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Renewable Energy and Economic Growth in Morocco

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Abstract

Environmental degradation, finite resources, and fluctuating oil prices have driven Morocco's transition to clean and renewable energy. However, the country faces challenges in meeting its future energy demand, leading to increased reliance on imported fossil fuels and carbon emissions. To address these challenges, Morocco has set ambitious targets for renewable energy deployment. This paper examines the relationship between renewable and non-renewable energy consumption and analyzes their impact on profitable growth in Morocco. Our empirical results show that renewable energy is positively associated with profitable sustainable development, and there is a causal relationship from renewable energy consumption to profitable growth and from profitable growth to CO_2 emissions. Innovative financing solutions are needed to support the growth of renewable energy systems, as they offer sustainable, unlimited, and decarbonized energy sources to address future energy challenges. Morocco's strategy to develop solar, wind, and hydroelectric power has placed the country in a promising position to meet energy demands while reducing carbon emissions.

Keywords

Profitable Growth, Morocco, Renewable and Non-Renewable Energy Consumption, Sustainable

1. Introduction

As with many other African countries, Morocco faces significant challenges regarding the future of its energy system, particularly in the electricity sector[1].

[1]Economic and Social Commission for Western Asia.

With global energy demand continuing to rise, there is a renewed focus on renewable energy sources that are sustainable, affordable, and accessible (Belakhdar et al., 2014). In response, numerous countries have adopted programs and initiatives to promote the use of renewable energy.

The Moroccan policy making process is confronted with substantial increases in electricity demand, with growth rates estimated to be twice as high as in the North Mediterranean area due to population growth and advances in socio-economic development (Kousksou et al., 2014; Ouammi et al., 2012). It is estimated that the annual electricity demand could rise from 35 TWh in 2016 to either 80 TWh or 170 TWh by 2030. This will require the deployment of new electricity generation capacities with volumes four times higher by 2030 and more than ten times higher by 2050.

Given the high intensity of fossil fuel use in Morocco's current electricity generation portfolio, meeting the electricity demand will also lead to increased reliance on imported fossil fuels and a rise in electricity-related carbon emissions. Additionally, global warming due to anthropogenic climate change will drive cooling electricity demand, and the potential impacts of climate change on the energy sector may be significant. All these potential future developments require a significant reconsideration of Morocco's energy policy.

As a result, Morocco has set ambitious targets for the further deployment of renewable energy sources in the electricity sector. The target foresees high penetration rates of renewable energy, namely 42% of total generation capacity by 2020 and 52% by 2030 (PMV, 2022)[2]. This review paper aims to contribute to this effort by examining the implications of renewable energy for the Moroccan economy, including economic growth, job creation, energy security, and environmental sustainability. We will analyze the growth rate of renewable energy consumption worldwide, explore the factors driving investment in renewable, and assess the progress made in promoting renewable energy in Morocco. The findings will shed light on the opportunities and challenges of scaling up the use of renewable energy sources and will inform policies and strategies aimed at achieving a more sustainable and resilient energy system.

Due to the scarcity of research on the renewable energy sector in Africa and specifically in Morocco, our paper will be an opportunity to promote and contribute to the creation of a relevant literature. It could therefore constitute a reference for professionals and university researchers to carry out more in-depth studies.

2. Brief Literature Review

Energy serves as the structure block upon which all sectors of ultramodern husbandry are innovated; thus, it underpins all of our profitable conditioning (Atems and Hotaling, 2018). Therefore, the significance of renewable energy to growth in Morocco cannot be overemphasized. Likewise, the growing damage of the GHGs emissions from the consumption of traditional nonrenewable energy

[2]Source: Ministry of energy.

to the atmosphere called for immediate lesser attention. Morocco's energy assiduity, which accounts for about 26 of its hothouse gas emigrations, has experienced significant metamorphoses in recent times. Due to these successful metamorphoses, Morocco is now shifting towards being one of the major seilers of the energy transition in Africa. Moreover, combined government strategies and programs have supported Morocco's significant achievements in the energy transition. Adding to that, energy is vital for profitable development (Wang et al., 2018). As a result, nations, regions, communities, and institutions are poised to find indispensable energy sources (Bilgili and Ozturk, 2015; Zafar et al., 2019). Keeping in mind and by shedding light on this matter, Morocco's energy sector metamorphosis began in 2009 with the National Energy Strategy, which aimed to strengthen its power force security by diversifying its energy blend. In light of the forenamed, and grounded on the being energy economics literature, determinants of renewable energy demand can be grouped under three major headlines profitable growth, transnational trade, and fiscal development (see e.g., Sadorsky, 2009; Brunnschweiler, 2010; Omri et al. 2015). This section reviews the being studies that analyzes and links the relationship between these three variables and renewable energy demand in Morocco and Arab countries.

Morocco, being devoid of conventional energy resources, relies entirely on international primary energy supply to meet its increasing demand driven by economic growth and demographic progress. In response, the country has adopted a significant energy strategy that promotes its transition to renewable energy and energy efficiency across all consumer sectors of the economy (housing, transportation, industry). The liberalization of the renewable energy sector was embraced to facilitate this energy transition. Financial mechanisms have been established to incentive private sector participation and promote public-private partnership initiatives. The government and public institutions, created to support Morocco's energy vision, have pledged to drive the development of systems in priority areas of renewable energy and energy efficiency, yet the country still faces various challenges related to policy, finance, and technology.

3. Transition from Non-Renewable Energy to Renewable Energy in Morocco

Knowing that Morocco is not a producer of fossil fuels, the nation is entirely dependent on the international and external market for its supply of oil and gas products. Adding to this, due to the sharp increase in oil prices on the international market, the country's overall energy bill weighs heavily on the state budget. Given this fact, in 2009, the Moroccan government launched a new strategy based on the utilization of renewable energy resources.

This strategy stands on four fundamental objectives (law 13-09 relative to renewable energy)[3]; the improvement of supply security and availability of energy at low prices, access and availability of this energy, demand management, and

[3]Promulgated by Dahir n˚ 1-10-16 of 26 Safar 1431 (11 February 2010).

environmental protection. In addition to these various efforts, Morocco added a new energy strategy, called renewable energy (clean energy), adopted in 2010, within a vision based on the triptych: constraints, wills, and opportunities. Still, in a global context full of uncertainties and facing a strong external energy dependence, Morocco is in a vulnerable situation in the face of erratic market fluctuations and the volatility of their prices. In this context, His Majesty King Mohammed VI officially launched the new energy strategy by inaugurating the Moroccan Solar Plan in November 2009 in Ouarzazate and the Integrated Moroccan Wind Energy Program in June 2010 in Tangier Objectives have been set for the achievement and completion of the energy transition: Launching of solar power plants (solar stations: Projects (NOOR I, NOOR II, NOOR III, NOOR IV) The "NOOR ATLAS" project; The NOOR Tafilalt project).

Launching of wind farms (wind parks; The first capacity of 150 MW is currently under development in Taza. The five other wind parks planned during the period 2018-2021 are the (Midelt) project, 180 MW; the (Tanger II) project, 70 MW; the (Tiskrad) project, 300 MW; the (Jbel Lahdid) project, 200 MW; The (Boujdour) project, 100 MW). Research and development (IRESEN: Solar Energy and New Energies Research Institute, MASEN: Moroccan Agency for Solar Energy, AMEE: Moroccan Agency for Energy Efficiency, ISE: Energy Investment Company…). The Moroccan legal framework has established several laws and regulations to support the development of renewable energy sources. One such law is Law 13-09 on renewable energy, which was announced by Dahir n˚1-10-16 on February 11, 2010, and published in the Official Bulletin n˚5822 on March 18, 2010. Another important law is Law n˚1-03[4], which focuses on the protection and improvement of the terrain. Additionally, the country has repealed the Dahir of December 13, 1954, on electricity prices and introduced Order n˚528-09, which outlines the "−20, −20" tariff. These legal fabrics play a crucial role in enabling the development and deployment of renewable energy technologies in the country. Aside from this, and among the objectives achieved by the energy transition, the objective of the 42% of the electricity mix set for 2020, will be achieved in 2022, and that of the 52% will be achieved in 2025 instead of 2030. This electricity mix will be raised to 52% by 2030: 20% from solar energy, 20% from wind energy, and 12% from hydropower.

4. Renewable Energy in Morocco

Morocco, being one of the largest energy importers in MENA, is making combined sweats to reduce its reliance on imported arch-conservative powers and non-renewable energy. This mainly told the nation's air-action to propose the creation of renewable energy as Morocco has nearly complete dependence on imported energy carriers. In 2012, Morocco spent around $10 billion US bones on all energy senses (crude oil painting oil and oil painting oil products, coal, natural gas, and electricity). To this extent, Morocco's electricity consumption

[4]Dahir N˚ 1.03.59 of 10 Rabiï I 1424 (12 May 2003), BO N˚ 5118 of June 2003.

stood at 33.5 TWh in 2014 and has been growing at a steady pace of about 7% per annum. It is important to note that solar and wind energies are the primary sources of renewable energy in the country.

Particularly, the northern and southern regions of Morocco are specifically well-suited for wind energy, with periodic average wind speeds exceeding 9 m/s at a height of 40 meters. Meanwhile, the country receives around 3000 hours per year of periodic sunshine, translating to 5.3 kWh/m^2/day of solar energy potential. As of 2015, the total installed capacity of renewable energy (excluding hydropower) in Morocco was approximately 787 MW. The Moroccan government has set an ambitious target of meeting 42% of its energy needs through renewables (2 GW of solar and 2 GW of wind) by 2020. To achieve this goal, Morocco is investing over USD 13 billion in the development of its renewable energy sector, which will significantly reduce its reliance on imported energy sources. And perhaps the swish samples of renewable energy being in Morocco are; solar and wind powers. It's worth mentioning that Morocco has launched one of the world's largest and most ambitious solar energy plans with an investment of 9 billion US bones The Moroccan Solar Plan is regarded as a corner on the country's path toward a secure and sustainable energy force that is clean, green, and affordable. The objective of this initiative is to install large-scale solar power systems at five locations in Morocco, including Laayoune in the Sahara, Boujdour in Western Sahara, Tarfaya in the south of Agadir, Ain Beni Mathar in the center, and Ouarzazate. The aim is to generate 2000 megawais of solar power by the year 2020, utilizing advanced solar thermal, photovoltaic, and concentrated solar power technologies. Notably, Morocco stands out as the only African country with a power string connection to Europe, and it is a vital player in both the Mediterranean Solar Plan and Desertec Industrial Initiative. An example of this is; The Ain Beni Mather Integrated Solar Thermal Combined Cycle Power Station, which became operational in 2011, is one of the most promising solar power systems in Africa. The plant seamlessly combines solar and thermal power to produce a total capacity of 472 MWe. The project's total cost was $544 million US dollars, with funding from various sources, including the Global Environment Facility (GEF) and two loans from the African Development Bank (AfDB), amounting to $371.8 million. Spain's Instituto de Credito Official (ICO) also contributed a loan of $129 million.

In 2010, the Moroccan Agency for Solar Energy (MASEN), a public-private partnership, was established to implement these innovative systems. Its mission is to oversee the project's overall design and coordinate and supervise related activities. The Agency's stakeholders include the Hassan II Fund for Economic and Social Development, the Energetic Investment Company, and the Office National de l'Electricité (ONE). It is worth noting that The German Environment Ministry (BMU) supports the Solar Plan, with financial backing provided by Germany. The German Society for International Cooperation (GIZ) is also involved in capacity building and other related activities for the industry. And as for Morocco's wind power, according to the Ministry of Energy, Mines and Sustainable

Development, Morocco could potentially induce 25,000 MW of wind power. The country is considered to have huge wind energy eventuality due to it 3500 km bank and average wind faves between 6 and 11 m/s. Regions near the Atlantic beach-fronts, analogous as Essaouira, Tangier, and Tetouan (with average periodic average wind faves between 9.5 and 11 m/s at 40 measures) and Tarfaya, Laayoune, Dakhla, and Taza (with periodic average wind speed between 7.5 and 9.5 m/s at 40 measures) has excellent wind power eventuality. A study conducted by CDER and GTZ has estimated that Morocco has a total potential of around 7936 TWh per year for wind power. This is equivalent to approximately 2600 GW. As of the end of 2015, the country's installed wind power capacity was 787 MW. Adding to this, the first wind farm in Morocco was installed in 2000 with a capacity of 50.4 MW in El Koudia El Baida, located 17 km away from the city of Fnideq. The wind farm produces approximately 200 GWh per year, which accounts for 1% of the country's total annual electricity consumption. Moreover, in 2007, the 60 MW Amogdoul wind farm, located on Cap Sim south of Essaouira, became operational. This wind farm was built by the national utility ONE and produces around 210 GWh per year. Another noteworthy project is the 140 MW wind farm at Allak, El Haoud, and Beni Mejmel, near Tangier and Tetouan, which was commissioned in 2010 with an annual production of 526 GWh. In this context, Morocco has set a target of achieving 2 GW of wind power by 2020, and it has made significant progress towards realizing this goal. The country's largest wind farm, Tarfaya, with an installed capacity of 300 MW, became operational in 2014. This wind farm, which cost approximately $700 million US dollars to build, has 131 turbines that can meet the electricity needs of several hundred thousand people and reduce CO_2 emissions by 900,000 tonnes per year. Morocco currently has an installed wind energy capacity of 1466 MW, which is the second largest to be in Africa after South Africa. The leading data and Analytics Company set up that Morocco had a renewable installed capacity of 3.9 GW in 2020 and it's estimated to have reached 4.3 GW in 2021, an increase of 9. Morocco's renewable installed capacity is read to reach 9.6 GW by 2030 at a compound periodic growth rate (CAGR) of 9.3 during 2020-2030. Taking the aforementioned into account, The National Office of Electricity and Water (ONEE) in Morocco has set a target of installing 10 GW of renewable energy by 2030, with 4.5 GW from solar, 4.1 GW from wind, and 1.3 GW from hydro power. As per projections, wind energy is expected to surpass hydro power and become the largest renewable energy source in the country by 2030. The plan is to increase the installed wind capacity from 1.4 GW in 2020 to 4.3 GW in 2030, with a Compound Annual Growth Rate (CAGR) of 11.5%. In the long run, Morocco is aiming to achieve 52% of renewable energy in its total power capacity by 2030, 70% by 2040, and 80% by 2050.

The nation has made significant progress in expanding its wind and solar power capacity during the first phase of the energy transition, according to the Global Data. To the extent that a Project Manager at Global Data remarked, "Morocco has plans to achieve its renewable energy targets for 2030, 2040, and

2050 by implementing technological advancements in energy storage, green hydrogen, and reducing renewable energy costs. The country is on track to meet its 2030 renewable capacity target, and will gradually decrease its reliance on thermal sources, such as coal and oil. The share of coal in the installed capacity is expected to decline from 38.8% in 2020 to 22% by 2030, while the share of oil-based thermal capacity will decrease to 9.2% in 2030 from 16.2% in 2020".

In below, Figure 1 and Table 1 show the distribution of energy by category between the period 2009 to 2030.

5. The Implication of Renewable on the Moroccan Economy

Morocco has set ambitious targets for the development of renewable energy, with a thing to increase the share of renewable energy in its energy blend to 52 by 2030. This transition to renewable energy isn't only driven by the need to reduce hothouse gas emigrations and alleviate the impacts of climate change, but also by the implicit profitable benefits of renewable energy development. In this paper, we examine the counter accusations of renewable energy on the Moroccan frugality, fastening on its implicit impact on profitable growth, job creation, energy security, and the environment.

5.1. Implication for Economic Growth Studies

Studies have shown that renewable energy can have positive goods on profitable growth. For case, a study by Khanniba et al. (2020) set up that the development of renewable energy in Morocco is anticipated to increase GDP by 0.51 by 2025. The study further revealed that investment in renewable energy systems could have a significant impact on employment and financial earnings, leading to increased economic growth.

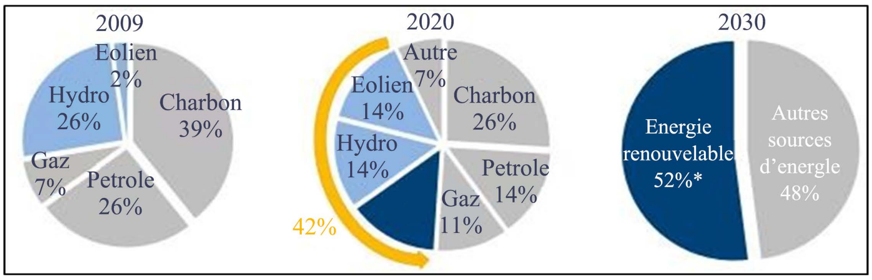

Figure 1. Evolution of the energy mix. Source: MASEN.

Table 1. Evolution of the energy mix from 2009, 2020 to 2030.

	2009	2020	2030
Fossil Energy	72%	58%	48%
Renewable Energy	28%	42%	52%

Do it yourself: Source MASEN.

Another study by Al-Huqail et al. (2020) showed that the development of renewable energy could help Morocco reduce its reliance on fossil energies and alleviate the impact of price oscillations in transnational oil painting requests. This, in turn, could lead to more stable profitable growth and increased competitiveness.

5.2. Implication for Job Creation

Renewable energy has the implicit to produce new job openings in Morocco. A study by Fehri et al. (2020) estimated that the renewable energy sector in Morocco could produce up to 163,000 new jobs by 2030, particularly in areas similar as solar and wind energy. The study stressed that the development of renewable energy could also give openings for small and medium-sized enterprises (SMEs) to share in the force chain of renewable energy systems.

5.3. Implication for Energy Security

The development of renewable energy can help Morocco enhance its energy security. A study by Ben Sassi et al. (2021) showed that the perpetration of Morocco's renewable energy targets could reduce the country's dependence on imported reactionary energies and increase its energy tone-adequacy. The study further revealed that renewable energy could give a stable and dependable source of energy for Morocco, particularly in remote areas where access to electricity is limited. Another study by El Mahrad et al. (2020) showed that renewable energy could help Morocco alleviate the impact of climate change on its energy system. The study stressed that Morocco is vulnerable to climate change impacts, similar as famines and water failure, which can affect its energy product. The development of renewable energy could give a more flexible and sustainable energy system for Morocco.

5.4. Implication for the Environment

Renewable energy has the implicit to alleviate the impacts of climate change and ameliorate environmental sustainability in Morocco. A study by Ben Sassi et al. (2021)[5] set up that the perpetration of Morocco's renewable energy targets could reduce the country's hothouse gas emigrations by 42 million tons per time by 2030, which would significantly contribute to Morocco's commitment to the Paris Agreement. Likewise, the development of renewable energy in Morocco could help reduce air pollution, which is a major environmental challenge in the country. A study by Ben Sassi et al. (2021)[6] showed that the perpetration of renewable energy targets could reduce the emigrations of air adulterants, similar as sulfur dioxide and nitrogen oxides, and ameliorate air quality in civic areas. The development of renewable energy could also have positive goods on the natural terrain in Morocco. For case, the perpetration of large-scale solar systems in

[5]https://link.springer.com/journal/477.

[6]A Review on Climate, Air Pollution, and Health in North Africa.

Morocco's desert areas could help cover fragile ecosystems by avoiding the use of land that's infelicitous for husbandry or other mortal conditioning. also, the perpetration of renewable energy systems in pastoral areas could give openings for original communities to share in sustainable development conditioning that save natural coffers and biodiversity.

Overall, the development of renewable energy in Morocco could have significant environmental benefits, similar as reducing hothouse gas emigrations, perfecting air quality, and guarding natural ecosystems. Still, it's important to insure that renewable energy systems are enforced in a sustainable manner that takes into account the implicit environmental impacts and promotes the conservation of natural coffers.

Overall, these studies suggest that the development of renewable energy in Morocco could have significant profitable, social, and environmental benefits. Still, there may also be some challenges and limitations that need to be addressed, similar as the high outspoken costs of renewable energy systems and the need for probative programs and regulations.

Figure 2 explains the evolution of energy by category for the four last decades.

6. Discussion

The results of this study reveal the progress made by Morocco in transitioning from non-renewable to renewable energy sources. The Moroccan government has taken several steps to improve the country's energy security, reduce its reliance on fossil fuels, and promote sustainable development. The launch of the Moroccan Solar Plan in 2009 and the Integrated Moroccan Wind Energy Program in 2010 are notable initiatives that have significantly contributed to this transition.

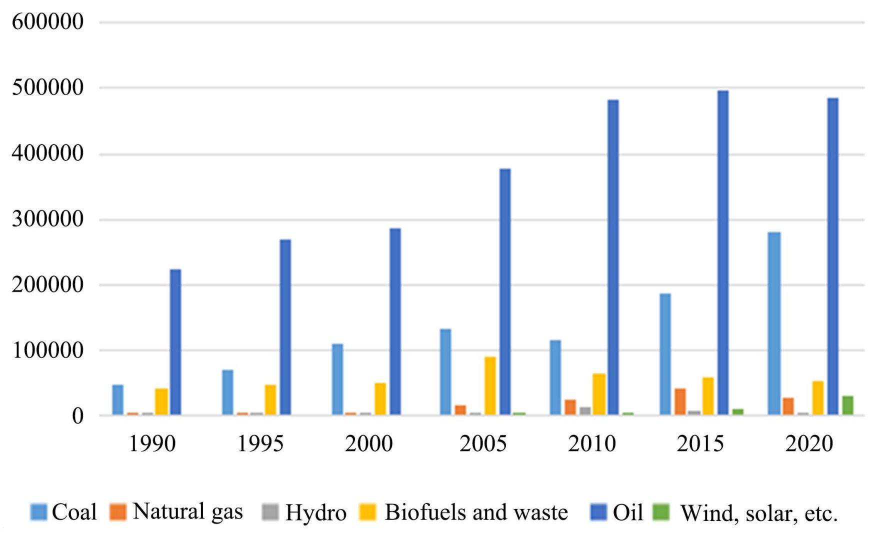

Figure 2. Total Energy Supply (TES) by source, Morocco 1990-2020. Source: Ministry of Energy, Mines, Water and Environment (2010).

According to the data obtained, as of 2021, approximately 35% of Morocco's energy comes from renewable sources, while the remaining 65% is derived from non-renewable sources. Although this percentage falls short of the government's target of achieving 52% renewable energy by 2030, the progress made so far is commendable. Morocco has become a leader in the renewable energy sector in Africa, and its commitment to increasing the use of renewable energy sources is clear.

The country has made significant strides in the deployment of solar and wind energy, with several large-scale projects currently underway. The NOOR solar complex, located in Ouarzazate, is one of the world's largest solar energy projects and is capable of producing up to 580 megawatts of power. The country has also initiated several wind power projects, including the Midelt wind farm, which is expected to produce 180 megawatts of electricity. These projects, along with others, are expected to significantly increase the proportion of energy generated from renewable sources in Morocco.

However, there are still challenges that must be addressed to achieve the government's renewable energy targets. The country's energy infrastructure and transmission networks must be improved to ensure the efficient distribution of renewable energy. In addition, financial barriers, such as high investment costs, continue to impede the growth of the renewable energy sector. Addressing these challenges will require sustained government support and the collaboration of private sector investors.

In conclusion, Morocco's transition to renewable energy is an ongoing process, and while there are challenges that need to be addressed, the progress made so far is significant. The government's commitment to renewable energy sources, as demonstrated through the launch of several large-scale projects, has placed the country on a path towards a more sustainable future.

7. Conclusion

This review paper has explored the transition from non-renewable energy to renewable energy in Morocco. The country's heavy dependence on fossil fuel imports and the volatility of global oil prices made it imperative for the government to develop a new energy strategy based on renewable energy. The Moroccan government launched a new energy strategy in 2009, which aimed to improve energy supply security and availability, increase access to energy, manage energy demand, and protect the environment. This strategy led to the launch of various renewable energy projects such as solar power plants, wind farms, and research and development centers.

The current energy mix in Morocco includes both renewable and non-renewable sources. While non-renewable sources still dominate the energy mix, the country has made significant progress in increasing the share of renewable energy in recent years. The Moroccan government aims to achieve 52% of installed capacity from renewable energy sources by 2030.

The transition to renewable energy has brought numerous benefits to Morocco. It has reduced the country's dependence on imported fossil fuels and helped stabilize energy prices. Renewable energy has also created new job opportunities and spurred economic growth in the country. Moreover, the use of renewable energy has reduced greenhouse gas emissions, contributing to the fight against climate change.

This review paper has highlighted the importance of renewable energy in Morocco and the progress made by the country in transitioning from non-renewable to renewable energy sources. It is evident that renewable energy has great potential to transform the energy sector in Morocco and create a more sustainable future. However, challenges remain, such as the need for more investment in renewable energy infrastructure and the integration of intermittent renewable sources into the energy grid. Therefore, it is crucial for the Moroccan government to continue its efforts in promoting renewable energy and to develop policies that encourage investment in renewable energy projects.

Overall, this review paper provides valuable insights into the transition from non-renewable energy to renewable energy in Morocco. It highlights the benefits of renewable energy and the progress made by the country in this regard. It also emphasizes the need for continued efforts to promote renewable energy and to overcome the challenges faced in the transition.

8. Limits and Perspectives

The energy transition is now an industrial imperative that must be grasped as an opportunity to be seized through ambitious investment projects.

However, our work has been confronted with certain structural, administrative and financial limitations and, above all, with a crucial lack of information sources. However, our work was confronted with structural, administrative, financial and above all, information limitations. This situation confirms the study carried out in 2021 by Sunny Gavin Daudu, who pointed out the lack of effective and relevant legislation on renewable energy in Nigeria.

Indeed, our work will enable us to launch more in-depth researches in the future while conducting:

- Statistical studies at the national and/or regional level;
- And comparisons with emerging countries such as Tunisia and Egypt.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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