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Amina Badreddine, Hadjira Larbi Cherif

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**PUBLIC HEALTH IMPROVEMENT BY REDUCING AIR POLLUTION:  
A STRATEGY FOR THE TRANSITION TO RENEWABLE ENERGY**

**Amina Badreddine**,  ORCID: <https://orcid.org/0009-0008-4863-8034>

University of M'HamedBougara (Algeria)

**Hadjira Larbi Cherif**,  ORCID: <https://orcid.org/0009-0008-1375-5871>

University of M'HamedBougara (Algeria)

**Corresponding author: Amina Badreddine**, [a.badreddine@univ-boumerdes.dz](mailto:a.badreddine@univ-boumerdes.dz)

**Type of manuscript:** theoretical paper

**Abstract:** *An important outcome for improving public health from the transition to renewable energy sources (wind, solar, and hydropower) is a significant reduction in emissions of important air pollutants. They are particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>) in contrast to fossil fuel resources. Experts estimate that the abandonment of fossil fuel combustion in the United States alone would avoid 53,000 deaths per year, which amounts to more than \$600 billion in monetised health benefits. In Algeria, there is a significant discrepancy between the declared national goals for the transition to renewable energy sources and their actual implementation. The article purpose is to identify reasons for this discrepancy and to develop effective mechanisms for its gradual reduction. The article argues that the main reasons for these discrepancies are limited determination and lack of a coherent plan, as well as structural obstacles, such as significant financial support for fossil fuels, a strong group of interests of oil and gas companies, problems with financing, and the dominance of monopolies in renewable energy projects. The article proposes a course correction for Algeria to realise its enormous solar, wind, and other clean energy potential through targeted reforms that will attract sustainable investment. Algeria needs a well-planned and long-term approach to development and diversification that meets the goals of the global climate agenda. The article offers and explains the gradual removal of fuel subsidies, liberalisation of energy markets, expansion of training initiatives, and exploration of new financial mechanisms. In order to utilise renewable energy resources, it is crucial for Algeria to have unwavering political will to overcome resistance from traditional fossil fuel industries.*

**Keywords:** public health; mortality; air quality; air pollution; concentrated solar power; energy transition; photovoltaic power; renewable energy.

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## INTRODUCTION

Renewable energy has risen to prominence globally amid intensifying debates surrounding its current and future role in sustainable environmental strategies (Lund, 2007; Jacobson & Delucchi, 2011). With growing recognition of the threats posed by continued fossil fuel dependence, countries and organizations increasingly advocate for clean energy criteria to safeguard the climate (IPCC, 2022; REN21, 2022). Algeria has substantive potential, particularly across solar and wind resources, yet remains heavily reliant on oil and gas revenue (Zahraoui et al., 2021; Fares, 2021; Bouraiou et al., 2020).

This paper reviews the Algerian context regarding channels and barriers impacting renewable energy development in relation to the country's stated ambitions. Despite having delineated targets envisioning an expanded renewable energy footprint, including generating 8,000 MW by 2020 and 22,000 MW between 2015-2030, Algeria has installed just 400 MW of solar photovoltaics capacity as of 2023 (Koussa & Koussa, 2014). The constraints underlying this disconnect between policy vision and on-ground implementation remain and need to be more scrutinised. Growth has thus far been severely hampered by a complex combination of obstacles, such as a lack of political will, subsidies for fossil fuels, resistance by incumbents, and insufficient incentives. To fully realise Algeria's renewable potential, these systemic barriers must be addressed through a strategic realignment that prioritises creating favourable circumstances for sustainable investment.

So, despite abundant renewable energy potential, why has Algeria struggled to develop solar, wind and other renewables over the past two decades, repeatedly missing targets? More specifically:

- What are the key technological, political, economic and social barriers that have severely obstructed renewable energy growth in Algeria until now?
- How can these myriad barriers be systematically overcome, through what policy, regulatory, institutional and strategic changes?
- What concrete recommendations and roadmap can unlock Algeria's immense renewable energy potential through realigning incentives and conditions towards sustainable investments at scale?

The problem statement highlights Algeria's failure to capitalise on promising solar, wind and other resources so far, the complex mix of obstacles behind this poor outcome, and the need for solutions spanning systemic reforms enabling renewable growth aligned with national development priorities. Framing this multi-dimensional challenge as a series of questions sharpens the analysis while retaining focus on practical pathways towards an improved renewable energy transition. By evaluating factors impeding the growth of renewables to date alongside potential measures to overcome impediments, this analysis aims to chart a strategic course correction for enabling Algeria to deliver on its immense solar (Fares, 2021), wind and complementary clean energy promise. With hydrocarbon reserves declining, transitioning towards an increasingly decarbonised energy system harnessing the country's significant renewable resources offers economic diversity alongside climate change mitigation and local environmental dividends.

In addition to accomplishing these objectives, utilising Algeria's abundant renewable energy resources is essential for mitigating the harmful consequences of air pollution. When compared to burning fossil fuels, a number of studies have shown that switching to renewable energy sources like wind, solar, and hydropower can result in a major decrease in emissions of important air pollutants like particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), and sulphur oxides (SO<sub>x</sub>). In addition to promoting economic diversification, switching to renewable energy offers observable advantages including reduced air pollution and climate mitigation, especially as fossil fuel sources run out. This study looks at the barriers to the development of renewable energy in Algeria and considers how more funding for these projects could lower air pollution. Algeria can simultaneously solve the urgent problem of air pollution and realise the full potential of renewable energy by including measures like improved infrastructure and education.

## LITERATURE REVIEW

### Overview of renewable energy sources and adoption

In recent decades, renewable energy has garnered growing interest as a sustainable substitute for fossil fuels. In 2019, renewable energy made up approximately 16% of the total global energy investment and accounted for 6.92% of primary energy consumption (Gielen et al., 2019; Angelis-Dimakis et al., 2011). Various studies contend that in order to tackle climate change and energy security concerns, renewable

energy must make up the majority of future energy systems (Jacobsson & Johnson, 2000; Lund, 2007; Sathaye et al., 2011). The literature examines several key sources of renewable energy, namely wind, hydropower, geothermal, biomass, and ocean energy. The advantages of renewable energy sources compared to fossil fuels include their plentiful supply, ability to be replenished, and positive environmental impacts (Hoogwijk, 2004; Kurt et al. 2006; Vakulchuk et al., 2020; Mohtasham, 2015; Shahzad, 2012; Fares, 2021). Nevertheless, the sporadic and comparatively expensive nature of certain renewable energy sources like solar and wind (Lebbihiat et al., 2021), is frequently identified as a hindrance to their widespread adoption (Moriarty & Honnery, 2012; 2016).

### **Government policies and public perception of renewable energy**

Government policies are crucial in fostering the advancement of renewable energy. Policy methods like as feed-in tariffs, renewable portfolio standards, tax incentives, and subsidies are commonly utilised (Wang et al., 2010; Aguirre & Ibikunle, 2014). Nevertheless, certain governmental initiatives can hinder the competitiveness of renewable energy sources (Wang et al., 2010). The growth of community renewable energy initiatives is significantly influenced by public approval (Walker, 1995; Walker & Devine-Wright, 2008).

### **Global scenarios for high renewable energy penetration**

Various global studies have examined potential scenarios for achieving aggressive renewable energy goals between 2030 and 2050. These studies have included multiple assessments of energy systems that rely entirely on renewable sources (Lund, 2007; Zafar, 2023; Bouznit et al., 2020). Nevertheless, critics contend that the practicality of using renewable energy sources (Carpejani et al. 2020) on a large scale may be hindered by physical and economic limitations, unless significant advancements in technology are made (Moriarty & Honnery, 2012; 2016).

### **The impact of renewable energy transition**

For the relation between renewable energies and air pollution, numerous studies have modelled the potential air pollution emission reductions from increased renewable electricity generation globally or in specific countries. Jacobson (2009) modelled conversion of 143 countries' all-purpose energy to wind, water, and solar. Associated air pollution deaths were projected to decrease by 70% in 2050 compared to business-as-usual fossil fuel emissions. For China specifically, green energy development modelled by Dai et al. (2016) was projected to reduce SO<sub>2</sub> emissions by 7.3% and NO<sub>x</sub> emissions by 8.6% in 2050 compared to a reference scenario. Xie et al. (2018) found that a SO<sub>2</sub> tax and increased renewable energy in the Beijing-Tianjin-Hebei region of China could cut SO<sub>2</sub> emissions by up to 27.4% and NO<sub>x</sub> emissions by 7.8% in 2020 relative to 2012. Cofala et al. (2020) estimated SO<sub>2</sub> and NO<sub>x</sub> emissions in India could decline by 90% and PM<sub>2.5</sub> by 60% in a sustainable development scenario emphasising renewables and energy efficiency. For the United States, Abel et al. (2018) calculated increasing solar PV to 17% of eastern US electricity generation could reduce NO<sub>x</sub>, SO<sub>2</sub>, and PM<sub>2.5</sub> by 20% in the most polluted cities. The avoided mortality was valued at over \$13 billion annually. Goodkind et al. (2019) estimated eliminating US fossil fuel combustion would prevent ~53,000 PM<sub>2.5</sub>- and ozone-related deaths per year, worth over \$600 billion in monetised health benefits.

### **Health impacts of air pollution**

Multiple studies have also highlighted large avoided mortality from cleaner household energy transitions, especially for rural populations relying on biomass cookstoves. Global atmospheric modelling indicates residential energy is responsible for about 40% of population-weighted mean PM<sub>2.5</sub> exposure in South and East Asia (Chafe et al., 2014). Advanced cookstoves, biogas digesters, and transition to liquefied petroleum gas or electric cooking can dramatically improve household air quality and prevent millions of deaths annually in developing countries (Puzzolo et al., 2016). Life cycle analyses consistently demonstrate lower lifecycle air pollutant emissions from wind, solar, hydro, and some biomass energy systems compared to fossil fuel power plants (Abbasi & Abbasi, 2000; Ellabban et al., 2014; Zhu & Cheung, 2013).

However, some renewable sources like bioenergy and geothermal energy can still produce PM, NO<sub>x</sub>, and SO<sub>x</sub> emissions. The net emission reductions depend on the specific technology, feedstock, and pollution control measures utilised.

While many studies model emission changes, fewer have assessed how increased renewable generation affects measured air pollutant concentrations and associated health impacts. Novan (2015) found that

renewable portfolio standards in the US reduced NO<sub>2</sub> concentrations by 2.5% on average. Xie et al. (2023) report that provinces in China with higher renewable shares from 2005-2017 saw greater reductions in PM<sub>2.5</sub>, PM<sub>10</sub>, and SO<sub>2</sub> concentrations. Modelling by Galimova et al. (2022) estimates that transitioning to 100% renewable energy globally could reduce PM<sub>2.5</sub> concentrations by 57-99% across world regions in 2050, resulting in 1.08 to 4.26 million avoided deaths annually from reduced air pollution exposure. Tarín-Carrasco et al. (2022) project that increased renewables in Europe could cut PM<sub>2.5</sub> concentrations by 15-25% in 2050 compared to a current policy scenario, avoiding around 49,000 and 125,000 premature deaths per year. However, research also indicates that the air quality benefits of renewable deployment can be diminished by factors like grid congestion and curtailment of renewable generation (Monforti-Ferrario & Blanco, 2021). The air pollution reductions achievable through renewable energy expansion are also projected to vary significantly by location depending on the existing energy mix, growth patterns, and climate policy implementation.

### **METHODOLOGY, THEORY AND CONCEPTUAL FRAMEWORK**

This study utilises a qualitative review and analysis technique to evaluate the reasons why Algeria hasn't made more progress with renewable energy during the past two decades, despite the country's stated national objectives, and the relationship between increased renewable energy and decreased air pollution. Considering the intricate socio-technical and political dynamics involved, conducting a thorough literature analysis is a suitable methodology for gaining a comprehensive understanding of the interactions among different economic, policy, and social factors that impede progress (Creswell & Creswell, 2017; Fragkos and Siskos, 2022).

To assess the current state, trends, obstacles, policy priorities, and co-benefits for air quality surrounding the growth of renewable energy in Algeria, published academic literature, official publications, and energy data were examined. To find peer-reviewed research on Algeria's renewable energy potential, adoption, policies, and transitions as well as their effects on emissions of air pollutants, a thorough evaluation of the literature was done. Relevant phrases such as "Algeria", "renewable energy", "air pollution", "health", "emissions", "PM<sub>2.5</sub>", "nitrogen oxides", and "sulphur oxides" were searched in databases such as ScienceDirect, Scopus, and Google Scholar. For perspective, studies measuring the advantages of renewable energy for public health and air quality worldwide and in other nations were also evaluated.

The considerations mentioned in the study by Abdmouleh et al. (2015) help explain why there is a divergence between Algeria's national renewable energy goals and the actual implementation on the ground. Proposed integrative solutions involve implementing specific measures in areas such as updated governance, enhanced electrical infrastructure, increased funding channels, and education centres that focus on renewable energy. The goal of this study is to examine the hypothesis that Algeria can tap into its significant renewable energy resources more quickly by strategically addressing key political and economic obstacles and enhancing its overall capacity. This will make it easier to switch to using less fossil fuel and relying more on clean energy sources within the country, aligning with the imperative of long-term ecological sustainability.

Official renewable targets, strategies, and progress indicators were determined by looking through Algerian government policy documents, laws, and data from the energy ministry. Background was supplied by global outlooks from institutions such as IRENA and REN21. The analysis reveals various factors that impede the growth of renewable energy, including limitations in technological capabilities, distortions caused by subsidies for fossil fuels, insufficient training of skilled personnel, and inadequacies in incentive mechanisms designed to stimulate investments.

Data on renewable energy sources and Algerian policy aims were combined with literature-based insights through a synthesis approach. Thematic analysis was used to identify the main barriers preventing the expansion of renewable energy sources and the corresponding improvements in air quality. On the basis of context, expertise, and examples from the literature, measures to remove obstacles were created. The approach mainly uses a qualitative synthesis of the available data. More research should use quantitative methods to assess various transition routes and co-benefits for Algeria's air quality, such as scenario modelling and statistical analysis of the links between renewable energy sources and air pollution. Interviews with stakeholders would offer different viewpoints.

## RESULTS

Hasni et al. (2021, p.5) stated that Algeria has proposed the construction of three power plants, with an individual capacity of 300 MW, which will be in addition to the current Hybrid Power Plant located in Hassi R'Mel. This was undertaken to facilitate the implementation of a 1050 MW power plant throughout the timeframe of 2006 to 2014.

Khouildat et al. (2019, p.287) stated that upon analyzing the report from the United Nations Commission regarding the current situation and future prospects, it becomes evident that the commission has taken charge of the NEAL (company developing projects in the production of electricity and heat from renewable energies) project, focusing on clean energy production. According to Hasni et al. (2021, p.5), this project is the first of its kind to involve both public and private entities, and it has been handed over to the Global Environment Facility (GEF) of the World Bank. The same authors noted that there were intentions to construct four thermal power plants capable of storing a total of approximately 1200 MW. UNECA (2012) mentioned that subsequently, an annual increase of 500 MW would be implemented until 2023, followed by a further increase of 600 MW until 2030. Sellami et al. (2016) pointed out that the 8,000 MW project was slated to be finished by 2020. UNECA (2012) mentioned that all access has been obstructed. The same source noted that a 22,000 W scheme was implemented in 2011, with the superior share allocated to CSP (Concentrated Solar Power). However, UNECA (2012) indicated that in 2014, the decision was made to eliminate CSPs and dedicate 13,000 MW specifically for PV. Nevertheless, UNECA (2012) stated that there is presently no publicly available information concerning the performance of these facilities.

### ➤ Driving renewable energy adoption through regulations and procedures

According to Hasni et al. (2021), it is undeniable that there are several institutions that were created with the purpose of advocating for renewable energies, and this quantity is expected to increase. The same authors noted that the justification for these innovations is that they are comprehensible only to the state. However, Hasni et al. (2021) stated that contrary to this, other countries with similar circumstances have demonstrated the opposite outcome. They mentioned that the NEAL Company, which is a wholly Algerian public-private partnership, stands as the sole enterprise that has accomplished a project effectively, exemplifying a triumph in neighboring nations and other locations through the Algerian firm NEAL's duplication. Hasni et al. (2021) further explained that NEAL, a project development firm, has the capability to utilize financial and technical engineering expertise, and can also participate in the ownership of the project company, which oversees operations, construction, and marketing. Additionally, the authors pointed out that in 2002, certain regulations were enacted to specifically target renewable energy. They stated that the Electricity Act was implemented to provide a structure for its advancement and to prioritize the utilization of renewable energy sources, but this foundation was not followed as legislation that adhered closely to the original wording was enacted. Hasni et al. (2021) remarked that the 2012 Electricity and Gas Act placed a high importance on renewable energy sources when it comes to regulatory structures, with the electrical market undergoing deregulation and a stock exchange suspended by a market operator, enabling the implementation of a feed-in law which grants access to the power market for renewable sources. The authors concluded that the determination was that without any indication of political resolve, it was impossible to predict any results.

Hasni et al. (2021) thus examined the particular challenges impeding the advancement of renewable energy generation. The same authors believe it would have been more beneficial to cease the practice of offering financial assistance to fossil fuels, which currently results in an annual cost of \$15 billion (Table 1).

**Table 1. Energy subsidies (billion US dollars)**

	2012	2020	2030	Observations
<b>Electricity</b>	0.197	4.352	7.232	
<b>Fuels</b>	0.460	15.510	20.000	2013: 3 Billion US\$ Importation
<b>Gas</b>	11.000	20.500	37.000	
<b>Total</b>	11.600	40.300	64.200	

Source: Hasni et al. (2021, p. 9)

According to Hasni et al. (2021, p.9), the findings of this evaluation in 2012 resulted from an analysis of the Finance Act. The authors stated that following projections were derived by approximating the export price and deducting the tariff on the domestic market. The export price of gas was expected to be \$8 per million British thermal units (MMBTU), while the local tariff for gas was set at \$0.27 per thousand British thermal units (MBTU). Hasni et al. (2021) mentioned that the anticipated cost of generated electricity was 8 DA/kWh, whereas the tariff was 4 DA/kWh. The authors noted that the evaluation conducted by the Finance Act indicated an energy subsidy amounting to \$15 billion in 2018. Additionally, Hasni et al. (2021) stated that the IMF’s assessment remained consistent, approximately representing 10% of the Gross Domestic Product (GDP).

➤ **Program for the advancement of renewable energy**

Guentri et al. (2020, p.107) stated that Algeria seeks to establish itself as a prominent participant in the field of electricity production. by leveraging the solar and wind power sectors as part of its renewable energy agenda . Fares (2021) noted that furthermore, the program seeks to incorporate biomass, geothermal energy, cogeneration, and solar thermal energy, starting in 2021. Bouznit et al. (2020) and Guentri et al. (2020) mentioned that the mentioned energy sectors will play a crucial role in promoting sustainable economic development and have a potential to stimulate a new paradigm of economic growth.

According to Sellam et al. (2016, p.618), the Algerian Ministry of Energy and Mines stated that by 2030, renewable sources will account for 37% of the total installed capacity and 27% of the power produced for domestic use. The same authors mentioned that Algeria recognizes solar energy as its primary source of renewable energy and views it as a significant opportunity for economic and social progress, with the country aiming to capitalize on this energy source by establishing enterprises that generate money and employment.

However, as stated in the passage, the possibility of launching multiple wind farm projects and carrying out experimental initiatives in biomass, geothermal, and cogeneration remains open. Alaoui et al. (2023, p.499) noted that renewable electricity production initiatives targeting the local market will be carried out in two phases:

**Phase 1** (2015-2020): This phase involved the installation of a total of 4,010 MW of power, with a distribution of photovoltaics and wind energy accounting for the majority, and biomass, cogeneration, and geothermal energy contributing a smaller portion of 515 MW (Alaoui et al., 2023, p. 499).

**Phase 2**, scheduled for the period of 2021 to 2030, seeks to provide electrical links between the North and the Sahara region, specifically Adrar. Implementing this would facilitate the construction of sizable renewable energy installations in In Salah, Timimoune, Bechar and Adrar , and figure out how to connect them to the domestic energy network. Currently, solar thermal technology has reached a stage of development where it is economically feasible (Alaoui et al., 2023, p. 499).

Bouznit et al. (2020) stated that the policy of Algeria focuses on fostering the growth of authentic renewable energy sources, while also implementing a program to enhance training and knowledge acquisition. The same authors mentioned that this will ultimately enable the utilization of native Algerian engineering and project management skills. Bouznit et al. (2020) further noted that the renewable electricity initiative targeted at the domestic market will provide a substantial number of both direct and indirect employment opportunities, amounting to several thousand jobs.

According to Bouznit et al. (2020, p. 3), the plan for using renewable energy scheduled for the domestic market between 2015 and 2030 will maintain a steady capacity of 22,000 MW. The distribution of this capacity by sector is represented in Table 2.

**Table 2. The renewable energy program in Algeria (MW)**

Unit MW	First phase 2015-2020	Second phase 2021-2030	Total
<b>Photovoltaic</b>	3,000	10,575	13,575
<b>Wind</b>	1,010	4,000	5,010
<b>CSP</b>	-	2,000	2,000
<b>Cogeneration</b>	150	250	400
<b>Biomass</b>	360	640	1,000
<b>Geothermal</b>	05	10	15
<b>Total</b>	4,525	17,475	22,000

Source: Algerian Ministry of Energy and Mines (2023)

Bouznit et al. (2020) stated that the current objectives for renewable energy were met within two specified periods (2015–2020 and 2021–2030), with a primary focus on significantly boosting investments in various RE sources like photovoltaic, (CSP) Concentrated Solar Power, geothermal, biomass, cogeneration and wind. The same authors presented in Table 2 the main renewable energy objectives for power production in both time periods. Bouznit et al. (2020) also mentioned that the objective for the year 2030 is to attain a cumulative generation capacity of 22,000 MW by harnessing renewable energy sources.

Boulakhras (2018) noted that out of this 22,000 MW target, 12,000 MW were designated for the domestic market, while the remaining 10,000 MW would be intended for exportation. The same author stated that attaining this level of renewable energy generation is projected to result in the conservation of about 300 billion cubic meters of natural gas, which is eight times the amount consumed nationally in 2014.

The Algerian Ministry of Energy and Mines (2023) demonstrated that the Algerian government has previously outlined a roster of power plant initiatives for development from 2011 to 2020 aiming to fulfil the goals of the initial phase. The same ministry demonstrated having planned a total of 60 power plant projects including 27 photovoltaic installations to be connected to the northern grid, six solar thermal projects, and seven wind power generation facilities. Furthermore, the ministry demonstrated that Algeria has integrated specific objectives pertaining to Concentrated Solar Power (CSP) for the following timeframe. Bouznit et al. (2020, p.4) demonstrated that in addition to the renewable energy targets, the National Program also embraces goals by 7% reduction in greenhouse gas emissions and 9% decrease in energy consumption, with the aims focused on three primary sectors: buildings, transportation, and industry.

Bouznit et al. (2020, p.4) stated that by 2030, the building sector aims to achieve a savings objective of more than 30 million tonnes of oil equivalent (Mtoe). It will be accomplished by implementing cutting-edge technologies and employing thermal insulation techniques in the construction process. The same authors mentioned that the plan entails annually insulating 100,000 homes, advocating for solar water heating, and distributing 10 million energy-efficient lamps while transitioning to light-emitting diodes (LEDs), with these measures projected to result in savings of 7.2 million tonnes of oil equivalent (Mtoe) and 20 Mtoe, respectively.

Bouznit et al. (2020, p.4) demonstrated that promoting the adoption of renewable energy is essential for attaining sustainable development in Algeria. Khouildat et al. (2019, p. 293) stated that the objectives outlined in Law No. 04-09 provide a clear direction for implementing a comprehensive strategy to advance both renewable energy and energy efficiency. To accomplish this, a set of fundamental principles was established.

Bouznit et al. (2020, p. 5) noted that the National Fund for Renewable Energy (NFRE) was created with the enactment of Law No. 09-09 in 2009, with the provision that 0.5% of oil royalties will be allocated for its financing. Consequently, a variety of financial aid will be offered to investors participating in all activities and initiatives encompassed by the government's renewable energy program. Khouildat et al. (2019, p. 293) mentioned that the establishment of the National Fund for Renewable Energies and Cogeneration (NFREC) is a direct outcome of the enlargement of the NFRE, as stated in Law No. 11-11 of 2011, to encompass cogeneration activities.

Bouznit et al. (2020, p. 4) reported that the government raised the financial allocation of oil royalties to one percent. According to Law No. 14-10, the National Fund for Energy Management was mandated to close, and its responsibilities were transferred to the NFREC. The same authors stated that in 2013, Executive Decree No. 13-218 was approved, outlining the specific incentive programs that would be used to increase generating renewable electricity. As a result, the government has pledged to provide financial incentives to offset the expenses related to diversifying the array of electricity sources. The implementation of Executive Decrees No. 17-98 and No. 17-204 took place in 2017 (Bouznit et al., 2020, p. 4).

Guentri et al. (2020) showed also that other incentive measures were planned. These include:

- Procurement and allocation of suitable land for the establishment of renewable energy facilities;
- Support provided during the process of obtaining the necessary permissions;
- Assessment of the capacity for generating renewable energy in all pertinent areas;
- Implementation of pilot initiatives in each sector;
- Establishment of institutions and facilities dedicated to the evaluation, quality assurance, and performance monitoring of components, equipment, and processes utilized in generating electricity from renewable sources and/or cogeneration systems;
- Provision of assistance, via a comprehensive program for recruiting and training technicians, by



vocational training institutes and the collaboration of national universities and research organizations, in the research and education of engineers.

#### ➤ **Relation between renewable energies and air pollution**

Air pollution is a major global issue, resulting in millions of deaths each year from cardiovascular and respiratory diseases. Major sources of air pollution include the burning of fossil fuels for energy production, transportation, industrial activities, and household cooking and heating. Transitioning to renewable energy sources offers a pathway to significantly reduce harmful air pollutants and improve public health worldwide.

According to Galimova et al. (2022), in this energy transition, and, total global energy emissions are expected to fall by almost 92% in 2050 compared to 2015, with annual premature deaths from energy-related air pollution decreasing by approximately 97%, from 5.2 million deaths in 2015 to 150,000 by 2050. The annual cost of damage is expected to fall by 88.5 per cent, from approximately 4600 b€ in 2015 to 529 b€ by 2050. (Galimova et al. 2022) also showed that fossilization and the shift to renewable forms of energy enable a massive reduction in emissions of air pollutants that are directly harmful to human health, resulting in enormous health and economic benefits in terms of prevented deaths and savings in health spending worldwide.

#### ➤ **Air pollutants from fossil fuel combustion**

Goodkind et al. (2019) and Parry et al. (2014) reported that the key air pollutants resulting from fossil fuel combustion include particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>), carbon monoxide (CO), and volatile organic compounds (VOCs). PM, NO<sub>x</sub>, and SO<sub>x</sub> are associated with the highest external costs related to their public health impacts. The same authors mentioned that coal combustion emits the highest levels of PM and SO<sub>x</sub> per unit energy, while transport fuels including diesel and gasoline are major sources of NO<sub>x</sub> and PM from internal combustion engines.

Several studies, such as, (Lelieveld et al., 2015; Klimont et al., 2017), have quantified global and regional air pollutant emissions from energy and transportation sources. The power, industry, transport, and household cooking/heating sectors account for most anthropogenic PM<sub>2.5</sub>, NO<sub>x</sub>, and SO<sub>2</sub> emissions.

EEA (2007) noted that road vehicles constitute about 57% of NO<sub>x</sub> emissions from the transport sector in Europe. Van Fan et al. (2018) stated that International shipping emits substantial SO<sub>x</sub>, NO<sub>x</sub>, and PM, equal to 32%, 40%, and 50% of total transport emissions in Europe, respectively. In addition, Oberschelp et al. (2019) and Akagi et al. (2011) showed that unregulated coal power plants and biomass cookstoves in developing countries have very high PM emissions per MWh.

#### ➤ **Health impacts of air pollution**

Extensive epidemiological research has demonstrated the adverse health effects of air pollutant exposure, especially ambient PM<sub>2.5</sub>. Increased mortality risk from PM<sub>2.5</sub> is linear, with an estimated 9.8% increase in mortality per 10 µg/m<sup>3</sup> PM<sub>2.5</sub> (Parry et al., 2014). Long-term PM<sub>2.5</sub> exposure is linked to increased risk of cardiopulmonary deaths as well as lung cancer (Pope et al., 2002; Raaschou-Nielsen et al., 2013). According to Lelieveld et al. (2015), the WHO (World Health Organization) estimates ambient air pollution results in 4.2 million deaths annually, while household air pollution causes another 3.8 million deaths per year (WHO, 2018). High PM concentrations in many Asian cities lead to over 1 million deaths annually.

#### ➤ **Air pollution reduction from renewable**

Multiple studies have estimated significant reductions in air pollutant emissions and related mortality under high renewable energy scenarios. (Jacobson, 2009) modelled conversion of 143 countries' all-purpose energy to wind, water, and solar. Associated air pollution deaths were projected to decrease by ~70% in 2050 compared to business-as-usual fossil fuel emissions (Cofala et al. 2020). Estimated SO<sub>2</sub> and NO<sub>x</sub> emissions in India could decline by 90% and PM<sub>2.5</sub> by 60% in a sustainable development scenario emphasising renewables and energy efficiency. For the United States, (Abel et al. 2018) calculated increasing solar PV to 17% of eastern US electricity generation could reduce NO<sub>x</sub>, SO<sub>2</sub>, and PM<sub>2.5</sub> by 20% in the most polluted cities. The avoided mortality was valued at over \$13 billion annually. (Goodkind et al. 2019) estimated eliminating US fossil fuel combustion would prevent ~53,000 PM<sub>2.5</sub>- and ozone-related deaths per year, worth over \$600 billion in monetised health benefits.

Multiple studies have also highlighted large avoided mortality from cleaner household energy transitions, especially for rural populations relying on biomass cookstoves. Chafe et al. (2014) stated that global

atmospheric modelling indicates residential energy is responsible for about 40% of population-weighted mean PM<sub>2.5</sub> exposure in South and East Asia. Puzzolo et al. (2016) noted that advanced cookstoves, biogas digesters, and transition to liquefied petroleum gas or electric cooking can dramatically improve household air quality and prevent millions of deaths annually in developing countries.

However, studies on the relationship between the energy transition to renewable energies and their benefits on air quality are almost zero for Algeria. The scarcity of research in this area mostly stems from limited data accessibility and inadequacy, compounded by the malfunctioning of air quality monitoring stations in recent years.

Belhout et al. (2018) conducted a study to determine the specific causes of air pollution in the greater Algiers area that are caused by human activities, including road traffic, industrial operations, residential activities, and waste management. The researchers also aimed to quantify the quantities of suspended particles in the air. They selected the Algiers region as a case study, because it serves as the political and economic hub of Algeria. Algiers has been plagued by air quality problems, as evidenced by the presence of pollutants such as particulate matter (PM), nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), and ozone at levels that can have adverse effects on human health. Industrial emissions, automotive exhaust, and other human activities are the primary causes of air pollution. Industrial operations, transportation congestion, and the utilisation of fossil fuels for energy are contributing factors to high pollution levels.

The authors suggested three emission scenarios for 2030: (i) business as usual (BaU), (ii) governmental energy policies, and (iii) additional measures. The air pollutants nitrogen dioxide (NO<sub>2</sub>) and particulate matter (PM<sub>10</sub>) were considered.

Results by Belhout et al. (2018) suggested that the maximum annual concentration levels for PM<sub>10</sub> and NO<sub>2</sub> will increase from 122 to 129 µg/m<sup>3</sup> and from 91 to 124 µg/m<sup>3</sup>, respectively, between 2012 and 2030 (BaU scenario). These values are much higher than those set by national and international guidelines. The planned governmental energy policies could reduce approximately 20 µg/m<sup>3</sup> of PM<sub>10</sub> and 15 µg/m<sup>3</sup> of NO<sub>2</sub> by 2030, representing a reduction up to 15% for both pollutants compared to the BaU scenario. Considering governmental and additional measures, a reduction of around 35 and 30 µg/m<sup>3</sup> for PM<sub>10</sub> and NO<sub>2</sub>, respectively, is estimated, which corresponds to reductions up to 24% for both pollutants. Based on the obtained results, the implementation of additional air quality planning strategies is strongly recommended to promote the citizens' health.

In a recent study conducted by Belhout et al. (2021), an evaluation was carried out to assess the impact of Energy Efficiency Program (EEP) policies on air quality and human health in the urban area of Algiers, the capital of Algeria, by the year 2030. Indeed, as presented before, Algeria has committed to an ambitious sustainable development and renewable energy program to enhance the utilization of renewable energies and conserve fossil energy reserves. Focused on the transport, residential, and industrial sectors, the EEP aims to diversify energy sources and achieve a reduction in pollutant emissions ranging between 7 and 22% by 2030.

## DISCUSSION

Although Algeria possesses substantial financial resources, we have found that private investors with confidence face challenging obstacles in obtaining funding and credit. Financing was only allocated to massive fossil fuel projects. External financing was prohibited, masquerading as a measure to prevent government indebtedness. The fact that investors had to secure their own funds for the implementation of Hassi R'Mel's plan was not previously recognised. Furthermore, the contractual assembly was designed to adopt the structure of project finance, indicating that the initiative would be self-sustaining without relying on government support. The state's debt was truly inconceivable. The return on investment for renewable energy projects is not immediate. In order to enhance competitiveness, the latest initiatives necessitated financial consolidation over a duration of thirty-five years. IRENA's 2020 report states that a PSC+PV solar panchayat may now be maintained at a cost of 7 cents per kilowatt-hour, including storage.

The problem of intermittency has been overcome. The projected rates for 2021 and 2022 are \$0.05 and \$0.06 per kilowatt-hour (KWh), respectively (IRENA, 2020). This statement elucidates the peril that fossil fuels are currently confronting, as evidenced by the significant surge in their pricing (IRENA, 2020). The oil industry's lobbying efforts are mostly responsible for this situation, as they were ill-equipped to handle it. The main obstacle encountered by the oil conglomerates was their unwavering quest for attaining the highest possible subsidies for fossil fuels. According to (Hasni et al. 2021, pp. 11-12), it was observed that the potential annual revenue might reach \$15 billion.

Furthermore, the Algerian oil lobby enforced a protective measure by stipulating that any investment in the field of renewable energy must involve local production of equipment, in addition to the aforementioned restrictions. The 2012 Act, which removed regulations and abolished monopolies, faced opposition, ultimately hindering the progress of renewable energy. Sonelgaz has been exclusively authorised by the Ministry of Energy, through an Executive Decree, to undertake renewable energy projects.

External factors such as energy security, health expenses, and environmental degradation or climate change have not been taken into account. The economic comparison between fossil fuels and renewable energy sources is skewed as a consequence. As previously mentioned, this exacerbates the misconception caused by the magnitude of subsidies provided to fossil fuels.

The existing scholarly literature strongly supports that the transition of electricity and energy production to renewable sources such as wind, solar, and hydropower can significantly reduce emissions of key air pollutants such as particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), and sulphur oxides (SO<sub>x</sub>) when compared to fossil fuel combustion. These emission reductions have been demonstrated to bring about tangible improvements in air quality and public health across various contexts.

However, the effectiveness of air pollution mitigation depends heavily on factors such as the specific renewable technologies implemented, the prevailing energy mix, and other intersecting variables. Ongoing research is crucial to further investigate and understand effective policies and strategies that can maximise the co-benefits of improved air quality associated with the global expansion of renewable energy.

The legislative and regulatory framework completely negates the advantages provided by the 2012 Act, effectively stifling the expansion and advancement of renewable energy sources. The absence of a well-defined strategic plan for the development of the national economy will now be significant to us. The culture of wealth has ultimately eradicated any effort towards diversification. As previously said, it is necessary to have a clear economic plan that emphasises sustainable development and a decarbonised green economy. This is the only path that financiers and investors are currently prepared to pursue. The health crisis has underscored the extent to which economic growth can be achieved. The current situation of the economy signifies the culmination of a historical period. According to (Hasni et al., 2021, pp. 11-12), the failure of all renewable energy initiatives can be attributed to Sonelgaz's lack of political determination and commitment, which, when coupled with an apparent conflict of interest, rendered their implementation unfeasible.

Hasni et al. (2021, p. 11) noted also that despite electricity constituting only 20% of overall energy consumption, policymakers, who should possess a deeper understanding of the energy industry, have traditionally held the belief that electricity is the sole guarantor of energy security in the country. They failed to grasp the fact that wind and photovoltaic electricity are sporadic, which reduced their importance in developing the energy consumption model.

The future success of the implementation program's strategic goal for economic development hinges on the presence of fresh, top-notch human resources, as they are the essential resource needed. Algeria requires additional manpower to strengthen the new framework for sustainable economic growth. Specialised training institutions for technicians and engineers, with a specific emphasis on renewable or fossil fuels, have been shut down. In order to adequately prepare for artificial intelligence, it is imperative to establish more management training facilities, implement 5G transition strategies, and actively pursue the generation of Big Data. (Hasni et al., 2021, pp. 11-12) stated that using virtual currency to support blockchain concepts is a viable approach to tackle the problem of funding.

The transformation of Algeria's energy infrastructure to take advantage of the nation's abundant solar, wind, and complementary renewable resources promotes economic diversification and is consistent with international climate goals. As fossil fuel stocks diminish, it also offers co-benefits related to local air pollution and public health. A greater reliance on renewable energy sources can significantly lower emissions of sulphur oxides, nitrogen oxides, particulate matter, and other dangerous pollutants.

To put it briefly, in order to fully utilise Algeria's enormous potential for renewable energy, political will must be unwavering and calculated steps must be taken to overcome opposition from well-established hydrocarbon interests. Algeria may initiate a renewable energy transition by utilising its plentiful solar, wind, and other clean energy resources for national development priorities, provided that specific reforms are implemented to enable sustainable investments at scale.

## CONCLUSIONS

This article is a comprehensive review of Algeria's endeavours in the past twenty years to establish renewable energy sources. Several ambitious goals were established, including the generation of 8,000 MW from renewable energy sources by 2020 and 22,000 MW between the years 2015 and 2030. Nevertheless,

there has been limited advancement thus far. Chinese enterprises have added approximately 400 MW of solar PV capacity in the past two years, as of 2023.

Furthermore, we have conducted an examination of the primary obstacles that have impeded the expansion of renewable energy in Algeria, and we can succinctly outline them as follows:

- Insufficient determination from political leaders and absence of a well-defined strategy for renewable energy;
- There are significant subsidies provided for fossil fuels, amounting to approximately \$15 billion annually;
- Resistance from the influential oil and gas industry – Challenges related to securing funding and attracting private capital;
- Ambiguous and volatile regulatory framework – Monopolistic management of projects by Sonelgaz, a state-owned corporation;
- Insufficient training and lack of skilled workforce;
- Incentives and support mechanisms.

Several measures have been put in place to encourage the use of renewable energy sources, including:

- Implementation of legal provisions ensuring feed-in tariffs for a duration of 20 years;
- Establishment of a National Fund for Renewables to cover any additional expenses;
- Simplifying the process of obtaining licenses and acquiring land;
- Provision of financial resources for the implementation of experimental projects and training programs.

Nevertheless, these efforts have not been adequate to foster substantial expansion. Renewable energy sources have not been successful in gaining momentum in Algeria due to the lack of a well-planned and sustainable development strategy that aligns with global climate objectives. Additionally, there is a need for economic diversification in the country. Furthermore, we put out the subsequent points as proposed remedies and recommendations:

- Eliminating government financial support for fossil fuels;
- Challenging the dominant control of the energy sector;
- Executing the deregulation steps outlined in the 2012 Electricity Act;
- Drastically enhancing the scope of training and education programs to cater to the needs of a burgeoning cohort of energy experts;
- Investigating novel financing strategies, such as those based on blockchain technology.

The projected global transition to renewable energy is expected to drastically reduce the emission of major air pollutants, averting millions of pollution-related deaths each year. Further research is required to optimise the health-related benefits of strategically deploying renewable energy sources in various worldwide locations. The socioeconomic advantages of promoting the growth of renewable energy globally should take climate change mitigation and improved air quality into account.

### Author Contributions

Conceptualisation: A.B., H.L.C.; methodology: A.B., H.L.C.; validation: A.B., H.L.C.; formal analysis: A.B., H.L.C.; investigation: A.B., H.L.C.; resources: A.B., H.L.C.; writing-original draft preparation: A.B.; writing-review and editing: A.B., H.L.C.; visualisation: A.B., H.L.C.; supervision: A.B.; project administration: A.B., H.L.C.

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### REFERENCES

1. Abbasi, S. A., & Abbasi, N. (2000). The likely adverse environmental impacts of renewable energy sources. *Applied Energy*, 65(1-4), 121-144. [[CrossRef](#)]
2. Abdmouleh, Z., Alammari, R. A., & Gastli, A. (2015). Recommendations on renewable energy policies for the GCC countries. *Renewable and Sustainable Energy Reviews*, 50, 1181-1191. [[CrossRef](#)]
3. Abel, D. et al. (2018). Potential air quality benefits from increased solar photovoltaic electricity generation in the Eastern United States. *Atmospheric Environment*, 175, 65-74. [[CrossRef](#)]
4. Aguirre, M., & Ibikunle, G. (2014). Determinants of renewable energy growth: A global sample

analysis. *Energy Policy*, 69, 374-384. [[CrossRef](#)]

5. Akagi, S. K. et al. (2011). Emission factors for open and domestic biomass burning for use in atmospheric models. *Atmospheric Chemistry and Physics*, 11(9), 4039-4072. [[CrossRef](#)]

6. Alaoui, T., Belfedel, M., & Denai, M. (2023). Towards sustainable development and low carbon economy: Algeria's energy transition to prevent hydrocarbon risks. *Journal of Politic and Law*, 55(15), 474-513. [[CrossRef](#)]

7. Algerian Ministry of Energy and Mines (2023). Visited on 15/11/2023. [[Link](#)]

8. Angelis-Dimakis, A. et al. (2011). Methods and tools to evaluate the availability of renewable energy sources. *Renewable and Sustainable Energy Reviews*, 15(2), 1182-1200. [[CrossRef](#)]

9. Belhout, D. et al. (2018). Air quality assessment in Algiers city. *Air Quality, Atmosphere & Health*, 11, 897-906. [[CrossRef](#)]

10. Belhout, D. et al. (2021). Impact of energy efficiency policies on the air quality of a North African urban area: Emission scenarios by the horizon 2030. *Energy Efficiency*, 14, 1-14. [[CrossRef](#)]

11. Boulakhras, C. (2018). *Report on the Projects Implemented within the Framework of the National Renewable Energy Program; SKTM, a Subsidiary of the Sonelgaz Group: Ghardaïa, Algeria*. [[Link](#)]

12. Bouraiou, A. et al. (2020). Status of renewable energy potential and utilization in Algeria. *Journal of Cleaner Production*, 246, 119011. [[CrossRef](#)]

13. Bouznit, M., Pablo-Romero, M. D. P., & Sánchez-Braza, A. (2020). Measures to promote renewable energy for electricity generation in Algeria. *Sustainability*, 12(4), 1468. [[CrossRef](#)]

14. Carpejani, P. et al. (2020). Affordable and clean energy: A study on the advantages and disadvantages of the main modalities. In: Leal Filho, W., Borges de Brito, P., & Frankenberger, F. (eds) *International Business, Trade and Institutional Sustainability* (pp. 615-627). [[CrossRef](#)]

15. Chafe, Z. A. et al. (2014). Household cooking with solid fuels contributes to ambient PM<sub>2.5</sub> air pollution and the burden of disease. *Environmental Health Perspectives*, 122(12), 1314-1320. [[CrossRef](#)]

16. Cofala, J. et al. (2020). *Implications of Energy Trajectories from the World Energy Outlook for 2015 for India's Air Pollution*. [[Link](#)]

17. Creswell, J. W., & Creswell, J. D. (2017). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*. SAGE. [[Link](#)]

18. Dai, H. et al. (2016). Green growth: The economic impacts of large-scale renewable energy development in China. *Applied Energy*, 162, 435-449. [[CrossRef](#)]

19. EEA (2007). *Air Pollution in Europe 1990–2004. EEA Report No 2/2007*. European Environment Agency, Copenhagen. [[Link](#)]

20. Ellabban, O., Abu-Rub, H., & Blaabjerg, F. (2014). Renewable energy resources: Current status, future prospects and their enabling technology. *Renewable and Sustainable Energy Reviews*, 39, 748-764. [[CrossRef](#)]

21. Fares, T. (2021). Solar energy in Algeria between exploitation policies and export potential. *Journal of the New Economy*, 12(2), 279-293. [[CrossRef](#)]

22. Fragkos, P., & Siskos, P. (2022). Energy systems analysis and modelling towards decarbonisation. *Energies*, 15(6), 1971. [[CrossRef](#)]

23. Galimova, T., Ram, M., & Breyer, C. (2022). Mitigation of air pollution and corresponding impacts during a global energy transition towards 100% renewable energy system by 2050. *Energy Reports*, 8, 14124-14143. [[CrossRef](#)]

24. Gielen, D. et al. (2019). The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, 24, 38-50. [[CrossRef](#)]

25. Goodkind, A. L. et al. (2019). Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions. *Proceedings of the National Academy of Sciences*, 116(18), 8775-8780. [[CrossRef](#)]

26. Guentri, H., Benasla, M., & Ezaeri, K. (2020). The impact of Naama's 12 MW solar project on the Algerian southwestern electricity network. *Algerian Journal of Renewable Energy and Sustainable Development*, 2(2), 105-114. [[CrossRef](#)]

27. Hasni, T., Malek, R., & Zouiouche, N. (2021). *Algeria 100% Renewable Energy: Recommendations for a National Strategy of Energy Transition*. Friedrich-Ebert-Stiftung. [[Link](#)]

28. Hoogwijk, M. M. (2004). *On the Global and Regional Potential of Renewable Energy Sources*. Doctoral dissertation. [[Link](#)]

29. IPCC (2022). *Climate Change 2022: Mitigation of Climate Change*. Cambridge University Press.

[\[Link\]](#)

30. IRENA (2019). *Renewable Energy: A Gender Perspective*. [\[Link\]](#)
31. IRENA (2020). *Renewable Power Generation Costs in 2019*. Abu Dhabi. [\[Link\]](#)
32. Jacobson, M. Z. (2009). Review of solutions to global warming, air pollution and energy security. *Energy & Environmental Science*, 2(2), 148-173. [\[CrossRef\]](#)
33. Jacobson, M. Z., & Delucchi, M. A. (2011). Providing all global energy with wind, water and solar power. Part I: Technologies, energy resources, quantities and areas of infrastructure, materials. *Energy Policy*, 39(3), 1154-1169. [\[CrossRef\]](#)
34. Jacobsson, S., & Johnson, A. (2000). The diffusion of renewable energy technology: An analytical framework and key issues for research. *Energy Policy*, 28(9), 625-640. [\[CrossRef\]](#)
35. Khouildat, S., Zaid, M., & Traiche, M. (2019). Trends and policies of renewable energy in Algeria between reality and crucial future programs. *Journal of Development and Applied Economics*, 3(1), 285-295. [\[CrossRef\]](#)
36. Klimont, Z., et al. (2017). Global anthropogenic emissions of particulate matter including black carbon. *Atmospheric Chemistry and Physics*, 17(14), 8681-8723. [\[CrossRef\]](#)
37. Koussa, D. S., & Koussa, M. (2014). HOMERanalysis for integrating wind energy into the grid in South of Algeria. In: *International Renewable and Sustainable Energy Conference (IRSEC)*. Morocco. [\[Link\]](#)
38. Kurt, H., & Ozkaymak, M. (2006). Performance evaluation of a small scale sodium carbonate salt gradient solar pond. *International Journal of Energy Research*, 30(11), 905-914. [\[Link\]](#)
39. Lebbihiat, N. et al. (2021). Geothermal energy use in Algeria: A review on the current status compared to the worldwide, utilization opportunities and countermeasures. *Journal of Cleaner Production*, 302, 126950. [\[CrossRef\]](#)
40. Lelieveld, J. et al. (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature*, 525(7569), 367-371. [\[CrossRef\]](#)
41. Lund, H. (2007). Renewable energy strategies for sustainable development. *Energy*, 32(6), 912-919. [\[CrossRef\]](#)
42. Mohtasham, J. (2015). Review article – Renewable energies. In: *International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES15* (pp. 1289-1297). [\[Link\]](#)
43. Monforti-Ferrario, F., & Blanco, M. P. (2021). The impact of power network congestion, its consequences and mitigation measures on air pollutants and greenhouse gases emissions. A case from Germany. *Renewable and Sustainable Energy Reviews*, 150, 111501. [\[CrossRef\]](#)
44. Moriarty, P., & Honnery, D. (2012). What is the global potential for renewable energy? *Renewable and Sustainable Energy Reviews*, 16(1), 244-252. [\[CrossRef\]](#)
45. Moriarty, P., & Honnery, D. (2016). Can renewable energy power the future? *Energy Policy*, 93, 3-7. [\[CrossRef\]](#)
46. Novan, K. (2015). Valuing the wind: Renewable energy policies and air pollution avoided. *American Economic Journal: Economic Policy*, 7(3), 291-326. [\[CrossRef\]](#)
47. Oberschelp, C. et al. (2019). Global emission hotspots of coal power generation. *Nature Sustainability*, 2(2), 113-121. [\[CrossRef\]](#)
48. Parry, I. W. et al. (2014). *Getting Energy Prices Right: From Principle to Practice*. International Monetary Fund. [\[Link\]](#)
49. Pope Iii, C. A. et al. (2002). Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. *Jama*, 287(9), 1132-1141. [\[CrossRef\]](#)
50. Puzzolo, E. et al. (2016). Clean fuels for resource-poor settings: A systematic review of barriers and enablers to adoption and sustained use. *Environmental Research*, 146, 218-234. [\[CrossRef\]](#)
51. Raaschou-Nielsen, O. et al. (2013). Air pollution and lung cancer incidence in 17 European cohorts: Prospective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE). *The Lancet Oncology*, 14(9), 813-822. [\[CrossRef\]](#)
52. REN21 (2022). *Renewables 2022 Global Status Report*. REN21 Secretariat, Paris. [\[Link\]](#)
53. Sathaye, J. et al. (2011). *Renewable Energy in the Context of Sustainable Development*. [\[Link\]](#)
54. Sellami, R. et al. (2016). Market potential and development prospects of the solar water heater field in Algeria. *Renewable and Sustainable Energy Reviews*, 65, 617-625. [\[CrossRef\]](#)
55. Shahzad, U. (2012). The need for renewable energy sources. *International Journal of Information*

*Technology and Electrical Engineering* (pp. 16-18).[\[Link\]](#)

56. Tarin-Carrasco, P. et al. (2022). Reducing future air-pollution-related premature mortality over Europe by mitigating emissions from the energy sector: Assessing an 80% renewable energies scenario. *Atmospheric Chemistry and Physics*, 22(6), 3945-3965. [\[CrossRef\]](#)

57. UNECA (2012). *The Renewable Energy Sector in North Africa: Current Situation and Prospects*. Addis Abeba. [\[Link\]](#)

58. Vakulchuk, R., Overland, I., & Scholten, D. (2020). Renewable energy and geopolitics: A review. *Renewable and Sustainable Energy Reviews*, 122, 109547. [\[CrossRef\]](#)

59. Van Fan, Y. et al. (2018). A review on air emissions assessment: Transportation. *Journal of Cleaner Production*, 194, 673-684. [\[CrossRef\]](#)

60. Walker, G. (1995). Renewable energy and the public. *Land Use Policy*, 12(1), 49-59. [\[CrossRef\]](#)

61. Walker, G., & Devine-Wright, P. (2008). Community renewable energy: What should it mean? *Energy Policy*, 36(2), 497-500. [\[CrossRef\]](#)

62. Wang, F., Yin, H., & Li, S. (2010). China's renewable energy policy: Commitments and challenges. *Energy Policy*, 38(4), 1872-1878. [\[CrossRef\]](#)

63. WHO (2018). *Ambient (Outdoor) Air Pollution*. [\[Link\]](#)

64. Xie, Y. et al. (2023). Large-scale renewable energy brings regionally disproportional air quality and health co-benefits in China. *Isience*, 26(8), 107459. [\[CrossRef\]](#)

65. Xie, Y., Dai, H., & Dong, H. (2018). Impacts of SO<sub>2</sub> taxations and renewable energy development on CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> emissions in Jing-Jin-Ji region. *Journal of Cleaner Production*, 171, 1386-1395. [\[CrossRef\]](#)

66. Zafar, S. (2023). *Renewable Energy in Algeria*. [\[Link\]](#)

67. Zahraoui, Y. et al. (2021). Current status, scenario and prospective of renewable energy in Algeria: A review. *Energies*, 14(9), 2354. [\[CrossRef\]](#)

68. Zhu, J. Z., & Cheung, K. (2013). Summary of environment impact of renewable energy resources. *Advanced Materials Research*, 616, 1133-1136. [\[CrossRef\]](#)