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Natural Gas as a Source of Energy

Konstantinos Gounaris, Postgraduate student
Plymouth University, School of Government
Student at the Hellenic National Defense College
Athens 17778,Greece

Deligeorgiou Georgios, Postgraduate student
Harokopio University
Department of Geography
Athens 17671, Greece

Abstract - Natural gas is found in abundance in many regions of the world, in quantities that ensure energy sufficiency for human activities for 250 years or so, based on current estimates. In the global energy industry's turnover in 2011 natural gas participated in a proportion of about 21% ranking just after oil and coal, as the third largest energy source [1]. In financial figures, that translates to hundreds of billions of U.S. dollars per year [2].

This paper will analyze the elements of that fuel demonstrate its importance as a source of energy and assess the perspective of its contribution to meeting energy needs in the future. The methodology includes the description of natural gas, its origin, probable stocks and their geographical distribution, the procedures of extraction, its use, comparison with other energy sources, prospects of exploitation of new deposits and modes of transport from point production to the place of consumption.

Key words: Energy Sources, Natural Gas, Deposits, Pipelines

I. Origin and existing deposits of Natural Gas.

Natural gas is actually a mixture of gases with a composition that varies and depends essentially on the deposit from which it was obtained. It is referred to as "dry", when all components other than methane have been removed from the mixture almost completely, and "wet", when there are other gases present in the mixture, along with methane. This distinction is important because it relates to the way the product is processed and transported and the original choice of the deposit to be mined. From the "wet" form of treatment we can also produce important gases such as propane, butane, etc. which are marketed for use in a variety of applications.

Natural gas was created millions of years ago through a similar process to other fossil fuels (oil, coal, etc.). After its creation it was either released into the atmosphere or trapped in pockets of impermeable rocks, creating underground deposits discovered in the modern era.

Historically, it is divided into gas coming from conventional and unconventional sources. The distinction relates to the ease with which it can be mined and is not related to its chemical properties. Unconventional sources are the deposits that were or still are being unexploited for economic reasons or because of inadequate technology, or because of the specific technical challenges for their extraction, or even because of the potential risks posed by mining on the environment. The past 4 decades the advancement of technology and the overall development of the gas industry have allowed access to previously inaccessible deposits and increased the production and the expectations for future exploitation of impressively large deposits. The verified unconventional sources brought a significant change to the world map of Natural Gas stock. It should be noted that the stock assessment is a continuous and uninterrupted process which has the effect of amending sizes after each announcement of discovery of new exploitable deposit. In each case the potential of unconventional deposits is strongly demonstrated.

Huge gas deposits give a new perspective on the economy of many countries that up to now had not significant exploitable amounts of hydrocarbons and the energy they required came from third countries and from other national sources, such as nuclear power. Typical example of an attempt to reduce dependence on imported energy is Japan, which is a pioneer in developing technologies of exploiting methane hydrates [3] [4]. Countries such as Greece and Cyprus as well, also expect a significant improvement in their economies, based primarily on natural gas deposits in their Exclusive Economic Zones (EEZ).

II. The use of natural gas.

A. *Historical data*

The production of heat and light by burning natural gas was observed thousands of years ago, when random events such as forest fires and thunderstorms caused ignition of gas emissions from the soil and the appearance of a continuous flame. The lack of knowledge and the inability to explain the phenomenon created myths and prejudices. One of the most famous "flame" of this type was discovered in ancient Greece, on Mount Parnassus around 1000 BC. The accidental discovery by a goatherd of what looked like a "flaming fountain" sprang from the hole of a rock, was characterized of divine origin and led to the founding of one of the most important places of worship of antiquity, the Oracle of Delphi [5]. About five centuries later the Chinese discovered the possibility of using the outgoing ground gas to their advantage. They built makeshift bamboo pipes and carried gas in the combustion area, not far from the source, to boil seawater for production of salt and drinking water.

During the 19th century natural gas was mainly used for illumination of roads and public buildings. In 1885, the American inventor Robert Bunsen created a device that was mixing gas and air in proper proportions to safely burn them, for use in cooking and heating [5]. The device known as a

Bunsen burner opened a new perspective on Natural gas usage. However, the weakness of its safe transport over long distances didn't allow the development of gas industry at that time.

B. Applications in modern times

With the growth of methods of processing and transporting natural gas, its use acquired gigantic dimensions in both quantity and variety of applications. The main uses can be categorized in the following areas:

1) Domestic use

The competitive cost of natural gas in relation to other forms of energy makes it very popular for household consumption, especially for house heating. The advancements of technology allow the increasing penetration of domestic gas appliances which gradually replace the corresponding electrical. Cooling with suitable air-condition devices, cooking, food preservation, heating water for personal cleanliness, pools and Jacuzzis, fireplaces, grills, clothes dryers, outdoor lighting are some of the current domestic uses of gas. Of course there are appliances that require electricity, such as televisions, PCs, microwave ovens, sound systems, door systems, etc., which are not directly served by natural gas. But, the development of domestic power generators, known as Micro-turbines, using natural gas, would solve this issue [5]. Technology already exists but needs further improvement and of course the relative legislation to be amended. If the above should happen, a large increase in home user gas appliances and in domestic gas consumption must be expected. The relatively slow transition is due to the higher purchase cost of these devices than the corresponding electric, and to that the gas distribution networks are expanding at relatively slow pace.

2) Commercial Use

Commercial use refers to the public and private sectors and is similar to the residential use. Public buildings, schools, churches, hospitals, gyms, restaurants, are using natural gas mainly for heating and water boiling, space cooling, cloth drying and preparing food. Another way of developing natural gas use in the commercial sector is to produce electricity with appropriate generators. Also, an innovative technology seeks to develop integrated systems that Combine Cooling, Heating and Power (CCHP) for commercial use, to the most efficient use of energy produced from natural gas.

3) Industrial use

Natural gas is used widely in industry. The steel, glass, petroleum, plastics and chemicals and processed food industries are some of the sectors that use natural gas. Industrial use is similar to domestic and commercial, e.g. heating, cooling and electricity. In addition, natural gas is used as an ingredient in chemical industry for the production of several goods. Other important industrial uses are in the process of production of methanol, which finds application in the chemical industry, as well as some byproducts such as butane and propane, which are used for the manufacture of fertilizers and medicine.

4) Transportation Fuel

Natural gas is used in the transport sector by 1930. Not only the development of technology but also the political will of many states gave impetus to the prospect of using natural gas as a motor fuel in public transport, trucks and passenger vehicles for private use.

Today, there are in traffic more than 15 million vehicles fueled by natural gas. The technology in this area is constantly evolving and soon the number of users of natural gas as a motor fuel will increase significantly, along with consumption. This prospect has resulted in hundreds of industries participating in organizations such as the International Association of natural Gas Vehicles, which in 2010 was renamed Natural Gas Vehicles Global-NGVG [6].

5) Production of electricity

The rapid penetration of natural gas in power generation is bringing a new perspective in the field. It is estimated that in the U.S. in the next 20 years electricity will be produced using natural gas in overwhelmingly higher rates compared with other resources. In 2012 the production of electricity in this way in the U.S., was up to 30.50% of the total electric power produced, compared to 24.8% in 2011 [7]. However, the estimated increase for the next 25 years will depend on the implementation of national and other factors involved in formatting energy policy.

Technology in the power sector is designed to make the process and methods of producing electricity with natural gas more efficient, in a bid to reduce the cost per kilowatt-hour (Kwh). At present, the efficiency of production, either by steam or gas generators, or CCHP, does not exceed 60% of the energy potential of natural gas [5]. Innovative technologies, such as Micro-turbines, are likely to yield up to 80% and produce from 25 to 500 kilowatts (KW), and will contribute significantly to the expansion of applications of natural gas in electricity generation and especially in household and commercial use.

C. Why Natural Gas?

The widespread use of natural gas and the number of its applications demonstrate the importance of this fossil fuel, but do not answer the question "why shall we select natural gas for use rather than other sources of energy"? To answer that we should take into account a number of factors:

1) Economic factor

Natural gas is found in abundance in many regions of the world. Since the cost of producing energy from natural gas is less than or equal to the cost of other sources, it is obvious that its use will be a priority for the consumer. Thus countries that are producers of natural gas or servers or located near the producing countries or enjoy special preferential tariff, should have the use of natural gas as a key energy source as a part of their energy policy. The low cost of natural gas contribute to an extended range of economic growth from cheap domestic heating and industry development to job creation and saving payments in foreign currency.

The implications of the use of natural gas in the economy of countries which do not have same stocks always depend on the relative savings compared of other sources, such as oil, renewable energy sources, nuclear power and coal.

An important financial factor is the development of technology which makes the use of natural gas more energy efficient [8]. The energy efficiency of natural gas is designated as high and economic, compared with the corresponding of other sources "Fig. 2". It should be clear that any comparison with the rest fossil fuels and energy sources is relative and depends significantly on the technology and methods of use of the fuel.

We should also take into account the strategic planning of the oil and gas companies that invest very large amounts of money around the fuel cycle, which includes research, mining, production, processing, transportation and management. Amortization of investment and expected gains realized over time and therefore the energy giants that manage natural gas are likely to make efforts to contain innovative technologies that have the potential ability to displace gas from the market.

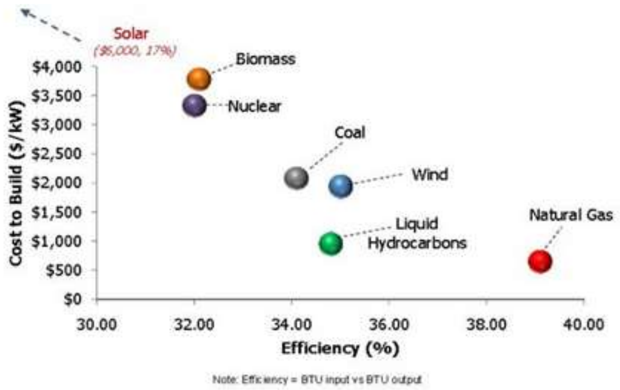

Figure 1. Electricity Production: Cost Comparison - Energy efficiency of resources in the U.S. [9]

2) Environmental Factor

The most disturbing phenomenon is that of global warming and its effects. It is known that the planet is undergoing heating and cooling schedule for 100,000 years, called the "natural cycle of warming" [10]. Human activity and specific pollutants emitted into the atmosphere, mainly CO_2, burden the natural evolution of the phenomenon and lead to increased climatic and environmental impacts.

Natural gas is by far "cleaner" than all the other fossil fuels (oil, coal) with significantly lower emissions of CO_2 and other pollutants "Table 1" [11]. However, natural gas does not cease to participate in the emission of gases that contribute to the "greenhouse effect".

A major environmental concern is the contamination of groundwater. Currently, data that indicate serious environmental impacts have not been formally notified, but the investigation continues. The US Environmental Protection Agency will submit its final study report on the issue in late 2014 [12].

In the field of mining, processing and transporting natural gas, environmental concerns derive from the effects of pipelines on the ecosystem and the possible leakage of methane into the atmosphere, the possible gas leak during extraction, the possibility of a ship sinking with liquefied natural gas and finally of the interventions in the environment during mining operations. In these areas natural gas lags behind carbon, but is less burdensome in relation to oil. The development of technology in every area of the gas cycle reduces the impact. Undoubtedly, there are effects which are often not due to the fuel itself but due to failure to comply with environmental protection, which should apply to an organized and well-governed state.

TABLE I. EMISSIONS FROM BURNING IN LBS PER 1 BILLION BTU[1]

POLLUTANTS	NATURAL GAS	OIL	CARBON
Carbon Dioxide CO_2	117,000	164,000	208,000
Carbon Monoxide CO	40	33	208
Nitrogen oxides NOx	92	448	457
Sulphur dioxide SO_2	1	1,122	2,591
particles	7	84	2,744
mercury Hg	0.000	0.007	0.016

3) Geopolitical factors

Choosing energy resources in regards to geopolitics primarily has to deal with the energy security. The energy policy of any nation in terms of geopolitics is designed to detox from energy monopolies, to exploit domestic sources and to the continuous and adequate flow of energy to meet its energy needs.

4) Innovative Technology

The discovery of huge deposits of hydrocarbons and mining technology's improvements ensured the adequacy of the planet for the next 200 to 250 years. It is clear that fossil fuels will eventually one day run out. The human foresight seeks to improve existing and discover new energy solutions. Nuclear fusion is one of the visions of the scientific community, which when it will become exploitable it will definitively resolve the energy issue and will put other energy resources in the margins.

Nuclear fusion produces energy by combining (fusion) of 2 or more nuclei of light elements such as hydrogen. Specifically, the fusion of hydrogens deuterium and tritium isotopes is responsible for the Suns energy. To achieve this reaction in Earth we must create conditions similar to those prevailing in the heart of the sun, i.e. a temperature of 100 million degrees Celsius and a pressure of millions of atmospheres. So far it has not been possible to produce more controlled energy than that consumed during fusion [13]. In Europe, production of fusion energy will be tested in the International Thermonuclear Experimental Reactor (ITER), which is constructed in Cadarache, France [14].

III. TRANSPORTATION OF NATURAL GAS

Before World War II miners used to release natural gas to the atmosphere or burn it or if it was a separate deposit to leave it underground, because they couldn't transport it. Today

[1]BTU: British Thermal Unit, is the heat required to increase the temperature of one pound of water, under normal conditions, by one degree Fahrenheit. Practically it is the heat emitted by the complete combustion of a match.

transporting gas from the source to the consumption is a crucial component of the gas industry. It is transported either by pipeline pressure or liquefied with suitable ships and land vehicles.

A. Natural Gas Pipelines.

One of the first pipelines was constructed in the U.S. in 1891. It had a length of about 200 km, was rudimentary and the transfer was not effective. Developments in technology now permit the safe, efficient and effective transfer of huge quantities of natural gas from the place of production to consumption, thousands of miles away.

Pipelines are distinct according to their size and scope in 3 categories. The first relates to the transfer from the production site to the user country and interstate. The second category is the national network of any country that carries gas to local networks. Finally there is the local distribution network to consumers. The pipeline construction projects are of high cost and require detailed planning. Pipeline's systems include:

1) *Pipes*
2) *Compressor stations.*
3) *Monitoring stations.*
4) *Flow valves.*
5) *The inspection and data collection and processing systems.*

B. Transfer of liquefied natural gas (LNG)

When the pipeline construction is deemed unprofitable, gas is being transported in liquid form with special ships or trains. Cooling dry gas at -2600 degrees Fahrenheit makes it liquefy at normal pressure and thus occupy a volume equal to 1/600 of the gaseous form.

The trade of LNG had a recession in 2012 after 30 years of continuous growth. Despite that, the increase in the last five years is 36%. This is due to increased demand from existing markets and new demand from emerging economies. The prospect of rising demand for LNG is encouraging because Japan is gradually replacing nuclear power plants, new markets appear and technology that will allow LNG to be dynamically inserted in the transport sector is improving.

The LNG system, besides the means of transport, includes liquefaction and gasification stations. These facilities are of high cost and their construction, just like pipelines, requires multiannual contracts between the contracting countries. The liquefaction stations are also used for liquefying pipeline gas for storage and transfer to points where constructing a pipeline is considered uneconomical.

IV. FINDINGS - CONCLUSION

Natural gas is found in abundance in many regions of the world, in quantities that ensure energy sufficiency for human activities, based on current estimations, for about 250 years.

Exploitation of localized deposits of natural gas from unconventional sources and the search of new, is an economic vision and a technological challenge, but raises serious environmental concerns and new geopolitical balances.

The combustion of natural gas is the cleanest compared with other fossil fuels, especially in CO2 emissions, but even these small emissions do not cease to contribute to creating the greenhouse effect.

The number of various uses of natural gas, the relatively low cost of its production and the continued expansion of pipeline networks and transportation of liquefied natural gas, coupled with estimates for increasing global energy needs are a cycle of self-reinforced actions that make gas an attractive energy source.

Natural gas is an important determinant of energy policy not only of many countries, especially the producers, but also of international organizations.

The advancement of technology in the energy sector may be able to bring revolution in the near future, by producing abundant, clean and economic power, which would marginalize the previously known sources. This will obviously cause conflict of powerful lobbies some of which favor the introduction of novelties and others to retain the status quo.

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