstention
Azerbaijan	2,500	2,5	Yes
Egypt	2,100	2	Yes

It can be seen from the detailed evaluations of the possible alternative gas suppliers and the summary table above, Qatar , United Arab Emirates, Saudi Arabia, Azerbaijan and Egypt seem to be favourable countries rich in natural gas and having potential to replace Russia.

In this respect as it is revealed that even if the current proved resources of Qatar, Saudi Arabia, United Arab Emirates, Azerbaijan and Egypt in total were to be used to meet the EU's need it would take several decades to run out all the current reserves. This time span can be said to be by far enough for the complete transition to the renewables as per the EU Green Deal. What is more, there is always a possibility of exploring new reserves if the exploration studies are enlarged and intensified.

It was emphasized before with its justifications that, EU' s future demand of natural gas grounded on total replacement of the high carbon fossil fuels which

is adding up to 70 % of the total energy need can not be met by only LNG delivery. Because LNG delivery requires ships that is by itself a vulnerable situation. Additionally, increase in LNG demand and supply to those considerable amounts (almost 8 times the current supply) requires substantial amount of new LNG stations and facilities both on the demander and the supplier sides. Also, carrying LNG with huge amount of ships means huge amount of carbon emissions due to the oil consumption by the ships which is controversial to EU green deal strategy. Therefore instead of trying to increase the LNG procurement, EU should focus on buying the natural gas via pipelines from the source to the EU's inland.

3.2 Alternative Pipeline Routes From The Suppliers To The EU And Turkey's Position

At this point we can argue out the alternative pipeline routes from the natural gas suppliers to the EU. Here 5 alternative natural gas suppliers; Qatar, Saudi Arabia, United Arab Emirates, Azerbaijan and Egypt are chosen as they were underlined to be the possible alternative suppliers in Table 2.

There are of course more route alternatives than the ones stated below but as those routes are less safer like passing through Russia and Ukraine instead of crossing Black Sea or running through Syria or going across Persian Gulf, they are not taken into consideration.

a) Qatar

There are three alternative pipeline routes from Qatar to the EU as follows;

1. Starting from Qatar, the pipeline route passes through Saudi Arabia, Iraq, Iran, Azerbaijan or Armenia , Georgia and then passes across Black Sea all the way from east coast to the west and then goes to Bulgaria or Romania and finally bifurcates into Europe .

2. Starting from Qatar, the pipeline route passes through first Saudi Arabia and then Jordan and Israel and passes across Mediterranean Sea until Cyprus, runs through Cyprus and crosses again Mediterranean Sea until Crete, lies across Crete and makes the third Mediterranean cross until Greece and then bifurcates into the EU. In this alternative, there are two more paths from Israel to Greece making a long pass from Israel coast directly to Crete without stopping by Cyprus or extending directly across Mediterranean Sea from Israel to Southern Greece. However these two alternatives of Mediterranean pass have longer Sea cross in one go and do not differ much from the firstly mentioned Mediterranean pass alternative in total length of sea cross and overall pipeline length. That is why, those are not taken into consideration.

3. Starting from Qatar, the pipeline runs through Saudi Arabia, passes across Iraq and then passes through Turkey goes to Greece or Bulgaria and finally bifurcates into Europe

b) United Arab Emirates

There are three alternative pipeline routes from United Arab Emirates to the EU similar to the routes alternative from Qatar as follows;

1. Starting from UAE, the pipeline route passes through Saudi Arabia, Iraq, Iran, Azerbaijan or Armenia , Georgia and then passes across Black Sea all the way from east coast to the west and then goes to Bulgaria or Romania and finally bifurcates into Europe

2. Starting from UAE, the pipeline route passes through first Saudi Arabia and then Jordan and Israel and passes across Mediterranean Sea until Cyprus, runs through Cyprus and crosses again Mediterranean Sea until Crete, lies across Crete and makes the third Mediterranean cross until Greece and then bifurcates into the EU. As it was explained before, the

alternative Mediterranean passes such as Israel to Crete without dropping by Cyprus or direct reach to Greek coast from Israeli shore through a long sea cross is not considered as they are not advantageous in any aspect.

3. Starting from UAE, the pipeline runs through Saudi Arabia, passes across Iraq and then passes through Turkey goes to Greece or Bulgaria and finally bifurcates into Europe

c) Saudi Arabia

There are three possible alternative pipeline routes from Saudi Arabia to the EU almost similar to the routes alternative from Qatar or United Arab Emirates as follows;

1. Starting from Saudi Arabia, the pipeline route passes through Iraq, Iran, Azerbaijan or Armenia , Georgia and then passes across Black Sea all the way from east coast to the west and then goes to Bulgaria or Romania and finally bifurcates into Europe

2. Starting from Saudi Arabia, the pipeline route passes through first Jordan and then Israel and passes across Mediterranean Sea until Cyprus, runs through Cyprus and crosses again Mediterranean Sea until Crete, lies across Crete and makes the third Mediterranean cross until Greece and then bifurcates into the EU. As it was said in the cases of alternative pipeline from Unites Araba Emirates and Qatar before, the alternative Mediterranean passes such as Israel to Crete without dropping by Cyprus or direct reach to Greek coast from Israeli shore through a long sea cross are not considered as they are not advantageous in any aspect.

3. Starting from UAE, the pipeline runs through Saudi Arabia, passes across Iraq and then passes through Turkey goes to Greece or Bulgaria and finally bifurcates into Europe

d) Azerbaijan

There are two possible alternative pipeline routes from Azerbaijan to the EU as follows;

1. Starting from Azerbaijan, the pipeline route passes through Georgia and then passes across Black Sea all the way from east coast to the west and then goes to Bulgaria or Romania and finally bifurcates into Europe

2. Starting from Azerbaijan, the pipeline route passes through Georgia or Armenia and then runs across Turkey all the way from east and west goes to Bulgaria or Greece and finally bifurcates into Europe

e) Egypt

There seems two alternative pipeline routes from Egypt to the EU but the second one does not seem to be possible as it passes through Syria. The routes are as follows;

1. Starting from Egypt, the pipeline route passes across Mediterranean Sea until Crete and then runs through Crete and again crosses Mediterranean Sea reaching to Greece and then goes into Greece and bifurcates into Europe

2. Starting from Egypt, the pipeline route passes through first Israel , then directs due north to Lebanon, lies through Lebanon and then goes through Syria along the Mediterranean coast, then enters into Turkey for a long cross all the way from south to the north west until Greece or Bulgaria border, finally goes into the EU territory to distribute the gas inland

Having covered the alternative routes and their alignments shown in the Figure 4 from the natural gas supplier country to the EU border, now we can predict the total lengths of the alternative pipeline routes for the same

distances. In calculating the lengths of the pipelines we suppose that the starting point of the pipeline stands in the central region of the supplier country and ends in the EU border. Additionally the distances of the routes shown in Figure 4 were measured by crow flies manner and increased by 10%. In comparison of the lengths and alignments of the alternative pipeline routes the segments of the pipelines within the EU territory is supposed to be the same that is why those parts taken out of the scope.

Table 3. Alternative pipeline routes from possible natural gas supplier countries to the EU border

Supplier Country	**Hosting Countries or Regions for Alternative Pipeline Routes**	**Total Length Onshore Segment (km)**	**Total Length Offshore Segment (km)**	**Overall Length (km)**

Qatar	Saudi Arabia, Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	3500	1300	4800
	Saudi Arabia, Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	3050	1150	4200
	Saudi Arabia, Iraq, Turkey to Greece or Bulgaria	**4300**	**0**	**4300**
United Arab Emirates	Saudi Arabia, Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	3500	1300	4800
	Saudi Arabia, Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	3050	1150	4200
	Saudi Arabia, Iraq, Turkey to Greece or Bulgaria	**4300**	**0**	**4300**
Saudi Arabia	Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	2200	1300	3500
	Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	1850	1150	3000
	Iraq, Turkey to Greece or Bulgaria	**3400**	**0**	**3400**
Azerbaijan	Georgia, Black Sea Cross to Bulgaria / Romania	1,750	6,500	8,250
	Armenia, Turkey to Bulgaria / Greece	**5,500**	**0**	**5,500**
Egypt	Mediterranean Sea Cross to Crete, Crete, Mediterranean Sea Cross to Greece	1000	550	1550
	Israel, Lebanon, Syria, Turkey, Bulgaria or Greece	3000	0	3000

When we look at the Table 3 summarizing the alternative pipeline routes, pipelines from Qatar, and United Arab Emirates excluding Turley involve 5 countries each as well as a multi stage long sea crosses but the routes including Turkey consist of only 3 countries each and have no sea cross. Similarly, routes from Saudi Arabia to the EU excluding Turkey runs through 4 countries with

long sea crosses, whereas the pipeline route including Turkey is as simple as involving only 2 countries (Iraq and Turkey) to pass through in order to reach to the EU border. As for the routes from Azerbaijan, the route without Turkey lies through one country but with a long Black Sea cross from very east coast to the very west whereas route with Turkey passes through 2 countries (Georgia / Armenia and Turkey) but without a Black Sea Cross.

Unlike the routes discussed above, the alternative route from Egypt including Turkey seems not eligible as it passes through so to say a ring of fire including several problematic and instable countries such as ; Israel, Lebanon and Syria, the other route is also not easy to construct as it passes across Mediterranean Sea all the way from African coast to Greek coast going through Crete.

In the presence of above given points and discussions based on possible routes of the pipelines between natural gas suppliers and the EU, it is eye catching that, pipeline routes including Turkey are almost equal in length or even shorter, consist of less number of border crossings as compared to all other alternatives and may be more importantly include no sea cross. These features lead to less sophisticated, more attainable and cheaper pipelines. Moreover these said routes are possibly supposed to be easier in terms of maintenance, repair and management since less number of pipeline hosting countries are engaged with no sea cross.

The alternative pipeline paths can also be examined and compared in terms of pipeline security. Looking at the alternative paths from Middle East (Qatar, Saudi Arabia and United Arab Emirates) one can easily come up with that each of the 3 paths entertain security risks in levels. One of the paths passes across Iraq, Iran, even Armenia the other passes through Israel even Jordan and the third one in which Turkey is involved lies through Iraq. In every aspect the alternative paths from Middle East the routes including Turkey carry less risks as compared to the others as it involves only Iraq classified to be a risky country in terms of pipeline security like the others such as Iran, Israel, Armenia even Jordan which are to host the segments of the other pipeline alternatives.

As to looking at the pipelines from Egypt the only safe route is the one passing across Mediterranean sea. The other route passing through Israel, Lebanon, Syria until to Turkish border is a highly adventurous one that has better be skipped. Considering the pipelines from Azerbaijan neither of the routes (passing across Black sea or going through Turkey) are risky in terms of safety.

Figure 4. Alternative pipeline routes from the natural gas supplier countries

3.3 Cost Comparison Of Alternative Pipeline Routes With Or Without Turkey

The cost of a pipeline depends on several factors such as; materials and labour; right of way, professional services and nature's challenges. If we go into more detail we may specify the followings:

a) Diameter of the pipe determines the amount of material to be used. That is; the greater the diameter the higher the amount of material. In parallel, when the amount of material rises the labour cost also increases proportionally.

b) The pipeline projects going through populated regions, ones running through less populated and flat regions. Because in populated regions the right of way fees (land acquisition, easement or other permits to pay) are higher than the unpopulated or less populated regions. Similarly, the pipeline projects going through hilly terrains with valley or river passes or road / highway passes are more costly than the projects in flat regions with plain alignments.

c) The onshore pipelines passing across only land are cheaper than the offshore pipelines crossing the sea.

The route of the pipeline can be either onshore or offshore or the combination of these two. The average cost – per - mile for the offshore projects are almost double as high as the onshore projects. The recent cost realizations reveal that average cost / mile on the land is 2,5 million USD whereas the offshore pipeline cost some 5 million USD / mile. Cost of off shore projects do not change too much as the route on the sea has almost no parameters to vary other than the laying depth of the pipes and may be the right of way when it passes through the continental shelf of the pipeline hosting country. However as it was mentioned above as far as the land pipelines are concerned the nature's challenge becomes more driving in terms of investability. (Global Energy Monitor, 2021)

If we take the above given cost / mile values of 2,5 million USD for onshore and 5 million USD for offshore for a 30 – inch - diameter pipeline and the 48 inch diameter of north stream 1 natural gas pipeline with its gas flow capacity of 55 bmc / year as examples then we can calculate the total investment costs of possible pipeline routes from alternative natural gas resources to the EU territory as shown in Table 4 with using the pipeline lengths given in Table 3. Concerning the maximum natural gas need of the EU stated previously as 1135

bcm / year, there will be either a number of 21 parallel pipe lines each of which has a size of 48 inch in diameter or one huge pipeline with a diameter of 220 inch or numbers of pipelines between 1 and 21 in varying diameters totally adding up to an equivalent of 220 inch to the extent as technology allows.

Table 4. Investment cost estimations of the alternative pipeline routes until the EU territory

Supplier Country	**Alternative Pipeline Routes**	**Cost of Onshore Segment (Billion USD)**	**Cost of Offshore Segment (Billion USD)**	**Total Cost (Billion USD)**

Qatar	Saudi Arabia, Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	294	218,4	512,4
	Saudi Arabia, Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	256,2	193,2	449,4
	Saudi Arabia, Iraq, Turkey to Greece or Bulgaria	**361,2**	**0**	**361,2**
United Arab Emirates	Saudi Arabia, Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	294,000	218,400	512,400
	Saudi Arabia, Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	256,2	193,2	449,4
	Saudi Arabia, Iraq, Turkey to Greece or Bulgaria	**361,2**	**0**	**361,2**
Saudi Arabia	Iraq, Iran, Azerbaijan / Armenia, Georgia, Black Sea Cross to Bulgaria or Romania	184,8	218,4	403,2
	Jordan, Israel, Mediterranean Cross to Cyprus, Crete and then Greece	155,4	193,2	348,6
	Iraq, Turkey to Greece or Bulgaria	**285,6**	**0**	**285,6**
Azerbaijan	Georgia, Black Sea Cross to Bulgaria / Romania	58,8	218,4	277,2
	Armenia, Turkey to Bulgaria / Greece	**184,8**	**0**	**184,8**
Egypt	Mediterranean Sea Cross to Crete, Crete, Mediterranean Sea Cross to Greece	84	90,7	174,7
	Israel, Lebanon, Syria, Turkey, Bulgaria or Greece	252	0	252

When we look at the alternative routes from the supplier countries Qatar, United Arab Emirates Saudi Arabia and Azerbaijan, it is unexceptional that every route including Turkey appears to be by far cheaper than the alternative routes without Turkey from the same supplier country. The routes excluding Turkey not only more expensive to construct but also they are more difficult to build and operate (maintenance and repair) as they all extend across the sea together with their land crosses. Moreover there are some routes going through Iran or Israel both of

which are less secured and stable and almost all routes having other than Turkey are more costly as compared to the routes passing through Turkey. Again routes including Georgia or Armenia are less reliable as these countries are still either directly under the influence of Russia or within the influence area of Russia. Furthermore, that the routes excluding Turkey pass through more number of countries is likely to put more trouble on realizing the project and operating the pipeline.

The offshore pipeline from Egypt crossing two times the Mediterranean Sea (Egypt – Crete, Crete – Greece) and excluding Turkey seems to be with more reasonable price but the construction and maintenance of such pipeline can be difficult technically. However the other route from Egypt running through a group of unstable and problematic countries such as Israel, Lebanon, Syria should be discarded as neither construction nor operating of it is possible. Here one thing to note that Egypt instead of natural gas piping supplier can be still be a LNG provider that can send more LNG to the EU through some additional investments to harness the reserve more. Its geographical location is an advantage as compared to the some of the other EU's LNG providers like US or Japan.

Turkey with its unique geographical location is situated on such a region that the above mentioned largest proved natural gas reserves in the world rest just on a stone throw distance. Furthermore, Turkey is the natural bridge, in other words a crossroads connecting Middle East, Asia and Europe or in a global scale East and West. That is why it can be a safe and stable energy bridge of Natural Gas from the source to Europe (Kısacık, S., Kaya, F., 2017).

Turkey has grown economically over the last a few decades very rapidly that led to increase in energy need of the Country. It is very well known that Turkey has a high dependency on external suppliers of energy fuels like petroleum and natural gas. Therefore Turkey started to establish more close and firm relations with the natural gas suppliers in order to assure the supply safety. The status of Turkey with having ability to form solid relations with the countries possessing immense natural gas reserves is very crucial for Turkey concerning its target of being the energy hub especially of the EU. (S. Tagliapietra, M. E. E. Fandozione, 2014, page 4)

Currently as mentioned before, Turkey is hosting one pipeline extending from east Anatolia to the very west called Trans Anatolian Pipeline (TANAP) which delivers the natural gas from Azerbaijan on the coast of Caspian Sea to Europe through connecting to Trans Adriatic Pipeline (TAP) that runs through Greece and crosses Adriatic Sea reaching up to Otranto Italy. TANAP is one of the lengthy pipeline extends along 1811 km. That is a perfect indicator of successful cooperation between Turkey, sister countries of Turkey and Azerbaijan in the energy field. TANAP begins in Ardahan Province on Turkey – Georgia border and extends to Edirne on Turkey – Greek border passing through 20 provinces in Turkey. By increasing the energy security of Turkey and Europe, TANAP brings Azerbaijan, Turkey and the EU closer together, reshaping the global geopolitical energy landscape with the potential it offers. This geopolitical feature of TANAP serves as a source of inspiration for future energy projects. (TANAP official website, 2024)

Taking into account the alternative natural gas pipeline routes from Middle East passing through Turkey , we may notice that Iraq appears to be the only country not as secure as Saudi Arabia, Qatar or United Arab Emirates that creates a risky situation concerning the pipeline security. In fact, a pipeline in any part of the world is open to sabotages or attacks independent from what region it runs through. The risk of being sabotaged is higher in the sea than on the land as controlling a pipeline in the sea is not as easy as a pipeline on the land. In our case the key pipeline hosting country in regard to a pipeline project coming from Middle East and reaching the EU through Turkey in terms of security is to be Iraq. It is beyond any debate that Iraq is one of the richest countries in oil and gas reserves in the world. It trades in oil with its neighbours via pipelines. There is a capacity crude oil pipeline which is Iraq's largest crude oil export line extending between Iraq (Northern Regional Government) and Turkey starting from Kirkuk and ending at Ceyhan (on the Mediterranean coast of Turkey) with a total length of 970 km.

Over the years Iraq gained great experience in securing the pipelines as it has been selling its crude oil via pipelines due to its position of possessing a very short piece of coast on the Persian Gulf. Turkey also has a considerable

experience on safeguarding a pipeline as it has been trading crude oil with Iraq via pipeline since 1970. In Iraq, the most critical part for a pipeline to secure is the segment running through the land controlled by the north regional government as there exist still terrorist groups in the region even they are not as effective as before thanks to Turkey' s operational success in the region. Moreover Turkey successfully secures its pipelines going across its territory against the terrorist groups solicited by PKK.

Security of a pipeline running across Iraq all the way from south to the north can be assured through bilateral agreements between Iraq and the EU or mutual agreements between the EU, Turkey and Iraq or with an indirect support of the EU through back to back agreements between Iraq - Turkey and Turkey - EU which are supposed to support Iraq as well as the North Regional Government in their military expenses to guard the pipelines. Even Turkey can directly cooperate with Iraq in securing the pipeline and undertake all the security issues on its own. Currently Turkey and Iraq are guarding its pipelines against terrorist attacks and possible sabotages by using drones besides the military elements. If the security of the pipeline is assured firmly by the parties then Iraq can even be considered as a natural gas supplier country beside the other countries.

In brief, when setting about natural gas transportation from Middle East to the EU through pipelines is concerned, one can should keep in mind that all alternative routes contain unsecure countries. Routes including Turkey contain only Iraq relatively unsecure country and in particular the northern part. If this small region is secured then the pipeline becomes safe that seems to be fairly possible.

4. Turkey As A Renewable Energy Supplier To The EU

It is not astonishing to see that countries are endeavouring to build their renewable energy capacities due to the concern of finding alternative energy sources. Because of the fact that the fossil fuels will run out sooner or later and on account of arresting the climate change resulted from extreme use of fossil fuels and retrieving the nature again, it is indispensable to replace fossil fuels with some other environmental friendly energy sources. Renewable power

generation can help countries meet their sustainable development goals through provision of access to clean, secure, reliable and affordable energy. Renewable energy has gone mainstream, accounting for the majority of capacity additions in power generation today. Tens of gigawatts of wind, hydropower and solar photovoltaic capacity are installed worldwide every year in a renewable energy market that is worth more than a hundred billion USD annually. (IRENA, 2012)

Turkey with its total installed capacity of 105,000 MW for electricity production is generating around 350 Billion kWh / year electricity. Turkey in order to meet its obligations as a signatory of the Paris Agreement on Climate Change has been increasing its renewable energy share in total use. As of 2023 39 % of the electricity was generated by renewable energy sources and the ratio is targeted to be kept rising until the carbon neutrality by the year 2053. (https://enerji.gov.tr/)

Turkey has certain energy potentials in each type of renewables. As it occupies considerable piece of rock on the earth, there are different geographical regions within the territory of the Country, where some part is rich in geothermal energy, some part has wind potential, another part is prosperous in hydro energy but in almost every corner of Turkey there is considerable solar energy potential.

Now, let's have a quick look at the potentials of different renewable energy sources in Turkey.

4.1 Renewable Energy Potential Of Turkey

a) Hydro Energy

Hydro energy is one of the oldest energy sources together with fossil fuels and a wind power. Not more than a century ago there was only these three energy

sources. In ancient times hydro power was used for running the mills that had different functions like carrying water to the residential places or grinding grains, wheat etc. The World's hydropower installed capacity is around 1,4 Million MW and it currently provides over 15% of the world's electricity. (International Hydropower Association, 2023)

Turkey has substantial and valuable hydropower potential, particularly in the introduction of small hydropower plants especially over the past 2 decades There have been several studies on the Country's technical and economic hydroelectric potential. According to the academic studies and the studies carried out by Turkish Directory of Water Works (DSI) that the theoretical hydroelectric potential is approximately 433 Billion kWh / year in which technically usable potential corresponds to 216 Billion kWh /year (almost half of the total theoretical potential) and the economic hydroelectric energy potential in other words economically feasible potential is 140 Billion kWh / year (almost two third of the usable potential) . However, these studies have proposed that the hydroelectric potential will exceed the calculation because the contributions of Small Hydroelectric Power Plants (SHPs) are generally disregarded. According to the works done by DSI , Turkey's fresh water reserves have been divided into 25 river basin sand more than 95% of the country's potential has been distributed into 14 river basins. (Yasar, 2017)

Currently Turkey has over 750 Hydropower plants with a total installed capacity of 32,000 MW which makes up 20-25 % of the total annual electricity generation in the Country. Of course it depends on the annual amount of precipitation but on average, obtained energy trembles between one fourth and one fifth of the total yearly generated electricity in Turkey. Hydropower plants generates around 55-60 Billion kWh / year that is less than half even around one third of the above mentioned economical hydropower potential of Turkey. Even if all potential were to be used then electricity generated from the hydropower yet could not meet the total annual electricity need of the Country. (Anadolu Agency, 2023)

Considering the economic potential of 140 Billion kWh / year, the remaining unused capacity comes up to be 80-85 Billion kWh / year. In the presence of current capacity usage factor of 1875 hours / year (using the given data of 32,000 MW installed capacity of hydropower plants and 60 Billion kWh / year annual electricity generation) the 85 Billion kWh / year can be generated by an installed capacity of 45,300 MW hydropower plant. Referring to the unit investment cost of 2 Million USD / MW on average (average of dam and river type projects) , total investment cost to exploit this capacity will be some 90 Billion USD.

To summarize, Turkey has some potential in hydropower but this potential is so limited in global scale that it can only feed Turkey itself and contribute the Turkey's transition to renewables, namely, it can't be used to meet the need of its neighbours or the EU. Also, the climate change may have negative effects on the water reserve of Turkey and the volume of precipitation the Country receives annually which leads to degradation on the capacity use of the hydropower plants. Additionally, degradation could be so drastic that Turkey would be in such a position that does not allow it to release enough water to the countries on the south through Euphrates and Tigris Rivers. Under those circumstances the importance of energy generation would fade away being replaced by importance of water itself for the human being to survive.

b) Wind Energy

Turkey, thanks to its geographic location surrounded by four seas (Marmara, Aegean, Black Sea and Mediterranean) and configured by steeply rising mountains, highlands and plains son the foothill of the high mountains is rich in wind energy potential. As of October 2023 the total installed capacity of wind farms in Turkey added up to 11,600 MW. Again in 2023, Turkey generated 34 Billion kWh / year of electricity from wind farms that corresponds to 10% of the total electricity generated annually. This capacity is made up by over 320 wind farms. (Anadolu Agency, 2023)

Looking at the geography of Turkey in terms of available wind, we notice from both the previous and current studies as well as the location of existing wind farms and ongoing investments that, there are adequate wind currents for energy production on Marmara, Aegean, Black Sea and Mediterranean coasts. Wind flow is formed due to geographic structure in the interior region of Turkey. In these regions, a potential for wind power generation is also available. Installable wind power capacity as per the wind speed 7.0-7.5, 7.5-8.0, 8.0-9.0 and >9.0 meter / second comprise to 61.15 %, 27.16 %, 11.29 % and 0.41 % of total installable capacity respectively. In this regard, it is possible to make economic investment of wind energy at 50,000 MW in power in Turkey. (Turkmenler, Sogukpinar, Bozkurt, Pala, 2015)

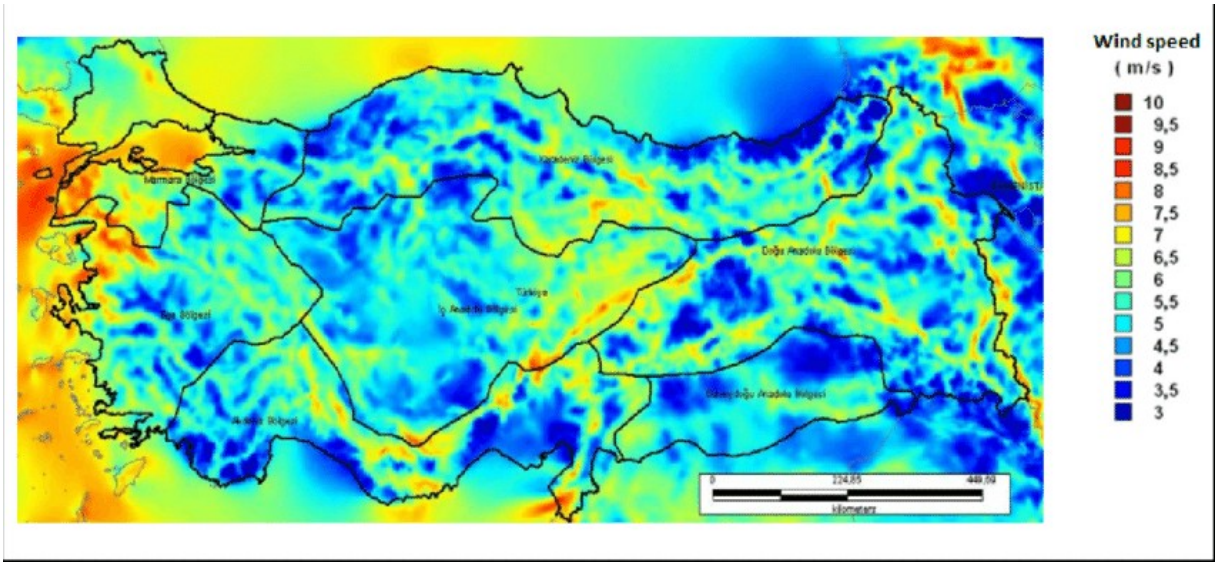

Figure 5. Wind map of Turkey including offshore regions

The recent researches by the World Bank demonstrates that total offshore wind energy capacity is another 75,000 MW, 63,000 MW of which is floating offshore wind and 12,000 is suitable for fixed bottom. In this regard, total capacity (potential) for wind may reach up to almost 125,000 MW. Considering the current total capacity of 105,000 MW referring to electricity generation in Turkey, the said potential of 125,000 MW is stunning. Referring to the cost of a 1 MW wind power plant being 1 Million USD on average for land type and 2,4

Million USD for offshore, the total investment cost of the wind farms amounting to 125,000 MW will be around 230 Billion USD.

However , climate change is liable to change the wind regimes negatively which we have been experiencing for a long period of time. In this circumstances it is of a big concern how reliable the wind energy will be the future. Besides, even if the 100% of the Turkey's wind potential put in service through a far reaching mobilization all over the country, it can barely contribute to the Turkey's transition to the renewables and be only used to meet its future needs, it is not enough large to be engaged in generating electricity for the other countries' utilization.

c) Biomass Energy

Biomass is a renewable organic material that comes from living things (plants and animals). Biomass possesses chemical energy originated from the sun which is produced by plants. It can be either burned directly in order to obtain heat or converted to liquid and gaseous fuels through various processes.

Biomass sources can be classified as follows

- Wood and wood processing waste—firewood, wood pellets, and wood chips, lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills
- Agricultural crops and waste materials—corn, soybeans, sugar cane, switch grass, woody plants, algae, and crop and food processing residues, mostly to produce biofuels
- Biogenic materials in municipal solid waste—paper products; cotton and wool products; and food, yard, and wood wastes
- Animal manure and human sewage for producing biogas (renewable natural gas)

(Nelson, 2011, page 77-78)

Biomass is able to be converted to energy through the following processes :

- Direct combustion (burning) to produce heat
- Thermochemical conversion to produce solid, gaseous, and liquid fuels
- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels

Direct combustion is the most common method for converting biomass to useful energy. All biomass can be burned directly for heating places and water, for providing industrial process heat, and for generating electricity in steam turbines. Thermochemical conversion of biomass includes pyrolysis and gasification. Both processes are thermal decomposition processes wherein biomass feedstock materials are heated in closed, pressurized vessels called gassifiers at high temperatures. The processes mainly differ in the temperatures and in the amount of oxygen present during conversion. (Energy Information Administration, 2023)

Biomass is a rising star among the renewables as it is a renewable energy the source of which is made up of organic wastes and disposables to be cleared away by all means even if it was not to be used for energy generation. Therefore energy production from biomass serves for two issues; getting rid of the waste and producing energy.

As of 2023, the world's total installed capacity of biomass power plants is around 150,000 MW. The world leading biomass energy producers are China, United States, Brazil as well as European Countries such as Germany, Netherlands, Norway. Turkey has a biomass installed capacity of 2440 MW as of 2023. Biomass energy although it is categorized as green energy source since it is the energy of the organic wastes, it dissipates carbon when they are processed to generate energy. Therefore, in the journey of the world to the carbon neutral earth, biomass should be used in limited amounts.

Biomass capacity of Turkey is not so impressive as the usable waste from industry, agriculture, forestry, livestock etc. are not in considerable amounts. Additionally, as emphasized before, the carbon emissions due to the combustion or other processes, biomass energy does not fit to the green deal in terms of

greenhouse gas emissions, hence using of it should be limited to the volumes serving only for removal of the wastes. As a result, biomass itself is not a main alternative to be used in transition to renewable energy sources or phasing out the high carbon fossil fuels, nor does Turkey have a considerable potential of it.

d) Geothermal Energy

Geothermal Energy is a domestic underground resource that is renewable, clean, inexpensive, and environmentally friendly. The usage of geothermal resources is widespread. Electricity generation from geothermal energy obtained in our country, heating (greenhouse and homes), thermal and health tourism, industrial mineral extraction, fishing, drying, and other activities are now utilized in these domains. According to data by the end of 2023, the world's installed geothermal energy capacity is 16,300 MWe. The United States, the Philippines, Indonesia, Turkey, and New Zealand are the top five countries in terms of geothermal energy electricity generation. Non-electrical use has surpassed some 105,000 MWt, with the United States, China, Sweden, Belarus, and Norway leading the globe in direct use applications. (https://www.statista.com/statistics/495238/installed-nameplate-installed-geothermal-capacity-worldwide-by-country/)

Geothermal energy has been being used in Anatolian region for thousands of years. Where ever you go in Anatolia you can see the ancient facilities that the humans constructed centuries or millenniums ago to harness geothermal hot water emerging either in the form of hot spouts or hot springs from the depths of the earth to the surface for their needs. As geography of Turkey (mainly Anatolia) is an earthquake region where complicated tectonic movements are taking place continuously , the geothermal activity is expected to exist in almost every part of the Country.

Turkey has been using the hot geothermal water for decades with an increasing amounts, mainly in district heating, health tourism (spa), green housing, although amount of usage is still well below the capacity. The first electricity generating power plant having an installed capacity of 15 MW was constructed and

commissioned in 1980's. From that time on until early 2000's there was no additional investment. Especially after the legislations issued in 2008 allowing the investors to be granted tempting incentives, the installed capacity rose so rapidly that in almost ten years period it increased 100 times. Nowadays Turkey's geothermal power installed capacity is 1690 MW made up by 63 geothermal power plants scattered on Aegean region and Marmara regions, where as the thermal equivalent of direct usage in such as; district heating, health tourism, green housing, fish farming and so on is some 5,100 MWt.

Turkey has more than 400 known geothermal fields in 63 different provinces where There are over 1000 natural outflows dispersed around in our country containing a variety of geothermal resources at various temperatures. (MTA 2019). Low-temperature resources with temperatures ranging from 20°C to 120°C are widespread. The country's total estimated geothermal potential is more than 60,000 megawatts thermal (MWt) Of that, the potential for direct applications is approximately 15,000 MWt; the potential for electricity generation is 4,500 megawatts electric (MWe) (Şener et al., 2022). The higher-temperature resources are concentrated at the country's western and eastern ends. It is conspicuous that despite rapid increase in capacity usage of the geothermal resources, the current utilization for both electricity and direct use are almost one third of their proved capacities.

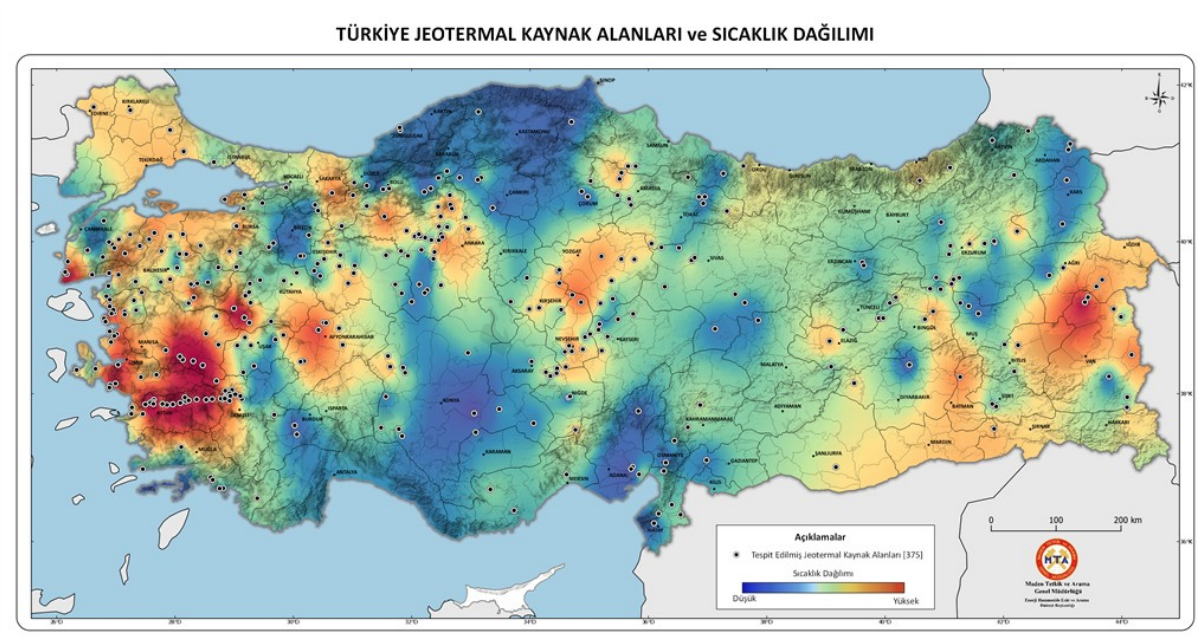

Figure 6. Turkey's map on geothermal resource areas and temperature distribution

From the figure it is obvious that explored our proved resources are accumulated mostly on the west Anatolia. In the map, highest temperatures are symbolized with red and lowest ones symbolized with blue. As the temperature goes up the colour changes from blue to green and then yellow and ultimately to red.

Ranking number fourth globally in terns of installed capacity, Turkey is a prosperous country in geothermal resources the expected capacity of which is some 4,500 MWe according to the recent studies as underlined before. In todays technology, geothermal energy in other words the heat energy is carried from the depths of the geothermal reservoir to the earth surface by the geothermal water coming out through wells drilled purposefully. Therefore if the reservoir although rich in heat energy is deprived of the geothermal water then that potential can not be used in producing energy. In fact, there are lots of such cases which we call "dry rock" where the potential rests idle. If the technology were not to need a water to carry the energy on the surface, and using only the heat to generate electricity were to be enough, then this potential would be incomparably tremendous. Nevertheless, expected total electricity generating capacity of 4,500-5,000 MWe is only a partial remedy to Turkey itself in transition to low or no carbon energy sources (renewables). Keeping in mind that the remaining capacity to put to use is to be some 3,400 MWe and the unit investment cost of 1 MWe geothermal power plant is around 3,5 Million USD, then total investment cost of installing 3400 MWe power plant amounts to 12 Billion USD.

Geothermal power plants are known for their emitted carbon dioxide which is dissolved in the geothermal water restored in the reservoir and leaves it after some processes and dissipates into the atmosphere. Therefore geothermal energy although renewable but not as green as wind, hydro or solar as they emits some carbon. However developing technology soon will enable the operators to reinject carbon dioxide in to the reservoir at least to some extent so that there will be a carbon cycle with less or no net emission. Furthermore, injected carbon dioxide will also help the geothermal wells in certain regions to keep wells'

artesian form of running rather than being pumped via submergible pumps installed inside the wells.

If one day the technology could allow the human being to harness only the heat of the earth captured in depths to produce energy then this would be a brake through changing the game in favour of geothermal energy. In that case the geothermal energy of the world on its own would be enough for meeting the whole world's energy need and Turkey would be one of the most significant energy supplier together with the other geothermal countries like US, Indonesia, Philippines, Malesia, Italy, Chile, Kenya and Eastern Africa even Iceland. What is more, with such a technology development, almost all regions in the world could be more or less available for exploiting geothermal energy either on a reasonable investment cost or higher.

e) Solar Energy

Solar Power resource leads the energy shift of the world and may be the most stunning among the other renewable resources. It is the 3rd largest renewable energy resource in terms of installed capacity, after wind energy and hydropower but in parallel with the developing technology solar power is liable to be number 1 among those. (https://www.forbes.com/home-improvement/solar/solar-energy-pros-and-cons/)

Solar energy is electrical or thermal energy exploited from sunlight. The use of sunlight is conducted by means of solar panels that contain photovoltaic (PV) cells made up of semiconductor materials such as silicon to absorb the particles from the sun called photons. When absorbed by the panel, the photons release electrons from the atoms of the semiconductor material and the flow of these electrons within the cell creates an electric current we can direct to our circuits. (Outka, 2010)

Solar panels can be placed anywhere receiving sunlight, such as open fields and rooftops. The panels produce more electricity as they are exposed to more sunlight during the day.

The solar energy has many advantages that has been luring the investors and making them focus more on that.

The main positive aspects of the solar energy can be listed as follows;

- It is the main energy source even the source of almost all other energy sources including fossil fuels and renewables except for the hydropower that is harnessed by using the gravitation of the earth itself by which the water is dropped from higher elevations to the lower that transforms the potential energy into kinetic.

- It is non carbon emitting even non- emitting energy resource that can be reachable all over the world where ever the sunlight hits on the earth surface.

- A solar power plant starts producing electricity from the dawn until the sunset. It is so uniform that one can easily predict how much energy is to be produced. Moreover, with the usage of storage facility solar power can be used during the night as well. In this way, solar power becomes a base load energy source for the grids.

- Solar power plants are the easiest in operating and maintenance among all other power plant types. It requires only cleaning the panels' surface to keep the efficiency at maximum and routine maintenance and repair of electrification system. It does not require a mass of technical staff during the operation.

- Solar power systems are silent and not harmful to the nature. They secure the quality of soil , water and air, namely, they are environmentally friendly.

- Solar Energy as a source contributes to the peace. Because there is no reason to fight for as the sunlight is everywhere unlike the war broke out in the past due to petroleum, natural gas, uranium or coal.

- Solar power plants are easy to construct and not only cheap to invest but also cost effective

- Unlike the fossil fuels, solar energy source is not limited in reserve or it is better to say its reserve limit governs by life time of the sun. Moreover, solar energy is incomparably less affected by the climate change than other renewables hydropower or wind as it can produce energy even in cloudy weather.

May be the only disadvantage of the solar power systems is its amount of land occupation per a unit produced energy. It covers large pieces of lands that can be an obstacle in carbon sinking strategy concerning land developing for solar through removing the green lands or lands suitable to afforestation and plantation. However developing technology resulting in panel efficiency as well as decrease in panel size per a unit produced energy will most probably get over this disadvantage in the future.

Economic viability of solar energy along with vast availability contributed to its unprecedented growth in recent years. According to an IRENA report, global solar PV generation increased by a record 179 TWh in 2021 (a 22 % rise from the previous year). The global solar capacity amounted to 849,000 MW in 2021 and hit to 1 million MW in 2023. Further, it accounted for 3.6% of the world's energy generation. (IRENA, 2021)

World's total solar power plant installed capacity has reached over 1 Million MW by the end of 2023. China is the leading country globally with an installed capacity of about 430,000 MW. China besides its leadership in installed capacity is also the largest manufacturer of solar equipment. According to reports, it has invested over 50 billion USD, in new PV supply capacity since 2011. This

figure is ten times greater than the amount invested by the entire continent of Europe in the same industry. China's share in all manufacturing phases of solar panels exceeds 80%. Today, subsidy-free solar power has become fortunately cheaper than coal in China. (https://ornatesolar.com/blog/the-top-5-solar-countries-in-the-world). China is followed by United States possessing a solar power installed capacity of 140,000 MW. Japan with its installed capacity of 85,000 MW in solar energy, Germany having 68,000 MW installed capacity and India possessing 68,000 MW solar power installed capacity are ranking 3rd, 4th, and 5th respectively. These top 5 countries made up almost 80% of the world's solar power installed capacity. (Pourasl, Barenji, Khojastehnezhad, 2023)

Technology related to electricity generation from solar energy is developing every day. There is a continuous increase in efficiency of the solar panels transforming the solar energy to electricity and decrease in dimensions of the panels keeping the same power capacity. As a matter of fact, the surface area covered by a unit solar power plant becomes smaller with an increase in efficiency.

Turkey due to its geographical location lying between the northern parallels of 36th and 42nd has sunny climate that grants high solar energy potential, specifically in the South Eastern Anatolia and Mediterranean regions. It is two times as sunny as Germany but the installed capacity of Germany is almost 6 times that of Turkey. Although the solar power installed capacity has been expanding in the Country, the rate is not fabulous. Above all, Turkey is an ideal region for producing solar power. There are about 2600 hours of sunshine each year (about 7 hours a day). Turkey's average annual solar irradiance is over 1 million terawatt - hours, that is about 1500 kWh/(m^2·yr) or over 4 kWh/(m^2·d). Solar power is also preferable to other renewable energy sources such as wind power and hydro power because wind speed and rainfall can be low in summer when the demand peaks, may be more importantly, sunshine is regular (appears in dawn and disappears in sunset), but wind and hydropower are less forecastable.

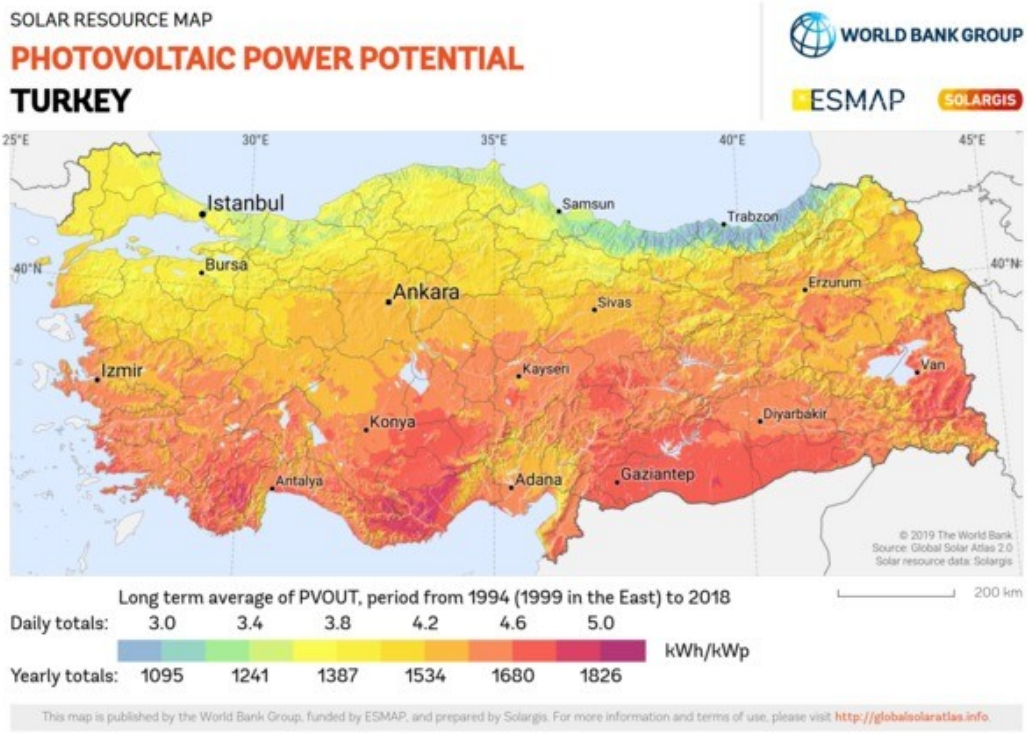

Figure 7. Turkey's solar resource map

Turkey has a total solar power plant installed capacity of 10,900 MW as of 2023. This installed capacity is made up by 10,500 solar power plants. It is quite noticeable that the number of power plants almost equals to the installed capacity that is because, in the last decade Turkey issued a legislation that allowed entrepreneurs to construct solar power plants under 1 MW installed capacity requiring less permits, easy environmental impact assessments, less legal commitments with doing by far less transactions. These power plants still can get benefit from the feed in tariffs and other favours on equal footing with the power plants greater than 1 MW. Therefore, the investors become motivated to invest in this type of small power plants and construction and commissioning of these power plants boomed at that period of time.

Solar power is the only sustainable non carbon emitting renewable that can be a base load for the network together with its storage facility, namely it can give the energy both in the day and night time. Wind and hydro are also non carbon and storable but they are not as uniform as solar to give base load to the network.

Referring to the current technology, solar power plant designs show that almost 12,000 m^2 (1,2 hectare) of a land space is required for a 1 MW installed capacity. (Pereyras 2019)

Turkey as a large country with vast lands has tremendous solar power capacity as it is situated geographically on a region where the solar insolation is quite high as compared to European countries. According to the data of Turkish Ministry of Energy and Natural Resources a solar power plant in Turkey can produce electricity in a year for 2600 hours on average. (Turkish Ministry of Energy and Natural Resources, 2022)**.** That means, it produces 2600 MWh electricity in a year. In order to calculate theoretical solar energy capacity of Turkey through imagining that the all unreserved lands for any use are set aside for solar power plants, we should go into the land use of Turkey in detail

4.2 Land Use of Turkey

Turkey is a transcontinental Eurasian country. Turkey covers two pieces of lands, Anatolian part resting on the Asian side comprises to 97 per cent of the tothal land whereas Eastern Trace is the European side of Turkey that constitutes only 3 per cent of the country. Turkey' total land surface area amounts to 78 Million hectares. It consists of mainly agricultural regions with a total surface area of 34 million hectares, forests, pastures and mountainous regions totally adding up to 40 million hectares, settlements corresponding to some 1,5 million hectares and the rest is made up by such as ; wet lands, watersheds and lakes. (OECD, 2017)

Now it is time to go into the land types and their current status more deeply

a) Forests

The total forest area of Turkey is almost 23 million hectares corresponding to 29.5 % of country's total surface area as of 2020. Turkey is aiming at expanding

its forest areas up to 30% namely 23,5 Million hectares by 2030. A significant portion of forests in Turkey is degraded or damaged mainly due to climate factors, as well as human activities and other factors. The main forested regions are situated in Black sea, Aegean and Mediterranean regions. Turkey's forest management data is regularly collected and updated through aerial photographing and ground surveys. Between the years 2000 - 2015, Turkey carried out afforestation works in a total land of 15 million hectares, rehabilitated another 2,8 Million hectares of degraded forestland and increased its forested land by around 1,2 Million hectares.

b) Agricultural Lands

Turkey's agricultural lands (cultivated lands) amounts to 24 million hectares according to Association of Turkish Statistics as of 2015. 25% of the total agricultural land is used for irrigated agriculture, 75% for dry farming. Besides, 17 % of total cultivated area is fallowed. The amount of agricultural land allocations rose significantly since the use of machinery in farming that began in late 1940s. However, increase in agricultural lands stopped in 1990s, and even began decreasing due to the allocation of agricultural lands to other uses, such as small scale enterprises, urbanization, property ownership related issues as well as soil degradation due to inappropriate agricultural practices. By 2030 through conducting some rehabilitation studies total agricultural land area is planned to increase up to 26 million hectares. However there is some additional potential of 8 Million hectares reserved for agriculture that can be rehabilitated which increases the total agricultural land up to 34 Million hectares. (Aydın, Çullu, Erşahin, Akça, Erdogan, Atatanır, Yorulmaz, Çilek, Ersoy, Miavaghi, Kapur, 2017)

c) Pastures

According to national official data the total surface of pasturelands in Turkey is 14,6 Million hectares. Approximately two third of the pasturelands are exposed

to various degrees of erosion. The target is to increase the total rehabilitated pasturelands including the current rehabilitated pasturelands of 585,000 hectares to 850,000 hectares by 2023, and to include an additional 750,000 hectares by 2030. The Pastures Law no. 4342, adopted in 1998, helps determine, confine and allocate pastures, summer pastures, winter quarters and publicly owned grassland and pasturage to village or municipality legal entities, ensuring usage of such lands in accordance with defined rules, increasing and improving their efficiency via maintenance and reclamation works, continuously inspecting and protecting their use and change of usage when deemed necessary. (UNCCD Land Degradation Neutrality National Report-Turkey, 2022, page 34)

d) Developed Lands (Settlements)

Turkey constitutes 81 provinces, over 1300 towns and thousands of villages with their buildings, roads, factories, energy facilities, municipality infrastructures etc. covering cumulatively 1,5 million hectares.

e) Other Lands

Other lands consists of sandy, marshy, bushy, salty and rocky lands as well as river beds and water surfaces (lakes). The total surface area of these lands yields to 5,1 Million hectares. These lands are almost unusable for any purposes, they are either not cultivable for agriculture, or not suitable for plantation and settlement.

These regions are not suitable to agriculture, afforestation or husbandry but they might be favourable for solar power plant projects. Within this 4,9 Million hectares of other lands it is likely that there are many fields suitable to laying solar power panels and constructing the related facilities the total surface area of which can be determined through objective and purposeful studies.

Even if one fifth of these lands that amounts to almost 1,000,000 hectares was suitable to exploiting solar power and knowing that the size of land covered by 1 MW solar power plant is 1,2 hectares then the total solar power installed capacity were to reach to some 850,000 MW. As per the data of 2021 the EU possesses total available energy of 61,000 Peta Joules (almost 17 billion Megawatt-hour) and if we imagine that the EU makes its energy transition completely to solar power than almost 6,500,000 MW of installed capacity of Solar Power Plant will be needed considering the Turkey' s average yearly radiation time of 2,600 hours. In this respect, when the Turkey's annual energy need of 400 Billion kWh corresponding to some 150,000 MW solar power installed capacity is subtracted from the above said 850,000 MW capacity then 700,000 MW of installed capacity is left to be put to the service for the EU. Given the fact that unit investment cost of a solar power plant is to be around 700,000 USD / MW in today's market conditions referring to the recent solar power plant projects in Turkey, the investment of a capacity of some 700,000 MW can be performed at a total cost of around 500 Billion USD**.** **)** (Inan, Simsek, 2022)**.** But we should also remember the rule of scale economy that as the capacity to invest rises the unit cost decreases.

As a matter of fact, in light of the above given circumstances, Turkey's solar energy potential can theoretically meet at least around 10% of the EU's total energy need. This potential directly proportional to the amount of land suitable to be reserved for the solar energy, namely, that is such an idle land which can not be recoverable for the purposes of agriculture, afforestation, settlement etc. The above mentioned solar power capacity to be reserved for the EU can vary as the amount of idle land in Turkey varies through wide ranging studies.

Table 5. Utilization of the Lands in Turkey

Type Of Land Use	**Total Surface Area (Hectares)**
Forest (Forest and Bush)	23 Million
Agriculture (Cultivated Lands, Gardens and Special Trees and Plants e.g.	34 Million

Olive)	
Pastures (Pastures and Meadows)	14,6 Million
Settlements (Provinces, Towns, Villages with Their All Infrastructures)	1,5 Million
Other Lands (Sandy, Marshy, Bushy, Salty, Rocky Lands River Beds and Lake Surfaces	4,9 Million
Total	78 Million

5. Conclusion

In this era, the global warming and its negative effects is being felt considerably in our everyday life. The measures to be taken for arresting this global climate change can only be effective through global actions. The EU with its Green Deal action plans is leading the World. Among these action plans, energy transition to low and zero carbon sources is vitally important. In the transition period natural gas usage should be maximized in order to replace the petroleum and coal. Therefore natural gas supply to the EU should by far increase and be secured and sustainable. Considering Russia' s position and EU – Russia relations, EU should find alternative suppliers and establish the necessary infrastructure to deliver.

Turkey thanks to its geographical location rests on a region where it neighbours the largest natural gas reserves. Having excessive capacity to replace Russia; Qatar, United Arab Emirates, Saudi Arabia, Azerbaijan can be new main suppliers for the EU through transmitting the natural gas via pipelines. In this scenario, Turkey as being the safest and most secured region among its alternatives can be cooperated with.

Again within the context of transition to renewable energy, solar power plays vitally important role with its characteristics of non carbon and uniformity. Turkey with its high potential of renewables particularly on solar power can be a strong renewable energy supplier with its huge solar power capacity in terms of

its high insolation and vast lands. The degree of land to be reserved for solar power plants is dependent on the size of the total lands irrecoverable and not usable for any other purposes through academic researches as well as the mutual benefits of Turkey and EU through such a corporation.

As a whole, Turkey can be the key strategic partner of the EU in the transition period to low / non carbon energy as it has the great potential of being natural gas corridor as well as the renewable energy supplier.

List Of Abbreviations

Bcm – Billion Cubic Meters

BTU - British Thermal Units

EBRD - European Bank of Reconstruction and Development

EEA - European Environment Agency

EPRS - European Parliamentary Research Service

ETS – Emission Trade System

EU – European Union

IPCC – Intergovernmental Panel on Climate Change

kWh - Kilowatt hour

LULUCF- Land Use, Land-Use Change and Forestry

LNG-Lequefied Natural gas

MW- Megawatt

MWe – Megawatt Electricity

MWt – Megawatt Thermal

TANAP – Trans Anatolian Pipeline

TAP – Trans Adriatic Pipeline

TWh – Terawatt hour

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