# Challenges to the Development of Unconventional Natural Gas – The Case of Shale Gas

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## Abstract

*The world is undergoing a radical transition to a low-carbon economy and natural gas is considered an important bridge in the transition of energy in the world. The potential for natural gas, especially unconventional gas, is very large, which will significantly affect the future energy structure in all regions of the world. However, the conditions for developing these resources are different between regions and countries. The development of unconventional gas is now facing many challenges, even opposition because the problem of extracting unconventional gas is very complex and the total impact is unknown. Therefore, at present, the expansion of unconventional gas remains a question for countries that possess and desire to exploit these resources. This article will analyze the opportunity and challenges of unconventional gas relying on the development of shale gas in recently.*

**Keywords:** *unconventional gas, shale gas, challenge*

## 1. Introduction

### *1.1. Trends in the energy transition in the world today*

The world is making a radical transition to a low-carbon economy, reducing dependence on fossil energy, and adapting to climate change. Low-carbon energy is an energy source that produces less greenhouse gas emissions than traditional energy sources such as wind, solar, geothermal, and nuclear. In addition, low-carbon energy also includes low-emission energy sources such as natural gas and carbon dioxide treatment technologies such as carbon capture technology. However, compared with traditional energy sources, being able to develop these types of energy requires a huge investment in technology, techniques, investment capital, and time. With renewable energy, the most important issues today are technology and cost. As for nuclear energy, although it is a clean energy source, its safety is still controversial.

In the current context, natural gas is considered as an intermediate energy source in the process of mankind's transition from traditional energy sources to renewable energy due to its superior properties. Although natural gas is also a fossil energy source by nature, natural gas is a clean energy source compared to oil and coal. When burned in the same amount, natural gas emits very little $CO_2$, only half as much as coal, and 75% as much as petroleum, it also emits very few other toxic substances and produces less carbon dioxide, dust as well as mercury (EIA, 1998). Because of this, natural gas is considered as a fuel that is friendly to humans and the environment, which has been used very widely in many different fields and will continue to be used more in the future compared to other fossil energy sources. Even, according to the forecast of the World Energy Organization, humanity is entering the golden age of natural gas to replace oil.

### *1.2. Natural gas reserves in the world*

As estimated by recent studies, global natural gas reserves are abundant, and progress has been made thanks to technological developments. Thanks to improved exploration methods, the world's natural gas reserves are increasing. In particular, the recent rapid development of technology has allowed people to exploit unconventional gases that are considered to have very large reserves, most notably the recent revolution of oil and gas shale in the United States.

Many gas reservoirs and deposits have been associated with the term unconventional gas. Unconventional gas resources, such as shale gas, coalbed methane, and tight gas, have emerged as potential alternative energy sources to meet the growing global energy demand (Boyer et al., 2007). In general, unconventional gases are gas resources trapped in deep, low-permeability clayey rocks or in coal deposits and difficult to trap in high density in conventional natural reservoirs. Rock permeability is measured in units called millidarcy (md) and gas passed through rocks with permeability less than 0.1md has been classified as unconventional gas. The gas flows in a well is a function of the permeability, but also of other variables such as the pressure of the reservoir, as well as its radius and the viscosity of the gas (McGlade et al, 2012). They represent significant underground reserves whose exploitation remains complex and costly.

At the end of 2020, according to BP statistics, proven natural gas reserves are around 190 Tm3 which equates to almost 50 years of consumption at current levels. The increase in proven natural gas reserves in the world over the past several years has been much faster than incineration production in some countries. The average annual growth rate of natural gas reserves in the world from 2009 to now is about 1.2%/year. The growth rate of natural gas reserves in the period 2009 to date has been concentrated mainly in North America (4.7%/year) mainly due to the rapid development of traditional gas, especially shale gas in the US, followed by the area of the former Soviet Union (2.7%/year); Although Middle Eastern countries hold about 40% of the world's total natural gas re-

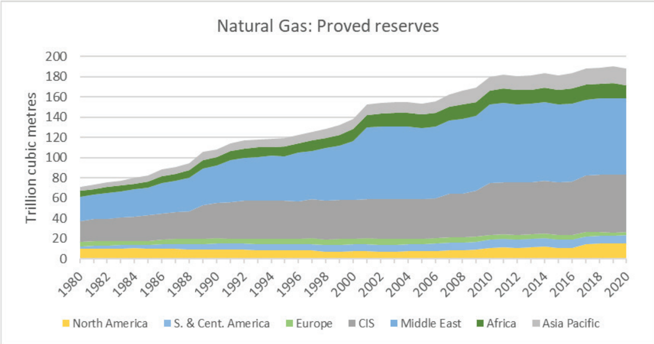


Fig. 1. Changes in proven reserves of natural gas in the world. Source: (BP, 2022)

serves at present, the rate of increase in reserves in the recent period tends to be slow with about 0.3%/year.

Thus, gas reserves in the world are still on increasing trend, natural gas is still discovered in different regions of the world, however, the contribution to the increase in the current gas reserves in the world is mainly focused on the discovery of unconventional gas sources, especially shale gas. The discovery of unconventional natural gas fields has changed the picture of natural gas reserves and influenced geopolitics in many regions of the world. For example, according to IFP, in the US, shale gas reserves account for more than four times the reserves of conventional gas, which has a great influence on the future energy development strategy of the US.

### *1.3. Forecast of future demand for natural gas*

The growth of the global economy and the increase in the population leads to the growth of energy demand and consumption. Besides, natural gas is likely to play a significant role in the global power generation mix due to its lower carbon emissions compared to coal and oil. As countries seek to reduce greenhouse gas emissions, natural gas-fired power plants may serve as a transitional energy source, especially when combined with renewable energy integration. As countries seek to reduce greenhouse gas emissions, natural gas-fired power plants may serve as a transitional energy source, especially when combined with renewable energy integration.

As a result, by many estimates, the demand for natural gas is expected to grow more than any other fossil energy source. All energy scenarios of world energy organizations or scenarios of oil companies, both offer a promising long-term future for natural gas. In many scenarios, natural gas will be the world's leading source of energy by 2050 (IGU, 2015). For example, according to an analysis by Exxon Mobil, 40% of global energy demand growth between 2014 and 2040 is expected to be met by natural gas (Exxon Mobil, 2016). Following the estimate of BP, the growth rate of about 1.4% per year in demand (BP, 2016).

According to the IEA, most of the major increase in energy demand will come from non-OECD countries. Non-OECD Asian countries will contribute about 60% of the increase in demand with the most prominent factor until 2025 being China before overtaking India. Global energy demand in 2040 will be 37% higher than 2012 levels in the New Policies scenario. The energy sector is the biggest driver of climate change, with 65% of all anthropogenic greenhouse gas emissions (IPCC, 2014). Therefore, establishing a sustainable and environmentally friendly energy system model is a top priority for energy and climate policymakers around the world, and natural gas is an important bridge in the energy transfer process.

Similarly, according to the IEA in its 'Golden Age of Natural Gas' report, by consuming more natural gas, the world could achieve its overall $CO_2$ reduction target. According to the IEA, global demand for natural gas is expected to grow by 50% between 2014 and 2040, faster than other fuels and more than twice as fast as oil. Most of the increase in natural gas demand has come from emerging economies, with China and India together accounting for about 30% of the increase and the Middle East with more than 20%.

According to the IEA scenarios in the "World Energy Outlook" reports from 2010 to 2020, the demand for natural gas will increase steadily, but the magnitude of the increase will vary from year to year and from region to region. The following table shows the growth rate of natural gas under the IEA scenario.

Natural gas has a faster rise than any other energy source. The average growth rate of demand for natural gas in the world ranges from 1.2% to 1.7 %/year while that of oil is only about 0.3 - 0.5 %/year. The demand for coal is even forecast to decrease in recent years. It is forecasted that by 2040 natural gas will overtake coal as the second largest source of energy in total primary energy demand. In the world, the Asian region will be the main growth driver for natural gas demand in the future with a very high rate of 2.9% to 4.3% per year.

## 2. Potential and development of unconventional gas

### *2.1. Unconventional gas evolution and its effects*

Although unconventional gases have been known for a long time, the potential and development of non-traditional gases and their impact on the energy market are only about a decade ago. Today, known unconventional gases include coal-bed methane (CBM), shale gas, tight gas, and hydrate gas. Especially from 2005 up to now, the development of shale gas in the US has become a phenomenon, a revolution in the energy field. This development has had a lot of impacts not only on the US gas market but also on the global gas market.

Unconventional gas production is also growing rapidly in other parts of the world. In 2010, Australia produced only a small amount of coal-bed methane (about 5 billion m3 of gas), 2015 became a liquid gas producer from coal-bed methane. Other countries such as China, India, and Indonesia also have activities to find and develop non-traditional gas energy sources including coal-bed methane and shale gas. With the development of shale gas, the proven reserves of natural gas

Tab. 1. Growth Rates of natural gas until 2040 in New Policies Scenarios of IEA. Source : IEA(2010); IEA (2011); IEA (2012a); IEA (2013); IEA (2014); IEA (2015); IEA (2016); IEA (2017); IEA (2018); (IEA, 2019); (IEA, 2020); (IEA, 2021)

| Region | WEO 2010 | WEO 2011 | WEO 2012 | WEO 2013 | WEO 2014 | WEO 2015 | WEO 2016 | WEO 2017 | WEO 2018 | WEO 2019 | WEO 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total world energy | **1.20%** | **1.3%** | **1.2%** | **1.2%** | **1.1%** | **1.0%** | **1.0%** | **1.0%** | **1.0%** | **1.0%** | **0.8%** |
| - Petroleum demand | 0.5% | 0.6% | 0.5% | 0.5% | 0.5% | 0.4% | 0.4% | 0.5% | 0.5% | 0.4% | 0.3% |
| - Coal demand | 0.6% | 0.8% | 0.8% | 0.7% | 0.5% | 0.4% | 0.2% | 0.2% | 0.1% | -0.1% | -0.6% |
| - Gas demand | 1.4% | 1.7% | 1.6% | 1.6% | 1.6% | 1.4% | 1.5% | 1.6% | 1.6% | 1.4% | 1.2% |
| **North America's gas demand** | **0.4%** | **0.6%** | **0.8%** | **0.8%** | **1.0%** | **0.7%** | **0.7%** | **0.7%** | **0.8%** | **0.6%** | **0.3%** |
| **Euro's gas demand** | **0.5%** | **0.9%** | **0.7%** | **0.6%** | **0.7%** | **0.1%** | **0.4%** | **0.3%** | **-0.1%** | **-0.4%** | **-0.6%** |
| **Asia's gas demand** | **3.8%** | **4.3%** | **4.2%** | **4.2%** | **3.8%** | **3.6%** | **3.6%** | **3.0%** | **3.1%** | **2.9%** | **2.9%** |

in the United States have increased significantly. Shale gas has helped the US to overtake Russia to become the largest gas producer in the world since 2009. According to the data of EIA, shale gas production in the US represented more than half of national natural gas production in 2015, and more than 67% in 2021 (EIA, 2023)

The shale gas revolution has already led to economic benefits and cost reduction at the state and local levels, individual sectors, and the nation. The exploitation of unconventional gas fields, particularly shale gas, influenced the United States' economic growth. According to the Thomas study in 2014, the macroeconomic impact is relatively limited: around 0.88% growth in the gross domestic product (GDP) between 2007 and 2012 (Spencer et al., 2014). According to the International Monetary Fund (IMF) report in 2013, the shale gas revolution's macroeconomic impact is between 0.3% and 1% of the US GDP that year (International Monetary Fund, 2013). The shale gas contribution to the American gross domestic product was more than $76.9 billion in 2010; in 2015 it will be $118.2 billion and will triple to $230 billion in 2035 (Wang et al., 2014).

The development of shale gas has helped the US achieve self-sufficiency in energy, improvements in the trade balance, and tax revenues. It helped to reduce the import of fossil fuels, therefore improving trade balance, and simultaneously representing a supplement to the federal budget. In 2012, the sector also generated $ 62 billion in additional tax revenue for the federal budget, the States, and the municipalities concerned (OPECST, 2013).

The development of shale gas in the United States has been the catalyst for the recovery of traditional industries. Natural gas strengthens industries as raw materials, for example, the petrochemical industry, fertilizer producers, plastics, and other industries that consume a great deal of energy as aluminum smelters, steel mills, refineries, etc. The decline of the gas price contributed to the competitiveness enhancement of these sectors in the global competition.

The increase in production of unconventional gas, in particular shale gas, and the strong decline in the natural gas price in the United States, have led to reductions in the consumption of coal in the electricity sector, at the same time increases of using natural gas in this sector. The volume of consumption increase in the electric power sector is about 60% of the total growth (Bros, 2012). Reports by the US Energy Agency and the International Energy Agency indicate that carbon emissions from burning fossil fuels in the US have plummeted in recent years. From 2007 to 2012, the United States reduced its total carbon dioxide emissions by 450 million tons, the largest reduction on record on the planet. In 2012, the United States reduced its emissions by about 70% of the $CO_2$ established under the Kyoto Protocol. The main reason for the reduction in $CO_2$ emissions was the significant conversion from coal to natural gas in the production of electricity.

### *2.2. The potential of unconventional gas*

Until now, knowledge of unconventional gas in general and shale gas in particular in the world is very weak and uncertain, except in the North American region. Estimates of unconventional gas resources are very different around the world. They depend on many factors such as geological information, technologies, and methods used, the number of exploration drilling. In the United States, with a favorable policy as well as the development of technologies in this industry, there are many publications on the estimation of the potential of unconventional gas and shale gas. Outside of North America, the unconventional gas industry is still in its infancy and important questions still need to be answered (Le, 2018) (Le et al., 2021).

Many organizations have carried out research on unconventional gas, particularly shale gas, such as the United States Energy Information Administration (EIA), the United States Geological Survey (USGS), the Energy International (IEA). Unconventional gas estimates have been published, especially by the EIA. In parallel with these studies and estimates relating to the United States, the EIA has studied the potential of unconventional gases in other regions or other countries. Although the data in each publication is different, they form an important basis for a general view of shale gas in the world.

Unconventional gas is considered increasingly playing an important role in securing the global natural gas supply. According to forecasts by the international energy organization, unconventional gas will account for more than 60% of the increase in total gas production in the period from now to 2040.

Although so far, forecasts on natural gas resources, especially unconventional natural gas, are still at a level of uncertainty. However, according to the International Energy Agency forecasts in 2017, the renewable resource of traditional natural gas is about 430 trillion cubic metres (Tcm), allowing about 120 years to be exploited at current production levels. For unconventional gas, the forecasted total recoverable shale gas resources are 239 Tcm, coal-bed methane is 50 Tcm, and tight gas is 81 Tcm. Hydrate gas is considered very large with a forecast of 10 times shale gas; however, the exploitation technology is still difficult. If adding both conventional and un-

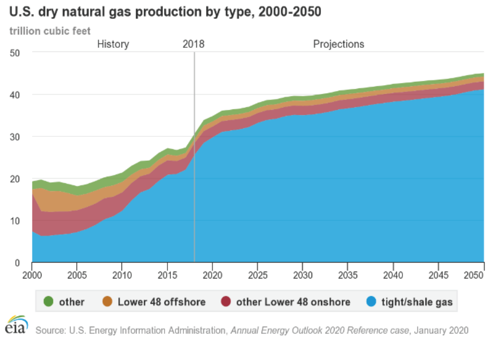


Fig. 2. Forecast of US gas production. Source: EIA, 2020

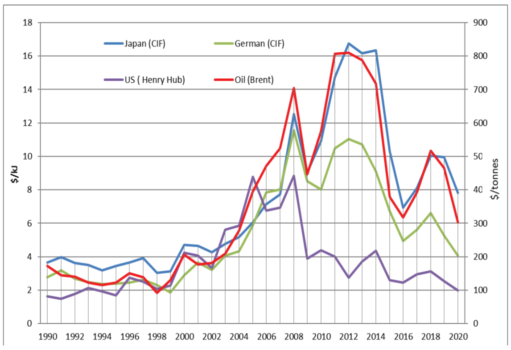


Fig. 3. World gas prices. Source: (BP, 2022)

conventional gas, about 250 years can be satisfied if exploited at current production.

Of the unconventional natural gases, shale gas is the potential gas with the largest reserves. Recent studies by scientists have shown that the potential for shale gas is huge, its forecast reserves are increasing, and this gas is widely distributed in many continental countries, this opens many opportunities for its exploitation and uses in the future, contributing to satisfying human needs for natural gas. According to recent publications by the US Energy Agency (EIA) and the American Geological Association, the total recoverable resource reserves of shale gas in 46 countries are assessed by the organization as 219.65 Tcm. Shale gas resources are concentrated mainly in China; Argentina; Algeria; the United States (EIA, 2013a) (EIA, 2015).

## 3. The challenges of unconventional gas development – case of shale gas

### *3.1.Basic conditions for the development of unconventional gas*

Knowledge about the location of unconventional gas deposits has been accumulated for decades, but it is the recent improvements in technologies for the exploitation of these resources that have contributed to economic development, resulting from a production boom in shale gas in the United States. In the opinion of the US Department of Energy (DOE), three important factors have reframed the economic viability of producing unconventional gas, particularly shale gas, (i) advances in horizontal drilling, (ii) advances in hydraulic fracturing, and (iii) the rapid increase in natural gas prices due to significant supply and demand pressures (Department of Energy, 2011).

The technology offers new opportunities for unconventional gas to play a major role in the future global energy mix and thus allay concerns about the reliability, profitability, and security of energy supplies. Horizontal drilling is a technique often used in shale gas deposits where the geology is significantly different from that of conventional oil and gas deposits. While horizontal drilling costs can be two to three times higher than vertical wells, it allows for more cost-effective gas production because it targets greater contact with gas plays. As a result, shale gas operators are increasingly relying on horizontal drilling to optimize recovery (Nakano, 2012). In the process of shale gas development, it is often necessary to combine horizontal wells with hydraulic fracturing to achieve economic exploitation. These two techniques play a key role in the development of unconventional gas production. However, the environmental rules were incomplete at the beginning of the exploitation of unconventional gases, which generated controversies about hydraulic fracturing (Barbier, 2014).

To make unconventional gas more accessible, a mixture of water, sand or other proppants, and specific chemicals are injected at high pressure into the unconventional gas reservoir. However, society's concerns about the consequences of unconventional gas production, in particular the threat of unacceptable environmental damage, have grown along with production. Reports of water contamination, earthquakes, and other disruptions to local communities have given the production of unconventional gas – and in particular the technique of hydraulic fracturing – very bad publicity in many countries (IEA, 2012a) (Le, 2018).

### *3.2. The challenges of unconventional gas development - lessons from shale gas in the United States*

"The revolution" of shale gas in the United States has achieved a lot of success. However, the development of shale gas is facing a lot of obstacles and challenges. The exploitation of shale gas can have impacts on human health and the envi-

Tab. 2. Forecast of recoverable natural gas resources in the world. Source: IEA, 2018

| Region | Traditional gas (Tcm) | Unconventional gas | | |
|---|---|---|---|---|
| | | Shale gas (Tcm) | Tight gas (Tcm) | Coal-bed methane (Tcm) |
| Eurasia | 134 | 10 | 10 | 17 |
| Middle East | 103 | 11 | 9 | - |
| Asia Pacific | 44 | 53 | 21 | 21 |
| North America | 50 | 66 | 11 | 7 |
| South America | 28 | 41 | 15 | - |
| Africa | 51 | 40 | 10 | - |
| Europe | 19 | 18 | 5 | 5 |
| **Total world** | **429** | **239** | **81** | **50** |

ronment, such as water contamination and high consumption of this resource during the fracturing process. The impact of the development of shale gas on the environment is very strong. Therefore, the development of shale gas has created a lot of concern in the public and the percentage of opponents has risen sharply. By the analyze the development of shale gas in the United States, many scientists and experts have indicated the challenges that all countries that want to develop shale gas must face. These are vast obstacles that countries must overcome if they want development shale gas.

a. The water demand is very strong: The production of shale gas consumes a large volume of fresh water. On average, we need 12–20 million liters of water are typically needed per horizontal well in shale gas production. The amount of water needed in the hydraulic fracturing process depends on the type of shale gas and the fracturing operations. Water consumption will grow with the increase in the number of wells and shale gas production. Certainly, such a large volume of water and a high rate of withdrawals from the local surface or groundwater sources have a significant impact on the local water system. The consumption of water is particularly important in areas where drought conditions are often limited strictly to the availability of water and its use (Richardson N. et al., 2013).

b. The capacity of pollution of the groundwater and surface water: In the case of fracturing, a process that injects pressurized water and chemical compounds into underground rocks. This technology consumes a lot of water and chemicals, so it can lead to pollution in the environment throughout the drilling and exploitation process. The chemicals represent from 0.5 to 2% of fluids of hydraulic fracturing; many of them are toxic and carcinogenic (Wang et al., 2014). These hydraulic fracturing fluids are injected directly into the ground and they can influence groundwater sources. In addition, the flow-back or "produced" water from fracturing fluid might contaminate the water surface. For example, it is estimated that a well in the Barnett shale gas in the US requires an average of 15 million liters of water during its useful life, and between 80% and 95% of them will be discarded as wastewater (Absar et al., 2018). They may adversely influence human health and the quality of the environment if they are untreated or directly discharged onto the land or into streams, rivers, and lakes.

c. Generation of greenhouse gases: Another worrying factor regarding the environmental impact is the GHG emissions related to shale gas. Shale gas contains more than 90% of methane ($CH_4$) which may contaminate the air and the water. Methane is a very powerful greenhouse gas compared to carbon dioxide. The effects of shale gas on climate change have become more complex to evaluate and controversial, partly because of uncertainty about the scale of methane leaks. Some researchers worry that expanded production of shale gas could increase the release of methane as fugitive emissions during the drilling, completion, production, transportation, and use of natural gas. This is one of the principal concerns because methane is a more potent "greenhouse gas" than $CO_2$, and thus, the fugitive emissions in the process of shale gas development may lead to a net increase in greenhouse gas emissions. From a holistic perspective, it is estimated that a shale gas well in Marcellus, US, emits about 5500 tons of GHG, or 1.8 g of carbon dioxide equivalent ($CO_2e$) / MJ (megajoule) of gas produced throughout its life cycle, representing an 11% increase in GHG emissions compared to conventional gas (He et al., 2018).

d. The production cost and price of natural gas: Economists believe that the marginal cost of real production in the USA could certainly reach $4 to $6 per kilojoules (kJ) (EIA, 2013b). Following many estimates of the production cost of shale gas in other regions, in Europe breakeven costs range from roughly $8 to $12 (Gény, 2010), in Asia Pacific this number is higher than 12 dollars per kJ because of the geological conditions of unconventional oil and gas reservoirs in these regions are more complex than those in North America, and the development technology and management mode are being explored and improved. For example, the full cost (cost of current profit and loss in the process of oil and gas production) of shale oil development in main basins in China ranges from 434-652 USD/tonne, which is much higher than that of Bakken shale oil in North America (an average of 217 USD/tonne), and there is still a significant gap to achieve benefit development (Guoxin et al., 2022).

Although the production cost of shale gas may decrease relying on technological progress, the price of gas currently in the international gas market is too low compared with the production cost of shale gas. At present, according to the data of the international gas report in December 2015 and January 2016, the price of gas at Henry Hub in the United States is very low about 2.1$/kJ; in the gas market in Japan the LKM spot LNG prices delivery closed at 6.5 $/kJ; in the Europe market, the natural gas price at NBP in the UK is about 5.5 $/kJ. Compared with the natural gas price at the end of 2014, le price of gas in the Europe and Asia market dropped about 3 times.

As a consequence of the falling of crude oil prices in recent years, the price of natural gas in the international gas market has been reducing strongly also. This price is less than the marginal cost of production in the long-term shale gas.

Therefore, with the price too low at present, it has reduced the interest of investors in shale gas. In fact, there are a lot of gas producers who have been reducing their production as well as abandoning their investments in shale gas development activities, comprised in the United States and other regions in the world, even going bankrupt.

On the contrary, when the natural gas price is high, it encourages investors in this sector. However, in the sectors of shale gas, the investors must invest much more money than in the project of conventional gas. Moreover, the life cycle of well shale gas is shorter than the well conventional natural gas, and the production of shale gas declines rapidly after the peak of production. So, it is necessary to continue the supply of investment capital to maintain production. At the same time when the high price of gas, the customers in particular in the sector of electricity, will find other energies which are cheaper to take the place of gas such as coal. So investment in shale gas will have a lot of risks, uncertainty, and difficulties.

e. The opposition from the population: A very important aspect of the development of shale gas in particular and unconventional gas in general is the "social license to operate" desirable for activities in this field. According to EIA, in the publication "Golden rules for a golden age of gas" in 2012, the need to build a "social license to operate" was emphasized (IEA, 2012b). Therefore, the absence of social acceptability, even the hostility of most of the population in the development of shale gas will be a greater restriction in the future, in particular in the countries European. The challenges associated with gaining public acceptance for shale gas development are much greater in Europe due to population density, stringent environmental regulations, water scarcity in certain regions, and the owners' lack of interest in shale gas exploration and production activities (Gény, 2010) (Lozano-Maya, 2013). Therefore, the conduct of the debate and the guarantee of local interests must take into account the opposition of the population in Europe because they can influence them (More T., 2013). For example, in France, in July 2011, through the "Jacob Law", prohibited the exploitation of shale gas by fracking. In the society's discussions on energy transition, which took place in 2012 and 2013, shale gas was not mentioned among the resources to be possibly explored in the future. In Germany, after a few years of debate, the German Parliament approved a bill in June 2016 that allowed the fracking of conventional oil and gas resources under strict environmental conditions but did not allow the use of the technique to exploit shale resources (Cantoni et al., 2018; Herrera, 2020). In Poland, the government wants to develop shale gas to reduce dependence on Russian gas sources, but due to geological difficulties conditions, prolonged legislative regulations, and declining gas prices on the world market in the early 2010s, leading to the failure of shale gas development in Poland, the shale gas companies here almost ceased operations in 2013 (Cantoni et al., 2018).

f. The uncertainty of resource estimation: as we present about the potential of unconventional in part 2.2 above, the estimates of unconventional gas resources in general, special shale gas are variable and uncertain. The uncertainty of the estimates will strongly influence the industry's future and the national energy policy. Therefore, the profitability potential of shale gas is still hard to predict. Except for the United States, other countries considered as holders of a significant potential for resources of shale gas have a lack of reliable estimates on the resources technically recoverable and resources economically recoverable. It could be a great obstacle to developing shale gases in the countries which desire to develop these resources.

## 4. Conclusion

Natural gas is a clean energy source, so the demand for this resource will inevitably increase in the future, especially in the context that all countries in the world must work together to prevent global climate change and the warming of the earth. Natural gas is an effective medium to short-term choice, a bridging energy medium while humanity is waiting for the transition of energy from traditional to renewable energy sources. Contrary to many previous predictions, today with the development of science and technology, technology allows people to discover and increase global natural gas reserves, especially unconventional gas sources. This will significantly add to the reserves and production of natural gas in the world, contributing to increasing demand for natural gas in the future.

The success of the United States in the development of unconventional gas in the past decade has been the subject of much debate and controversy around the world. Unconventional gas resources in general, shale gas, in particular, is an important additional gas source when conventional gas is running out. It can therefore play a major role in terms of energy security in the future. The success of the shale gas "revolution" in the United States is a great experience for other countries who want to develop this resource. However, there are also many doubts, a lack of confidence, and even a strong opposition to the development of unconventional gas. The problem of unconventional gas is complex, and the impacts are only partially known. Unconventional gas resource estimates are highly variable and uncertain. So, developing these unconventional gas resources will face many challenges. These will be huge barriers that strongly affect the prospects as well as the role of unconventional gas in particular, natural gas in general in the energy transition in the future.

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