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Shale Gas Exploitation: Challenges for Development in Algeria

Boualem Ammar CHEBIRA^{1*}, Lynda AMIRAT²

Abstract

This paper aims to assess the situation of Algeria in the field of shale gas to illustrate the various potential benefits and risks in the exploitation area. The constraints for Algeria are numerous : the risks due in its exploitation, particularly the pollution generated by hydraulic fracturing and also the increased risk of earthquake; the scarcity of water resources and the high cost of such investments. Currently, and under conditions of non-availability of clean and safe technologies, the most available choice for Algeria is the diversification of non-hydrocarbon exports and the development of renewable energies.

Keywords: *Shale gas, natural gas, water resources, hydraulic fracturing.*

1. Introduction

The energy sector occupies a predominant place in the Algerian economy and the hydrocarbons alone account of 95% in export earnings.

However, the price fluctuations of hydrocarbons on the world market, and mainly the latest declines, have caused a real crisis affecting all economic sectors. Given the growing need for global hydrocarbon demand and the great shale gaz potential of the country which has been estimated at four times its conventional gaz reserves and to protect its economy, Algeria is preparing to start up the exploitation of this gas.

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The question is whether the exploitation of this shale gas, through its economic spin-offs as well as its negative environmental externalities, can be a solution to overcome the current crisis and protect the national economy.

The research gap of this paper highlightes the Algerian position concerning the shale gas exploitation and also aims an analysis of the reasons towards illustrate the main constraints and also the expected benefits for the Algerian economy within the shale gaz exploitation.

Shale gas³ is a gas trapped in microcavities of a puffed clay rock called shale. The extraction concerning the accessing the microcavities and fracturing them to provide the gas for recovery. Contrary to certain ideas, the chemical composition of shale gas and conventional gas is identical. The only difference is in their original geological location. Indeed, the gas forms in a sedimentary rock rich in organic matter. A good amount of this formed gas is released either by the action of heat and pressure or by fermentation of the bacteria, and thus accumulates in pressure pockets. For unconventional gas remains trapped in the rock and its exploitation requires the advanced technologies to recover the maximum quantity while remaining financially viable [4].

There are some similarities in drilling techniques between the two categories of gas but differ in extraction processes. The drilling is generally vertical at first and can reach depths ranging from 3000 to 4000m. For better performance, horizontal drilling can be performed after vertical drilling to improve performance. As for reservoirs with low permeability which do not ensure a good circulation of gas, the use of the hydraulic fracturing technique is interesting. It makes it possible, by injection of a fluid in the reservoir, generally water, to increase the pressure until the reservoir is cracked. A retaining agent composed of grains of sand or ceramic balls and a set of chemicals, added to the injected fluid, allows the maintenance of open fractures, thus ensuring a better circulation of the raw material [1].

Today, the technique in exploitation of shale gas uses this hydraulic fracturing technology. However, it should be pointed out the economic advantage of such a technique and also all the negative externalities generated by this type of activity.

The first gas discoveries in Algeria took place in 1956 during the libaration war of our country in Ain Salah areas and Hassi R'mel. The first gas field was exploited in Hassi R'mel in 1961 and the production was exported to France for their energy needs [1].

³ "Shale gas" references to "shale" that's a rock with a laminated appearance which can decompose into fine plates.

The Evian agreements, leading to the independence of our country in 1962, recognized Algerian sovereignty over the Sahara, which was the object of several stumbling blocks during the negotiations.

The country will use hydrocarbons in general as an important resource in its development process and will, from the country's independence to date, explore and research new deposits in partnership with foreign companies. Several discoveries were made following the example of Alrar and gas complex was inaugurated in 1984, Rhourde Nouss (1988), and TFT in 1999 [10].

Table 1. The most important gas fields of Algeria

Area	1 st gas discovery	Initials reserves	1 st gas exploitation
Ahnet (In Salah)	1954	100 million m ³	2004
In Salah	1956	-	2004
Hassi R'mel	1956	2000 bln m ³	1961; 1964
Tin Fouyé Tabankort (TFT)	1960	110 bln m ³	1963;1999
Gassi Touil	1961	138 bln m ³	-
Alrar	1961	132 bln m ³	1965
Rhourde Nouss	1962`	132 bln m ^{3`}	1988
Ohant (Illizi)	1960	-	1961 ;2003
Tiggentourine (Illizi)	1960	9bln m ³	2006

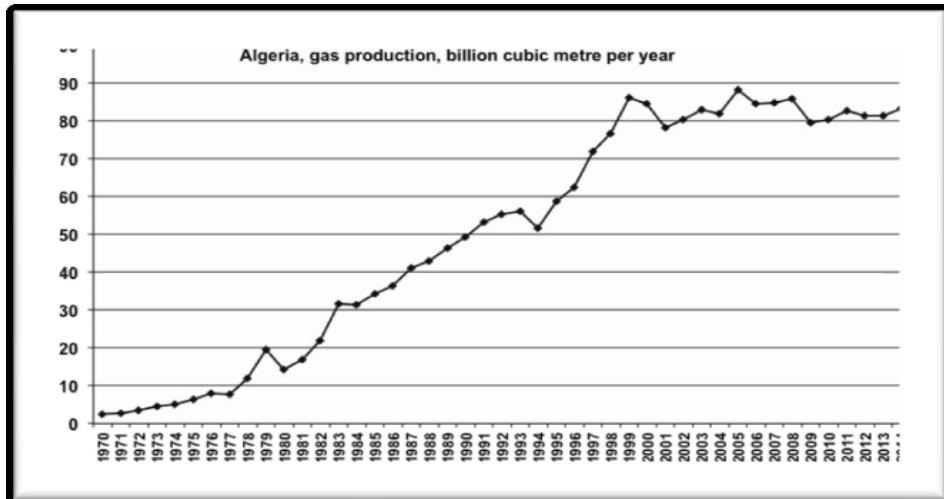
The gas exploitation and also production will experience a constant linear increase from 1961 to 1999 to meet the investment needs of various development plans carried out by the country. However, it is clear from the graph below that from 1999 to date, production has stabilized to maintain 80-90 billion m³/year.

One of the main causes of this downturn is due to the shortening of the Hassi R'mel deposit, which is considered to be the largest deposit in Africa and represents the "breast" of Algeria. It is a deposit that has had a major impact on the global gas market and has placed Algeria among the world's largest producers and exporters of natural gas.

Other gas deposits were discovered mainly after 1991 when the country decided to open up to foreign investment for gas exploration and production, and BP estimates that the natural gas reserves of Algeria was around 4.500 billions m³ cubic by the end of 2015. The country would thus rank 10th of the world with 2.4% of the world total and the second rank in Africa behind Nigeria. In 2015, conventional gas production in Algeria,

down 0.4% from the previous year, was 83 billion m³ reaching the 9th Rank of world (2.3% of the world production) and first place of Africa [13].

Figure 1. Gas production in billions m³/year



2. Problem Statement

The estimated world reserves of bedrock gas are in billion 206.700 m³ (about 30% of the world natural gas reserves) according to U.S. Energy Information Administration and U.S. Energy Department and they are located in 41 countries (42 with USA) of all continents within Algeria reached the fourth world position after USA China and Argentina [6].

But must noted that these are large estimates that remain uncertain and could be revised upwards. Unconventional deposits are located in the northeast, south-central areas of Algeria and west of the country. The essential basins are: Ghadames (Berkine), Illizi, Timimoun, Ahnet and Mouydir, Reggane and Tindouf [7].

If Algeria is moving towards the exploitation of these unconventional deposits, it will surely ensure, at least for some decades, its internal needs and will as a preferred supplier for European and Asian countries. It could even increase the production and move towards new markets. Economic interests appear obvious and however the world shale gas reserves estimated show more than 41 countries with such reserves.

The exploitation of these resources by all these countries may be a sharp decline for the Algerian gas demand, especially such country as China, Qatar and Russia together account more 50% of all world resources.

Table 2. Technically recoverable shale gas resources (Top-10)

Rank	Country	Shale gas resources (T cf)
1.	USA	1,161
2.	China	1,116
3.	Argentina	802
4.	Algeria	707
5.	Canada	573
6.	Mexico	545
7.	Australia	437
8.	South Africa	390
9	Russia	285
10.	Brazil	245
	Others	1,535
	TOTAL	7,795

Oil and natural gas are the main resource of the Algerian wealth and their importance stand at two levels: strategic export source that provides an importnt revenue for the our economy and also internal development resource to increase internal consumption.

For the Algerian export the main customer clients are the countries of South Europe which are the suppliers directly by two gas pipelines linking the country to Spain and Italy. New gas pipelines with larger capacities are planned. It is Medgaz, a pipeline with a capacity of 8 bln m³/year connecting Hassi R'mel with Almeria of Spain within it has been operational since 2011 and Galsi another pipeline of the same capacity. Other should link the country to Italy via Sardinia but which is experiencing economic and political difficulties as to its realization.

An other mega project concening to build a trans-Saharan gas pipeline a link between Nigeria and Algeria and then Europeean countries. With a length of 4,128 kms this pipeline should carry up to 30 gas in billion m³/year. [Freedom Daily]

If this mega project were to be realized, Algeria, with such capacity, would certainly be an important international hub for the commercialization

of natural gas. Some European countries such as Spain and France are mainly supplied by Algeria. Other European countries but also Asian countries benefit from Algerian gas.

Compared to domestic consumption, the Algerian economy's needs have continued to increase, reaching 39 billion cubic meters of natural gas in 2015, an increase of 4.1%, making it 27th in the world, with 1.1 % Of world consumption. [BP, 2016, p23]. It also appears from the statistics that while the Algerian population increased by 25% between 2000 and 2015, natural gas consumption doubled over the same period from 19.8 million m³ per year to 39 million m³ per year [].

3. Research Questions/Aims of the research

The study was designed starting from the main challenges as identified by the aforementioned studies to understand/answer at the following question: “*for Algeria is necessary to invest in this unconventional resource or should be oriented towards new strategies*”?

4. Research Methods

This work aims and discuss the results based on a quantitative analysis of data collection from secondary sources to provide the opportunities/advantages and also the threats issues for the Algerian economy as results of the shale gas development exploitation of our country.

5. Findings

The gas resources are a strategic export resource that generates significant revenues for the country economy and also to increase the internal consumption of Algeria.

Regarding the export of Algeria, the main customers are the European countries which are supplied directly by two gas pipelines linking the country to Spain and Italy. New gas pipelines with larger capacities are planned. It is Medgaz, a pipeline with a capacity of 8 billion cubic meters per year, connecting Hassi R'mel with Almeria in Spain and which has been operational since 2011, and Galsi another pipeline of the same capacity as The precedent that should link the country to Italy via Sardinia but which is experiencing economic and political difficulties as to its realization.

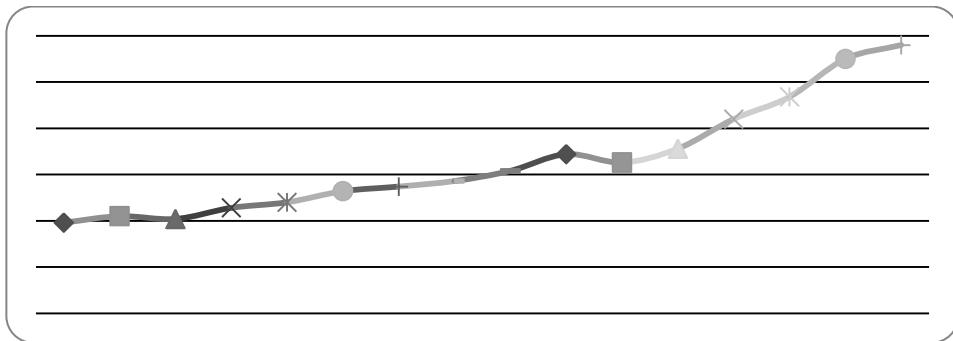
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Concerning the domestic consumption, the Algerian economy needs have continued to increase, reaching 39 billion cubic meters of natural gas in 2015, an increase of 4.1%, making it 27th in the world, with 1.1 % of world consumption[14].

Because the Algerian population increased by 25% between 2000-2015 years and over the same period the annual natural gas consumption doubled from 19.8 million m³ to 39 million m³ [11].

Figure 1.The nature gas consumption of Algeria between 2000-2015 years



5.1. Exploitation of shale gas challenges for Algeria

Must do the exploitation of gas from the skies and the fuels exploitation in Algeria because the Algerian gas exploitation advantages provide the economic and financial advantage that assures an important source of entrepreneurs for the benefit of more than one employer. It's an investment source of investment in the home to the electricity production for the benefit of the local market for export. Also it can provide a positive impact on the development of localities in the South and also under the infrastructure and transport sector that improves the balance of energy efficiency of the world economy and to the economic and social stability of the procurements.

Also, the advantage is political because it would also give the country a major role in the global gas trade and would thus weigh heavier in the global energy balance giving it a certain economic and social stability over the coming decades.

Only economic problem would be to use the wealth generated by this activity more rationally and make it a basis for sustainable development.

In this case, it is necessary to go back to the management problem that has posed and is still a major concerning the decision-makers.

Pierre Thomas in his paper regarding the shale gas said: "As we have seen, the exploration of shale gas can help to combat the desertification, economic and popular, of certain regions [12].

It may leave behind, if initially required, more sustainable developments such as reforestation, water-drilling, or catchment (drilling, holding) systems, which have been necessary to Fracturing and which can be used for irrigation, for example. Everything is about agreements and preliminary contracts between local authorities and operators [10].

6. Discussions

Inconvenients

It seems difficult to cite all the disadvantages associated with the exploitation of shale gas. Their ranking can be based on the nature of the negative externalities generated by this activity. They can be waterborne, geological and financial.

Water negative externalities

Water large quantities using : The first major disadvantage in the present technique of exploiting this unconventional resource is the use of large quantities of fluids, usually water, which are injected into the well to Increase the pressure. The average quantity required for the fracturing of a well is of the order of 10,000 to 15,000 m³ water. However, some wells require larger quantities of water. While this amount may seem reasonable, large-scale exploration requiring hundreds of wells may be problematic. It is true that much of this water is recovered and can be treated for future use. But the injected water is mixed with chemical additives, as well as with sand or ceramic grains. This recovered water can be used for further fracturing but can also be used for other purposes once it has been treated. But Algeria's great concern is the scarcity of water. The country is classified by FAO as "the most water stressed countries, with per capita resources far below the absolute water scarcity threshold" [8].

Moreover, the distribution of the resource between the North and the South is very uneven. It is also very uneven between the different regions of the country. The south of the country where unconventional gas reserves are located are those most affected by the current scarcity of water. This region of the South is classified as a high-risk region. Thus, the exploitation of shale gas in these regions raises important conflicts of use.

Another equally important factor is the potential contamination of drinking water, surface water and groundwater by additives incorporated into the fracturing water. For each well, about 50,000 liters of chemicals are added. The recovery of water after fracturing can not be done completely and significant quantities will remain in depth. Only 60 to 80% of the injected water is recovered on the surface. Although there is a steady rise in salt water during operation, the risk of contamination is high.

This risk is at the level of potential incidents in the casing of wells, or at the level of some fractures that can join pre-existing fractures. In this case, the risk of contamination of the water table is high. Furthermore, as regards the decontamination of surface-recovered water, which is generally carried out in tailings ponds, the slightest neglect of treatment will result in pollution [13].

Earthquakes caused by hydraulic fracturing Another equally major disadvantage in the well fracturing process is that related to seismic risks. It is recognized that these risks remain somewhat moderate but remain potentially dangerous. (e.g. according to B. Dessim, the fractures of wells in Great Britain have caused earthquakes of magnitude 2.3 on the Richter scale).

The fracturing can be the cause an imbalance in the rock mass. Repeated fractures will result in the search for a new equilibrium in the massive rock that is established by repeated earthquakes. Moreover, if the operation is located in naturally seismic zones, the risk is aggravated. Algeria is known for its seismic activity, mainly in the north of the country and thus presents a definite risk. Estimate Investment Costs for unconventional drilling well are relatively large, around 8-20 million \$ or twice of a conventional size.

An economic profitability study must be carried out to study the financial impact of such an operation

Table 3. Effects of the shale gas using into Algerian economy

Favorable	Unfavorable
Job creation	Too much water into a country under water stress
Increasing the revenues	Potential contamination of surface water/ underwater
Strengthening of the commercial position of Algeria	Earthquakes risks into the region known by seismic activity
Economic and social stability	High Investment Costs

Environmental benefits (combating desertification ...)

Investment source into electric power generation

A strictly economic analysis would certainly tilt the balance towards the benefits generated by the exploitation of this resource, especially in view of the prospects of economic and political stability of the country. But this vision is not a vision of sustainability. Environmental and social dimensions, which are often neglected and difficult to evaluate, should be integrated in order to form an informed opinion on the subject. Conflicts in the use of water resources for the exploitation of shale gas and the risks of contamination of groundwater are definite deterrents, the economic, social and environmental consequences of which can be disastrous.

Taking into consideration the enormous reserves of non-renewable water of Albian aquifer found into Algerian Sahara subsoil estimated in billion between 35.000-40.000 m³ promoting the risk of contamination of such a resource would constitute a “crime against humanity” [14].

Indeed, this water table is considered the largest water table in the world and 70% of this water table is located in the Algerian Sahara.

At the current rate of consumption of water in Algeria and with a constant population, this reserve would cover the country's needs for a period of more than 3000 years.

This strategic reserve must be preserved from any risk of contamination so minor as to allow future generations its use.

The social risks are also very high in these desert regions where every drop of water is crucial.

The Algerians of South country is aware of the situation and has not approved the project of some decision-makers to move towards the exploitation of shale gas. Early 2015 year, Algerians expressed their dissatisfaction within important demonstrations against this project.

Thus, and without resorting to cost-benefit analysis, it is clear that, given the environmental issues and the sustainability of water resources, the current shale gas resource option is not appropriate in point of technological view.

Pending technological development that can safely ensure this exploitation, Algeria will have to move towards other options for its economic development and to ensure its growth.

This work doesn't pretend to initiate an economic strategy for our country but can nevertheless give an opinion on the main orientations to be carried out.

Firstly to ensure in the short and medium term, an income for the country and to maintain the strengthening of its commercial position, Algeria should invest more in the prospecting of new conventional deposits.

Indeed, in view of the large area of the country, there are still large unplanned areas that can reveal important discoveries. The foreign investment in partnership may be an option and also a more voluntary policy to attract the foreign direct investments together can improve the exploration and development of the industrial sector.

6. Conclusions

Certainly Algeria is confronted with a strategical choice into their development model. It is true that the mixed results that it has recorded since its independence to date have been thanks to hydrocarbons, but the management of the revenues generated by the exploitation of this resource have finally plunged the country gradually into an economy rentier.

Today the first signs of a decline in hydrocarbon production and reserves are beginning to worry the country's leaders, but also all of its customers. The country is reassuring and does not hesitate to assert its intention to use the enormous reserves of shale gas as a solution. However, the exploitation of this resource today can potentially generate negative externalities of such severity that it seems inadmissible today to think about its exploitation.

Our country has other strategic paths that need to be scrutinized with greater attention to effectively restore economic growth and move towards sustainable development. The problem of the country isn't so much a problem of resource availability as management focus to problems generated by resource. A more rational use of these incomes within an economic vision of diversification of the orientation towards the productive sector generating wealth seems the most appropriate solution.

This innovative approach highlighting the competitiveness importance as the key indicator of prosperity adjusted by two pillars [3]:

- social sustainability regarding to "a set of institutions, policies and factors to enable all members of society made experience the best possible experience in health, participation and securit and also to maximize their potential contribution to the economic prosperity of the where they live;
- environmental sustainability pillar concerning "the institutions, policies and other stakeholders available to provide/implement an efficient customers' management focus to "prosperity of the present and future generations".

Covering 96% of the world's population and 99% of global GDP, "Legatum Prosperity Index™" provides a more complete picture of global prosperity than any other tool of its kind [9].

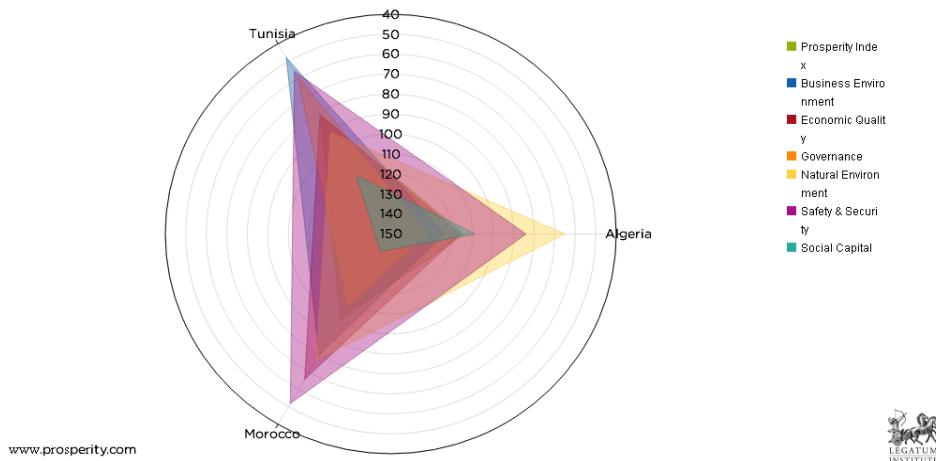


Figure 2. Legatum Index Prosperity™ in Algeria VS. Tunisia & Morocco between 2011-2016 years

Accelerating the innovation efforts may be crucial to maintain current levels of prosperity and our country should be strategically oriented towards to Algerian economy diversification within it has bogged down since the country independence.

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