Algerian's new energy model: between renewable energies and shale gas

النموذج الطاقوي الجديد للجزائر: بين الطاقات المتجددة والغاز الصخري

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Abstract:

Algeria has multiple energy resources, including traditional and renewable ones. Due to the increasing consumption of energy, an urgent necessity arises seek for a new energy model, which is based on energy transformation by the exploitation of new resources as renewable and shale gas in order to meet domestic and external consumption.

The aim of this paper is to give evidences about the most important alternative sources to fossil energy in Algeria, namely renewable energies and shale gas, and which one is better for achieving energy security and sustainability. This study found that the investment in renewable energies is the priority, because it maintains and preserves environment although its high cost of exploitation comparing with the traditional energy and even shale gas exploitation cost. However, the rational energy model indicates the need to mix between different energy sources to obtain an appropriate combination that allows achieving energy security and the desired sustainability in one of the most important economic sectors.

Keywords: renewable energy; gas shale; energy model.

JEL Classification Codes: Q2, Q4 , O13 , P28.

ملخص:

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تزخر الجزائر بموارد طاقوية متعددة، منها التقليدية والمتجددة ونظرا للاستهلاك الطاقوي المتزايد، أصبحت عملية التحول الطاقوي والتوجه نحو مصادر حديثة الاستغلال ضرورة ملحة لتلبية الاستهلاك المحلي والخارجي الذي يعرف منافسة معتبرة في ظل توسع أسواق الطاقة الخضراء، ومن هنا تظهر أهمية هذه الورقة البحثية التي تهدف إلى تسليط الضوء حول أهم الموارد البديلة للطاقة الأحفورية في الجزائر على غرار الطاقات المتجددة والغاز الصخري، وأيهما أفضل لتحقيق الأمن الطاقوي والاستدامة، وقد تم التوصل إلى أولوية الاستثمار في الطاقات المتجددة، والتي تعتبر أكثر استدامة ومحافظة على البيئة بالرغم من أن تكلفة استغلالها مرتفعة بالعودة إلى تكلفة الطاقة التقليدية وحتى الغاز الصخري، إلا أن النموذج الطاقوي الرشيد يشير إلى ضرورة المزج بين مختلف مصادر الطاقة للحصول على توليفة ملائمة تسمح بتحقيق الأمن الطاقوي والاستدامة المنشودة في أحد أهم القطاعات الاقتصادية.

كلمات مفتاحية: الطاقات المتجددة، الغاز الصخري، ،النموذج الطاقوي.

تصنيفاتJEL : Q2، Q4 ، O13 ،P28 .

INTRODUCTION

Energy is the fuel of economic life; we cannot insure any economic activity without using energy, therefore consumption and production of energy increases constantly to satisfy the worldwide demand. In parallel, the ways in which community get and consume energy, especially traditional energy, are irrational and harmful for the environment; These situations make the world in front of big challenge to seek for other sources of energy without harming the environment such as the renewable sources. Given the high demand for energy, many countries as United States of America has taken a way to produce energy from the shale gas to protect its energetic security; however, the riskiest factor in shale gas production is water usage and waste water management due to the hydraulic operation (Zendehboudi & Alireza, 2017, pp. 5-7).

Algeria, as an energy producer country, must be aware of challenges and opportunities that accompany the investment in such energy sources. In this field, Algeria has not only an extensive gas reserve, but also huge renewable energy resources, especially wind and solar power; and it is

considered as the third worldwide power in shale gas reserve. The Algerian government has made many strategies to use renewable sources and also the shale gas, but until now there is no effective result, thus, the fundamental question is:

Which suitable combination of renewable energy and shale gas must Algeria develop as an energy model?

- Hypotheses: to give an answer to the fundamental question of this paper we formulated two hypotheses as follow:

- The exploitation of renewable energy resources is the best choice to achieve the energetic transition towards a new energy model.
- The exploitation of shale gas is the best choice to achieve the energetic transition towards a new energy model.

- Review of literature: there are many researchers who share with our study set of similarities and differences in terms of purpose, we could list some of them hereafter:

Mostefa Ouki, (2019), in their study Algerian Gas in Transition: Domestic transformation and changing gas export potential outlines the key trends over the past three years and updates the outlook for gas production, demand and exports. He highlights the fact that Algerian politicians have come to realize the gravity of problems that facing the country's gas sector, such as political volatility that, clearly, continues to undermine energy sector policy. As a result, it is vital to understand both the industry dynamicity, that influence the Algerian gas sector, and the external factors that will determine whether the country can still remain a major exporter of gas to both Europe and the global LNG market for coming years, or its role will start to diminish because of inadequate policy initiatives and political inertia.

This study does not focus mainly on shale gas, but it discusses it as an alternative for Algeria to satisfy the internal and external demand on gas.

Zhour Abada, Malek Bouharkat, (2018), in their research Study of management strategy of energy resources in Algeria establishes projections on the strategy of management of energy resources in Algeria. It will be

carried out in different phases: The first phase will be oriented towards the renewable and non-renewable potential available in Algeria. Then, understanding and analyzing the different aspects of the country's energy strategy (production, export), shows that the Algerian economy is mainly based on the export of exhaustible and polluting fossil fuels, while the integration of renewable resources into its energy strategy remains very low compared to the available potential.

The author makes at least an analysis of the current and future energy situation of Algeria to guarantee the energetic security of the country. This study discusses the general energy strategy in Algeria and did not focus only on renewable (green) energy.

1. Shale gas capacities in Algeria

Before presenting an overview about the capacities of Algerian shale gas, we will try to clarify its meaning and the different ways used to extract it.

1.1 shale gas

The term shale gas refers to produced gas from fine-grained sedimentary rocks which are organically rich in shale. Since conventional gas is produced from granular, porous and permeable sandstone formations, shale gas is considered to be an unconventional gas resource (Beckwith, 2011).

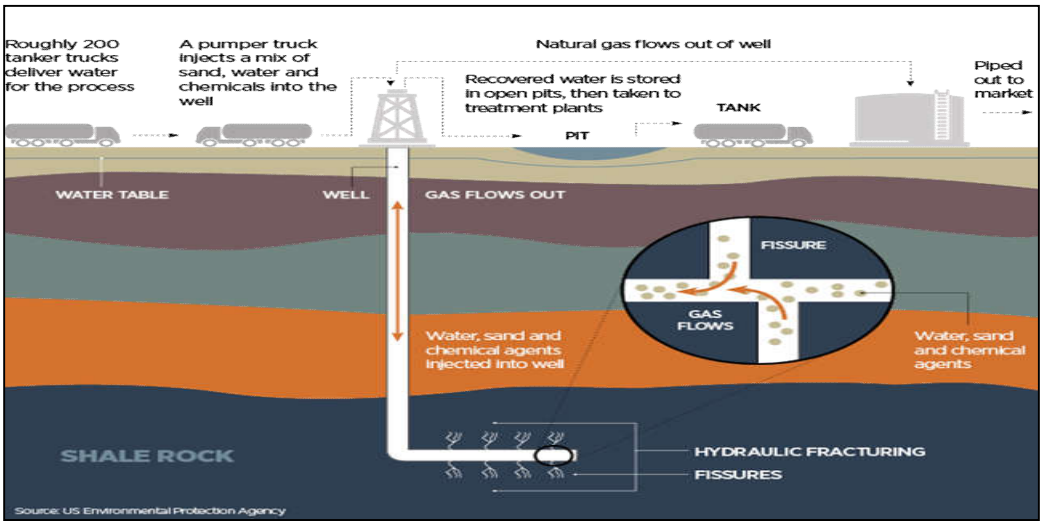
Gas is normally stored through three ways in gas shale's:

- Free gas: The gas is within the rock pores and natural fractures;
- Adsorbed gas: The gas is adsorbed on organic materials and clay;
- Dissolved gas: The gas is dissolved in the organic materials.

Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. The production of natural gas from shale formations has rejuvenated the natural gas industry

(Zendehboudi & Alireza, 2017, pp. 24-26). The figure below gives more explication:

Fig.1. the extraction of shale gas



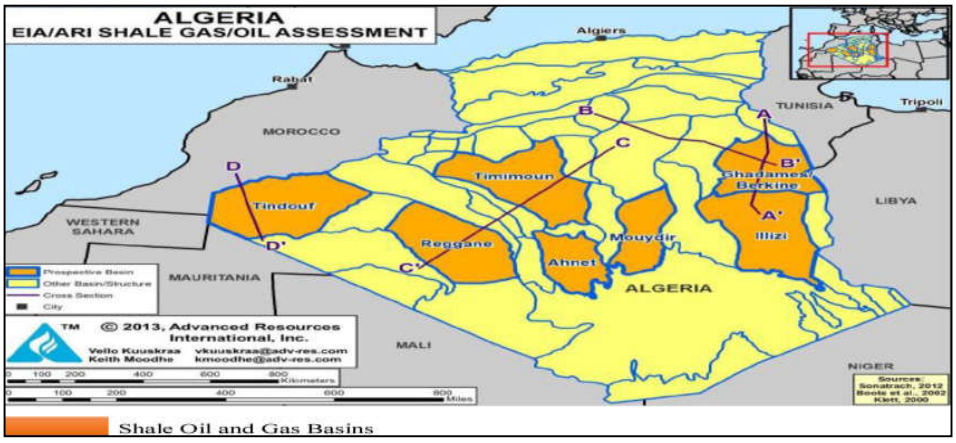
Source: Matthew Timms , 2014, avalable on :
https://www.theneweconomy.com/insight/shale-gas-extraction-explained

Shale gas extraction process takes several stages, and has a very important on environment through the contamination of groundwater and the degradation of air quality, the full impact of shale extraction is not yet known and will likely take years to calculate. But many are concerned about its environmental impact.

1.2 shale gas resources of Algeria

Algeria has a very important potential of shale gas, the map below shows the different area where it is located:

Fig.1. Shale Gas/oil Basins in Algeria



Source: Energy Information Administration report, 2013, available on: www.eia.gov.

This map shows seven of these shale gas and shale oil basins that are: Ghadames (Berkine) and Illizi basins in eastern Algeria; Timimoun, Ahnet and Mouydir basins in central Algeria; Reggane and Tindouf basins in southwestern Algeria. This potential source makes Algeria within the top five countries worldwide according to the same report:

Table 1: the rank of Algeria (shale gas)

Table 6. Top 10 countries with technically recoverable shale gas resources

Rank	Country	Shale gas (trillion cubic feet)	
1	China	1,115	
2	Argentina	802	
3	Algeria	707	
4	U.S.[1]	665	(1,161)
5	Canada	573	
6	Mexico	545	
7	Australia	437	
8	South Africa	390	
9	Russia	285	
10	Brazil	245	
	World Total	7,299	(7,795)

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

Source: Energy Information Administration report, 2013, available on :www.eia.gov**.**

According to the data base above, Algeria ranks third globally after China and Argentina in terms of technically recoverable shale gas reserves with 20 TCM.

3. Algerian's renewable energy capacity

In addition to its hydrocarbon resources, Algeria has a high potential in renewable energy and aims ambitiously to develop it with foreign partners. The different sources of renewable energy in Algeria include:

- Solar energy;
- Wind energy;
- Geothermal energy;
- Hydropower and biomass.

3.1 Solar Energy

Due to its geographical location, Algeria has the highest solar reservoirs in the world that is estimated at five billion GWh / year. Sunshine

duration on almost all the country exceeds 2500 hours annually and can reach 3600 hours (Highlands and Sahara). The daily energy received on a surface horizontal of $1m^2$ is around 5 kWh in most of the country, or nearly 1700 kWh/m^2/year in the North and 2650 kWh/m^2/year in the south of the country. The table below shows the solar potential of Algeria.

Table 2: solar potential of Algeria

Regions	Coastal Region	Highlands	Sahara
Surface (%)	4	10	86
Average sunshine duration (Hours/year)	2650	3000	3500
Received average energy (Kwh/m^2/year)	1700	1900	2650

Source: the national report of Algeria about the climate change to the CNUCC, (2017), Algeria, p: 47

Presented data is supported by data compiled by the World Energy Council, it stays in the same range. Annual average insolation through Algeria is rated at 2,000 hours, while the high plateaus receive around 3,900 hours. This produces an average solar energy potential of 2,400 kWh/m^2/.

3.2 Wind energy

The wind resource in Algeria varies greatly from one location to another. This is mainly due to topography and climate diversity. Algeria has moderate wind regime (2-6 m / s). The South is characterized by higher speeds than the North, especially the south-west, in which speeds exceed 4 m / s and more than 6 m / s in the region of Adrar. This potential energy can be used for pumping water especially in the High Plateaus. it is important to note that wind energy is very late compared to other sources of renewable energy due to many challenges, foremost among which the lack of infrastructure (Abdeladim, Bouchakour, Arab, & amrouche, 2014, p. 412).

3.3 Geothermal energy

The main advantage of using geothermal renewable energy is to provide power over 24 hours a day. This resource is generally invariant with less intermittence problems compared to other renewable sources such as solar

or wind energy (Mahmoud, Spahis, F.Goosen, Ghaffour, Drouiche, & Ouagued, 2010, p. 512) . Limestone geothermal reservoirs in northern Algeria are important, they generate more than 240 thermal springs located mainly in the Northeast and Northwest of the country. The temperatures of these sources often exceeds 40°C, and the hottest one is Hammam Chellala (eg Meskhoutine) at 96°C. These natural springs, which are usually leaks from existing reservoir, they provide alone more than 2 m^3 / s of hot water. This represents only a fraction of the production possibilities of the reservoir. Further South, the formation of continental infill, is a large geothermal reservoir which stretches over 700000 km^2. This reservoir, commonly called "water Albian" is operated through drilling over 40 m^3 / s water of this aquifer is at an average temperature of 57 °C. If the speed of the water Albian operation is combined with the total flow of the hot springs, a power of 700 MW will be generated. There are three areas where the temperature gradient exceeds 5 °C/100 M (Saibi, 2015, pp. 5-7):

- Relizane and Mascara
- Ain Sidi Aissa and Boucif.
- El Jebel Onk and Guelma.

3.4 Hydropower and biomass

The portion of hydro capacity in the electricity production base is 4% or 230 MW. This low power due to the low number of exploitable hydro sites. Biomass potential consists of biomass from forests, urban and agricultural waste. The current potential of forests biomass of is estimated at about 37 Mtoe. The potential recoverable is around 3.7 Mtoe. The energy potential of urban and agricultural waste is estimated at 5 million tons as not recycled urban and agricultural waste. This potential represents a pool of approximately 1.33 Mtoe / year.

The total power of all projects so far in the field of renewable energy, excluding hydroelectric installations, reached 250 MW, with the installation of 22 stations. Energy policy calls for increasing the contribution of renewable energy in national energy balance and encouraging efficient energy systems.

The total conventional installed electrical capacity of Algeria currently is 8 500 MW, and 40000 GWh. Gas is the primary energy source, and it likely remain. The level of the natural gas volume produced for the domestic market will be about 45 billion m^3 in 2020 and 55 billion m^3 in 2030. The current renewable energy is around 250 MW (mainly hydro power), and represents about 2.7 % in the energy mix. The objective of the National Program is to increase the production capacity of photovoltaic modules by 200 MW/year. The target for 2017 is to integrate 5% of renewable energy in the energy mix (750 MW). The energy consumption per capita in 2011 was 1,140 kWh 116. The rise of electricity demand is about 7% compound (annual growth rate) between 2010-2017.The electricity consumption is expected to reach 75-80 terawatts (TWH) in 2020, and 130-150 TWH in 2030 (ADB, 2017, pp. 80-81).

4. A balance between the shale gas and renewable energy

The exploitation of shale gas is a new way to get energy in many countries; there are a several studies which try to answer this principal question: which is best for the economy, using shale gas or renewable energy? The following section is devoted to discuss this issue and compare between them.

4.1 Environment perspective

The natural gas industry claims that shale gas is an environmentally safe energy and argues that some effects of renewable energy, such as solar and wind, are relatively high or higher than using natural gas. This is because life-cycle effects can vary greatly depending on the assumptions used in the analysis (Rivereeper, 2020):

- Research's is documenting that the 3% figure is being exceeded. It has been estimated that "during the life cycle of an average shale gas well, 3.6 to 7.9% of the total production of the well is emitted to the atmosphere as methane". Among the most recent scientific findings is that up 9% of methane produced during gas exploration is lost in the atmosphere.
- Since shale gas is expected to be cheap and available, economic modeling suggests that the rapid expansion of shale gas will drive out most other sources of electricity, including renewable. Since power

plants are designed for the past decades, natural gas power plants built today will lock in our energy system for a significant time period.

- Sufficient resources are available for solar power and wind technology. The capture of just 1% of the theoretically available solar power would supply more than the world's power needs. The wind power available in locations over land in the US is almost twice that of current US energy consumption. Wind resources off the shallow Atlantic coast can supply a large portion of the entire US electrical power.
- Lifecycle analysis (LCA) examines the technology-related impacts over the entire life span, including resource extraction/ fabrication, construction, commissioning, and decommissioning. These analyzes may differ depending on the assumptions used in the calculations. Furthermore, a full understanding of the impacts of renewable energy lifecycle is necessary to create the most effective and safe energy options.
- Environmental measures that are considered in life-cycle analyses include greenhouse gas (GHG) emissions, water consumption, land use impacts such as deforestation or forest degradation, impacts on wildlife and biodiversity, and health impacts including toxicity and carcinogen output. Solar power technologies have an impact on water use, land use, and hazardous material, whereas wind power impacts include land use and wildlife.

4.2 Costs perspective

Shale gas extraction can be more expensive than conventional gas, but so cheap compared to renewable energies, the table below shows the costs of the different sources of energy study:

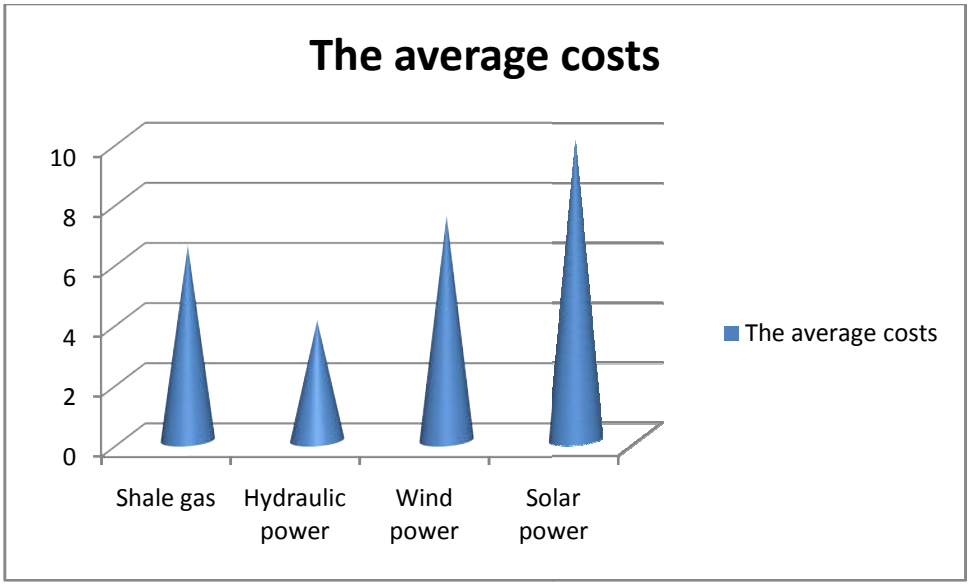
Table 3: the costs of shale gas and renewable energies

The source of energy	Costs (cent/Kwh)	The average
Shale gas	**3-10**	**6.5**
Hydraulic power	**3-5**	**4**
Wind power	**5-10**	**7.5**
Solar power	**7-13**	**10**

Source: established by the researchers using: the data base of IEA (Energy Information Administration)

The graph below clearly shows the different costs of shale gas and renewable energies:

Fig.3. the average costs of (shale gas and renewable energies)



Source: established by researchers using the above table database.

The data shown in the above table relates to the assumed costs in the three most producing and consuming countries for this type of energy, namely Germany, the United States of America and China. It indicates that shale gas cost is less than wind and solar power cost but more than hydraulic power cost.

From this comparison, we conclude that the use of shale gas for energy generation is not a matter of extraction cost, but it is related to measures' costs which should be taken to reduce its environmental damage. However, the use of renewable energies is more linked to the methods used to cut cost of clean technologies, given that its impact on the environment is not significant.

5. Opportunities for Algeria to develop a new energy model

The huge resources that Algeria possesses in renewable energy and shale gas make the situation more complicated to choose the appropriate sources that Algeria must develop to implement the new energy model.

This latter is necessity if the Algerian authorities take into account growth in international energy markets and consumption of the domestic market.

5.1 **prospects and opportunities of renewable energy in Algeria**

The energy sector has developed a pilot program for the development of renewable energy centered on the production of renewable electricity and thermal uses in order to achieve 6% contribution objectives, in meeting the energy needs for 2020.

5.1.1 **Solar thermal**

According to the projections of electricity generation, the goal for renewable energy penetration is up to 30٪ of national electricity production in 2050, results in power generation of more than 13000 GWH for the same horizon.

Table(3): Evolution of production capacity of solar thermal electricity

Year	2030	2040	2050
Production capacity (MW)	2200	4000	6000
Electricity generation (GWH)	7049	12852	19338

The Source: the national report of Algeria about the climate change to the CNUCC, 2017, Algeria, p: 181.

The achievement of thermal concentration program objectives, in the short term (2019 -2025) should be done by hybrid solar / natural gas. For the medium term (2019-2035), with a share of 5% for solar energy, solar should take the major part in power hybrid solar / gas. For this purpose the production of solar electricity is expected to reach 80% of the total production of these plants. Finally, the long term, by 2035, these plants will be entirely dedicated to the sun.

5.1.2 **Wind energy prospect**

The development program of wind power production will be approximately 4% of the national electricity production by 2050. For the period 2020-2025, it is anticipated to complete a 100 MW wind farm, and

the ability to install by the end of the program (2050) is 5650 MW, representing a production of 11 300 GWh. The table below shows the prospects hoped to achieve for wind power by 2050.

Table 6: Prospects for development of wind power

Year	2030	2040	2050
Combined capacity to be installed (MW)	1100	2700	5650
Wind power (GWH)	2200	5400	11300
Part of photovoltaic in the national electricity production (%)	2	3	4

Source: the national report of Algeria about the climate change to the CNUCC, 2017, Algeria, p: 182.

This table clearly shows that the Algerian renewable energies policy gives more importance to the solar power than the wind power.

5.2 prospects and opportunities of shale gas in Algeria

Algeria has the third largest reserves of shale gas, while field remoteness poses potential difficulties in terms of accessibility to sites and lack of infrastructure. There are also many other challenges, foremost of which the society's refusal to extract this type of energy.

- **The investment on shale gas**

There is no doubt that potential shale gas development in Algeria will require a significant involvement of international partners to provide financial resources, technology and experience (Ouki, 2019, p. 7). But in fact, there is no competition in the sector, at the same time; the Algerian authorities have struggled to raise the attractiveness of the country's hydrocarbon sector for new investors. This fundamental issue hinders Algeria from taking full advantage of its existing infrastructure, pipelines and LNG liquefaction plants to serve international markets. Energy companies are regularly exposed to risk or even outright danger, providing clear evidence that the energy community at large is not interested in investing under the current conditions. If Algerian policymakers want to

attract new foreign direct investment, investment conditions must be evaluated and improved accordingly. The recent modification amendment to financial law 2020 might give more opportunity to boost investment in this sector.

- **social unrest**

Algeria's first exploration wells for shale gas received much media attention—not for their promising results, but rather for the local protests that were triggered. Small protests were everywhere in Algeria, so they swelled and caught the attention international media. In January 2015, demonstrations broke out in the main square of Ain Salah, a desert town of approximately 35,000 inhabitants, located 650 miles south of Algiers in Tamanrasset province. Other town in the region, including Tamanrasset, Adrar, and Ouargla, known a spread of protests in a three month. The protesters' fears were environmental and health-related, with worries about the impact of shale gas exploration on the depletion of the aquifers that sustain the traditional oasis and Bedouin agriculture in the region, and about possible contamination by fracking fluids and wastewater (Boersma, Vandendriessche, & Leber, 2016, pp. 14-15).

- **Water concerns**

At the global level, concern over water use, treatment, and pollution in hydraulic fracking operations is not new, and in an arid country like Algeria, water has a vital importance. According to the World Resources Institute (WRI) Aqueduct Water Risk Atlas, the country's baseline water stress level is "arid and low water use," and with more than 95 percent of Algeria's shale oil in the Algerian desert, 96 percent of their area is completely arid, featuring extremely low levels of available surface water. Moreover, renewable internal freshwater resources stand at 295 cubic meters per capita, placing Algeria among the bottom 15 percent of countries worldwide in terms of availability of these resources. In addition, almost two thirds of the territory (mainly the South, home to the unconventional resources) faces extremely high physical risks regarding water quantity (e.g. floods and droughts), which may impact short or long-term availability.

Algeria in fact located above large groundwater reserves. Given the lack of surface water in southern Algeria, these deep and often non-renewable reserves of groundwater make up approximately 96 percent of total water use in the region. However, concerns are rising regarding the decrease in both quantity and quality of the aquifer, due to factors such as increasing extractions estimated at 2.5 billion cubic meters annually in 2007, exceeding annual renewal (1 billion cubic meters per year) and seawater intrusion. Though groundwater is currently abundant, the water-intensive technology of hydraulic fracturing (typically requiring some 10 to 20 million liters of water per well) would further contribute to the decline of water stocks in the aquifer, given its non-renewable nature. As such, the application of new technologies in water use including using brackish groundwater or other alternatives in place of freshwater, or water reuse could possibly make hydraulic fracturing more socially feasible in Algeria. Nevertheless, given that environmental concerns are rarely the unique driver behind management decisions; economics will also prove critical in the water management strategies employed in Algeria (Boersma, Vandendriessche, & Leber, 2016, pp. 15-17).

6. Conclusion

Global energy markets have known several fluctuations since its creation, the recent one is caused by the crisis of corona virus COVID19 (2019/2020) which has affected a wide range of energy markets, but its impact on oil markets is particularly severe. Economics of rents, like the Algerian one, are more affected. Therefore, Policymakers have to think seriously to move to the new energy model in order to minimize the risk.

The new energy model, as we propose, can be based on renewable energies or shale gas. Based on a review given about the situation of the two sources of energy in Algeria, we can give examine our research hypotheses as follow:

- The exploitation of renewable energy resources is the best way to make the transition towards the new energy model. It's Correct**,** Because, Algeria has very important sources that may make it a leader to develop non-oil energy sources. However, regarding the

risks caused by oil prices volatility and the need to diversify its energy mix, Algeria must address a number of difficult issues before it can take advantage of the long-term opportunities provided by renewable energy sources.

- The exploitation of shale gas is the best way to make the transition to the new energy model. Currently, this is incorrect; so far this type of energy is less attractive to investors, given its negative impact on the environment. But we propose to think about it for the future generation, because Algeria has a large reserve of this energy.

Considering the above results, we suggest investing in renewable energies as a priority now, because it safe the environment despite the high costs that new clean technology makes it less and less. The decision of the Ministry of Energy on April 2020 to re-launch the DESERTEC project with the German partner is a prospect for progress in the exploitation of renewable energies. We think that the rational energy model indicates the need to mix between different sources of energy (renewable, shale, fossil) to obtain an appropriate combination that allows achieving energy security and the desired sustainability in one of the most important economic sectors.

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