

ENERGY TRANSITION IN ALGERIA: OPPORTUNITIES AND CHALLENGES



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Abstract:

Since the beginning of the current century, the world has been witnessing significant transformations in the energy system. The excessive exploitation of non-renewable fossil fuels has led to various environmental issues, making the energy transition an inevitable solution. In this context, and similar to many other countries, Algeria has developed programs to harness its available renewable energy sources to achieve energy transition and security. However, the results have been modest despite the resources allocated.

The reasons for this include several challenges and obstacles. Politically and economically, Algeria's economy heavily relies on hydrocarbon revenues. Technologically, the exploitation of renewable energies requires advanced technology that Algeria does not yet possess. Socially, the lack of community involvement in the transition process could be a barrier. Finally, there is the issue of environmental protection and the increasing importance of balancing social and economic development with environmental preservation. The path toward energy transition in Algeria appears to be long and complex, given its political and economic specificities. It requires structural transitions and changes at multiple levels.

key words Energy transition, renewable energies, challenges of energy transition, Algeria

ملخص: يشهد العالم منذ بداية القرن الحالي تحولات كبيرة في النظام الطاقوي، حيث أدى الاستغلال المفرط للوقود الأحفوري غير المتجدد لعدة مشاكل بيئية، الأمر الذي فرض الانتقال الطاقوي كحل حتمي. في هذا السياق وعلى غرار العديد من الدول، وضعت الجزائر برامج لاستغلال طاقاتها المتجددة المتوافرة بغية تحقيق انتقال وامن طاقيين، إلا أن النتائج المحققة كانت متواضعة رغم الوسائل المسخرة. يعود السبب في ذلك إلى جملة من التحديات والمعوقات منها ما هو سياسي -اقتصادي نظرا لطبيعة الاقتصاد الجزائري الذي يعتمد بشكل مفرط على عائدات المحروقات، ومنها ما هو تكنولوجي كون استغلال الطاقات المتجددة يتطلب تكنولوجيا عالية لا تمتلكها الجزائر بعد، ومنها ما هو اجتماعي فقد يشكل عدم إشراك المجتمع في عملية الانتقال عائقا وأخيرا موضوع حماية البيئة والأهمية المتزايدة التي يشغلها ضرورة التوازن بين التنمية الاجتماعية والاقتصادية وحماية البيئة. يبدو المسار نحو الانتقال الطاقوي طويلا ومعقدا بالنسبة للجزائر في ظل خصوصياتها السياسية والاقتصادية ويتطلب انتقالات\تغييرات هيكلية وعلى عدة مستويات.

الكلمات المفتاحية: الانتقال الطاقوي، الطاقات المتجددة، معوقات الانتقال الطاقوي، الجزائر.

.Introduction:

Humanity has long been concerned with energy and its utilization, as it is the driving force behind all human activities. Before the last two centuries, human energy needs were primarily met through renewable sources, mainly the sun. However, the discovery and exploitation of fossil fuels, including coal, oil, and natural gas, starting in the 18th century, led to unprecedented economic, social, and civilizational development. Technological advancements that accompanied this discovery, along with improved living standards in developed countries and the desire of developing nations to achieve economic growth, significantly increased the demand for these resources.

This growing demand elevated the importance of these energy sources, which have played and continue to play a decisive role in shaping global events. Fossil fuels have become central to the economic, political, and geopolitical stakes of nations. Consequently, many researchers have focused on studying their impact on the development paths of countries, particularly those heavily reliant on them to build their economies. This intellectual debate revolves around whether these resources are a blessing or a curse.

The development model based on the increasing consumption of fossil fuels has faced two fundamental problems. The first is geological, related to their depletion and non-renewable nature. Although future reports vary on the timeline for their exhaustion, they all agree that they will run out eventually. The second problem pertains to their significant contribution to environmental degradation, particularly their role in climate change and global warming. Numerous scientific studies have established the link between carbon-based fuels, their methods of exploitation, and the current environmental challenges.

All of this has led to a rethinking of the development model that humanity has followed for more than a century and the need to modify or entirely change it. The environmental factor has become essential and, at times, rivals the economic factor in shaping public policies. Investment in renewable energies has begun as an alternative to traditional energy sources, especially since they are non-polluting, decentralized, readily available, and reduce dependency.

These factors have placed the world in a position where it must accelerate the development of alternative energy sources before facing an impending energy crisis. As a result, the world today is undergoing fundamental changes in the energy system, with renewable energy sources taking an increasingly prominent place in the strategies of both importing and producing countries. However, for the latter, the challenge is more profound due to their economies' dependence on revenues generated by these traditional energy sources, which are the near-exclusive source of public treasury enrichment, especially in a rentier, non-productive economy, such as that of Algeria. Algeria, rich in fossil fuels, has adopted an economic system heavily reliant on oil and gas revenues, and has based its entire development path on them.

In light of a changing global context, Algeria has also decided to invest in available renewable energies, particularly solar energy, to conserve traditional resources from depletion on one hand, and to respect its international environmental commitments on the other. Thus, energy transition has become an internal and external necessity.

In this context, Algeria launched an ambitious program for renewable energy exploitation and energy efficiency, aiming to produce green energy for domestic use while directing a portion for export to Europe. The official discourse in Algeria has recently shown increasing interest in energy transition, as evidenced by updates to laws, the establishment of research centers, and the pursuit of appropriate partnerships. However, the program has achieved only a very small fraction of its goals, raising the question of what is delaying the energy transition despite all the resources allocated. This transition cannot be viewed solely through a technical lens. The success or failure of the energy transition policy must consider the political, economic, and social factors, thus requiring a holistic perspective on the prevailing situation in Algeria. Therefore, we pose the following question:

Main Question: What truly hinders energy transition in Algeria as an oil-based economy?

We likewise raise the following sub-questions:

- Why has energy transition in Algeria been delayed?
- Does Algeria's excessive reliance on the hydrocarbons sector obstruct a smooth energy transition?
- How should Algeria's energy transition strategy look like?

To answer these questions, the study is divided into three parts as follows:

First: Definition of Energy Transition

Second: The Algerian Energy Landscape

1. Potentials
2. Renewable Energy
3. Algeria's Energy Transition Programs

Third: Obstacles and Challenges to Energy Transition

1. Rentier Economy and Rentier State
2. Lack of Technology
3. Social Dimensions
4. Environmental Protection

Conclusion

FIRST HEADLINE: The Definition Of Energy Transition

In recent years, energy transition topic has gained increasing attention from both policymakers and researchers. This transition is not tied to the invasion of a major technological innovation as much as it imposes itself as a rational choice. The energy transition has gone through several stages until the definition, steps, and goals it seeks to achieve were crystallized. The concept of energy transition was originally linked to sustainable development, with this concept first emerging in Germany and Austria within a set of scientific expectations and proposals put forward by the "Öko-Institut" aimed at finding an alternative to oil and increasing the reliance on renewable energies (Hammiche, 2015).

Energy transition refers to the shift from a particular pattern of energy production and consumption to a more efficient and effective mix with the aim of preserving the environment, "meaning the transition from an energy production and consumption system to an energy mix with lower carbon intensity and higher proportions of renewable energies" (Zidan Hanan, 2022).

Although the replacement of fossil fuels with renewable energies is the core of the energy transition, the process is complex and represents a long, multi-level and multi-directions journey. It is linked to the political system, the prevailing economic situation, the environment and its prioritization in the political agenda, the culture of society, and other factors. As such, it leads to a fundamental change not only in the energy system but in society as a whole. This is confirmed by Laurence Reneau, who stated: "Energy is not a simple variable that feeds a technical system; it encompasses institutions, political, economic, and social systems. Therefore, the choice of an energy source is a societal choice" (Hammiche, 2015).

The change will occur on three important levels (Fattouh Bassam, 2019):

- **Tangible elements:** This refers to infrastructure, markets, technologies used, distribution chains, and other elements that will change with the exploitation of renewable energies and the abandonment of fossil fuels.
- **Energy actors:** The new system will impose new strategies and investment patterns, which may require shifting alliances and partners, and could alter the status of countries and companies in the global energy landscape.
- **Legal and social systems:** The transition requires public policies, laws, and institutions to frame it, as well as changes in mindsets and beliefs to embrace a new energy system.

As a consequence, energy transition is a difficult and long-term process, as moving from oil to these new sources requires a change in the way energy is produced, distributed, and consumed, or more accurately, a fundamental transformation of the entire lifestyle in the framework of what is called the "carbon footprint."

The energy transition we are discussing here is not humanity's first. The idea of seeking better or more abundant sources has always accompanied human development. Energy transitions have occurred before, from natural energy to fire and wood, then to coal, oil, and natural gas. However, previous energy transitions either happened naturally or by chance, unlike the current transition, which is characterized by its link to economic, political, and environmental considerations (Fattouh Bassam, 2019).

The current energy transition follows a systematic path that requires investments, strategies, and national and international policies to address the various risks threatening human civilization, such as the depletion of fossil fuels, increasing demand, environmental problems, and market and price instability/volatility caused by recurring crises.

Therefore, the World Energy Council has defined three dimensions or determinants (energy trilemma) for any energy system to be healthy: "energy security, energy equity, and environmental sustainability" (Council)¹. Thus, energy transition is the shift from fossil fuels to renewable energies to protect the environment and meet current energy needs without compromising the rights of future generations to energy.

The Algerian Energy Landscape

Thanks to its geographical location, Algeria is one of the countries rich in both fossil and renewable energy resources. These resources have allowed the country to play an important role in energy supply, not only for the local population but also for many regional countries. Algeria is considered a reliable energy partner, as its supplies have not been interrupted, even in the most challenging security circumstances. Through its energy policy, Algeria has sought to exploit traditional sources to meet the increasing demand due to population growth on the one hand, and to export energy to finance development on the other. At the beginning of the millennium, the local authorities decided to gradually invest in renewable resources and move towards an energy transition.

Algeria's Fossil Energy Potential

The first oil discoveries in Algeria were made in 1915 by the French colonizers. As the importance of this resource increased after the end of World War II, efforts to discover new wells intensified. In 1956, the most significant oil fields

were discovered in the south of the country. The issue of oil became one of the central topics during the Evian Accords negotiations.

After independence, Algeria established the National Company for the Transportation and Marketing of Hydrocarbons, which gradually developed and expanded to encompass the oil industry. In July 1965, Algeria signed its first cooperation agreement with France in this field, where the national company became involved in all stages of exploration, exploitation, and the preparation and distribution of oil with foreign companies.

Following Algeria's decision to adopt a socialist approach, the hydrocarbons were nationalized on February 24, 1971, as part of the goal to nationalize the means of production and ensure fair distribution of wealth. This was in the context of a wave of nationalizations across oil-producing countries, aimed at asserting control over their national resources, which had previously been exploited by major oil companies.

Algeria boasts significant oil reserves, placing it third in Africa (after Libya and Nigeria) and fourteenth globally. It is also a key producer, granting it an important role in the global oil market, particularly at the regional level (Mediterranean basin), with production exceeding 1 million barrels per day in 2002 (DATA)

As for natural gas, which is considered one of the least polluting fossil resources and a partner or ally in the global energy transition, Algeria ranks tenth in terms of reserves, seventh globally, and first in Africa in terms of production (technology), with a production capacity of approximately 101 billion cubic meters in 2023 (OPEC). The year 2022 was considered a golden year for Algerian gas due to the renewal of contracts with major customers (France, Italy, Spain), as well as the discoveries made that year (Mines). Additionally, the geopolitical shifts in the global energy market, triggered by the Russian-Ukrainian war and the decision to ban Russian energy resources from entering Europe, led to part of the Russian supply being replaced by Algerian gas

Algeria's Renewable Energy Potential

Solar Energy:

Due to its geographical location, Algeria possesses some of the world's most significant solar fields, with sunlight shining across most of the country for around 2,000 hours per year, reaching up to 3,900 hours (Hajmoun, 2012) in the desert.

Wind Energy:

Algeria is geographically divided into two distinct regions: the northern part, consisting of a 1,600 km long coastline, plains, and mountain ranges, and the southern part. Wind energy is primarily influenced by the terrain and climate, giving Algeria a good potential for wind power generation, particularly in Djelfa, M'sila, and Méchria, where wind speeds range between 6-7 m/s.

Additionally, other southern areas like Adrar and Ain Salah also have significant potential in this field (Mines).

Geothermal Energy:

This refers to the stored hot water, steam, and hot rocks. The collection of geological and geophysical data has identified more than 200 hot springs in the northern region, 33% of which have temperatures equal to or exceeding 45°C, located within the so-called "Jurassic limestone" (Lorraine, 2023).

Hydroelectric Power:

Algeria's annual rainfall is estimated at 65 billion cubic meters, with currently renewable and usable resources amounting to 25 billion cubic meters. The country has identified 103 dam sites, and more than 50 dams are operational.

Algeria's Energy Transition Program:

Algeria expressed early interest in developing renewable energies by establishing the High Commission for Renewable Energies in 1982, which led to the production of the first solar panel in 1984 (Khaled, 2018). However, the financial and security crises of the 1990s influenced badly the project.

Algeria renewed its interest in renewable energies at the beginning of the millennium by passing several laws and launching a series of local programs, such as a project to supply 18 southern villages with solar-generated electricity, as well as initiatives by the High Commission for Steppe Development. In 2011, the national program for developing renewable energies and energy efficiency was announced.

In recent years, the official discourse has increasingly focused on energy transition. In 2020, the "Ministry of Energy Transition" was created to oversee projects, update laws, and ensure the implementation of the national strategy in this area.

The 2011 national program for renewable energies and energy savings aims to produce electricity from renewable sources by 2030, targeting a production capacity of 22,000 MW and ensuring that 40% of national electricity production comes from renewable sources. The program is divided into the following phases (Mines):

- First phase (2011-2014): Focused on confirming data through the study of pilot projects.
- Second phase (2015-2020): Dedicated to implementing projects and expanding programs. By the end of this phase, production was expected to reach 4,525 MW, with 5% of national production dedicated to the local market and 2,000 MW intended for export .
- Third phase (2030 outlook): Production is expected to reach 22,000 MW, with 40% of national production from renewable sources, including 10,000 MW for export.

In order to position itself in the international renewable energy market and fulfill its international environmental commitments, several amendments were made to the program in 2016 and 2020, extending the target to 2035.

In addition to solar and wind energy, Algeria planned projects to produce green hydrogen in the first quarter of 2023, given the increasing interest from European countries, particularly Germany, in partnering with Algeria in this field (Lorraine, 2023).

However, despite the series of enacted laws, allocated investments, and Algeria's renewable energy potential, the announced goals have only been achieved to a limited extent. An evaluation of the first two phases (by the end of 2018) revealed that only 390 MW of renewable energy was produced, representing 8.6% of the target (Saydani Nabila, 2019). Moreover, a report by the "Renewable Energy Policy Network for the 21st Century" (REN21) ranked Algeria third in Africa (after South Africa and Egypt) in terms of installed renewable energy capacity, with 0.5 GW by the end of 2020 (Agency).

This outcome raises questions about the reasons behind the delay in achieving a successful renewable energy transition to ensure the country's energy security, particularly given the increasing domestic demand and the recurrent crises caused by fluctuations in oil prices, despite Algeria's natural and financial resources.

Obstacles and Challenges to Energy Transition in Algeria:

Algeria faces a range of obstacles and challenges in implementing its Energy Transition Policy :

Over dependence on the Hydrocarbon Sector (Rentier Economy and Rentier State):

It is difficult to understand the state of the economy, development, or any change in any field in countries with rent-dependent economies, including the energy sector, without understanding rent and the role it plays, and how it has evolved and intertwined in the economy and society.

A rentier economy refers to sectors that generate large profits without engaging in any productive or creative activity. These are stagnant, non-productive economies relying on rent derived from the sale or export of natural resources extracted from the earth (Khaled, 2018), in contrast to dynamic productive economies based on production chains where many individuals are involved in transforming raw products into completely new products, ultimately driving the entire economic wheel (Khaled, 2018). Rentier economies thus depend on others' needs for these resources.

Rentier economies flourished in oil-producing countries, especially after a series of nationalizations, which turned them into mere consumer markets for foreign goods and products without any productive activity. Countries that rely on the rentier economy are described as "rentier states."

A rentier state, in general, refers to "a state that derives a significant portion of its revenues from external sources, namely natural resources—whether agricultural or extractive—on a rent basis, controlling its management and distribution." The term's origins are linked to Mahdavi's studies on pre-revolutionary Iranian society (Michael, Does oil hinder democracy?, 2001), and its usage expanded to include studies of Middle Eastern societies and later African and Asian societies, especially oil-rich countries. This concept became one of the most important contributions to the studies of the region (fawzia, 2020).

Hazem Beblawi defined it as "the reliance primarily on external resources that ensure the continuation of the economy without the need for a significant productive sector." (Michael, Does oil hinder democracy?, 2001).

Algeria suffers from excessive dependence on the hydrocarbon sector, with hydrocarbons accounting for 97% of total exports and contributing 60% to 70% to the State budget. This has made the national economy heavily dependent on this sector, giving it the "rentier" character. Therefore, the strategy for exploiting hydrocarbons has not only been intertwined with energy policy but also with all economic and social policies and development plans, as it remains the near-exclusive source of income. Oil revenues have thus shaped the economic, political, and social organization of Algeria, and its development has become closely tied to the fluctuations of oil revenues (Hafner).

Rent plays a significant role in shaping public policy outcomes, and, according to the research of both Beblawi and Luciani, it is characterized by four main features (fawzia, 2020):

- Rent constitutes the primary source of state revenues.
- The sources of rent are internal, not external.
- There are few participants in rent generation, while the majority are involved in its distribution and consumption.
- The main beneficiary of rent revenues is the government.

After the wave of nationalizations that swept the world, and the control of national companies over their oil resources, it was expected that this would be an opportunity for economic takeoff and rapid development for these countries, compared to those that do not possess such wealth (Michael, Does oil hinder democracy?, 2001). However, this did not happen. These revenues did not create sustainable new wealth that would provide a long-term alternative, which led many researchers to study and theorize whether these resources are a blessing or a curse for nations. These studies concluded that the failure of these countries in their developmental paths is mainly due to reasons all related to oil, or rather oil wealth, with its impact manifesting in three key areas:

- Fiscal and spending policy
- Economically by creating a fragile, undiversified economy
- The expansion of the public sector
- Finally, the social impacts

Fiscal and Spending Policy:

The fact that governments obtain revenues from oil leads them to impose very low taxes or not impose taxes at all. In return, citizens do not demand accountability or representation in the government, and the accountability that exists is usually ineffective or superficial.

Governments also use oil revenues to set large budgets that allow them to provide spending benefits far exceeding the value of imposed taxes, indefinitely. These include subsidies for fuel prices, free education, healthcare, housing, and certain goods and services, all aimed at maintaining the status quo. Citizens may perceive this as good government performance, which exempts the government from accountability and scrutiny. Thus, legitimacy is derived from spending, not performance.

Moreover, this spending policy enables governments to strengthen various security apparatuses to protect the status quo (fawzia, 2020), rather than investing in economic development.

Price instability is one of the key features of the oil market, affecting the stability and sustainability of budgets in these rentier states. Often, when prices drop, these countries maintain public spending to avoid social unrest, which pushes them to draw from foreign currency reserves. In Algeria, for example, after the drop in oil prices in 2014, the authorities resorted to foreign currency reserves, which decreased from \$195 billion in 2014 to \$59 billion in 2020 (Hafner).

Fragile and Undiversified Economy and Public Sector Expansion:

Excessive dependence on oil resources creates a fragile, undiversified economy and causes harm to both the industrial and agricultural sectors, especially due to two factors mentioned by Michael Ross in his book *The Oil Curse* (Michael, *The oil Curse: How petroleum wealth shapes the Development of Nations* , 2014) which together form what is known as the "Dutch Disease":

- The Resource Movement Effect :The boom in one sector naturally attracts labor and capital, diverting them from the industrial and agricultural sectors, which raises production costs. Consequently, all focus shifts to the extractive sector, which remains isolated and has little impact on other sectors.
- The Spending Effect :The influx of money from the booming hydrocarbon sector causes an appreciation in the real exchange rate, making imports cheaper than producing them domestically. This leads to the local product losing its market share domestically, with difficulty competing internationally.

This phenomenon occurred in Algeria, where industrial and agricultural exports declined twice, once in the 1970s and again in the 1990s (Michael, *The oil Curse: How petroleum wealth shapes the Development of Nations* ,

2014). The exploitation of renewable energies is particularly dependent on developing industrial capacities.

Oil-exporting rentier states typically adopt energy diversification policies when oil prices drop, as a quick response or temporary relief. However, they quickly abandon these policies when markets recover and prices rise again. According to a World Bank study in this context titled *From Privileges to Competition in 2008: Unlocking Private-Led Growth in the Middle East and North Africa*, it stated that "... the dominant private sector, benefiting from previous policies and existing distortions, rarely acts as a force for change but rather defends the status quo." (Munif). Therefore, there is a weak private sector, also linked to state spending, that thrives during oil booms and shrinks when prices fall and government spending is reduced.

- **Public Sector Expansion:** Citizens of oil rentier states perceive that they have the right to hydrocarbon revenues, which diminishes their incentive to work and create wealth, pushing them to seek public sector jobs. Instead of integrating society into productive activities that generate income for the state, authorities expand public sector employment, typically for non-economic reasons, aimed at ensuring political stability and buying social peace. Employment then becomes a tool for maintaining the status quo, without adhering to performance or achievement standards (Hafner). For example, oil-producing Arab countries, including Algeria, have relied on the public sector to employ their citizens, distribute benefits, and address unemployment issues, often with better salaries and benefits than the private sector, thus reinforcing a non-productive rentier culture (Munif). As a result, the Middle East and North Africa (MENA) region has become the world's most public sector-employment heavy, with rates reaching 32% in Algeria and 38% in Saudi Arabia (Hafner).

Social Impacts:

Civil society institutions in rentier states are often met with suspicion, particularly if they advocate for democracy, change, and accountability. Additionally, the rentier system affects the ethical and moral fabric of society, leading to diminished respect for work and a general tendency towards compliance and subservience (Hafner).

Rent, therefore, becomes a system of relationships and incentives that evolve and intertwine in the political, economic, and social spheres, ultimately affecting culture and morals. This creates difficulties in enacting change (Munif).

As a result, what is known as the "rentier social contract" emerged, where the state guarantees political boundaries and free services such as education, healthcare, and employment, while citizens, in turn, refrain from making any political or economic demands (Samuel, 1993).

The paradox here is that official discourse in these countries acknowledges the problem of dependence on oil revenues and the need for economic diversification. Algeria, for instance, adopted several plans and strategies for economic diversification, such as introducing a new economic development model aiming to increase non-hydrocarbon exports to 9% by 2019, up from less than 5% in 2016 (Fattouh Bassam, 2019). However, this goal was not achieved. The reason for this, as Timothy Mitchell suggests in *Carbon Democracy*, is that "governments find it easier to rely on rent resources than to implement strategies for economic diversification." (Timothy, 2011)

From the above, it can be concluded that the rentier system and the rentier state, as previously discussed, constitute a significant obstacle to any change, including the energy transition. This transition requires a stimulating investment environment and a strong, independent private sector. Many partners, especially the Germans, have expressed reservations, primarily regarding energy subsidies (Institut, 2010). Furthermore, the transition requires the establishment of a strong national industrial base capable of keeping up with the global trend toward energy transition.

Lack of Renewable Energy Technology and knowledge:

The development of science and knowledge has had a significant impact on all aspects of social, economic, and political life. The most notable characteristic of this phase of human history is the unprecedented use of technology, which has led to a knowledge explosion that laid the foundation for significant changes in thinking patterns, production mechanisms, and tools. This has placed the world's economies before challenges related to knowledge and how to manage it. The focus has now shifted to the "knowledge economy" or "smart economy," where scientific research serves as a cornerstone. This explains the economic leaps made by some countries despite their lack of resources and wealth.

The United Nations Development Programme (UNDP) defined the knowledge economy in 2003 as "the dissemination, production, and use of knowledge in all fields of societal activity: economy, civil society, politics, and private life, to enhance the human condition, which requires building human capacities and the successful distribution of human abilities." (Tayeb)

Development thus lies in the ability to shift from resource-based development to a knowledge-driven one, where intangible elements such as knowledge play a central role in the production process. Knowledge occupies the top rank among production factors due to its effective and fundamental role in wealth creation and overall production processes. (Tayeb)

Investing in renewable energy requires modern, complex, and advanced technology, making research and development essential for developing and utilizing renewable energies. This is crucial for supporting the energy transition process.

Talking about research and innovation means investing in human capital before tangible physical capital, particularly in the face of increasing resource scarcity.

This can be achieved through research institutions, universities, and research centers.

Scientific research significantly contributes to increasing the knowledge stock at both the state and institutional levels. Innovation relies on producing new or significantly improved goods, services, production processes, or models. Scientific research, therefore, becomes the engine of development, including the development of renewable energies, which can pose a real challenge for countries with limited control over it, including Algeria.

Intellectual property also plays a crucial role in understanding the connection between energy transition and technological development, as well as its impact on investment costs. According to the World Intellectual Property Organization (WIPO) (Emmanuel, 2020), patent applications filed between 2006 and 2011 exceeded those filed between 1975 and 2005, with an annual growth rate of between 13% and 27% in the four key renewable energy sectors: biomass, wind energy, and solar energy (thermal and photovoltaic).

Green technologies, in terms of investment, are concentrated geographically in three major regions: the United States, Europe, and China, which lead in renewable energy investments compared to fossil fuels. However, in terms of patents, Japan and South Korea, along with the United States and Germany, are at the forefront of technological innovation. (Emmanuel, 2020)

Aware of the importance of research and development for successfully investing in renewable energies and ensuring a successful energy transition, and to master renewable energy technologies, particularly solar energy, Algeria has established several institutions and research centers related to technological research and development, as well as numerous national schools and universities. These include: the National Polytechnic School, the Renewable Energy Development Center in Bouzaréah, the Solar Equipment Development Unit, and the Silicon Technology Development Unit, along with numerous university-affiliated or independent laboratories. Despite all these efforts, Algeria remains far from mastering the complex and rapidly evolving technologies required for renewable energy development.

This shortfall can be attributed to several reasons, including:

- The absence of an incentive system for researchers, as scientific research has not been prioritized, leading to instability and a significant loss of accumulated expertise, which is difficult to regain.
- The brain drain of Algerian experts, which has affected all sectors, and the lack of a comprehensive plan to mobilize the various national capabilities related to this field.
- Weak financial resources allocated to scientific research compared to Western countries. For example, Algeria's spending on scientific research in 2008 was 0.23%, and it did not exceed 0.5% of the general budget

between 2016 and 2021 (Boutoura Fadila et al, 2014), a figure far lower than countries that chose to invest in research and development, like South Korea, where research spending reached 5%.

- Complete reliance on government allocations with no private sector or corporate initiatives, with government funding exceeding 98%. (Boutoura Fadila et al, 2014)
- The impact of the hydrocarbon sector and the discovery of new reserves has led to the neglect of research and development in renewable energies.
- The spread of corruption and nepotism in appointments and management.

Caught between the lack of technological mastery and the inevitability of the energy transition, Algeria has no choice but to resort to technology transfer. But under what circumstances and conditions?

Technology transfer is a relatively new concept, referring to the localization of technology in the hands of local populations and their economy. This includes the technical aspect, training, institution creation, and financial management. For a sustainable impact, it should also include the installation, management, and repair of new technology. (Sarah, 2009)

Technology transfer has long been a key issue in the development of renewable energies and was a central point in negotiations on various environmental protection agreements, as part of the historical responsibility of industrialized nations for environmental degradation. Article 04, paragraph 05 of the United Nations Framework Convention on Climate Change (UNFCCC) states, "...issues to be considered include financial institutions, insurance, and technology transfer," ((UNFCCC), 1993) especially environmentally sound technologies for developing countries. Agenda 21, Article 34 also states, "Cooperation between institutions, governments, and research centers should be in the provision or utilization of technology," focusing on less polluting technologies.

Therefore, the technological factor is essential for Algeria to exploit its vast potential in this field. Resorting to foreign expertise through a win-win partnership that ensures real technology transfer, aligning with the country's ambitions and capabilities, without creating a new form of dependency, is necessary. Germany is one of the countries most interested in investing in Algeria's renewable energy market, whether in solar energy or green hydrogen, presenting an opportunity for Algeria to ensure the necessary technology transfer.

Societal Aspect of the Energy Transition:

Energy transition provides several benefits to any society, as investing in renewable energies can offer energy supplies, create jobs, preserve the environment, and improve the overall quality of life. It also helps stabilize populations in their original regions due to its decentralized nature. However, for

this process to succeed, there must be societal acceptance and an understanding of its motives and dimensions.

Historically, interest in environmental issues and renewable energies began with civil societies and organizations that sought to pressure governments into adopting public policies aimed at environmental protection, transitioning to green energy, and raising ecological awareness, especially in developed countries like Germany and Switzerland. It is worth mentioning what is known as "advocacy coalition frameworks" in public policymaking developed in the late 80s by Paul Sabatier.

Society's participation in the creation of public policies for developing renewable energies ensures it shares both the benefits and burdens of the transition equitably. Societal acceptance of a particular energy choice is crucial in preventing resistance to the public policies that may arise. Algeria had an experience in this regard when the government decided to exploit shale gas without involving the public, leading to widespread opposition, and the government had to abandon the plan, at least temporarily.

The lack of societal awareness regarding the importance of renewable energies and current energy challenges has made North African and Middle Eastern oil-exporting countries (including Algeria) some of the least energy-efficient, due to the low prices resulting from subsidies. Thus, it is important in the early stages to activate the role of society in ensuring the success of this transition by adopting different practices and behaviors that aim to increase energy efficiency in line with the overall goal of energy policy. The International Renewable Energy Agency (IRENA) refers to this as the "social footprint of the energy transition." ((IRENA), 2022).

Environmental challenge:

Since the beginning of (Hafner) the focus on environmental issues, energy has been accused of being responsible for significant ecological degradation (Achour, 2003) and is at the core of the climate change problem. For over two centuries, humans have released carbon that was buried underground into the atmosphere without regulation. Coal is the most polluting source, followed by oil, which is the largest supplier to the global energy system (Deron), and then natural gas, which is less polluting and considered a partner in the energy transition process.

The primary source of pollution is not the energy facilities themselves, particularly the oil ones, but rather the end products intended for consumption (Deron). The changes in lifestyle and standards in industrialized countries, combined with the developing nations' desire for economic and social growth, have significantly increased global consumption.

Since the publication of the Brundtland Report (by the former Prime Minister of Norway), which introduced the term "sustainable development" in 1987 (Hammiche, 2015), a global wave of awareness has emerged regarding the fragility of the contemporary development model that relies heavily on oil and

non-renewable energies, and its threat to future generations. The world today is witnessing increasing attention to environmental issues, particularly climate change, which has become a growing priority on the political and economic agendas of countries. This has led to the emergence of an international regime for climate change (Hafner) policies over the past two decades.

This system, which looks at economic development in a new way, aims to ensure a transition to an economy that addresses the challenges of sustainable development. It has become a guide for achieving an energy transition towards more sustainable sources for both producing and consuming countries.

Algeria has ratified most environmental protection agreements, starting with the United Nations Framework Convention on Climate Change (UNFCCC) and followed by other agreements. The Paris Conference of 2015 was a historic milestone in the global shift towards reducing greenhouse gas emissions, with most countries committing to lowering their emission levels. Algeria ratified the agreement on October 13, 2016, committing to a 7% reduction in emissions ((UNFCCC), 1993). However, the Russian-Ukrainian war negatively impacted Algeria's energy transition plans, as green transition tax reforms and subsidies were canceled to meet the obligations of new gas contracts with Italy, covering part of the shortfall caused by the ban on Russian gas. (Zegar, 2023)

Geographically, Algeria is situated in a region highly vulnerable to the consequences of climate change, namely the "Mediterranean Basin." (Hammiche, 2015) Climate change is becoming increasingly apparent through rising air and sea temperatures and reduced rainfall. Thus, accelerating the energy transition is an inevitable necessity, a transition that protects the environment in line with international commitments while ensuring the right to economic development that respects the country's specific conditions. The energy transition in a large country like Algeria, with its challenging transportation and climatic conditions, differs from the transition in smaller countries like Denmark or Switzerland.

Conclusion and Discussion:

The energy transition, which refers to the shift from a fossil fuel-based production and consumption model to a more sustainable energy mix with lower carbon intensity and higher proportions of renewable energy, aims to preserve the environment and ensure future generations' right to energy within the framework of sustainable development. In this context, developing countries, particularly oil and gas exporters, face significant challenges when transitioning to renewable energies. Achieving economic development and energy security while protecting the environment requires well-defined and carefully planned strategies.

Algeria's interest in developing renewable energies began recently with the goal of achieving energy security, particularly given the abundance of solar energy. The delayed exploitation of renewable energies stems from fears of negatively

impacting the existing energy system, as well as regional and international balances and energy independence. The energy transition will inevitably lead to structural changes in traditional energy-exporting countries and raise many questions, not only about how to integrate lower carbon-intensive energies but also about how to finance the treasury.

The study concluded that the main obstacles to the energy transition in Algeria are as follows:

- First, the rentier economy and rentier state, where dependence on oil resources has freed the government from relying on citizens for revenue generation and spending decisions, creating an unsustainable and non-diversified economy that depends on government spending and is unable to generate wealth, what has jeopardized fiscal and financial sustainability
- Second, the lack of control over the advanced technologies required for the transition, forcing reliance on technology transfer, which could pose a risk of another type of dependency;
- Third, the lack of societal involvement in such a significant shift, which could create difficulties during the transition process;
- Finally, the environment has emerged as a fundamental factor in the path toward energy transition, balancing environmental protection with Algeria's international commitments on one hand, and its right to economic and social development on the other.

These factors, individually or collectively, present challenges to Algeria's energy transition. This new path is far deeper than just a technical and economic shift; it requires a broader perspective and a comprehensive approach to understand its political and social dimensions.

After identifying these obstacles, the question arises again: Is this transition possible?

The answer is yes, it is possible, only if the following conditions are met:

- Adopting a clear strategy and holistic approach with strong political will to build independent institutions capable of achieving financial governance and directing oil revenues toward real development. The "resource curse" is not inevitable, as many experiences have shown;
- Creating a diversified and productive economy, since Algeria has significant potential in other economic sectors, such as agriculture and tourism, and involving all societal forces in the production and wealth creation process;

- Prioritizing research and development, creating a conducive environment for researchers, investing in human capital, and working toward localizing advanced technology;
- Involving society at all stages of this process, fostering independent, creative, and innovative individuals;
- Understanding that developing renewable energies does not conflict with the continued exploitation of traditional energy resources; on the contrary, it ensures their sustainable use and preservation;
- Striving for sustainable development that guarantees current generations' right to prosperity while ensuring future generations' right to resources and a healthy environment.

Again, the energy transition in Algeria is possible but difficult, complex, and multi-dimensional. It does not only require legal and technical adjustments but also necessitates renegotiating the "social contract," which has long been tied to the advantages and disadvantages of a rent-based economy. This is why the discourse increasingly revolves around "transitions" (in plural) toward renewable energies, with some even describing it as a transformation.

The world is currently experiencing a phase of energy and environmental uncertainty, making it difficult to predict how fast, smooth, and painless the transition will be. However, Algeria, given its gas reserves, is in a safe zone, providing the opportunity for proper planning to adopt a balanced energy mix and ensure a safe energy transition that considers various factors. This opens a new chapter in international relations governed by renewable energies, especially as Europe seeks sustainable solutions in the aftermath of the Russian-Ukrainian war.

Within such circumstances, Algeria is now more than ever called upon to strengthen its economy and institutions and to found a new philosophy of energy security, based on the increased exploitation of renewable energies, within a regional environment characterized by natural risks, conflicts and instability.

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