Renewable Energy: Reality and Challenges in Algeria



Nabil Benmoussa

University of Setif2, Algeria, n.benmoussa@univ-setif2.dz

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Abstract:

Energy is the pillar of growth and development. With rapid population growth and increasing global interest in environmental issues, renewable energy has become a focal point. The study addresses the global status of renewable energy*, focusing on policies to promote renewable energy in Algeria. The study concluded that renewable energy includes sustainable, clean, reliable, and abundant sources that primarily contribute to reducing greenhouse gas emissions (GHG), mitigating climate change, enhancing energy security, reducing costs, creating jobs, and promoting sustainable development. These advantages have led Algeria to launch promising projects to promote renewable energy. However, efforts have focused on harnessing solar energy while neglecting other abundant renewable energy sources, such as wind and biomass, thereby necessitating incentives for the private sector to invest in this promising sector.*

Keywords: *Renewable Energy; Solar Energy; Wind Energy; Energy Policy; Algeria*.

*** Corresponding author: Nabil Benmoussa, n.benmoussa@univ-setif2.dz**

Introduction:

Energy is the lifeblood of the economy and the foundation of development; it enables investments that create jobs, inclusive growth for all, and shared prosperity. However, it is no longer certain that these gains will last, because traditional energy sources like oil, gas, and coal cannot keep up with the growing demand driven by faster economic and population growth, leading to more energy crises and increased GHG. Because of this, renewable energy is the best alternative to traditional energy sources, which are likely to run out. renewable energy is important for sustainable development and achieving the goals of the UN Millennium Declaration because it can be used repeatedly, is environmentally friendly, and enhances energy security. It also helps the economy grow by creating new jobs, making sure that resources last, and reducing reliance on unstable fossil fuels. Most parts of the world have access to renewable energy sources. Since the start of the current millennium, countries have been actively supporting and encouraging the use of renewable energy sources. This is especially true for solar and wind energy, but also for biofuels, though to a lesser extent. International agencies think that demand for renewable energy, the clean and sustainable energy, will grow in the following decades. Renewable electricity could help reduce our reliance on fossil fuels and GHG by making up a bigger part of the energy mix. Algeria was not immune to these global changes; it worked to promote renewable energy even though it had a lot of traditional energy reserves. This paper examines the current state of renewable energy in Algeria by elucidating the policies implemented to increase its share in the energy mix and capitalize on the renewable energy sources within its territory. The paper discusses how global energy policies have changed to support renewable energy. The paper looks at the steps and projects that Algeria has taken to increase renewable energy. These steps help the country meet its international obligations to cut GHG and achieve sustainable development.

1. Development of energy policies in the world:

Interest in renewable energy emerged in the 1970s when oil prices hit a historic peak, forcing industrialized countries to rationalize energy consumption and increase the use of renewable energy sources.

a. The 1990s policies:

After the Soviet Union fell apart and the restrictions on Russian oil were lifted in the early 1990s, the markets were flooded with cheap oil. The fall in oil prices hurt renewable energy projects a lot. People stopped funding these projects because they cost more than fossil projects (oil, gas, coal), even as people became more aware of the environmental problems associated with using more oil (Rajab, 2011).

Due to increased economic activity, CO_2 emissions worldwide are rising. In 2019, they made up 30.7% of all emissions, the fastest rate in human history (Liu &

Li, 2023). There were oil spills in the 1990s, which made people more worried about using oil as a safe fuel (Al-Hamash, 2013). These changes have made it essential to switch to renewable energy sources. renewable energy sources are considered sustainable because they can help lower carbon footprints, slow down climate change, and reduce our reliance on fossil fuels, which are limited and will run out by the end of this century (Ojuekaiye, 2025) Oil will run out in about 50 years, coal in about 114 years, and natural gas in about 53 years (Rabbani et al., 2024).

In 2019, developing countries' GHG rose much more than developed countries' GHG fell. This trend shows that developing economies are bearing the costs of industrialization caused by developed economies, which were responsible for 64.8% of the world's total CO2 emissions (Liu & Li, 2023). Thus, developing nations have initiated projects to enhance renewable energy to deliver sustainable energy, thereby guaranteeing efficient alleviation of energy scarcity and global warming (Emodi, Yusuf, & Boo, 2014).

The Kyoto Protocol was signed at the end of 1997 in response to the world's need to reduce GHG (Ojuekaiye, 2025). The protocol requires developed countries to improve energy efficiency and rely more on clean, renewable energy sources. Algeria joined the Kyoto Protocol on 16 February 2005. At the "Cancun Agreement" in the US in 2010, people made decisions, such as improving the Clean Development Mechanism under the Kyoto Protocol by allocating more funding to clean renewable energy and projects that promote sustainable development (Ayad, 2013). To obtain clean energy, we need to use more renewable energy and energy efficiency and slowly cut back on fossil fuels (The World Bank, 2025).

b. The post-1990s policies:

Despite declining interest in renewable energy in the 1990s, several events at the beginning of this century have revived renewable energy projects, most notably:

- Increase in the demand for energy;
- The rise in fossil prices since 2004, making renewable energy projects attractive for investment;
- The production capacity reached its peak in many regions, leading to increased concerns about energy security (Rajab, 2011);
- The increase in geopolitical risks in oil-producing countries has heightened energy security concerns, which have become a top priority for industrialized countries and encompass five main dimensions. The first dimension is the economic aspect, which includes the abundance of resources, the ability to access and develop them, balancing the conflicting interests of producers and consumers, and reaching an agreement on the fair price issue. The second dimension is natural

security, which includes the security of properties, facilities, infrastructure, supply chains, and trade routes, and protecting them from sabotage operations. The third dimension is the institutional aspect, meaning the existence of international organizations capable of regulating the global oil market and opening channels for dialog to bridge the viewpoints of producing and consuming countries. The fourth dimension is the environmental aspect of energy resource use, including the ongoing debate over global warming and its relationship to the use of fossil fuels. Finally, there is the investment dimension, which plays a role in energy security and involves clear policies from consumer countries that ensure future energy demand, alleviate the concerns of producing countries, and provide a suitable environment that guarantees fair prices, encourages investment, and ensures a secure and continuous flow of supplies (Al-Zitouni, 2020);

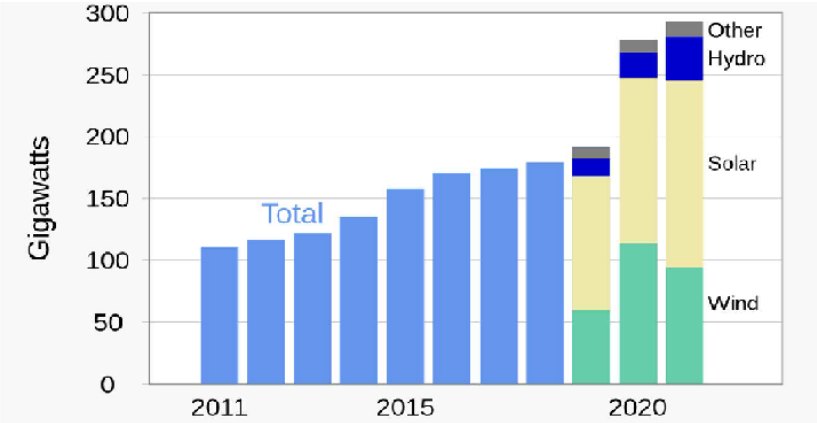
- The increasing risks of generating electricity from nuclear energy, especially after the Fukushima incident in Japan in 2011, have led many countries to shift toward developing investment strategies to increase their renewable energy capacity to meet the high growth in domestic energy demand. The International Energy Agency forecasts that demand for energy from renewable sources will increase to 3,925 million barrels of oil equivalent by 2032, surpassing demand for conventional energy sources (Rajab, 2013);
- The increase in blowout and oil spill incidents, including the oil spill in the Gulf of Mexico in 2010 (Al-Hamash, 2013).

These circumstances have driven industrialized countries to seek These circumstances have driven industrialized countries to seek sustainable alternatives to fossil energy sources that achieve energy self-sufficiency and respond to public demands for environmental preservation by reducing GHG and combating climate change (Aglanu, 2016). The current century has witnessed increased interest in renewable energy as an alternative to oil and gas, which have seen significant price hikes and account for about 90% of the world's total energy supply (Emodi, Yusuf, & Boo, 2014). Consequently, these issues posed challenges for countries in achieving harmony among enhancing energy security for their people, combating climate change, and ensuring sustainable economic development. In this context, industrialized countries adopted policies to encourage renewable energy, and the rise in oil and gas prices served the renewable energy projects that became a priority in energy policies. Currently, countries around the world are focusing on renewable energy technologies, with an emphasis on solar, wind, geothermal, biomass, and biofuels as the most promising REs, offering high efficiency and significant development potential.

During the 2008 financial crisis, the renewable energy sector demonstrated its resilience; thereafter, developed economies have invested in

renewable energy projects. Their policies to revive their economies included allocating significant budgets to finance renewable energy and incentives, which contributed to an increase in investment flows into renewable energy projects. The total investments in the renewable energy sector reached 50 billion U.S. dollars in 2009, a 15% increase from 2008 and more than 44% from 2007. As a result of increased investments and advancements in renewable energy technologies, some types of renewable energy have achieved high growth rates (Aglanu, 2016). Rabbani et al. (2024) note estimates predicting that renewable energy will be a substantial addition to the global energy supply by the end of this century as renewable energy capacity gradually increases. As the world population grows rapidly, it is anticipated that by 2050, 90% of the world's energy will come from renewable sources, with about 70% from wind and solar photovoltaics combined. The International Energy Agency (IEA) forecasted in 2014 that the sun could be the world's main energy source by 2050 (Rabbani et al., 2024). Figure 1 shows the increase in renewable energy capacity between 2015-2020.

Figure 1: Renewable energy capacity from 2015 to 2020



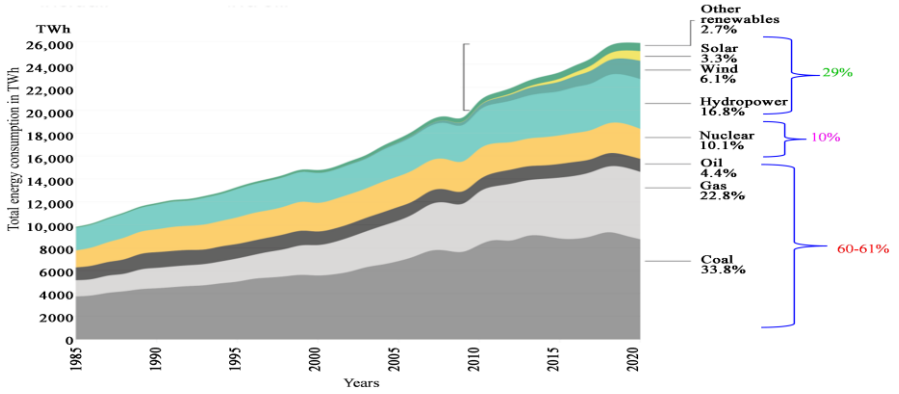
Source: (Rabbani et al., 2024)

The rise in renewable energy has enhanced the energy mix with more variety. Renewable energy has improved and grown, but it still cannot compete with fossil fuels. Additionally, it is very challenging to manufacture and operate renewable energy systems. Wind power is still pricier than coal and natural gas (Rajab, 2011). Wind farms should be built in areas with stronger, steadier winds, such as coastal areas or high-altitude sites. The wind speeds there are about 90% higher than on land (Rabbani et al., 2024). Wind and solar energy do not always work because the sun does not always shine, and the wind does not always blow. This implies that the weather can fluctuate the power output at any given time. This inconsistency can affect the amount of electricity generated, making it challenging to maintain a steady energy supply and a stable grid. Because of this inconsistency, we need to spend money on batteries that can store energy (Talaat

et al., 2013). wave energy is also harder to use well because it needs special infrastructure that can handle the harsh conditions at sea. This makes it less common than systems that use solar and wind power (Ojuekaiye, 2025). Countries like China still use coal to make electricity because wind and solar power are not always available (Wang et al, 2015).

In this sense, renewable energy systems still have problems because they do not use resources efficiently, conventional energy grids cannot handle distributed renewable energy sources effectively, and batteries do not last long, store much energy, or perform well (Ojuekaiye, 2025). This explains why fossil fuels are so important for making things and using them. In 2019, fossil fuels accounted for 84.32% of total primary energy consumption. The use of renewable energy grew more slowly, making up 11.41% of all primary energy use (Liu & Li, 2023). By 2050, it is expected that the use of renewable energy will have grown to 247 exajoules, or 68,666 TWh (Rabbani et al., 2024). Figure 2 shows how much energy was used around the world in TWh from 1985 to 2020.

Figure 2: Total amount of energy used globally between 1985 and 2020



Source: (Rabbani et al., 2024)

Estimates suggest that energy use worldwide is likely to rise by almost 78% between 2013 and 2030. Between 2020 and 2021, the percentage of renewable energy in total power generated worldwide remained constant at 28.1%, down from 26.3% in 2019, increased dramatically between 2019 and 2020, and then remained constant in 2022. Many countries already generate over 20% of the required energy from renewable sources, and others produce more than 50% of the required electricity. renewable energy markets are expected to continue growing rapidly into the 2020s and beyond, and they can achieve energy self-sufficiency by transitioning to 100% renewable energy across all applications, including heating, electricity, transportation, and desalination (Rabbani et al., 2024).

Despite the global struggle to enhance renewable energy, the share of fossil fuels in global primary energy consumption remains dominant, even though renewable energy's growth rate is much higher than that of fossil fuels (Liu & Li, 2023). To achieve the energy transition, investments in developing countries must grow sevenfold to reach 1–2 trillion U.S. dollars annually by 2030. This can help address the energy deficiency. Estimates indicate that 685 million people worldwide still lack access to electricity (The World Bank, 2025). In addition, integrating two types of renewable energy, such as solar and wind, in hybrid systems can address the reliability and feasibility of RE; they provide a high level of energy security and reliability (Swarna et al., 2024).

2. Renewable energy policies in Algeria:

Currently, the majority of the global energy comes from conventional sources; this reliance makes importing and exporting countries prone to price and supply fluctuations. Global shocks, such as the coronavirus pandemic, the war in Ukraine, and the conflict in the Middle East, have raised global concerns about disruptions in energy supply. Climate change has increased demand for renewable energy, boosting its share of the energy mix.

a. Advantages of renewable Energy:

Renewable energy is characterized by the fact that:

- It is non-polluting due to its low or nearly zero GHG; it mitigates the impacts of climate change and improves environmental sustainability.
- With proper infrastructure in place, it offers a reliable source of energy.
- Maintenance for renewable energy facilities could be less expensive than conventional generators (David, Uzorka, & Makeri, 2022).
- It improves public health, it decreases early deaths from pollution, and minimizes associated expenditures that might save a large sum of money annually (Rabbani et al., 2024).
- It creates new jobs by enhancing small and medium-sized enterprises to share in the supply chain of renewable energy systems.
- Development of renewable energy can be profitable; it can generate and export electricity, reduce the reliance on fossil energy, and alleviate financial imbalances (Moudene et al., 2023).
- It can help economies build resilience to price volatility and reduce energy costs (The World Bank, 2025). Therefore, access to an affordable, abundant, and consistent sustainable energy supply is a key driver for achieving sustainable development, in light of high costs associated with conventional sources of energy, such as health hazards, environmental consequences, and adverse economic effects due to foreign policy vulnerabilities for imported fuels (Aglanu, 2016).

- It provides electricity to remote areas.
- It preserves fossil energy sources from depletion for future generations.
- It diversifies the economy and secures a sustainable source of income (Bensabt et al., 2021).

b. Renewable energy status in Algeria:

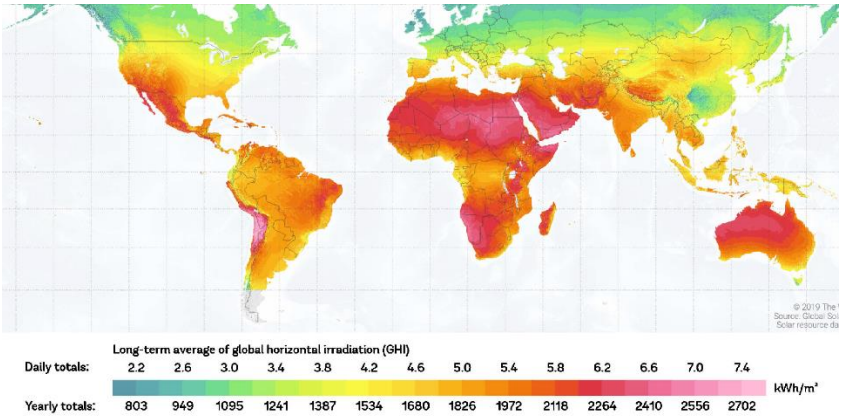
The benefits of renewable energy have encouraged Algeria to invest in renewable energy sources to develop them and diversify its energy mix to meet the growing local demand for energy. This will improve health, boost productivity, make the economy more competitive, promote economic growth, and reduce the electric sector's reliance on fossil fuels and GHG. This goal is achieved by exploiting abundant renewable energy sources, namely solar and, to a lesser extent, wind energy, as they are cost-competitive and provide a reliable electricity supply when combined with battery energy storage (Liu & Li, 2023). Solar arrays are long-lasting, emission-free, and require very little maintenance throughout their lifecycles (Karimanzira & Rauschenbach, 2018). It is noteworthy that solar energy, including solar thermal and photovoltaic, is the most abundant renewable energy source, with 173,000 terawatts per second reaching Earth, accounting for more than 10,000 times the world's total energy consumption. As the prices of infrastructure investment continue to fall, solar energy is becoming an economical energy source for residents and businesses, driving demand (Liu & Li, 2023). In addition, whether used in a grid-tie, grid-tie with battery backup, or off-grid system, solar systems are considered healthy and efficient (Nada & Hamed, 2015).

Oil and gas accounted for 97% to 98% of Algeria's energy consumption, making the economy vulnerable to fluctuations in their prices. Despite the abundance of conventional energy, the early years of the current century witnessed an increasing interest in Algeria in diversifying energy sources to keep up with international developments and the rising demand for sustainable energy, especially given its significant renewable energy sources (Bensabt et al., 2021).

Algeria has a lot of natural gas reserves, which have allowed it to build power plants to meet electricity demand. However, it has also diversified its energy sources by building hydroelectric, solar, and wind power plants. Algeria has fully utilized its hydroelectric generation capacity. However, apart from photovoltaic solar and plants, and to a lesser extent, wind power and hydroelectric power, the development of other renewable energy sources has been relatively slow. The situation has prompted Algeria to launch projects to enhance renewable energy plants to meet the growing local demand and then export to regional markets, especially to the European Union, which has announced its goal of becoming climate-neutral by 2050 by making its economies free of GHG (Hamash, 2021). Despite the renewable energy plant that relies on wind speed or solar insolation being considered intermittent and unreliable due to the weather changes or other natural changes, causing instability in power generation (Talaat et al., 2013), as well

as requiring large areas for the installation of solar panels and wind energy fields (Rajab, 2011), Algeria proceeded to build plants that rely on these energies, taking advantage of the year-round sunny weather for long hours in desert regions.

Figure 3: Global map of horizontal irradiation



Source: (Rabbani et al., 2024)

Algeria's focus has been on photovoltaic solar energy, which is more advantageous than solar thermal energy, which requires water (Jarman, Khalil, & Khala, 2013). Photovoltaic energy produces a continuous electric current and is environment-friendly, with very low operating costs; it is free energy, generously and abundantly provided by the sun (Bri, Elalami, & Nakheli, 2012). In addition, photovoltaic power is the least expensive form of electricity because it requires no long wires. Thus, it can help alleviate capacity problems on local grids and reduce GHG from electricity generation (Nada & Hamed, 2015). This feature makes the power system easy to extend, stable to operate, reliable, and silent, making the method especially suitable for some small-scale distributed energy supply areas (Azad et al., 2014). The integration of renewable energy, particularly wind and solar energy, into the grid reduces the energy crisis and significantly contributes to developing a sustainable society (Swarna et al., 2024). Solar energy has been used for a long time in many different ways, like making electricity and heating and cooling (Azad et al., 2014). Photocatalysis can also use solar energy to make green ammonia. This characteristic makes it appealing and possible to make in small amounts because it has a high energy density, burns without releasing carbon, and can be turned into a liquid for storage and transportation. Kumar, Sharma, and Yadav (2025) noted that ammonia can store energy for a long time and can be used to generate power when renewable energy sources are not available. Green ammonia also lowers GHG. It is a clean fuel for shipping, industry, and power. It can be made when there is extra power and used in the power, transportation, and industrial sectors to make the grid more reliable (Kumar, Sharma, & Yadav, 2025). Algeria has a lot of natural gas, which is the main ingredient for making ammonia. It

is also a major producer and exporter of ammonia and green nitrogen fertilizers (urea) in Africa. Algeria has strong potential to produce and export ammonia, supported by its natural gas resources and projects transitioning to green energy, putting it in a leading position in the African and global markets.

Likewise, the economic viability of green ammonia depends on governmental incentives to make it competitive. Algeria has set ambitious plans to increase the share of renewable energy in its electricity generation systems, which are expected to reach between 27% and 37% of total installed capacity by 2030, as shown in Table 1. The capital cost of solar-wind systems remains the lowest among the other REs, and they are simpler to build and maintain. Several wind and solar power generation projects under the FIT system have been launched (Al-Sadiq, 2021). It is noteworthy that this system has been widely used; most EU governments have adopted the feed-in tariff (FIT) system as a tool to promote renewable energy (Hernández & Hernández-Campos, 2011). It offers energy producers a guaranteed, above-market price for the electricity they supply to the grid, making renewable energy projects financially attractive by providing long-term contracts from 15 to 20 years and fixed prices, which help reduce the risks associated with these investments (Kenton, 2025). However, this system raised concerns about rising costs and the prices consumers may pay, which are likely to force governments to bear the burden to avoid further increases in energy prices.

Table 1: Plans to develop renewable energy capabilities in Algeria

Wind energy	Solar energy		Biomass energy	Geothermal energy	Total		Plan prospects
	Photovoltaic	solar thermal			Megawatts	%	
1000	3000	-	360	5	4375	15	2020
5010	13575	2000	1000	15	21600	27 - 37	2030

Source: (Qattab, 2019)

In 2011, several plans were launched to add 11.8 gigawatts of wind and solar generation capacity by 2030, accounting for approximately 41% of the total generation capacity on the electricity transmission grid. Later, the generation capacity development program was adjusted to include photovoltaic power plants operating at a rate of 450 megawatts each year during the 2022-2030 period. This number is particularly significant, as Algeria has a direct normal irradiance (DNI) that solar power plants require, reaching up to 2700 kilowatt-hours per square

meter per year, making the resulting electrical energy low-cost (Al-Sadiq, 2021). In 2030, it is expected that renewable energy plants will produce about 4632 megawatts of electricity. This amount includes about 4394 megawatts from solar power plants, about 228 megawatts from hydroelectric power plants, and about 10 megawatts from wind power plants. By 2030, this is expected to make up 15.3% of the total generation capacity on the electrical grid (Qattab, 2019). By then, the share of renewable energy in the electricity mix is expected to reach 27% (Abdel-Moaty, 2021).

Despite the promising projects, integrating renewable energy into existing power grids remains a complex process; these grids were designed around the stable output of conventional fossil-fuel-based power plants, while renewables are inherently unstable, posing a risk to the electricity grid and resulting in supply-demand imbalances. Despite the advanced energy storage solutions, such as batteries, that can help mitigate this issue, these technologies still face high costs and limited scalability. These inefficiencies lead to increased operational expenses, energy losses, and a larger environmental footprint than necessary, undermining the potential benefits of renewable energy (Ojuekaiye, 2025). Therefore, future projections are subject to technological challenges that can affect the generation capacities using renewable energy, their costs, feasibility, and spread (Farhat, 2019). To help address the challenges posed by renewable energy systems, particularly their intermittency and variability, Ojuekaiye (2025) suggests using Artificial Intelligence (AI); it has the potential to improve the efficiency, stability, and sustainability of renewable energy systems by predicting, optimizing, and controlling energy generation, storage, and distribution in real-time. AI methods are widely used to improve the sustainability of renewable energy systems by enhancing operational efficiency, minimizing emissions, and optimizing resource use (Ojuekaiye, 2025). Despite the abundant solar and wind energy resources in Algeria and the successive governments' investments to exploit the abundant solar and wind energy, their contribution to the energy mix remains modest due to the high cost of establishing solar and wind energy projects and the relatively high investment costs of solar and wind energy technologies compared to fossil fuels, which receive government support.

As for biomass energy, waste recycling projects for energy generation in Algeria are still under study, where the majority of waste is disposed of in landfills unsustainably through incineration and burial, exposing communities to pollution risks and wasting the potential benefits of waste utilization (Al-Zitouni, 2018). It is noteworthy that plastic waste ranks third, after natural gas and crude oil, in terms of energy content, indicating that Algeria is missing out on the opportunities offered by waste recycling. This concern is particularly significant, as waste is ubiquitous (Baghdadi, 2020). The same is true for hydrogen. Algeria has the parts it needs to build a booming hydrogen economy and is an important player in ensuring hydrogen is available to global markets. Algeria has some advantages over other countries, such as its proximity to major markets, low costs, and abundant

renewable energy resources (Abdel-Moaty, 2021). Hydrogen is important to the functioning of renewable energy as a chemical energy carrier; it enables energy systems that cannot operate effectively with only electricity. They also need chemical fuels for processes such as transportation. Fossil fuels are the world's primary sources. They are also energy carriers, but as the world's energy sources become less reliant on fossil fuels and environmental concerns grow, hydrogen is expected to become a dominant energy carrier for end-use services. Thus, hydrogen energy systems allow greater use of renewable energy resources (Rosen, 2015).

Conclusion:

The reliance on conventional energy sources to meet growing demand has led to increased energy crises, pollution, and GHG, which are major concerns today. To address these challenges, most countries have turned their attention to renewable energy sources, which are deemed clean, more reliable, effective, sustainable, and well-suited to meet increasing energy demand, making them a pillar for achieving sustainable development. To accelerate renewable energy projects, countries have allocated subsidies and incentives.

In keeping with international developments, Algeria has turned to developing abundant renewable energy sources, particularly solar energy, to enhance its contribution to the energy mix, meet the increasing local demand for electrical energy, and export it while implementing its commitments to reduce GHG.

However, to maximize the benefits from renewable energy sources, efforts should focus on adopting policies that encourage the private sector to invest in the promising renewable energy sector and on increasing public awareness of abundant renewable energy sources, particularly solar, wind, and biomass. This can be achieved by providing subsidies, incentives, and tax advantages for using RE, such as acquiring homes equipped with hybrid systems that integrate solar and wind energy simultaneously and purchasing electric or hydrogen fuel-cell vehicles.

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