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Renewable Energies, Transition and Prospects: The Case of Algeria

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Abstract: The primary objective of this paper is to study and shed light on how the transition to renewable energy is taking place in the world and to highlight the link between this transition and the sustainable development of countries. The guidelines are to increase the use of renewable energy in order to detect its effects on economic growth. The inclusion of environmental variables is a de facto part of this study in order to know its impact on the potential of these energies. Thus, we will detect the achievements in this field and know the different techniques used to overcome the gaps related to technology and financing. Technological developments, cost reduction of renewable energies, innovations and digitalization offer opportunities for the benefit of these energies. Finally, we will take Algeria as a case study in this paper.

Key Words: Renewable energy, Transition, Economic growth, Sustainable, Development, Climate change.

Introduction

Access to energy services is more than necessary to achieve economic and social development. The energy policy to be pursued requires a great deal of rigor and determination to follow a responsible approach leading to sustainable growth. All beneficiaries opt for an inexhaustible and free source of energy offered by nature, such as the sun, the moon, the earth, and the wind.

The goal of energy transition targets the preparation for a post-oil era and the establishment of a new sustainable energy model to address energy supply challenges, rising prices, and resource depletion (Bernard, 2015). Despite this, global energy usage remains heavily dependent on fossil fuels (approximately 78.3% in 2013) (Omrı, 2016). Global energy consumption continues to grow at a steady pace, especially with climate change driven by industrialized nations. Several revelations were made at the recent global climate conference (COP26), where accusations were leveled against the world's major powers. Consequently, there was a significant demand for fossil energy in 2021, leading to a rise in global prices, particularly for oil and gas. A substantial demand for these energies is expected from OECD member countries. Meeting this demand must take into account environmental considerations in accordance with the recommendations of the climate conference.

Throughout the world, particular attention has been given to renewable energies in recent years. The growth of renewable energies goes hand in hand with the economic growth of countries. Investment in this direction allows for cost optimization and environmental protection, which is currently under threat. Enormous sums of money have been allocated in this field to establish a new structure for renewable energy consumption. According to Taladidia (2004), the development of a natural resource accounting system becomes a necessity, especially in developed countries, to consider natural resources and the state of the environment in economic policies. This heritage is offered to us by nature, we have inherited it, and we must pass it on to future generations. The inventory of the heritage takes into account economic, ecological, and sociocultural aspects. These elements must go hand in hand and cannot be separated. From the above, we pose the following issue: What is the impact of renewable energies on socio-economic development? From our central question, the following questions arise:

How can the transition to renewable energies be successfully achieved?
Is socio-economic development dependent on renewable energies?
What are the factors that encourage the transition to renewable energies?
What is the situation of Algeria in the field of renewable energies?

To address our issue, we propose the following hypotheses:

H1 - Socio-economic development is dependent on renewable energies.
H2 - An appropriate business climate encourages investment in the field of renewable energies.

Research Methodology: For the smooth completion of our work, we initially relied on a descriptive methodology while referring to a review of literature from various articles and books by leading experts in the fields of energy, economics, and the environment. In the second phase, we employed an analytical methodology to thoroughly structure our theme, and we chose Algeria as an empirical case study to understand how the transition to renewable energy is taking place and to identify the factors hindering this transition.

Significance of the Topic: This subject holds particular importance across various sectors. It stands out for its originality and relevance, especially in terms of its limited treatment by economists, despite its impact on the economic and social development of countries embracing this technology. The world continues to advance in renewable energy technologies. However, most developing countries heavily depend on fossil fuels, primarily oil and gas. These countries have not fully grasped the importance of renewable energies, even though they have the necessary financial means for investment in this sector. The topic has become increasingly important as the transition to renewable energies has become a necessity, even for countries rich in fossil fuels like gas and oil. Through this study, we aim to shed light on the role of energy in the economy, taking into account the historical evolution of energy balances.

Theoretical Aspects of the Transition to Renewable Energy

According to the definition by Larousse (n.d.), renewable energies encompass various forms of energy derived from inexhaustible resources such as the sun, wind, water movement, terrestrial heat, or those that can be regenerated on a human timescale, such as forests and crops. In contrast, fossil fuels are non-renewable (e.g., oil, gas).

The subject of renewable energy gained prominence starting from the 1970s, particularly during the oil crisis (oil shock of 1973), with the aim of achieving energy independence. The development of renewable energy sources has become a significant issue, driven by the awareness that petroleum reserves are limited and finite, and the need to combat CO2 emissions. The primary goal is to reduce waste and promote transport and storage technologies, aligning with the principles of sustainable development. Renewable energies now contribute a substantial share of global energy consumption.

The world is in constant development, and energy is a fundamental component of this evolution. As natural energy sources seemed abundant and relatively inexpensive, people often took energy for granted and were not fully aware of its importance. Between 1920 and 2000, oil consumption increased fortyfold. In three centuries, humans will have consumed all the hydrocarbons that nature took 300 million years to create (Bernard, 2015).

The increase in energy consumption is closely linked to economic growth and demographics. In the 20th century, energy consumption increased twentyfold. It was temporarily halted by the 2008 economic crisis, but the International Energy Agency (IEA) predicts a 45% growth between 2009 and 2030, with China accounting for 50% of the demand increase (Bernard, 2015).

Energy can be both a consumer good and an intermediate consumption. The relationship between a country's total energy consumption in a year and its Gross Domestic Product (GDP) provides insight into the role of energy in the economy. The same applies when considering the per capita annual energy consumption. Various factors explain spatial and temporal differences, including geographical factors (availability of national energy resources), structural factors related to the type of energy used, and technological factors.

Consequently, we can categorize energy into three types: primary energy (unprocessed energy available in its raw state, produced locally or imported), final energy (energy used to meet various needs such as heating,

transportation, industrial processes), and useful energy (energy that is actually available), as described by Hasen Jean-Pierre (2015).

Factors Promoting the Transition to Renewable Energy

There are several reasons to discuss energy-related issues. According to J.C. (2012), there are three main reasons:

First, fossil fuels, such as oil and gas, are limited resources. Therefore, alternative energy sources must be found, and since these fuels have valuable applications, they should be used for other purposes (better utilization instead of burning them, for example, in the petrochemical industry). Second, energy supply security is a concern for everyone. Even in countries with fossil fuel availability, dependence on these resources can pose a problem. Third, the use of fossil fuels contributes to climate change. This change is attributed to various human activities, with the major contributor being the increase in the greenhouse effect caused by CO2. Emissions of this gas result from the combustion of fossil fuels. To address the issue of climate change, an alternative energy source must be found. Therefore, significant capital is allocated to developing the production capacities of producing countries, in addition to the risk associated with hydrocarbon exploration and the need to develop markets for final energy consumption (Pierre, 2013).

From this, we can conclude that two essential factors in this equation can determine the direction of countries toward alternative energy sources (renewable energies): limited natural resources and unlimited human needs.
In addition to the reasons mentioned above that drive countries toward renewable energies, there are other elements related to socio-economic development and economic growth. The energy policies of countries that are aware of environmental issues lean toward green economy, recognizing that greening the economy leads to sustainable development.

The green economy enhances human well-being, social justice, reduces environmental risks, and mitigates ecological scarcities. Green economy activities encompass environmental protection and the management of natural resources, such as water resources and renewable energies. In this context, investors promote revenue development and job creation while rationalizing resource use, reducing carbon emissions, and combatting climate change (Oliver, 2015).

Energy Transition and Economic Growth

The transition to renewable energies has a significant impact on economic growth. To understand the relationship between these two aspects, let's explore them further. Energy Transition: The fight against climate change has the potential to generate $26 trillion by 2030, according to reports by international experts. This leads to wealth creation and encourages states and businesses to engage effectively.

In the transition from fossil fuels to new renewable energies, Franco (2007) emphasizes the crucial role of energy in technological development and economic growth. It is noted that electricity and gas have become indispensable tools for technological innovation. Currently, it is renewable energies and low CO2-emission technologies that hold promise for driving economic growth.

According to the International Renewable Energy Agency (IRENA) report titled "Renewable Energy Capacity Statistics 2021," renewable energy technologies have consistently decreased in cost. Notable cost reductions were observed in areas such as concentrated solar power, onshore wind, offshore wind, and photovoltaic solar, with respective reductions of 16%, 13%, 9%, and 7%. This makes renewable energy costs increasingly competitive compared to existing coal-fired power plants. Renewable energies, due to their lower production costs, provide an opportunity for both developed and developing countries to move away from coal in line with net-zero emission goals. In addition, renewable energy projects offer significant savings for emerging economies, with potential savings of around $156 billion over their lifetimes, according to IRENA. According to international experts, the fight against climate change leads to growth and wealth creation. This commitment is a driving force for governments and private companies to engage effectively. Private enterprises are required to adopt climate-related strategies and are encouraged to innovate in favor of the climate, promoting the progress of renewable energies.

In a publication titled "Global Renewables Outlook: Energy Transformation 2050," IRENA describes how the decarbonization of the global energy sector will replace fossil fuels and create a significant number of jobs. This transition will boost the global GDP by 2.4% through industrial development. Developing countries, especially African nations, can move towards a sustainable future that preserves their vital resources and the environment (Renewable Energy Transition Africa, 2021).

The conditions are favorable for all countries to benefit from renewable energies, especially with technological advancement, falling technology costs, and digitization. Success in these projects requires political will and an attractive investment framework. The transition to renewable energies not only addresses environmental concerns but also provides economic opportunities and contributes to sustainable development. It is a win-win scenario for both the environment and the economy.

Economic Growth

According to Larousse (n.d.), economic growth can be defined as an increase in production over an extended period, which is characterized by an expansion of distributable income. Gross Domestic Product (GDP) and Gross National Product (GNP) are the most commonly used indicators to measure economic growth. LeCaillon (1972, pp. 10-11) describes economic growth as the long-term increase in production or national output. He emphasizes that production capacity grows, provided that it is effectively utilized. The most commonly used instruments for measuring overall production include GNP, national income, or gross domestic product, expressed in volume (at constant prices to avoid the effects of inflation).

The goal of our intervention is to understand the impact of embracing renewable energies on economic growth. According to a study by Gharnit Saïd (2021), the interdependence between renewable energy consumption and economic growth indicates that renewable energies are not only crucial for the environment but also for economic growth. Omri (2016) suggests that the expansion of a network's size increases its importance to users, resulting in positive feedback effects and significant technological interdependencies. Drawing from the experiences of developed countries, the transition to renewable energies has a substantial impact on economic growth, particularly on the GDP. Several factors come into play, including technology, cost of utilization, and performance.

In the case of Algeria, incentive measures have been introduced to encourage investment in this promising and future-oriented sector, which leads to socio-economic development. In our view, this is a necessary step for the country's emergence. Economic growth in a country is measured by variations in the GDP and represents the increase in wealth over a specified period. The increase in wealth and prices leads to improved growth.

Determinants of Economic Growth

Ababou (2020) describes in his thesis that GDP is used as a criterion to measure economic growth and varies from one country to another due to variations in the levels and methods of using the elements that determine it. These elements mainly include labor, capital, and technology, along with their components and participation rates at different levels of production. These factors are part of the overall production function, which is represented as follows:

$$Y(t) = F(K(t), A(t), L(t))$$

Where:

Y: Quantity of real output.
L: Labor volume.
K: Capital.
A: Level of technology.
t: Time.

The key determinants of economic growth are the quantity of real output, labor volume, capital, and the level of technology. In this function, what matters most to us is technology, which is a crucial determinant of economic growth. The adoption of new technologies increases the level of production, labor volume (through the growth of the workforce and demographic expansion), and capital (capital accumulation).

In our study, we have identified and confirmed that the adoption of renewable energies leads to sustainable and responsible socio-economic development that benefits all segments of society. While these technologies require significant investments, the returns are substantial in the medium and long term, positively influencing economic growth. We can see this in the example of the G20 countries, many of which are poor in fossil fuels and have adopted new alternative technologies (clean and cost-effective renewable energies). In the case of Algeria, despite the efforts made, much remains to be done to develop this sector, which requires political-economic will and consistency in achieving the objectives (projects) set by the government.

Obstacles to the Transition to Renewable Energy

The transition to renewable energies is not easy, yet it is essential for any country seeking to achieve socio-economic, technological, and environmental development. Sometimes, the shift to renewable energies encounters problems related to slowness, uncertainty, and technological lock-in caused by dominant technologies, particularly fossil fuel technologies.

The issue of technological lock-in has been extensively discussed. Landel (2015) tried to define this phenomenon based on the studies of Arthur (1989). Arthur sees technological lock-in as a situation in which one technology may be adopted at the expense of another, even if the latter subsequently appears to be more efficient (involving multiple competing technologies and the choice of solutions not necessarily the most performant for specific objectives).

Investment risks in the field of renewable energies pose a significant barrier to transitioning to this technology. These risks encompass both financial and non-financial aspects in the broad sense. The lack of willingness to take and manage these risks deprives a country and its people of various benefits (socio-economic, technological, and environmental development).

In our review of the literature, we noted that several countries advocate for a lock-in favoring fossil fuels (market dominance despite being polluting compared to their competitors), which hinders the transition to renewable energies. In this context, we can raise the issue of the resource curse, as the abundance of fossil fuels prevents the transition to new energy technologies. This policy cannot positively address the major concerns of economic agents, not to mention the negative impacts of fossil fuel consumption.

The exorbitant costs of replacing investments in the technological system hinder the shift even toward better technologies. Therefore, the issue of conflicts of interest is a significant challenge for various stakeholders (government, companies, and other actors) opposing the introduction of renewable energies, often accepting inferior and outdated technologies.

Renewable Energy in Algeria: Context and Challenges

The Algerian economy relies in part on energy. According to the Bank of Algeria (2015), hydrocarbons account for 60% of budget revenues and over 95% of export revenues. Currently, Algeria ranks 16th in oil production, 10th in natural gas production, and 7th in natural gas exports worldwide. Production and consumption depend almost 100% on hydrocarbons, which has prompted Algeria to invest in renewable energies. To this end, a renewable energy development program was established in 2012, but it did not achieve the goals set by the authorities (very modest achievements in solar, electricity, and wind).

Another program (Sonelgaz program, 2021) was developed in 2021 with the aim of increasing electricity production in Algeria from renewable energies by 2030 to conserve gas reserves. The program invites public, private national, and foreign investors to participate in its realization. Thus, the company SONELGAZ has launched a program for the development of renewable energies, with plans to implement several solar power plant projects in the Adrar, El-Oued, and Béchar provinces. Fifteen solar power plants will be installed in 11 provinces, ranging from 80 MW to 200 MW, as per the bidding documents published by Algerie Eco. Bids must be submitted no later than Monday, May 29, 2023, at 10 AM. On January 30, the Chief Advisor to the CEO of Sonelgaz officially revealed that the government had tasked the project with generating 1,500 MW from renewable energy and that a national and international tender would be launched by the end of the first quarter of 2023 to produce 2,000 MW of renewable energy as the first phase.

To replace oil and gas, Algeria must diversify its energy sources and invest even more in the field of nuclear energy (Algeria already has two nuclear reactors, one in Ain Oussara and another in Draria, inspected by the International Atomic Energy Agency). Diversifying the national economy has been a priority for Algeria since the 1980s. Despite efforts made in this regard, the expected results have not been achieved, as non-hydrocarbon exports remain at a single-digit percentage (about 5%). Due to the mismatch between political and economic cycles, Algeria is left with non-renewable resources that have become decisive for its development (Boukrami, 2013).

The economic and social development of Algeria is closely linked to the hydrocarbon sector and energy issues. According to the REN21 Renewables Global Status Report, Algeria ranked third in Africa in terms of renewable energy capacities. Compared to OPEC countries, Algeria has a negligible rate of production and reserves, especially as domestic energy consumption will not allow it to export significant quantities of oil in the future. The crude oil reserve-to-production ratio is estimated at 18 years, and the gas ratio is at 55 years, at the current production rate (Eddrief-Cherif, 2012).

Algeria is among the countries concerned about a reduction in revenue due to the gradual abandonment of oil as a primary source of energy, especially in the context of an agreement with carbon emission obligations. In summary, in the National Energy Transition Program 2020 (Energétique, 2020), Algeria targets the diversification of energy sources through the development of renewable energies to reduce dependence on conventional resources. This policy takes into account the following considerations:

The valorization and preservation of fossil resources.
The transformation of the energy production and consumption model.
Sustainable development and environmental protection.
Cost control in this sector.
Strengthening the regulatory framework.

Gross Domestic Consumption of Primary Energy in Algeria

The following table sheds light on the gross domestic consumption of primary energy in Algeria while distinguishing the trending priorities (tendency towards one type of energy or another).

Table 1. Gross domestic consumption of primary energy in Algeria by source (million tons of oil equivalent - mtep)

Source	1990	%	2000	%	2010	%	2016	2017	%2017	Var 1990 /2017
Carbon	9.69	3.1	0.52	1.9	0.34	0.9	-	0.22	0.3%	-68%
Oils	9.32	42.0	9.59	35.5	16.39	40.9	19.07	19.36	34.9%	+108%
Natural gas	12.17	54.9	16.84	62.4	23.32	58.1	34.66	35.90	64.7%	+195%
Total fossil	12.17	99.9	26.95	99.8	40.05	99.8	53.73	55.48	99.94%	+150%
Hydraulic	0.012	0.05	0.005	0.02	0.015	0.04	0.019	0.005	0.01%	-58%
Biomass-waste	0.011	0.05	0.054	0.20	0.052	0.13	0.006	0.010	0.02%	-9%
Solar, wind							0.01	0.05	0.09%	NS
Total EnR	0.023	0.10	0.059	0.22	0.67	0.17	0.035	0.065	0.12%	+183%
Pay exp.electric	-0.008	-0.04	-0.008	-0.03	-0.006	0.01	-0.02	-0.03	-0.05%	+260%
Total	22.19	100	27.00	100	40.11	100	53.75	55.52	100%	+150%

Source of data: International energy agency. Mtep: Million tons of oil equivalent. Total RE: Renewable energy

In 2017, the total primary energy consumption in Algeria was estimated at 55.48 Mtep, which equates to 1.34 tep per capita, 28% below the global average of 1.86 tep. However, it is twice as high as the African average (Algeria, n.d.). Through this table, we observe a significant inclination towards fossil fuels. Thus, a substantial evolution was felt during the period under study (see the various rates of change). As for renewable energies, consumption remains low compared to fossil fuels, despite the significant rate of change (see the table).

Primary Energy Production in Algeria

Using this table, we will discern the trend in Algeria's economic policy in the energy sector. Table #2 illustrates this trend from 1990 to 2017 (by decade).

Table 2. Primary energy production in algeria by source (million tons of oil equivalent - mtep)

Source	1990	%	2000	%	2010	%	2016	2017	%2017	Var.1990 /2017
Oil	61.24	61.2	72.32	50.8	78.50	52.1	72.68	70.95	46.4%	+16%
Natural gas	18.94	38.8	69.85	49.1	71.96	47.8	80.56	81.83	53.5%	+111%
Total fossil	100.08	99.98	142.16	99.96	150.46	99.96	153.24	152.79	99.96%	+53%
Hydraulic	0.012	0.01	0.005	0.004	0.015	0.01	0.019	0.005	0.003%	-58%
Solar, wind							0.01	0.05	0.03%	Ns
Biomass-waste	0.011	0.01	0.054	0.04	0.052	0.03	0.006	0.010	0.007%	-9%
Total EnR	0.023	0.02	0.059	0.04	0.067	0.04	0.035	0.065	0.04%	+183%
Total	100.11	100	142.22	100	150.52	100	153.28	152.85	100%	+53%

Data Source: International Energy Agency. Mtep: Million Tons of Oil Equivalent. Total RE: Renewable Energy.

From these data, we observe an evolution from decade to decade in the production of fossil fuels during the period from 1990 to 2017. In this regard, the government has favored the exploitation of such energies at the expense of renewable energies, as evident in the present table. Therefore, public authorities should give more importance to alternative energies through partnerships aimed at exploiting this sector.

Conclusion

Through this study, we have observed that developed countries stand out by adopting policies involving fossil-nuclear-hydraulic, as seen in the cases of the USA, China, Russia, Canada, and Germany. Other countries have chosen nuclear energy. Some have adopted diversified energy policies, including fossil, nuclear, wind, hydropower, and solar. Developing countries remain dependent on fossil energy sources. Algeria, on the other hand, must diversify its energy products by developing renewable energies. Various economic sectors cannot meet their energy needs and export in large quantities without resorting to renewable and clean energies.

Finally, countries aware of the importance of renewable energies spare no effort in investing in this field to achieve significant economic growth and adequate socio-economic development. The cost of new technologies is significant, but the return on investment is immeasurable as it affects various aspects: economic growth, GDP, the environment, and the social aspect. Throughout the world, fierce competition is felt daily in the energy sector, especially among major economic powers, as evident.

Recommendations

The transition to renewable energies is an obligation even for countries rich in fossil fuels to meet the needs of the country's economy. Embracing new technologies and investing in renewable energies promotes development in all sectors, which inevitably leads to economic growth. The business climate, particularly in the energy sector, needs improvement through facilitation for foreign investors and private Algerian investors (assistance in terms of advice and financing, as well as the implementation of appropriate regulatory measures). Algeria's dependence on fossil energies hinders its economic development, and it is time to move towards alternative energies whose technological progress remains essential. The experiences of other countries and various studies have shown that energy shortages reduce the growth rate.

Furthermore, the results obtained allowed us to verify our hypotheses. For the first hypothesis, "Socio-economic development depends on renewable energies," socio-economic development still relies on renewable energies, and as we have demonstrated, the dynamics of the economy depend on energy, and the lack of energy can negatively affect economic growth, confirming this hypothesis. For the second hypothesis, "An adequate business climate encourages investment in the field of renewable energies," stimulating investment in renewable energies commonly relies on a favorable business climate and political commitment to continuing the development of infrastructure in the field of energy technologies, which confirms our hypothesis. Thus, through theoretical and empirical aspects, we have arrived at recommendations and perspectives summarized as follows:

Programming investments in renewable energy production means while monitoring the average growth of each product over several periods. Strengthen the development of energy from renewable sources to increase a country's capacity in wind power for industrial development. Give importance to renewable energies because adopting this system benefits countries in terms of energy rationalization and reducing the energy bill.

Transforming the economic model toward a low carbon economy provides several opportunities, including the emergence of cleaner cities, clean energy, and environmentally friendly agriculture. The expected goal is to achieve significant efficiency, energy savings, and significant social inclusion.

Nuclear power can allow Algeria to initiate a new energy policy. However, Algeria's energy future must be considered within an energy policy/strategy framework. The use of clean and renewable energies such as nuclear and solar energy is a serious alternative to the use of fossil fuels. Anticipate energy demand based on economic growth prospects.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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