DESIGN ANALYSIS OF NATURAL GAS AS AN ENERGY CONNECT FOR MULTIFARIOUS NEEDS

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ABSTRACT

Energy is rising importance and significance in completing nations' economic growth. Natural gas is becoming one of the world's most significant energy sources due to its minimal greenhouse gas emissions. As a result, global natural gas consumption is fast expanding. Natural gas, the principal raw source for many chemical processes, supplies a large portion of global energy demand. Natural gas is clearly the second most important non-renewable fossil fuel source after crude oil. This research examines natural gas networks from all angles. In this sense, natural gas as an energy source was briefly described initially. Then the global natural gas market is analyzed in terms of reserves, consumption, production, lifespan, and storage. A discussion of the pollution generated by natural gas is followed as it is used in numerous sectors such as residential structures, cars, and industries. Aside from that, available pipelines transporting natural gas to customers are included, as are upcoming pipeline developments. Finally, liquefied and compressed natural gas are addressed as alternate energy sources.

Keywords: *Natural gas, non-renewable energy, primary energy, fossil fuel.*

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1. INTRODUCTION

Everywhere in the globe, energy is a major problem that must be taken into consideration when it comes to promoting social and economic progress. Consistently obtaining and effectively using energy that is low-cost, dependable, and environmentally friendly is a significant achievement.

There is a lot of methane gas in natural gas because it was created by the pressure and temperature changes that occurred between the earth layers of organisms that lived millions of years ago. H-type petroleum gas is another name for it. As with petroleum, it may be found in the earth's subsurface. Methane, less ethane, propane, butane, nitrogen, and carbon dioxide gases make up the majority of its composition. In its gaseous form, natural gas is a combination of paraffin, carbon, and hydrogen, the proportions of which are determined by the source of the gas.

2. HISTORICAL DEVELOPMENT OF NATURAL GAS

The history of natural gas, which is one of the biggest energy sources of our era, dates back hundreds of years. Statement of the “Sacred Fire” has been used throughout the humanity history. Sanctuaries established before Christianity have retained their importance for centuries in a variety of areas where the gas flames are existed in Azerbaijan. For the first time, natural gas as an energy source was employed for drying salt by Chinese in the reign of Shu Han, after the birth of Chris. In recent history, Chinese have tried to transport natural gas to other places by means of hollowed bamboos.

In Europe, the first natural gas was found in the UK in 1659. There are some documents which shows that natural gas was used for lighting and heating purposes by Northern Italians in this century. Alessandro Volta, who was known especially as a battery finder, declared natural gas as "Flaming Air of Swamps" in 1776. An Italian scientist, Lazzaro Spallanzani, termed as “Natural Gas” in 1795, was inspired by the gas term created by a Dutch scientist, Jan Baptista Van Helmont, in 1609.

The lighting of the streets and houses benefited largely from natural gas. The first discovery of gas fields was in the vicinity of a salt mine in Charleston city of the U.S. state of West Virginia in 1815. In the following five years, the first commercial gas operations were conducted in state of New York in 1820 by William Hart.

The transportation of natural gas for commercial purposes to a long-distance place was implemented when it is transported to Pittsburgh through pipelines. The total length of pipelines for natural gas distribution reached about 750 km in the same city. On the same date, the total length of other transmission lines within The United States of America borders was just about 40,000 km.

Until Second World War (also known as World War II), natural gas technology was not almost available in the countries outside of the United States. Afterwards, production and consumption of natural gas became widespread with the discovery of prominent sources in Pakistan, the Soviet Union, and North Africa. After the Second World War, there were even more advancements in the production of pipes as well as welding technology, and this led to a significant enhancement in the volume of natural gas transported in the course of time. Canada had an immense amount of natural gas, some of which was exported to America owing to excessive need for natural gas use. In Russia, the gas produced by developing natural gas field was initially shipped to Central Asia, Northern European Russia, and Eastern European countries.

In the mid-1900s, Germany, Italy, France, and Austria were utilizing their existing natural gas potentials. With improvement of the Groningen field in the Netherlands, some potentials here were exported to neighboring countries in 1959. Germany was linked to Groningen gas system in 1964. However, when it comes to rising irretrievable energy demand from internal sources and neighboring countries, natural gas as liquefied was transported by tanker from Algeria, Libya, Brunei, Nigeria, and especially Middle East. In this manner, Japan and the United States of America carried out the transfer of the energy on a vast scale. Natural gas was connected to the system of Western Europe by the Soviet Russia based on the condition that it would start from Germany in 1974 [1].

The first natural gas was detected in Kirklareli / Turkey in 1970. After 6 years, it was utilized at a cement plant in Kirklareli, which was operated under Set Cement Industry and Trade Joint Stock Company. Petroleum Pipeline Corporation (BOTAS in Turkish initials), which will play a very important role in the Turkey natural gas market in the coming years, was established by Turkey Petroleum Corporation (TPAO) in 1974. Natural gas found in the muddy pitch in 1975 was allocated to Mardin Cement Plant in 1982. Electricity generation using natural gas was carried out with domestic sources at Hamitabat Combined Cycle Power Plant in 1985.

When the history of the studies related to natural gas is painstakingly examined in Turkey, it is seen that the first studies pertaining to this topic were the research on "Natural Gas Demand and Supply" carried out by the General Directorate of BOTAS in 1983. This work was carried out with signing of a framework agreement by the Soviet Union with respect to natural gas purchased in 1984. Within 2 years following this agreement, commercial agreement was signed by BOTAS and Sovyet Soyuz Eksport for a 25-year on natural gas imports, which was expected to reach 5 to 6 bcm / year in the 1990s.

This first initiative for the supply of natural gas was made in order to ensure that imports can be carried out effectively. The construction of 842 km long pipeline starts from Malkoclar on Bulgarian border, and then reaches Gemlik-Bursa, Bozuyuk-Eskisehir through Ankara. By the fall of 1988, natural gas was operationalized for the potential use of settlements unit on the route. Along with the construction of this main line, international tenders were launched by the General Directorate of EGO and IGDAS for the construction of natural gas networks among these cities in 1988.

Natural gas was used for the first time in Turkey in residential and commercial sectors in Ankara in October 1988, in Istanbul in January 1992, in Bursa in December 1992, in Izmit in September 1996 and in Eskisehir in October 1996 [2].

3. AN ASSESSMENT OF THE GLOBAL MARKET FOR NATURAL GAS

Increased natural gas consumption in the 1950s, which provided just 10% of the world's energy needs, has been continuously increasing since then. The 1970s oil crisis had a negative impact on the economy, and the increased usage of coal as a result of the crisis was one of the most significant factors. The increased use of natural gas as a transportation fuel has been attributed to its superior cleanness when compared to other fossil fuels.

The International Energy Agency (IEA) conducted a research that predicted that global natural gas consumption will rise from 3.68 tcm in 2015 to 4.78 tcm by 2030, with an annual growth rate of 2.1%. Natural gas is expected to be the sole fossil fuel whose share of global energy sources increases through 2035. Natural gas output is expected to rise in all areas except Europe as a result of this.

Global natural gas consumption is predicted to reach 4.75 tcm in 2035, according to the New Policy Scenario, while coal consumption is expected to remain at the same level. In addition, non-OECD (Organization for Economic Co-operation and Development) nations were predicted to account for 81% of the rise in natural gas consumption [3].

3.1 The global distribution of natural gas reserves

In light of the global oil crisis, natural gas has become more important in the production of growing energy demand as well as the development of new technologies and investigations to lessen the dependency on oil.

Over the last two decades, natural gas reserves have increased by more than 56%. There were 119.9 trillion cubic meters of natural gas in reserves at the end of 1995; this climbed to 157.3 trillion cubic meters in 2005, and to 186.9 trillion cubic meters in 2015. Global natural gas reserves were 43.4 percent and 30.2 percent, respectively, in 1990, but by 2015, Europe & Eurasia's portion had dropped to 30.4 percent, while the Middle Eastern region's share had risen to 42.8 percent (see Fig. 1). In 2015, Russia ranked top with 32.3 trillion cubic meters of proved reserves, followed by Iran with 34 trillion cubic meters, and Qatar with 24.5 trillion cubic meters. It is estimated that Turkmenistan possesses a total natural gas resource of roughly 17.5 tcm, which is the greatest among Central Asian countries (see Fig. 2).

Natural gas's percentage of overall energy consumption is slowly rising as a result of the emergence of several new producers and users. As the day progresses, natural gas is predicted to account for 21% of the world's overall energy needs. If technology advancements continue at their current pace, it is expected to reach around 25% to 30% by 2030. Cleaner than other fuels, it is likely to have a substantial impact on worldwide commerce. Since 1980, there have been three main elements that have influenced the worldwide energy market.

- Energy businesses have supplanted the old oil and gas giants in this industry's landscape.
- Since 2005, there has been a widespread belief that natural gas would overtake oil as the primary fuel for global energy use.
- To protect the source of natural gas, instead of the traditional purchase and sale of natural gas, the sale is carried out in the production field by selling the reserve.

3.1.1 Natural gas reserves in the world's

In 2009, the economic crisis caused a decrease in natural gas output. As a result, natural gas reserves have a longer life expectancy, with a life expectancy of 62.7 years as of 2009. Using the total current reserve of 186.9 tcm divided by the entire current output (3.538 tcm), it was anticipated that the global reserve life would be 52.8 years. Natural gas reserves are expected to last fewer than 20 years in the US, the world's largest producer of the commodity. Non-traditional sources of natural gas that have been generated in the United States over the last 10 years are expected to prolong the reserve life to 200 years, however. A "natural gas reserve life" of 52.8 years, which is described in general terms, refers to reserves that have been demonstrated to be economically producible using today's current conventional technology. The Netherlands' reserves account for around half of the EU's total reserves. If the UK continues to produce at its present rate, there will be 4.5 years of reserves [6,7].

3.1.2 Natural gas production over the world.

In 2015, global natural gas output climbed by 2.2% (to 3538.6 bcm) from 2014 levels. Russia's natural gas output fell by 1.5%, although it climbed by 5.4% in the United States, 16.4% in Myanmar, and 5.7% in Iran. With 763.7 billion cubic meters (bcm), the United States became the world's leading natural gas producer. The Middle East (45.2 percent), Asia Pacific (22.6 percent), and North America (21.3 percent) had the biggest increases in natural gas output in 2015 [5]. Fig. 3 shows the top 10 nations with the most overall share in these areas.

3.1.3 Global usage of natural gas

Throughout the period from 1965 to 2015, the usage of fossil fuels grew significantly and their proportion of the energy supply increased. Since then, despite fluctuations in use, natural gas has been widely used throughout the country and has earned a prominent position among fossil fuels. Between 2005 and 2008, there was a continuous rise in the amount of natural gas used, which was followed by a fall in 2009. If 2009's economic crisis is overlooked, global natural gas consumption climbed by 4.7% (from 3051.2 to 3201.4 bcm) between 2008 and 2010, according to the International Energy Agency.

2015 had the largest rise in consumption in Asia Pacific (20.1%), North America (28.1%), and Europe & Eurasia (28.8%). US natural gas consumption grew by 20 percent (129.3 bcm) from 2009 to 2015, whereas Russian Federation's consumption, the world's second-largest consumer of natural gas, climbed by less than 0.5 percent over the same time period (1.9 bcm). Although consumption in Europe and Eurasia, which includes Turkey, grew by 10% (3.3 bcm) in 2010 compared to 2009, this consumption level in 2015 was lower than consumption in 2014. To provide a sense of historical perspective, Figure 4 depicts annual natural gas consumption quantities starting in 1965.

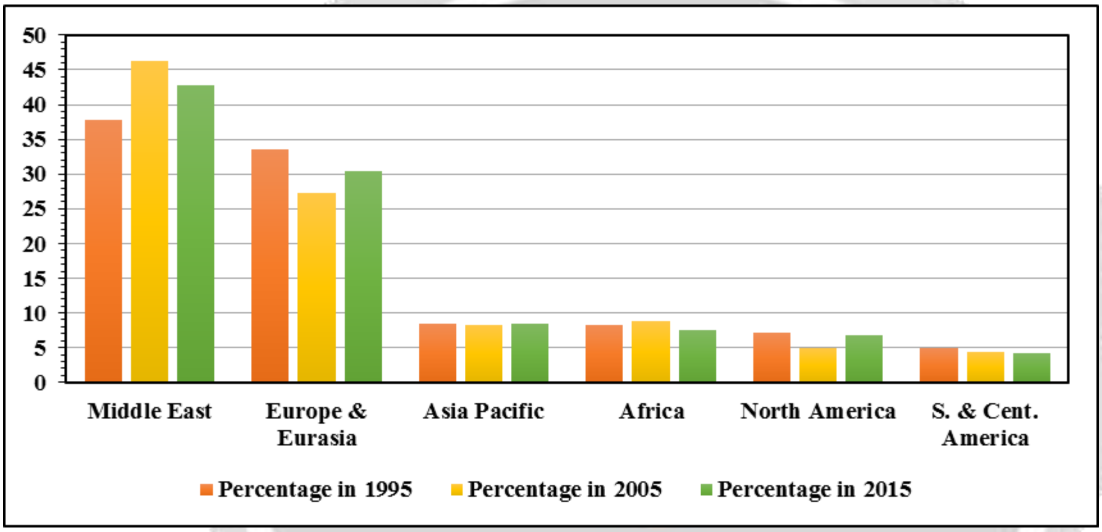

Fig. 1. Regions with proven natural gas reserves [5].

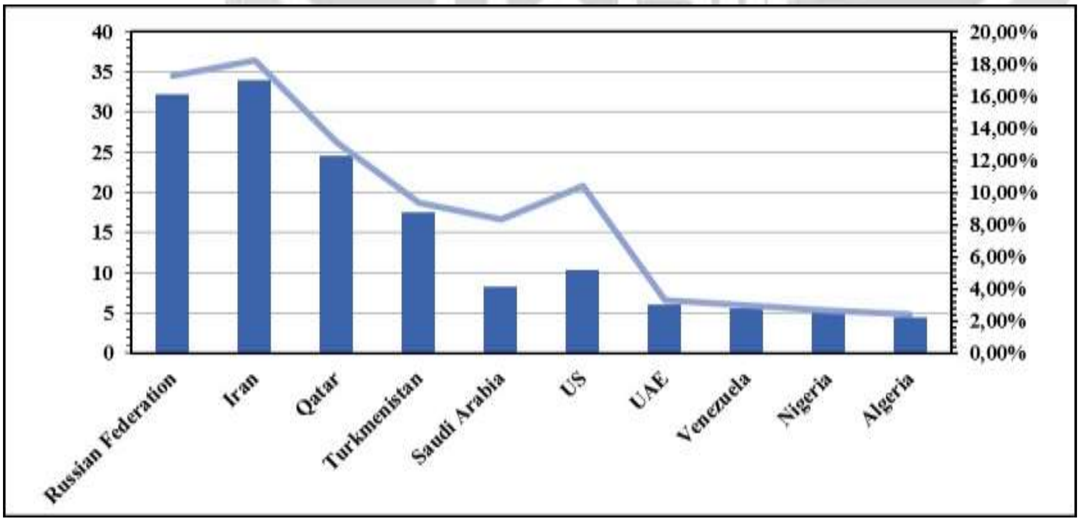

Fig. 2. World proved gas reserves and ten nations' share (tcm) [5].

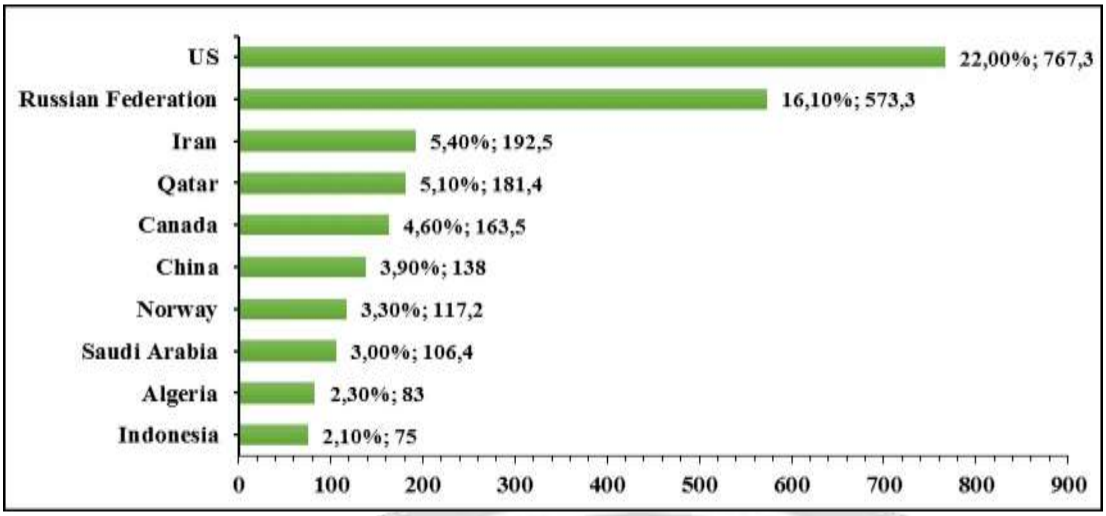

Fig. 3. Ten nations' natural gas output (bcm) [5].

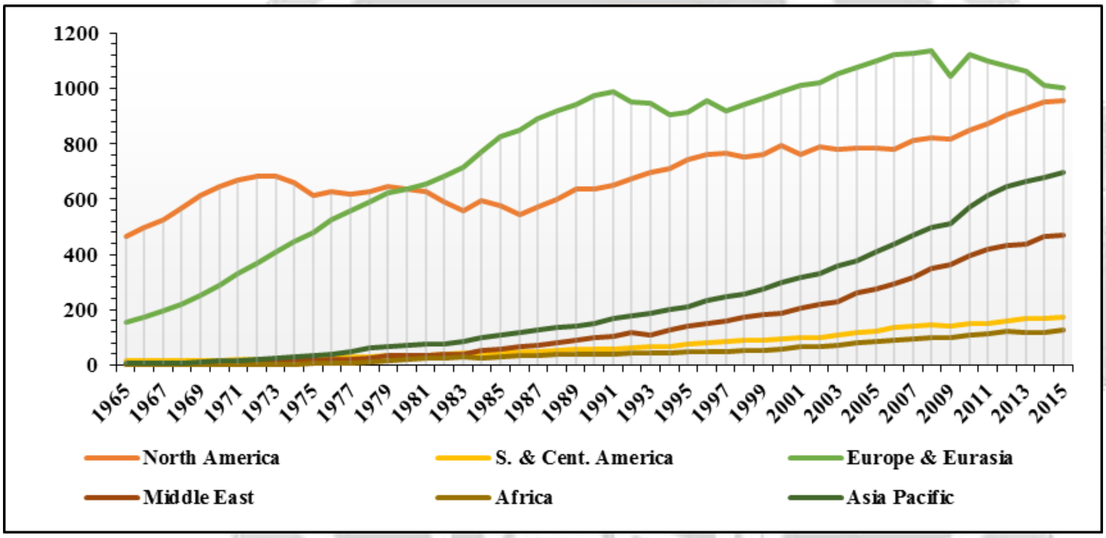

Figure 4. Years of global gas use (bcm) [5].

Fig. 4 shows that industrialized nations utilize more natural gas than developing countries. Around 80% of the world's consumption is accounted for by the industrialized nations of North America, Europe, and Asia. Because natural gas is a clean fuel and can be used in a variety of ways, it might be cited as a factor in this region's increased use.

The IEA predicted in 2011 that China's natural gas demand will climb from 197.3 bcm in 2015 to 500 bcm in 2035 under the New Policy Scenario. It is predicted that Russia will become the world's greatest natural gas producer with 860 bcm per year by 2035, and that North American natural gas production and demand would be in balance by then. As seen in Figures 1, 2, 3, and 4, the results;

- Natural gas reserves are concentrated in Russia and Iran, which hold more than a third of the world's reserves.
- Nearly 75% of the world's natural gas reserves are concentrated in the Middle East and Europe and Eurasia.
- The greatest natural gas deposits are found in Iran and Qatar in the Middle East and in Russia in Europe and Eurasia.

- Iran and Qatar's combined reserves make up about a third of the Middle East's total (42.8 percent).

- The Russian Federation, Iran, and the United States provide around 43% of global natural gas output.
- North America is ranked sixth in terms of proven reserves, despite its significant role in global natural gas production.

3.1.4 Gas Reserves for Long-Term Use

Underground gas storage was first attempted in a depleted gas reservoir in Canada in 1915, then in New York in 1916, and finally in Kentucky in 1919, all before the decade was through. Natural gas storage technology has been constantly evolving since 1917, when it was first introduced.

As of the end of 2014, the world's total underground natural gas storage working gas capacity was 270.6 bcm, down from 328 bcm at the end of 2000, according to the International Energy Agency. With 452 storage facilities in North America, including 402 in the United States and 50 in Canada, North America accounts for 70 percent of the world's storage capacity. It is expected that the need for natural gas storage will rise as natural gas markets become more flexible and short-term trading becomes more commonplace [9].

This underground natural gas storage facility was completed by the Iranian Natural Gas Storage Company (NGSC) in May 2011 so that shipments may continue unabated during winter months. In the beginning, it was necessary to increase capacity from 7.3-9 m3 to 30 m3

Underground natural gas storage and Turkey's reserves were explored for Russian Federation gas storage as soon as the "Underground Storage Coordinatorship" unit under BOTAS was established in 1988. Salt masses located south of Salt Lake and north of the Marmara gas field were determined appropriate for use as a storehouse at the conclusion of these investigations. Silivri, Turkey's sole natural gas storage facility, was managed by TPAO and has an overall capacity of 2.6 billion cubic meters. Silivri will be able to store an extra 4 billion cubic meters of natural gas after the installation of new capacity-building facilities. Chinese Tianchen Engineering Company invested in Salt Lake natural gas storage, which is expected to go into operation in 2019 [10].

4. EFFECTS OF NATURAL GAS ON AIR POLLUTION

In all cities of the world, fossil-based energy sources are being used extensively, either directly or by converting to electricity, in the face of the majority of energy needs. The production and use of fossil-derived energy brings many negative effects on human and environmental health. Air pollution caused by burning varies depending on the amount of fuel burned, the fuel pollution and combustion characteristics, combustion systems and operating conditions, pollutant emissions to atmosphere, and topographic and meteorological conditions.

The most common air pollutants around the city are sulfur dioxide (SO_2), nitrogen oxides (NO or NO_2, often called NOx), carbon monoxide (CO), ozone (O_3), particulate matter (PM) and lead (Pb). CO_2 emissions are the inevitable product of combustion technology based on the use of fossil fuels, and the amount of CO_2 in the atmosphere increased just about 1.3 times in the last century. In the next 50 years, this amount is likely to increase by 1.4 times. The greenhouse effect caused by CO_2 in the atmosphere enhanced the world average temperature by 0.7 °C over the last century. Particularly in developing regions, pollution has been increasing along with the increase of urbanization and energy consumption.

In turkey the need for heating is supplied by coal, petroleum-based fuels, natural gas, and geothermal sources. While the most consumed energy source is coal, natural gas agreements and investments has been made in recent years and natural gas have begun to be used to meet the significant heating needs. Also, natural gas has been exploited in order to overcome the air pollution arising from intensive urbanization.

Natural gas is a fuel that does not pollute the environment compared to other fuels. The three main polluting factors (SO_2, PM and smut) are not found in natural gas fumes. One of the most important features of natural gas is that it is nontoxic. There is no poisonous and lethal effect in case of natural gas inhalation. However, if there is too much accumulation in the environment, there is a danger of suffocation due to the reduction in oxygen to be inhaled. If the combustion product gases are emitted to the atmosphere, they may poison due to the increase of CO as in other fuels. For this reason, the use of natural gas instead of coal in heating significantly reduces harmful gas emissions [11,12].

As a result of combustion of natural gas which is a cleaner fuel than other fuels due to the emission of pollutants resulting from combustion, CO_2, CO and NO_X are formed. There is no sulfur oxides in it because it does not contain sulfur. It is also an important advantage that it does not form soot and flying ash particles as seen from above table. The lack of carbon monoxide formation, which is described as unburned gas and which is an extremely harmful gas, is another advantage compared to other fuels. NO_X is another component of combustion products that is harmful to the environment. One of the main reasons for the formation of nitrogen oxides is the high combustion temperature [13].

5. NATURAL GAS IS USED IN THE FOLLOWING PLACES

Energy generation is the most common application of natural gas. Additional uses for natural gas include supplying energy for industrial and domestic usage; cooling systems; enhancing the performance of thermal power plants; delivering improved emission values; and as a raw material in the manufacturing sector. Natural gas has also been used as an engine fuel across the globe. In recent years, natural gas-powered automobiles have become increasingly common in Turkey.

Since natural gas is an ecologically friendly and efficient fuel, there has been an increase in the number of natural gas-producing power plants across the globe. There are two primary ways in which it is utilized to generate power. Electricity is generated by burning natural gas in the gas turbines or by turning the steam turbines of water vapor created as a consequence of combustion of natural gas. Natural gas is more efficient and less expensive than other fuels when it comes to generating power. By 2035, the UEA's World Energy Outlook 2010 projects that natural gas would account for 33% of power generating [16].

White goods painting, adhesive industry, synthetic rubber cutting of metals in industry, heavy industry, manufacturing ceramics in the ink business, and getting antifreeze are all uses of natural gas.

5.1 Residential use of natural gas

A country's social, economic, and industrial growth is dependent on the availability of energy, which is regarded as a fundamental value. Countries throughout the globe are working to find more efficient and ecologically responsible ways to utilize natural gas, which accounts for a large share of global energy consumption. Since urbanization and rapid population expansion are being felt to their fullest extent, several considerations might be critical when deciding on a building's heating system. Included in this list are criteria such the building's usage, the length of time it will be in use, the kinds of fuel that may be used, and the project's budget.

Alternative heating systems should be examined in order to find an appropriate solution for each building with regards to energy efficiency and the environment. The same structure may be heated using a variety of techniques. Central and individual heating systems, for example, may be preferable in residential settings [17].

Vehicles powered by natural gas are becoming the norm as a low-emission alternative to gasoline and diesel engines, natural gas is gaining in popularity in recent years. Despite the abundance of natural gas reserves and the widespread availability of pipelines in many countries, the use of natural gas as a transportation fuel has lagged behind other uses. It's becoming tough to keep pace with the significant rise in the number of vehicles needed to keep the environment clean. As a result, nations in the European Union place a high value on alternative fuels and reducing emissions from transportation. Natural gas is just as significant as other fuels in this aspect. The IANGV and ENGVA, two well-respected organizations in the field of natural gas vehicle research, have lent their support to these investigations [18-22].

It is widely believed that compressed natural gas (CNG) is an ecologically beneficial alternative fuel with low emission levels that may be used in many western nations. For the purpose of illustration, let's take a look at the United States, which has the most automobiles on the road in the world. 190 million of the world's 520 million automobiles and trucks are located in the United States. The exhaust from these automobiles accounts for an average of 50 percent of the air pollution in the United States. In the United States, catalytic filters were placed in all gasoline cars, engine designs were modified, and gasoline and diesel fuel structures were revised in order to minimize exhaust emissions from these oil-dependent vehicles. Because these measures are insufficient, the 1990 and 1992 enacted Clean Air Act and Energy Law as a result, they began looking into other fuels.

China, Pakistan, and Argentina are the next most advanced countries in the use of natural gas-powered automobiles. Figure 5 shows the top ten nations in the world by the number of natural gas-powered automobiles. Argentinia and Iran are significant players in the Asia-Pacific and Southern Hemisphere

Centennials, respectively. IANGV (International Association for Natural Gas Cars) estimates that by 2020 there will be 65 million natural gas vehicles on the road throughout the globe [26].

For the first time in Turkish history, TOFAS-produced natural gas automobiles are being sold to a number of European markets. Successful natural gas-powered automobiles include the "Natural Power" Doblo and Fiorino. As of 2012, the market for natural gas automobiles has been established under the direction of Naturelgaz. There are CNG conversion systems that may be used on any vehicle ranging from trucks and tractors to busses and passenger automobiles. CNG vehicles are also available from a number of well-known automakers, including Iveco, Mercedes, MAN, Scania, and Volvo.

The usage of new natural gas-powered buses in public transit in Turkey's Kocaeli, Ankara, Kayseri, and Istanbul provinces has reduced air pollution and fuel costs caused by exhaust fumes. In December 2009, Kocaeli Metropolitan Municipality commissioned 45 natural gas buses, which saved the city 20% in 2010 [27].

5.2 Natural gas as an Industrial Fuel

Natural gas is increasingly being utilized as a major energy source since it is more readily available and has a lesser environmental effect than other energy sources. The use of natural gas-fired combined cycle power plants in electric energy generation has increased in recent years due to benefits such as high efficiency and quick operation [28].

In a combined cycle power plant, gas turbines and steam turbines work in concert. Additionally, the steam created from the waste heat of the exhaust gases from the turbine exhaust and steam turbines give extra power production. Combining the benefits of high-temperature gas turbine cycles with low-temperature steam turbine cycles results in total cycle efficiency of roughly 60% in these facilities. There are a number of advantages to natural gas-fired combined cycle thermal power plants over other fossil-fuel-based power plants in terms of operational duration as well as cheaper installation costs.

Because of this, the usage of natural gas in power rose and presently 55% of the imported natural gas is utilized in electricity. Consequently, Natural gas-fired power stations now provide 45 percent of all electric energy generation. Turkish Natural Gas Power Plants have a total capacity of 22,584.60 MW. It is estimated that in 2015, natural gas power plants generated 98.326.026.435 kilowatt hours of energy.

6. NATURAL GAS PIPELINE TRANSPORTATION

Transportation of natural gas commenced with small scale and short-haul routes in the late 19th century. A long distance transportation of natural gas was brought to Pittsburgh in commercial for the first time in 1883 by way of pipelines. Until the Second World War, natural gas technology was not very common in countries outside the US. After the Second World War, developments in pipe manufacturing and welding technology have resulted in a significant increase in the volume of natural gas transported by allowing pipeline pressures of 25-30 bar to be increased to 60-70 bar and pipeline diameters up to 75 cm. Today, in the international arena, natural gas pipelines can reach up to 150 cm in diameter. In order to facilitate the transportation of natural gas, R&D studies have been continuing in the world and to increase the applicability of new technologies, namely Absorbed Natural Gas (ANG) and Natural Gas Hydrate (NGH) [31].

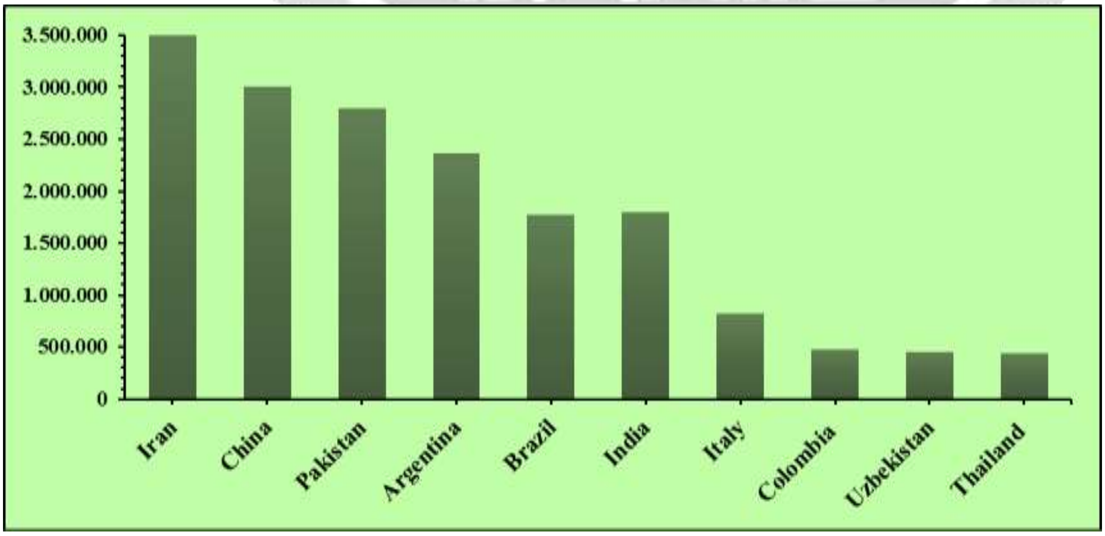

Fig. 5. Country-by-country breakdown of natural gas-powered automobiles in 2014 [27].

Pipelines are the safest and most efficient means of transportation in our globalized world, especially when it comes to delivering goods and services. As a bridge between Asia and Europe, Turkey acts as a conduit for 67 percent of the world's oil reserves and 40 percent of the world's gas reserves, which are located in the country's borders. Several nations provide Turkey's natural gas requirements, including Russia and Iran as well as Nigeria, Algeria, Azerbaijan, and

Turkmenistan. Liquefied natural gas is transported by tankers from Russia, Iran, Azerbaijan, and Turkmenistan through pipelines [33].

At acceptable pressure levels, natural gas is transferred from the source to the end user using appropriate pipe materials. Natural gas from Russia to Turkey across the Black Sea will arrive in under 12 hours at a pressure of 250 bar according to the Blue Stream Project. Turkey's gas supply is distributed by BOTAS. The RMS (Regulation Measuring Station), the zone regulator, and the service box all receive natural gas from BOTAS. Steel pipes deliver natural gas between cities at high pressure (40-70 bar). At the city's primary pressure-reduction stations, the pressure drops from 14 to 19 bar. In certain parts of the city, the pressure is as low as 4 bar. Polyethylene pipes transport the 4 bar natural gas to the regulator stations located at residential entrances, where it is decreased to 21 mbar or 300 mbar at high consumption sites by the regulator stations. The business that won the city's distribution contract is responsible for these installations.

6.1 Natural gas pipes already in place in Turkey

It is clear that Turkey's role in the energy industry is quickly expanding. Turkey's growing economy and limited natural resources are driving up the country's energy imports. A total of 13,276 kilometers of natural gas pipelines were built in 2015, with 12,963 kilometers built by BOTAS and 313 kilometers built by TPAO, according to 2015 research findings.

Natural gas will be supplied to all city centers after the transmission and distribution line projects that are now underway and will continue beyond 2015 are completed. For 95-99% of its natural gas needs, Turkey imports it from other countries. Agreements between nations and natural gas producers are becoming more common. After signing its initial deal with the Soviet Union on September 18, 1984, Turkey has been buying 6 bcm of natural gas per year [34] from outside. Turkey's primary natural gas partners are included in Table 1, along with a brief description of each.

6.1.1 Pipeline between Russia and Turkey in the west

BOTAS inked an arrangement with ENKA and its French partner Spiecapag in September 1986 to provide Russian gas pipeline. On its way to Ankara, the 842-kilometer-long Russian–Turkish gas main transmission line crosses the Bulgarian border at Malkoclar before passing into Turkey on its way to Malkoclar and the Bulgarian town of Hamitabat. An additional 20 MW compressor station is included in the deal as are 11 reduction and measurement sites, 9 piggery sites, 32 line valves, dispatch centers and 3 maintenance sites as well as communication infrastructure. The pipeline from Ukraine to Turkey can provide 14 mcm of natural gas per year at a pressure of 70 bar. About 75% of Turkey's current consumption falls within this category. US Exim, JEXIM, Coface, and ECGD were among the export credit agencies that contributed to the initiative..

Table 1. Turkey's international natural gas deals [35]

Agreements	Amount (bcm/year)	Signed Date	Status	Expiration
Algeria (LNG)	4,4	1988	In operation	October 2024
Nigeria (LNG)	1,3	1995	In operation	October 2021
Iran	9,6	1996	In operation	July 2026
Rus. Fed. (Blue Stream)	16	1997	In operation	End of 2025
Rus. Fed. (West)	4	1998	In operation	End of 2021
Turkmenistan	15,6	1999	-	-
Azerbaijan (Stage-I)	6,6	2001	In operation	April 2021
Greece	0,75	2003	In operation	End of 2021
Azerbaijan (Stage-II)	0,15	2011	2018	*1*

6.1.2 The Russian route pipeline connections (Blue Stream)

The biggest energy project to date, the Blue Stream project commenced with the signing of an intergovernmental agreement on the shipping of Russian natural gas from the Black Sea to the Republic of Turkey on December 15, 1997. The Blue Stream Pipeline B.V., a joint venture between Russian Gazprom and Italian Eni, built the pipeline. As laid out in the original blueprints, the line's capacity was pegged at 16 bcm. According to the 1997 deal signed by Moscow and Ankara over a 25-year term, the Blue Stream project foresees importing 16 billion cubic meters of natural gas from Russia each year. More than 380 kilometers of a total pipeline length of 1213 kilometers transporting natural gas travel beneath the Black Sea In the ocean, a 2150-meter-deep pipeline carries crude oil to market. As of November 17, 2005, the Gas Transportation Agreement became effective [36].

6.1.3 The Azerbaijan-Turkey pipeline (Shah Sea)

On March 12, 2001, BOTAS and SOCAR (Azerbaijan's state oil company) inked a contract for the transportation of Azerbaijani natural gas to Turkey through Georgia. 1850 km long line starting from Turkgozu village of Ardahan provinence on Georgian border passes through 20 provinces, including Ardahan, Kars, Erzurum, Erzincan, Bayburt, Gumushane, Giresun, Sivas, Yozgat, Kirsehir, Kirikkale, Ankara, Eskisehir, Bilecik, Kutahya, Bursa, Balıkesir, Canakkale, Tekirdag, and Edirne coming to an end in Ipsala district of Edirne on the Greek border [37]. Located in Azerbaijan's Caspian Sea region, the massive Shah Sea natural gas field is home to millions of cubic meters of gas. There are seven separate firms with a combined 28.8 percent stake in BP (British Petrol), making it the primary focus of corporate activities in this sector Since 2007, 6.6 billion cubic meters of natural gas have been exported to Turkey from the Shah Sea field's Stage 1 project. Azerbaijan and Turkey inked agreements in October 2011 for the sale of Shah Sea Stage 2 gas and transit permits, and construction work got underway soon after.

6.1.4 Baku-Tbilisi-Erzurum pipeline (BTE)

Baku-Tbilisi-Erzurum Pipeline is also known as South Caucasus Pipeline or BTE pipeline. BTE gas pipeline, which carries the gas produced from Shah Sea field located in the Caspian Sea of Azerbaijan, is 692 km in length and has a maximum capacity of 25 bcm per annum. As a result of negotiations relating to the supply of gas from Azerbaijan, intergovernmental agreement between Azerbaijan and Turkey for the shipment of Azerbaijani gas to Turkey, and for importation of 6.6 bcm of natural gas sale and purchase agreement was signed by SOCAR and BOTAS on March 12, 2001. The pipeline was constructed between 2005 and 2007, and has been operational since mid-July 2007. Increasing the capacity of portions between territories of Azerbaijan and Georgia in conjunction with production of the Stage 2 of Shah Sea field, BTE was planned to be linked to TransAnatolian gas pipeline project on December 17, 2003 [38].

6.1.5 The Iran-Turkey pipeline

A pipeline is planned to carry natural gas from the East to Turkey. On August 8, 1996, the National Iranian Gas Company (NIGC) and BOTAS inked a natural gas sales and purchase deal for 9.6 bcm of natural gas imports over a 25-year term. About 1491 kilometers long, the Eastern Anatolia gas main transmission line distributes 9.6 billion cubic meters of natural gas from Iran to Turkey each year. Iran's natural gas supply started on December 10th, 2001, with the completion of the metering station in Bazargan (an Iranian city). By the agreement, gas flow began at 3 billion cubic meters per year and reached 10 billion cubic meters per year [39].

6.1.6 Turkey-Greece pipelines

The interconnection of Turkey's and Greece's natural gas networks has been constructed as part of the European Commission's INOGATE Program (Interstate Oil and Gas Transport to Europe). On February 23, 2003, an intergovernmental agreement on the provision of natural gas was signed. On November 25, 2004, BOTAS put out a tender for the construction of a natural gas network, which began in 2005. When the 285-kilometer-long gas pipeline was completed on November 17, 2007, the total cost was around $250 million euro. According to an assessment of the Desk Study [40], a 17-mile pipeline from Karacabey in Turkey to the Greek port city of Komotini was contemplated.

6.2 Incoming pipelines to Turkey are included in this section - Pipeline projects

Turkish donations to worldwide initiatives have increased significantly since the year 2000. With this development, it has taken on the role of a major regional player in the process of bridging the West and the East. Below, Turkey's initiatives are explained in a clear and understandable manner.

6.2.1 Iraq-Turkey pipeline route

In 1996, Iraq signed agreements for the development, production, processing, and building of pipelines for natural gas reserves in northern Iraq. In 2003, fresh political events in Iraq prompted BOTAS to begin negotiations with TPAO (Turkish State Petroleum Company) and Shell. By signing a Memorandum of Understanding (MOU) in 2008, the three businesses stated above in the industry of natural gas export from Iraq to Turkey renamed the project the Iraq-Turkey Gas Export Project (ITGEP). As a framework for reviewing Turkey's natural gas infrastructure and exporting greater natural gas to Turkey and Europe, the Memorandum of Understanding's interested parties and prospective linkages to neighboring countries will be used to analyze the potential for natural gas exploration and production.

On October 15, 2009, the Iraqi Petroleum Ministry and the Ministry of Energy and Natural Resources signed a Memorandum of Understanding for the establishment of a natural gas corridor. Under the Memorandum of Understanding, Iranian natural gas will be transported to Turkey, where it will be used in Europe and other European nations [41].

6.2.2 Egypt - Turkey pipeline

There's a lot of confusion about the Egyptian-Turkish natural gas pipeline. As a consequence of the transfer of 10 billion cubic meters of gas from Egypt's pipeline to the Mediterranean Sea, this project arose after the LNG (Liquefied Natural Gas) project started in 1996 was cancelled. June 22, 1998 saw the signing of a Memorandum of Understanding between Turkey's Energy and Natural Resources Ministry and Egypt's Petroleum Ministry on natural gas shipments from Egypt to Turkey.

EGAS, the Egyptian natural gas company, and Turkey's BOTAS inked a framework agreement on March 17th, 2004, in Cairo, to allow BOTAS to import and transport Egyptian natural gas from Egypt to Europe through Turkey. Jordan, Syria, and Lebanon are now receiving Egyptian natural gas via the Arabian natural gas pipeline, which was completed earlier this year. Egypt's gas may be used as an alternative to Russian and Iranian gas once the project is finished for Turkey. Rather than an alternative, Egyptian natural gas should be added to other Arab countries, according to some experts [42].

6.2.3 Turkmen-Turkey-Europe pipeline

The Turkmenistan-Turkey-Europe natural gas pipeline project aims to carry Turkmenistan's natural gas to Turkey and then on to Europe through Turkey via the TransCaspian gas pipeline. The heads of state of Turkey and Turkmenistan signed a framework agreement in 1998 as part of negotiations to bring this project to fruition. There are 30 billion cubic meters (BCM), 16 BCM and 14 BCM of gas in Turkmenistan that will be sent to Turkey and Europe under this mutual arrangement. On May 21, 1999, BOTAS and the President of Turkmenistan's authorized organization for the utilization of hydrocarbon resources inked a 30-year natural gas sale and purchase agreement. [43].

6.2.4 Turkey-Greece-Italy Connector

South European natural gas ring (ITGI) is the initial ring of this network. Natural gas will be supplied through the project, which was signed by the ministers of nations responsible for energy initiatives in Rome in 2007, in 2007. Intercompany Memorandum of Understanding was signed on June 17, 2010 by the CEOs of BOTAS, DEPA (the Greek Public Natural Gas Supply Corporation), and EDISON (the Italian Energy Company).

The project's onshore segment spans 592 kilometers from Komotini (a city in East Macedonia and Thrace) to the Adriatic coast, including a sea crossing section of 212 kilometers in length. This isn't all: The greatest depth is predicted to be 1450 meters. A total of 11.6 bcm / year of gas are scheduled to be transferred via Turkey at the plateau level, 3.6 bcm / year for Greece and 8 bcm / year for Italy of which are supplied from Caspian sources.

6.2.5 Anatolian pipeline across Anatolia (TANAP)

Azerbaijani natural gas will be transported to Europe through Turkey as part of this pipeline project. To create a Southern Gas Corridor, the South Caucasus Pipeline (SCP) and the Trans Adriatic Pipeline were integral parts of the plan (TAP). The 3rd Blach Sea Energy and Economic Forum, held in Istanbul in November of 2011, was the first time the project's seeds were sown. On December 24, 2011, in Ankara, Turkey, the two nations' energy ministers signed an Intergovernmental Memorandum of Understanding. In 2015, BP, BOTAS, and SOCAR inked a deal after discussions. The partnership behind the TANAP project is headed by the SOCAR. SOCAR has 58 percent of the project; BOTAS holds 30 percent; and BP holds 12 percent.

Upon completion of its construction, this pipeline will be utilized to transport natural gas collected from the Shah Sea gas fields. The main line has a distance of 1850 kilometers, of which 19 kilometers are crossed by the Marmara Sea. In addition, there are seven compressor stations, four metering stations, 11 pig stations, 49 block valve stations, and two gas outputs to feed into the national gas station network in Turkey.

Shah Sea Stage II's first phase capacity is set at 16 billion cubic meters per year, of which 6 billion cubic meters will be sold domestically and the other 10 billion cubic meters will be exported to European markets. The gas should arrive in Turkey sometime between 2018 and 2020. There is a goal capacity of 16 billion cubic meters for 2020, 23 billion cubic meters for 2023, and 31 billion cubic meters for 2026 [45].

6.2.6 The west Nabucco pipeline

On October 11, 2002, Turkey's BOTAS signed the Nabucco West Treaty in Vienna, Austria. On July 13, 2009, an agreement was reached between the two governments that expedited construction of the Nabucco pipeline. Natural gas was to be transported to the EU through Turkey as part of the project. The primary goal of the project is to transport natural gas from the Shah Sea gas resource in West to Europe through the Trans-Anatolian gas pipeline project. European Union money for feasibility and engineering studies has also helped make this line a component of the Trans-European Energy Line. Initially, the entire cost of the project was estimated at between $4 and $6 billion. Although both nations had agreed to the 1320-kilometer route, which intended to transfer 20 billion cubic meters of gas to Central Europe, the project was formally scrapped in 2013 due to disagreements [46].Russia-Turkey-Europe natural gas pipeline (Turkish Stream)

Turkish Stream is the name of the natural gas pipeline project that was planned to transfer from Russia and natural gas to Turkey via the Black Sea. An intergovernmental agreement was signed for the Turkish stream natural gas pipeline project in October 10, 2016. Even though the starting point of the pipeline was determined as the Russkaya compressor station near Anapa, there is no official information on where it would enter Turkey. When the starting point in Turkey is determined, it is expected that Gazprom (a large Russian company) will start works on pipe-laying immediately. The construction of 4 submarine pipelines is planned. In addition, within the scope of the ongoing technical work, a maximum of 63 bcm natural gas has been considered to be transported on annual basis. It is thought that Turkey will supply about 14 bcm of natural gas per year from this project and the remaining 49 bcm of natural gas will be exported to Europe [47].

6.2.7 Natural gas pipeline over the Adriatic (TAP)

Nabucco West was scrapped and replaced with the TAP project. As part of a natural gas pipeline project, the 478-mile long pipeline from Northern Greece to Turkey / Ipsala connects across Albania and beneath the Adriatic Sea. On September 19, 2013, the Shah Sea Consortium signed a deal for the project, which would have required an investment of $35 billion. As soon as the pipeline construction can be finished at the beginning of 2018, the natural gas flow will commence within a short period of time.

7. THE TRANSPORTATION OF LIQUEFIED NATURAL GAS (LNG)

When pipelines cannot be used, natural gas is carried by ship. Refrigerating natural gas to a temperature far below 163 °C and raising its pressure reduces volume by 600 times. The liquefaction process removes pollutants from natural gas, making it cleaner than natural gas. After that, ships outfitted with a methane tanker-specific passageway deliver it. Natural gas from the North Sea has been piped to Germany through a 2000-kilometer route, making it the world's longest natural gas undersea pipeline.

Turkey's government inked a deal with Algeria in 1995 for a 26-year term, and with Nigeria in 1988 for a 36-year period to import 12 bcm of LNG for the purpose of diversifying supply sources and balancing seasonal burdens [50]. Built between 1989 and 1994, the Marmara Eregli LNG Terminal is situated in an area of 66 hectares. Aliaga/Izmir is home to Turkey's second LNG facility, which was put into service in the winter of 2006 [51].

8. CARRIAGE BY COMPRESSED NATURAL GAS (CNG)

Pressures of 206 bar are used to compress natural gas to enhance its energy density, which is known as Compressed Natural Gas (CNG) (CNG). It is one of the fuels that might be used in the future. Fuel for cars and special trucks in remote locations where natural gas pipes aren't available, it also serves customer demand via transportation by articulated lorry and special trucking. While natural gas pipelines are ubiquitous in Italy, industrial cities like Genova use CNG systems to meet their demands, such as the People's Republic of China. In contrast to Italy, numerous European nations, including Germany, the Netherlands, France, Austria, and Switzerland, make use of it. [Page 52 and Page 53]

Natural gas may be a viable replacement to petroleum fuels used in mass transit vehicles because of the environmental harm they have caused. Particularly in recent years, rapid growth in personal vehicle ownership has hastened the trend toward more cost-effective alternative fuels, which has begun to grow gradually as a consequence of R&D expenditures by enterprises in this field [54-56].

9. CONCLUSION

Since it was first discovered, natural gas has been one of the most important energy sources of our time. People have used the phrase "Sacred Fire" for millennia. Natural gas, a Chinese energy source for salt drying, has been used for the first time. They then used hollowed bamboos to carry natural gas to other locations. As a result, the use of natural gas has taken off in a significant way. The majority of people have accepted it and it has spread steadily throughout significant portions of the globe for many years.

During the past two decades, the usage of natural gas for power production and housing has skyrocketed. By 2030, natural gas will account for 23% of primary energy resources in emerging nations, up from 4% in 2016. The increase in energy sources and the environment will have a significant impact on nations' consumption, increasing it by an average of 1.3% year.

In the future, natural gas will be the most popular fossil fuel due of its steady development and minimal carbon emissions. Natural gas will be in a better position in the future because of the increasing need for energy and the high hopes for petroleum. Global demand for natural gas is likely to rise as its political, economic, and environmental benefits become more apparent.

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