

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2026, 16(6), 109-122.

Morocco's Energy Mix in the Context of Global Climate Change: A Socioeconomic Perspective

Asmae Chakir*, Hamida Lahjouji, Mohamed Tabaa

Multidisciplinary Laboratory of Research and Innovation, EMSI of Casablanca, Casablanca, Morocco. *Email: a.chakir@emsi.ma

Received: 09 June 2026 **Accepted:** 15 September 2026 **DOI:** https://doi.org/10.32479/ijeep.24326

ABSTRACT

As global climate challenges intensify, the transition toward low-carbon energy systems has become a central pillar of national sustainability strategies. Morocco, with limited fossil fuel resources and growing energy demand, has embarked on an ambitious energy transition aimed at enhancing energy security, promoting renewable energy, and contributing to global climate mitigation efforts. This paper adopts a qualitative descriptive approach based on a structural analysis of secondary data to provide an integrated and analytical reading of Morocco's energy transition in the context of climate challenges, emphasizing its economic implication. As a results, the country's energy transition strategy has a positive outcome in terms of job creation while dealing with climate change. This is because Morocco's economy is gradually developing alongside the country's energy transition, which has a positive impact on both the labor market and environmental conservation. Consequently, Morocco can fully realize its potential as a hub for renewable energy innovation and green growth.

Keywords: Morocco, Energy Transition, Climate Change, Sustainability, Energy Policy, Economic Development
JEL Classifications: Q42, Q43, Q52, Q58

1. INTRODUCTION

After 28 years and during COP28, a clear announcement affirming the correlated relationship between climate change and fossil fuel excess use was affirmed (Bourzac, 2024). After this confirmation several decisions and reforms were needed to be made to let the planet's temperature under control and below 2°C and perfectly control it around 1.5°C (Maka et al., 2024). One year later, in COP29 that was held in Baku, Azerbaijan, from November 11th to 22nd, 2024 (Mulcahy and Smith, 2024), was the right opportunity to unite and accelerate these reforms by trying to make it happened as quick as possible. This was further exacerbated after the extreme high planet temperatures recorded recently. Indeed, the World Meteorological Organization (WMO) reported recently on September 2024 that during all 2024 year the global mean surface air temperature was at 1.54°C, representing a temperature clearly judged above the pre-industrial average. This change has caused several heatwaves, floods, and cyclones that led to people deaths, injuries, missing and evacuation. These phenomena were especially remarked in low-income and middle-income countries, noting among others: Brazil, Kenya and Bangladesh (Mulcahy and Smith, 2024). Following thins, in COP29, two major issues was treated, namely: eliminating fossil fuels sources by increasing the use of renewable energy and demanding high-income countries to increase their financial support to vulnerable countries (The Lancet Regional Health – Europe, 2024). These countries contribute less to climate change but suffer most of its consequences, remains not fair at all (Wei et al., 2025). Those low-income countries need to get benefits and support to overcome any climate change-related natural disasters.

Globally speaking, this goal could be translated by a reinforcement of the share of energy use by 2030, by reaching 11000 GWh of capacity which needs to go side by side with a worldwide improvement in energy efficiency of between 2% and 4% every year until 2030 (COP28: Global Renewables and Energy

This Journal is licensed under a Creative Commons Attribution 4.0 International License

Efficiency Pledge, n.d.). This was announced in a public statement beforehand, and cooperation between the world's countries is an obligation, but of course the way to achieve it depends on each country and its specifications (Işık et al., 2025). However, no one can deny that the major cause of climate change is energy consumption and the demand for electricity, which is totally correlated with urban development and citizens' energy lifestyle (Wang and Moriarty, 2019; Abbass et al., 2018).

We should note that various countries especially those located near or surround the mediterranean sea has faced several periods of drought, due to lack of rainfall and water scarcity (Altieri et al., 2024). Morocco by its turn confront a huge variation of rainfall with a decrease in annual average rainfall to 30% depending on World Bank Group. The water resources of Morocco also tend to decrease due to the successive years of drought and the high temperatures due to evaporation that leads to lose the moisturization of soil which affects agriculture, food security directly and other sectors indirectly. Due to these issues that started at first with climate change, a commitment to overcome this global interest starts to be a necessity. For that reason, Morocco has showed a strong engagement to Paris agreement by addressing at its first Nationally Determined Contributions (NDCs) by setting targets to reduce greenhouse gas (GHG) emissions and submitted to the UNFCCC in 2016 (El Hafdaoui et al., 2024a).

The target was to reduce the greenhouse gas to 32% by 2030 (Ammari et al., 2022). This reduction was conditional and depended on external financial and technical support. This ambition was recently raised to 42% by 2030. During the updated NDC in 2021 (Fragkos, 2023; Kuramochi et al., 2021). Otherwise, a focus on renewable energy, energy efficiency, agriculture and water management were cited during the first and updated versions of the NDC during 2016 and 2021, respectively. Moreover, Morocco put the target to reduce up to 18.3% unconditionally and independently on external financial support (Kharbach and Chfadi, 2022).

The focus on renewable energy comes from the huge renewable potential that Morocco has. Indeed, Morocco dispose of around 5-7 kWh/m^2/day what lets the country able to install up to 20GW by 2030 (Mahdavi and Vera, 2023; El Hafdaoui et al., 2025). Furthermore, Morocco due to its coastline estimated around 3500 KW is characterized by 6-11 m/s as wind speed in their key areas like: Sahara, Atlantic coast and Rif mountains this is let up to 25 GW of wind energy available to be captured (Bousla et al., 2023). Noting that the hydropower energy has theoretically about 5 GW power distributed throughout the country. As a result, Moroccan potential is included between 50 GW and 75 GW of renewables which exceeds way much the energy needs (Allouhi, 2024; Mouhaya et al., 2025).

Actually, the use of energy of any type is related to the country with all its characteristics and especially its economic growth (Moudene et al., 2023). Energy is a fundamental driver of economic growth because it drives industry, transportation, infrastructure, building and human daily life (Economidou et al., 2020; Ibn Batouta et al., 2024). So, the way a country gets its energy gives an idea of its economic level. Furthermore, how sustainable this economic growth is, represents also represent a significance. Economic growth is done in a sustainable way when this development contributes less to the GHG emissions (Mekila Mbayam and Bounahmidi, 2025; Zakari et al., 2022). This was announced first by the organization for economic co-operation and development (OECD) as decoupling term (Nikfar and Mozaffari, 2024). Decoupling is the phenomenon when economic growth occurs without a significant increase in the use of material or a harmful environmental impact on the environment (Ben Azzeddine et al., 2024).

2. LITERATURE REVIEW

Among developing countries, we find Morocco with and economy, that is based essentially on the agriculture and the export. Recently the country took the decision to attract advanced industries, this factor has contributed positively to the economy development of the country (Ikram and Nahdi, 2025). This switch let the country be more dependent to the energy availability and make it harder to achieve the sustainability especially that Moroccan's energy imports exceed the 80% (Bouhal et al., 2018). However, the renewable energy sector that also gain a significance of importance in the country gives a positive future about the balance between economic growth and sustainability (El Mostafa et al., 2019a; Lebrouhi et al., 2024).

The use of renewable energy has gained this importance due to its contribution for the Moroccan strategy to reduce the GHG emissions, the commitment to climate goals and sustainability, the economic growth and job creation and the energy security and independence (Moore, 2017). In Morocco the demand for electricity is beginning to show a steady increase of more than 6% per year (Boulakhbar et al., 2020). This percentage will continue to rise, especially with urban development (Zhang, 2016). This, and the existence of problems related to climate change, has prompted Morocco to take the step of installing large-scale renewable energy production facilities and to commit, during the COP21 (Boulakhbar et al., 2020). This step is reinforced by Morocco's renewable energy potential as part of the African continent. Morocco has started to implement reforms and laws to create energy agencies and institutions dedicated to manage renewable energy in the country (Leonard et al., 2024; Slimani et al., 2024). In addition, Morocco is also encouraging private production based on renewable energy and has adopted a law (13-09) to control the production, sale and distribution of energy on Moroccan territory (Sahbani et al., 2016). Morocco has also set up several renewable energy production plants based on hydroelectricity, solar and wind energy. Indeed, around 5337 MW is produced just by renewable sources, distributed as follows: 2120 MW for Hydraulics, 2360 MW from wind energy and 857 MW from solar energy as announced by MASEN in 2024 (Projets, n.d.). With this strategy, Morocco achieved a renewable energy consumption of 34% last year. Morocco is continuing this strategy to reach a 52% share of use in 2030, as promised at COP21 (Moore, 2017). This strategy allows a safe and clear electrical evolution to meet the green objectives set by Morocco (El Hafdaoui et al., 2024a).

Morocco's energy situation and its renewable energy potential have been the subject of several publications. Most authors focus their analyses on the availability of this potential and the various energy sources that Morocco can leverage to meet the country's energy demand despite climate change. Furthermore, Morocco's geographic location and political stability give it economic significance and make it a target for economic investment. This latter aspect is also of great importance in literature. However, few articles address the significant descriptive relation between the country's economic growth and their environmental impact—and vice versa—nor do they address the socio-economic impact of the energy transition driven by the climate change.

Against this background, this paper aims to provide a structured analysis of Morocco's evolving energy mix and the governance mechanisms that support the energy transition. It addresses the following research question: How does the transformation of Morocco's energy mix contributes to the country's energy transition; how does it relate to the economic impacts of climate change and to what extent can it support a more sustainable growth trajectory?

By bridging technical and socioeconomic perspectives, the study provides a more comprehensive understanding of the dynamics shaping energy transitions in emerging economies that was not considered by previous studies.

To do so, the paper is organized as follows, the first session is dedicated to methodology, following by the second section summarizing the energy landscape in Morocco, Renewable energy and its current situation in Morocco is described in the third session, the fourth session present the Moroccan energy transition and policy, the fifth session examines the impacts of climate change on economic growth and the labor market, as well as the job creation potential of the energy transition. And prospects concerning the news energy sources in Morocco are summarized in the 6th session. Otherwise, the future and our future works are drawn at the end of the paper.

3. METHODOLOGY AND DATA

This study adopts a qualitative descriptive approach based on a structured analysis of secondary data. The objective is to provide an integrated and analytical reading of Morocco's energy transition in the context of global climate challenges.

The analysis relies exclusively on secondary sources selected for their institutional credibility, relevance, and temporal consistency. These sources include:

- Official national publications (Ministry of Energy Transition and Sustainable Development, MASEN, ONEE, HCP)
- International reports (IEA, World Bank, IRENA, UNFCCC)
- Peer-reviewed academic literature indexed in Scopus and Web of Science
- National and international policy documents related to climate change and energy transition.

The selection of documents followed three main criteria:

- Relevance to Morocco's energy transition and climate policy
- Publication date, prioritizing sources published after 2015 to ensure alignment with post-Paris Agreement dynamics
- Consistency and cross-validation of information across multiple sources.

The collected material was analyzed following a thematic and analytical framework structured around four dimensions:

- Energy system structure and vulnerabilities
- Renewable energy deployment and policy orientation
- Institutional governance of the energy transition
- Climate change and energy transition impacts on socio-economic and labor market.

This framework enabled a systematic organization of information and ensured coherence between energy, climate and development dimensions.

As a qualitative study based on secondary data, this work contributes to the literature through an analytical synthesis and a contextual interpretation of Morocco's energy transition. Unlike existing descriptive studies, which tend to address either the technical dimensions of renewable energy systems or their socioeconomic implications in isolation, this paper adopts an integrated approach that combines the analysis of the energy mix with its socioeconomic impacts. This interdisciplinary perspective remains relatively scarce in the existing literature.

4. ENERGY MIX IN MOROCCO

It's well known that achieving sustainable development in a certain country involves a balance between economic growth and environment protection (Azimi et al., 2025). Otherwise, securing the right amount of energy to satisfy economic development may affect the health of the environment (Fu et al., 2021; Huang et al., 2021). There is a strong relationship between development in several sectors in a country and the demand of energy (Gasparatos and Gadda, 2009). As a country's economic development is strongly linked to its energy consumption, the damage affecting the environment could be also important (Petrović, 2023). This link has contributed directly to climate change by increasing the greenhouse gas emissions (Saqib and Lean, 2023; Tao et al., 2023). This harm is caused essentially by using conventional resources as was clearly declared during the last COP.

Therefore, a change in energy sources and the adoption of renewable energies seems a safe step towards ensuring sustainability (Islam et al., 2025; L. Wang et al., 2025). So, we can name sustainable energy growth as the collaboration between economic, environment and social, as it's clear in Figure 1. Environmental side collaborates with raw materials and in return the economic side should control and minimize as much as possible its emissions. The environment in its turn gives the basic energy needs to the social side but in return people need to stand for environment protection. The social side also waits for job creation from the economic side and then goods, services and life facility

are then ensured. As result a sustainable growth in general is ensured and sustainable energy growth in specific is done.

Nowadays sustainability and responding to climate change in a sustainable way starts to get attention from countries all over the world, since the concern is global. Morocco as an active member of the UNFCCC (United Nations Framework Convention on Climate Change) and regularly participates in the COP (Conference of the Parties) climate summits, has also this mission to ensure a sustainable economic growth. Morocco is the country located in the North-West corner of Africa continent, its capital is Rabat and the country in all cover an area of around 710 850 km^2 with a coastline up to 3500km and a population of 36 828 330 in 2024, with up to 62.5% of the total population in 2023 representing people between 15 and 59 years, representing the active population according to High Commission of Planning (HCP). The growing population and especially the active population needs investment in different fields, such as education, health infrastructure and job creation. To satisfy all a concentration in economic development and growth is the point. To do so, Morocco developed different sectors for its economic growth that are judged as strategic for the country development, namely: industry, agriculture, energy mining, crafts, tourism, sea fishing, transport (Fakhraddine et al., 2025). These sectors need also energy to be developed.

Consequently, in 2023 most of the energy supply come from coal and oil. Figure 2, clarify that oil is the source of energy that contribute the most to the energy mix in Morocco with around 58% more than the half and followed by coal with a percentage of 31.7% (Morocco - Countries and Regions - IEA, n.d.). We can notice that the energy supply in Morocco is based essentially on oil and coal. These two sources constitute about 86% of the total energy supply in Morocco in 2023. The total energy supply represents the total amount of energy produced or imported by a country without counting the energy exported or stored. We noticed also that just oil and coal have seen a serious increase since 2000. Otherwise, since the natural gas and biofuels and waste know a slight decline. Furthermore, wind, solar and others are concerned by a sure increase since 2011, its collaboration in the total energy supply has doubled every year since then. We should note that the amount of energy imported has decreased from 96% in 2015 to 86% in 2023, which reflects the country's efforts to combat climate change. Otherwise, the rest is ensured by domestic energy production. Indeed, the energy produced domestically is based on renewables with around 40% in 2022 and 2.7% from natural gas, as it is clear in Figure 3. Otherwise, the energy coming from biofuels and waste is considered around 58.3%. With this percentage we can say that Morocco achieved nearly the target of increasing the part of use of energy coming from renewables that was set previously during the COP21, noting a percentage of 42% in 2020 and 52% in 2030. All percentage that is mentioned in this section is sourced from the International Energy Agency (IEA). The agency collects energy statistics from national administrations then harmonizes it into energy balances.

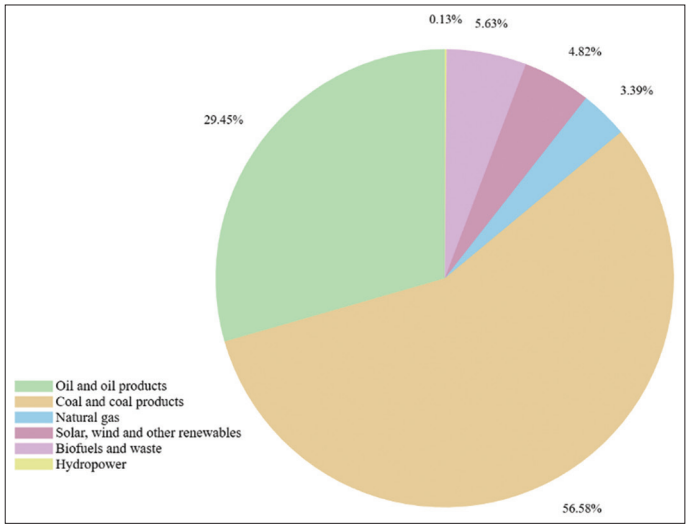
The main purpose of the total energy supply is to the energy transformation. At this stage the energy produced or imported like

Figure 1: Sustainable energy growth



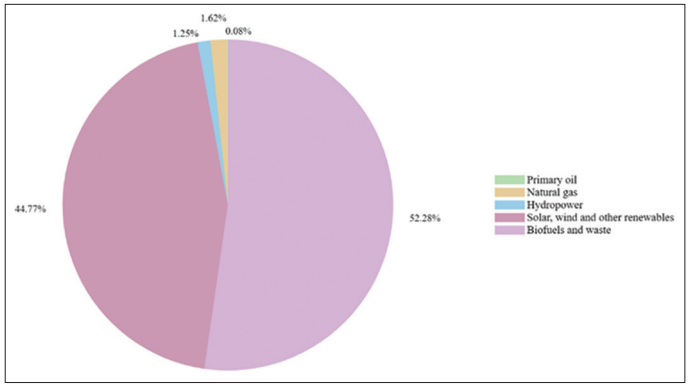
Source: Created by authors

Figure 2: Energy mix in Morocco



Source: By authors based on International Energy Agency (IEA), 2023

Figure 3: Domestic energy production in Morocco



Source: By authors based on International Energy Agency (IEA), 2023

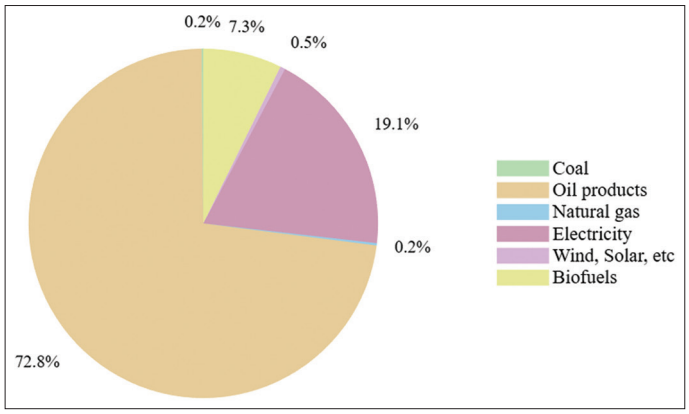
oil or coal is transformed into many other fuels and oil products that are more useful and practical. Otherwise, it can be burned like coal and natural gas to produce electricity and heat. For wind, solar and others, electricity is produced directly in a form which can be used as it is or also being involved in other transformation processes. In 2023, the total energy supply was mainly consumed for oil products following by electricity generation, as its clear in Figure 4.

The main sectors that consume this energy are the transport sector, followed by residential then industry sectors, Figure 5. Due to the urban growth the transport and residential sectors are increasing constantly. The industry sector is also increasing but less than the two major sectors consuming energy. The reason for that is the country's economic growth. Since 2002, Morocco has started the emergence plan for economic growth and decide to boost economic competitiveness. The other sectors have a steady development and then represent a consistent demand for energy. The reason is the implementation of energy efficiency strategies inside the commercial building and the shift for digitalization so the energy demanded remains the same or even less. Otherwise, the large cities in Morocco are already well developed when it comes to commercial building, and characterized with a strict energy budget that needs to be followed.

4.1. Energy Transition in Morocco

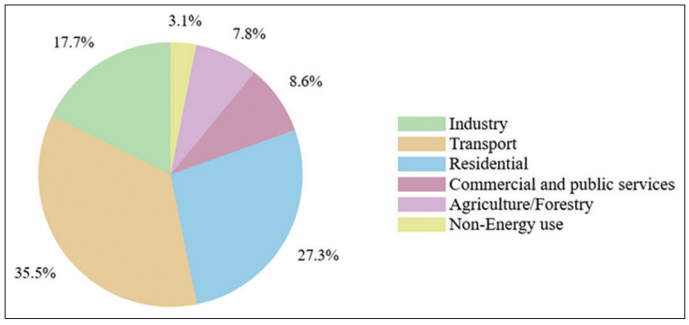
According to the previous section Morocco used to be a great importer of energy in the North Africa, with a percentage that hits around 90% and most of it comes from fossil fuels. Although, this percentage starts to decrease over years by increasing the investment in renewable energies (Sabry, 2025). Otherwise, the country will continue to do so, especially with what is happening in the world fossil fuel market. By considering also the correlation between economic growth and the demand for energy (Chen and Zhang, 2025). Furthermore, urban development increases constantly which raises the electricity demand in building and influencing the inhabitants' electrical behavior that needs to be satisfied to ensure the consumer electrical and thermal comforts (Modarres, 2017).

Figure 4: Final energy consumption



Source: By authors based on International Energy Agency (IEA), 2023

Figure 5: Energy consumption by sector



Source: By authors based on International Energy Agency (IEA), 2023

Morocco and due its location is considered as a rich country in terms of renewable energy potential, namely: solar energy, wind and hydropower energies (Assadiki et al., 2025). These three sources are considered now in Morocco as the three beams that helped the country to reach its goals set in 2016 for the horizon on 2020 and 2030, a part of use of renewable sources of 42% then 52%, respectively (El Hafdaoui et al., 2025). In the same context, we note hydropower energy as the most mature and historical source of energy in the country. Morocco has some stations installed and in operation since the previous century based on this kind of energy. The country encounters a lot of dams that are in service not only to produce electricity but also for irrigation and water supply (El Majdoubi and El Ayadi, 2025). Otherwise, the main objective of these stations is to produce electricity specifically (Mouhaya et al., 2025). The most powerful stations are in the center, especially the Atlas Mountains, the north/northwest, and the southwest regions. The choice of these regions was not made arbitrarily but based on geography, rivers, altitude, and water availability. The summary of the locations on the map are presented in Table 1. These latter are counted for electricity production and have played a significant role since their creation. However, recently this source has declined for many reasons, and mainly with the hydric stress and drought (El Asli and Azeroual, 2025). In 2010, the contribution of hydropower reached 14,5%, but recently and in 2021 and depending on Statistica research department this percentage has declined to <3% (Morocco: Hydropower Share in Electricity Production| Statista, n.d.). Due to this decline Morocco made significant improvement in other renewable energies that contributes recently to the 38% in the share of use of electricity (El Hafdaoui et al., 2025).

For this reason, Morocco has focused its effort to implement solar and wind energies due to the large amount of potential that is available. Indeed, Morocco has positioned itself as a leader in solar energy in Africa. The Moroccan kingdom has more than 5 kWh/m^2/d as average Global Horizontal Irradiation (GHI) (Benbba et al., 2024). This could be estimated as more than 1825 kWh/m^2 of solar potential over the year that could be captured (Belmahdi and El Bouardi, 2020). This huge potential has enabled Morocco to commit during the COP21, the 21st Conference of the Parties held in Paris, France, from November 30 to December 12, 2015, to contribute into letting the global temperature of the plant under control and not exceeding 2°C above pre-industrial levels, then make efforts to limit the value by not exceeding 1.5°C. Thereafter, Morocco continues its strategy to ensure energy transition and implementing reforms towards this engagement. Agencies, foundations and clusters were created just to take the

Table 1: Hydropower projects in Morocco

Implementation site	Characteristics	Implementation site	Characteristics
Mohammed V	Surface area: 0.15 ha Installed power: 23 MW CO_2 avoided: 53,100 t/year Commissioned: 1967	Boufekrane	Installed power: 0.6 MW Commissioned: 1925
Bouareg	Installed power: 6.4 MW Commissioned: 1969	El Kansara	Surface area: 0.2 ha Installed power: 14 MW CO_2 avoided: 17,000 t/year Commissioned: 1935
Allal El Fassi	Surface area: 2,1 ha Installed power: 240 MW CO_2 avoided: 191,160 t/year Commissioned: 1994	Boufekrane	Installed power: 0.6 MW Commissioned: 1925
Al Wahda	Surface area: 0.32 ha Installed power: 240 MW CO_2 avoided: 283,200 t/year Commissioned: 1998	Oued El Makhazine	Surface area: 0.5 ha Installed power: 36 MW CO_2 avoided: 42,480 t/year Commissioned: 1979
Taza	Installed power: 0.6 MW Commissioned: 1929	Al Massira	Surface area: 9 ha Installed power: 128 MW CO_2 avoided: 255,000 t/year Commissioned: 1980
Imezdilfane/Taskdert/Tajemout	Installed power: 128 MW CO_2 avoided: 140,000 t/year Commissioned: 2025	Mouley Youssef	Surface area: 1 ha Installed power: 24 MW CO_2 avoided: 47,700 t/year Commissioned: 1974
El Menzel	Installed power: 95 MW CO2 avoided: 165,000 t/year	Hassan I	Surface area: 70 ha Installed power: 67 MW CO2 avoided: 89,700 t/year Commissioned: 1991
Ahmed El Hansali	Surface area: 1.2 ha Installed power: 92 MW CO_2 avoided: 260,000 t/year Commissioned: 2003	Agdez	Installed power: 20 MW CO_2 avoided: 22,500 t/year Commissioned: 2023
Lau - Talambot	Installed power: 14.1 MW Commissioned: 1942	Lalla Takerkoust	Surface area: 7.22 ha Installed power: 12 MW CO_2 avoided: 11,700 t/year Commissioned: 1934
Afourer	Surface area: 2.5 ha Installed power: 94 MW CO_2 avoided: 273,000 t/year Commissioned: 1953	Step Abdelmoumen	Installed power: 350 MW Commissioned: 2022
Fez	Installed power: 3.1 MW Commissioned: 1934	Maachou	Installed power: 20,8 MW Commissioned: 1929

Source: by authors based on MASEN, 2025

renewable energy and solar sources to a high level. These key actors helped to implement until now a lot of plants based on wind turbine and solar energy in all the territory of the Moroccan Kingdom. To that date Morocco has installed up to 2024, 2120MW from hydroelectricity, 2360MW from wind turbines including private projected that are developed in 13-09 law context, and 857 MW from solar energy (MASEN, n.d.).

Solar energy in Morocco is advanced while integrating several large-scale power plants, many of them are under the name of Noor, this name that means light or irradiance selected at first by the project developers and government officials giving a positive impact and a bright future for the project, as the name has a significant and deep meanings. We find among these project, Noor Ouarzazate Solar Complex located in Drâa-Tafilalet region (Laaroussi et al., 2021). These projects use the Concentrated Solar Power (CSP) technology, that utilizes parabolic through systems and molten salt thermal storage. This helps in providing reliable production for the grid, because it continues generating electricity even after sunset and with no irradiation. It includes Noor I, Noor II, Noor III and Noor IV, providing 160 MW, 200 MW, 150 MW and 72 MW, respectively (Boulakhbar et al., 2020). We should note that the fourth Noor used photovoltaic technology as a strategic decision that comes 2 years later in 2018 after the launching of the project at first in 2016 (Azzaoui and Alami Merrouni, 2025). In fact, the use of this technology is chosen for cost, scalability and to take advantage of the last advances of solar technologies. With the same technology other large-scale plants but with less power are also in operation, noting among others: Ben Guerir Solar Plant, Laayoune Solar Plant, Tafilalet Solar Project, Oualidia Solar Plant, providing 70 MW, 80 MW, 100 MW and 30 MW, respectively. Other well-known projects are under construction or development to strengthen the solar energy part of use, like: Khouribga Solar Plants, Noor Midelt I, Dakhla Hybrid Project, using technology PV, CSP and PV, then Wind and solar, respectively. Table 2 resumes all the

Table 2: Solar projects in Morocco

Implementation site	Characteristics	Implementation site	Characteristics
Ain Beni Mathar	Superficie: 160 Puissance installée: 20 Mise en service: 2010	Noor Midelt I	Superficie: 939 Puissance installée: 800 CO_2 évité: 675,360 Mise en service: 2022
Noor Bouanane	*Projet ONEE	Noor Bejaad	Superficie: 400
Noor Guercif	Superficie: 400	Noor Kelâa des Sraghna	Superficie: 473
Noor Outat El Haj	--	Noor Ouarzazate I	Superficie: 480 ha Puissance installée: 160 MW CO_2 évité: 280,000 t/an Mise en service: février 2016
Noor Enjil	--	Noor Zagora	Puissance installée: 40 MW Mise en service: 2019 *Projet ONEE
Noor Missour	Puissance installée: 40 MW Mise en service: 2019 *Projet ONEE	Noor Lakhtatba	Superficie: 300
Noor Boudnib	--	Noor Tata	--
Noor Erfoud	Puissance installée: 40 MW Mise en service: 2019 *Projet ONEE	Noor Taroudant	Superficie: 393 ha
Noor Lhajeb	Superficie: 212	Noor Tantan	--
Noor Boujdour I	Superficie: 60 ha Puissance installée: 20 MW CO_2 évité: 23,855 t/an Mise en service: 2018	Noor Laâyoune I	Superficie: 240 ha Puissance installée: 85 MW CO_2 évité: 104,300 t/an Mise en service: 2018

Source: by authors based on MASEN, 2025

PV plant station that Morocco encounter until date with sites specification.

Otherwise, Morocco also has a focus for wind energy due to the favorable geographical site, especially in the coast and mountains (Anoune et al., 2018). As the end of 2024, Morocco has around 2360 MW just from wind that reflects the commitment of the country to expenses and meet the target set previously. Starting with Amogdoul wind farm, Essaouira, in 2007 with a capacity of 60 MW, Morocco continued to develop its farms gradually and like every 3-4 years the country reached a milestone (Haidi et al., 2021). Three years after the country succeed Tangier I Wind Farm, in 2010 with a capacity of 140 MW, we found Tarfaya Wind Farm, Akhfenir Wind Farm, Aftissat Wind Farm, Khalladi Wind Farm, Midelt Wind Farm and Taza Wind Farm Phase I, with capacities 301 MW, 200 MW, 200 MW, 120 MW, 210 MW, 87.2 MW, respectively (Bousla et al., 2025). Other wind farms will be developed soon especially in Essaouira, Midelt, Boujdour, Taza and Laayoune, with interesting capacities, noting for example for Laayoune the capacity will reach the 300 MW. Table 3 resumes all the wind farms that Morocco encounter until date and their actual places.

4.2. Morocco's Energy Policy and Stakeholders

Since 1971 and with an energy imports rate of around 61%, Morocco has faced an increase in the Kingdom's imported energy of about 1-2% every year until reaching 88% in 2007-2008 and recording a peak of 96% in 2018 (Morocco Energy Imports: Volume: Annual|Economic Indicators|CEIC, n.d.; Morocco Energy Imports - Data, Chart|The Global Economy.Com, n.d.). Consequently, and since then the country tried to reduce as much as possible the dependance to energy imports, particularly fossil fuels like oil, natural gas and coal (Mahdavi and Vera, 2023).

This strategy comes with the energy transition that Morocco started since 2008. Officially in 2009, Morocco's National Energy Strategy was launched as a long-term planning aimed to transform the country's energy sector (Alhamwi et al., 2015). The target was to lower the energy dependance by increasing the use of renewable energy use up to 42% by 2020. Then increasing this part of use up to 52% by 2030, by allocating a contribution of 20% from solar, 20% from wind and 12% from hydropower. Noting that natural gas can reduce greenhouse gas emissions by up to 50% compering to other fossil fuels sources like coal and oil (Crow et al., 2019). For these matters, Morocco put that time a target to install an additional capacity of 3,900 MW from gas turbine system using imported natural gas by 2030. Also, by this year Morocco expected to improve the energy efficiency up to 15%. Moreover, energy consumption needs to be reduced to meet the previous targets, especially for building, industry and transportation. These three sectors are considered the most consumer of energy in any country, notably Morocco. The reduction was expected to reach 12% by 2020 and 15% by 2030 (El Iysaouy et al., 2019).

Three years after the launching of the energy transition strategy, wind and solar projects starts officially. In 2012, Morocco started the Tarfaya wind turbine farm (El-Maaroufi et al., 2025), completed in 2014 and considered now as the largest wind farm in Africa, and the Noor solar complex power plant project that started its construction in 2015 in Ouarzazate (Terrapon-Pfaff et al., 2019). This plant is considered now as the important concentrated Solar Power (CSP) plant. Some interconnection also was launched that time to export the renewable energy from Morocco to Europe, passing by Spain (Coordinator et al., n.d.; Escribano, 2019).

In 2015, Morocco patriciate to COP21 that was held in Paris, France. This version insists on climate actions and steps towards

Table 3: Wind projects in Morocco

Implementation site	Characteristics
Haouma*	Installed power: 50 MW Commissioned: 2013 *This project falls within the framework of Law 13-09
Jbel Khelladi*	Installed power: 120 MW Commissioned: end of 2017 *This project falls within the framework of Law 13-09
Koudia Al Baida Repowering	Surface area: 230 ha Installed power: 100 MW CO_2 avoided: 308,000 t/year Commissioned: 2024
TAZA – PEI Phase I (150 MW)	Surface area: 800 ha Installed power: 150 MW CO_2 avoided: 200,000 t/year Commissioned: 2022
Midelt - PEI (850MW)	Surface area: 2 230 ha Installed power: 210 MW CO_2 avoided: 326,000 Tco2/year Commissioned: 2020
Amogdoul	Surface area: 1 600 ha Installed power: 60 MW CO2 avoided: 136 000 Tco2/year Commissioned: 2007
Akhefennir 1 and 2*	Installed power: 203 MW Commissioned: 2013-2016 *This project falls within the framework of Law 13-09
CIMAR	Installed power: 5 MW Commissioned: 2012 *This autoproduction project falls with the framework of Law 54-14
Aftissat	Installed power: 200 MW Commissioned: 2018 *This project falls within the framework of Law 13-09

Source: by authors based on MASEN, 2025

energy transitions taken before COP22 (Slighoua et al., 2022). Morocco has played an important leadership during the event and submitted its Nationally Determined Contribution (NDC), where it mentioned a reduction of greenhouse emissions up to 42% by 2030 and confirming the increase of the part of use of renewable energies up to 52% by 2030 (Fragkos, 2023). As a result, the country was selected to host the following COP22 in 2016, in Marrakech and known as COP of actions, responsible for transforming COP21 commitment into actions. Also, a focus on promoting the climate finance and climate justice especially for developing countries and African countries as they are the most touched with the climate change. Morocco during his host of COP22 showcases the project of Noor solar complex as a huge step towards performing COP21 decisions. Another important point was tackled during this version of COP is the fact of promoting the inclusion women in climate decision-making, as a part of supporting gender equality (Huang et al., 2021).

From COP22 until now Morocco continued to install renewable power plants, notably for solar, wind and hydropower (Gargab et al., 2025). To this date, Morocco accounts around 45% of renewables just for country's electricity generation (International Monetary Fund. Middle East and Central Asia Dept, 2024). The country maintained its role as a leader of climate action and participates in several climate forums around the world. Morocco has strengthened its partnerships with international organization from European union and united states/From than to now Morocco has enacted several laws and energy key actors to help in the green economic agenda (Choukri et al., 2017). To achieve all the objectives set at first and collaborate with maximum countries to reach all together the COP's goals, several reforms have been implemented in Morocco (El Hafdaoui et al., 2024b). In 2006, law 54-04 was launched to delegate management of electricity to private entities, bringing together technical expertise, innovation and quick response to issues. Two years later, in 2008, law 16-08 was launched to encourage self-production using renewable energy generation, this law allows individuals and companies to produce electricity for their own use (self-generation), especially from renewable sources like solar and wind. In 2010, four laws have been launched, 57-09, 16-09, 13-09 and 40-09 that stands for establishing MASEN (Moroccan Agency for Sustainable Energy), the creation of ADEREE (National Agency for the Development of Renewable Energy and Energy Efficiency), which was amended and supplemented by Law 39-16 and has been operating since 2016 under the name AMEE (Moroccan Agency for Energy Efficiency), regulating the use of renewable energies throughout Moroccan territory and merging the National Office for Electricity and the National Office for Drinking Water into ONEE, respectively.

In 2015, by law 58-15, private generators could sell up to 20% of their production to the grid and in 2016 law 38-16 was launched to transfer the renewable energy assets to MASEN, things that were under the management of ONEE. The law 54-14 comes to raises the threshold for self-generated electricity from 10 MW to 50 MW, allowing individuals and entities to produce more electricity for their own use, it's a law that comes to amend and supplement Article 2 of Dahir No. 1-63-226 of 14 Rabi' I 1383 (August 05, 1963) establishing the National Office of Electricity, and Article 5 of Law No. 40-09 concerning the National Office of Electricity and Drinking Water (ONEE). In the same year, 2015, the Autorité Nationale de Régulation du Secteur de l'Électricité (ANRE) was indeed created under Law No. 48-15. This authority has the responsibility to manage the electricity sector and regulate prices and maintain the service quality.

In 2022, law 40-19 was established that aims to enhance Morocco's energy security, promote sustainable energy sources, and support the transition to a greener energy economy. And lastly, in 2023, a significant step towards a more sustainable and resilient energy system in Morocco was ensured by the law 82-21, this law allows individuals and businesses to produce electricity for their own use with a maximum generation capacity for different categories of producers and establishes procedures for connecting self-generation systems to the national grid and sale the surplus of the energy of the grid under certain conditions. From the law creation we could identify several energy key actors that are working for a more sustainable future in Morocco, but still others have also significant role or even the main collaborative of previous created actors or agencies.

4.3. Climate Change Impacts on Morocco's Economic Growth, Labor Market and Green Job Prospects

Over the past decade, Morocco has experienced an important economic growth driven by an ambitious national strategy aimed to improve the country's regional and global competitiveness. As a result of this structural transformation, the composition of Morocco's GDP has significantly changed (Haddadi and Lahjouji, 2025). Three decades ago, the agricultural sector represents for 18.6% of the national GDP, actually, in 2024 its contribution has decreased to 10.6%, reflecting a long-term decline in agricultural value added to GDP. Today, the Moroccan economy is dominated by the services sector, followed by industry, representing consecutively 52.8% and 25.6% of GDP, confirming Morocco's transition to a more diversified economic structure (Afonso and Blanco-Arana, 2024).

This decline of agricultural sector productivity is the result of combination between structural reforms and climate change impacts (Belmahi et al., 2023). The intensification of hydric stress and recurrent droughts has directly affected both economic growth, employment dynamics and food prices (Lahjouji et al., 2025).

In addition to recurrent drought, Morocco faces a growing exposure to natural hazard, with a record of 20 major flood events between 2000 and 2021 and direct losses estimated at 450 million USD. The IMF (International Monetary Found) estimate that the flood related damages could reach almost 1% of GDP by 2050, therefore, mitigating these risks and strengthening resilience will require approximately 77.7 billion USD between 2022 and 2022 (Alfani et al., 2023).

These climate change challenges highlight the broader macroeconomic vulnerabilities Morocco faces as temperatures continue to rise and water scarcity intensifies. Long-term projections towards OECD levels suggest that, climate change will gradually affect economic performance: persistent warming could reduce GDP per capita to 0.7% under a high-warming scenario and to 1.4% under a very-high-warming scenario by 2050. This decline reflects a possible deterioration in living standards (Document PBT 25-27 Version Fr Finale.Pdf, n.d.). However, Morocco deployed a long-term strategy response to this climate change statement, this vision is articulated through the National Sustainable Development Strategy (2017) and the National Climate Plan (2019), both central objective is to reconcile economic growth with emissions reduction while promoting national energy security.

To operationalize this transition, Morocco has progressively strengthened its legal and institutional framework (Nationally Determined Contributions Registry|UNFCCC, n.d.).

- Law 47-09 (2008) institutionalizes energy efficiency audits across all sectors
- Law 13-19 (2010) focuses on enhancing energy security and reducing GHG emissions
- Law 57-09 (2010) established MASEN, responsible for implementing large-scale renewable energy programs
- Law 82-21 (2022) regulates self-generation of electricity, promoting decentralized clean-energy production.

These reforms directly support Morocco's Nationally Determined Contribution (Siriwardana and Nong, 2021), which the total cost of implementing is estimated at USD 38.8 billion (Morocco_NDC_Eng.Pdf, n.d.).

Morocco has also strengthened its climate-finance ecosystem by mobilizing substantial support from the Green Climate Fund (GCF) (Fonds Vert Pour Le Climat/FVC|Climate Promise, n.d.). These include:

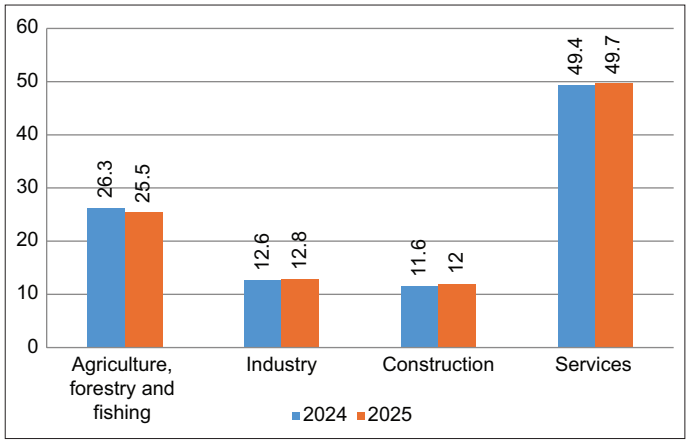
- A USD 35 million grant for a multi-country program with the EBRD to expand sustainable renewable-energy financing
- USD 31 million for the transformation of climate-aligned financial systems in partnership with AFD
- USD 100 million under the Climate Investor One facility supporting renewable-energy project preparation and implementation.

Despite Morocco's advances in climate policy, the growing intensity of climate impacts is increasingly disrupting employment and transforming labor market conditions.

The Moroccan labor market has been characterized by contrasting dynamics in the last decade, marked by significant structural changes (Moussir et al., 2020). While new growth sectors have emerged, traditional activities still remain crucial for the country's social and economic balance. According to the High Commission for Planning (HCP), the agricultural sector is a key component of the Moroccan labor market. It ranks as the second-largest employer, after the services sector, which comprises 49.2% of the workforce. By 2025, agriculture accounts for 26.3% of total employment, of which 61.7% in rural areas (Situation Du Marché Du Travail En 2025, n.d.). However, despite this perceived importance of the agricultural sector, this one is the only sector to record a net decline in employment, with a loss of 41,000 jobs in 2025, while other sectors, such as services, industry, and construction, have created more jobs compared to the previous year (Figure 6). This negative trend highlights the growing vulnerability of Moroccan agriculture to climate shocks.

In fact, Morocco is facing a sustained rise in temperatures and increased water stress, which are putting a strain on agricultural

Figure 6: Employment structure by economic sector (%)



Sources: HCP (2026)

production systems (El Haddadi et al., 2025). Recent work by Alfani et al. (Alfani et al., 2024) clearly shows that increased drought events, water scarcity and soil degradation affect the sector's ability to maintain its workforce and productivity levels. However, this structural fragility opens up an essential debate on the future of job creation in Morocco, particularly, on the role those renewable energies, the green transition and new production models could play in building a more resilient, inclusive and sustainable labor market.

According to the World Bank report on job creation in Morocco during the energy transition, the government's energy efficiency and renewable energy targets could generate an average of 25,000 jobs per year between 2020 and 2050, which is about 8,5% of Morocco's annual job creation shortfall. By 2050, this would represent a cumulative potential of around 760,000 net jobs, confirming the sector's capacity to contribute significantly to the transformation of the labor market (Job Creation and Skills Development During the Energy Transition - Morocco, n.d.). This dynamic affects a wide range of professions in RE and EE companies, such as: consulting, technical engineering, operations and maintenance (O&M), research and development (R&D), training and education. This type of jobs reflects a growing need for qualified professionals and expert on technological innovation and the green transition (Accélérer La Transition Énergétique Pour Installer Le Maroc Dans La Croissance Verte - CESE, n.d.), and lead to the creation of new jobs related to solar and wind energies, such as installers, technicians, plant managers and quality engineers in Solar and Wind sectors (International Labour Organization, 2018).

Moreover, based on a survey conducted by the World Bank in 2024, the companies active in energy efficiency account for 88% of highly skilled employees, compared with only 12% of technician's profiles. Renewable energy companies have a more varied structure: 44% of employees are highly skilled, 33% technicians and specialists and 23% manual workers and operators. Indeed, these sectors are attractive to young people, with 45% of employees in EE companies are under the age of 25, confirming their ability to absorb a part of the youth active population (Job Creation and Skills Development During the Energy Transition - Morocco, n.d.). While the impacts of climate change are affecting negatively the agriculture sectors, the energy transition is clearly positioning as a strategic path for reshaping employment in Morocco.

The effectiveness of the energy transition's impact on economic development depends on national policy efforts that should strengthen financial and institutional frameworks while enhancing workforce capabilities.

According to the World Bank recommendations, this includes targeted financial supports to SMEs to facilitate their participation in renewable projects, establishing a clear strategic vision with defined job creation targets adapted to the local content development. In addition, improving coordination among stakeholders and reinforcing governance mechanisms for policy coherence and implementation efficiency.

On the labor side, enhancing employability through inclusive training programs, particularly for low-skilled, highly qualified, and disadvantaged or rural youth.

Finally, adopting a just energy transition approach that prioritizes social inclusion, decent work, and poverty reduction remains fundamental to maximizing the socioeconomic benefits of Morocco's energy transition.

4.4. Green Hydrogen and Morocco's Sustainable Future

Morocco's energy transition dates back a long way. In fact, the oldest renewable energy source is hydroelectricity, represented by the oldest dam that was commissioned in 1945n, and since then Morocco has been making steady progress towards the energy transition and expanding its use of renewable energies (Meliani et al., 2021). This is illustrated by the number of renewable energy projects that have been launched, as well as future projects under construction or in the planning stage (Nakach et al., 2023).

Morocco expands its renewable energy progressively with an objective to be the regional leader in clean energy (Daoudi, 2024; Sakhraoui et al., 2024). Indeed, the motivation that every African country has is the potential of renewable potential availability (Bouramdane, 2024). In fact, Morocco dispose of more than 5KWh per m^2 just for solar energy and a wind speed of around 4-5 m/s for wind energy (Bakkari et al., 2024). This amount of potential lets Morocco do plans to extend projects and plants in both sources, solar and wind energy. More than 7 billion euros of investment has been dedicated to securing over 7 gigawatts (GW) in renewable energy capacity over and above the existing. This was declared by Leïla Benali, Morocco's Minister of Energy Transition and Sustainable Development, on December 17, 2024 in Casablanca during the opening of the 9th edition of the X-Maroc Colloquium.

The Solar energy is expected to dominate, by planning to install 3.2 GW of additional capacity for the horizon of 2030, actually passing from 857 MW in 2024 to 4083 MW up to 2030, the key projects for this expansion are: The Noor Midelt II hybrid complex and the Tafilalet solar program (Yahya et al., 2024). The first project will be able to give access to 400 MW of energy. This project combines bifacial PV modules with molten salt thermal storage. This hybridization will facilitate the task for the dispatching between energies. For the second project the target is 120 MW of decentralized PV especially for rural electrification. Furthermore, the wind energy is concerned by an expansion of 1.7 GW for an objective of 5 GW by 2030 (Bakkari et al., 2024). Morocco has 1.5 GW and there is a project to add 850 MW with the integrated wind program, that will deploy 4.2 MW turbine at Jbel LAhdid (Projet De Parc Eolien Jbel Lahdid, n.d.). With these projects there is a risk for grid stability as critical challenge. As a solution, 350 MW of pumped hydro storage in Abdelmoumen were ensured. Depending in Research of Morocco continues with this persistence and this growth in a steady way will reaches 60% of renewable penetration by 2030.

Prospects also remain a reality with investments by Morocco and EU partnerships for the green hydrogen production (Bahou, 2025;

El Hassani et al., 2024; Ourya et al., 2023). With this news and collaboration, Morocco strategically and potentially could become the global leader in the production of green hydrogen. The strategy is to involve the future projects for empowering electrolysis at a competitive price. This cost depending on studies can achieve 2$/kg by 2030 (Marzouk, 2023; Rasul et al., 2022). Like that Morocco will be in position to help in decarbonization efforts especially for Europe countries. A large-scale project in Tarfaya was already launched for ammonia production. This Project is named HEVO backed by international investors for a production of 183,000 tons/year (Weko et al., n.d.).

Since Morocco has a relevant geographical site which is so near to Europe, GH_2 exports seems so easy and cost effective. Indeed, pipeline and maritime routs between Europe and Morocco represent a logistical advantage. The European union launched a plan to import 10 million tons of renewable hydrogen by 2030, called REPowerEU. This project aims to cancel progressive imports of fuels that could be influenced by geopolitical tensions or conflicts, save energy, diversify the energy supply and produce clean energy. This will help to keep climate change under control, since it's a global concern. This vision was supported by the Moroccan government and launch "Green Hydrogen Roadmap" with a target of 4GW of electrolyzes capacity by 2030. To do so, partnerships with Germany, Portugal and the World Bank was formed. This objective is facing some challenges that the country overcomes once identified, such as the scarcity of water that the government managed with sea water desalination investments. Morocco can reinforce its role as a renewable energy hub if the country could just capture a certain percentage of the global GH_2 market (Khaldi and Mounir, 2025).

Morocco also took steps toward energy efficiency, with the consideration of research, recent technologies and public-private collaboration to reduce the energy demand and carbon emissions (Gargab et al., 2025). An amount of advancement has been used and developed for this purpose, noting among others: Smart grid applications, high efficiency LED lighting and building insulation standards like RTCM for thermal regulation, can cut the excessive use on energy and optimize it up to 20%. The Moroccan Agency for Energy Efficiency (AMEE) is the public agency that stands under the supervision of the Ministry of Energy Transition and Sustainable Development, and work to promote the energy efficiency policies. Moroccan Agency for Solar Energy (MASEN) also took the responsibility to implement the National Energy Efficiency Strategy (Morocco's National Energy and Energy Efficiency Plan | Inequality Solutions, n.d.).

Meanwhile, pilot projects like solar powered irrigation and agriculture are funded by international partnerships like GIZ and World Bank. Also, the energy management system with ISO 50001 has started to be adopted widely by organizations to systematically improve their energy performance (Nait Abd et al., 2025). Challenges remain in financing and awareness, but Morocco's integrated approach—combining regulation, incentives, and tech adoption—positions it as a regional EE leader, aligning with its NDC targets under the Paris Agreement.

5. CONCLUSION

The energy transition in Morocco is a real model for sustainable development. Since this transition is driven by ambitious renewable energy targets, laws and standards, policies, organizations creation and strategic investments. These investments relay on international partnerships and government own financial inputs to carry expansion in wind turbines, solar power and energy efficiency implementation. Through those efforts the country has made an important progress in the part of use of renewable energy that accounts now nearly 40% of the total capacity installed. If the country continues so on the plans to reach 52% by 2030 will come true. However, several challenges come as things progress, like grid integration, water scarcity that needs to be overcome every time for long-term success.

As a result, we observe that Morocco's energy transition has not only been a crucial step in addressing climate change but also impacted the country's economic development. Indeed, the increased demand for energy encourages the irrational use of fossil fuels, which directly impacts the climate. This impact primarily and negatively affects the main driver of Morocco's economy, which is largely based on agriculture. However, through the country's energy transition strategy, there has been a positive outcome in terms of job creation alongside environmental protection. This transformation significantly affects Morocco's labor market, as the country's economic development is increasingly driven by the energy transition, which has a positive impact on both the labor market and environmental conservation.

Furthermore, Morocco presents vast opportunities for growth, particularly in green hydrogen, large-scale solar and wind projects, and energy-efficient technologies. International cooperation through partnerships with the EU, World Bank, and private investors will be crucial in unlocking these opportunities. As Morocco continues to expand its renewable energy infrastructure and implement energy-saving measures, it solidifies its position as a regional leader in sustainability. By leveraging its natural resources, policy frameworks, and geopolitical advantages, Morocco is not only advancing its own decarbonization goals but also positioning itself as a key player in the global clean energy market. The country's transition serves as a blueprint for other nations in the MENA region and beyond, proving that a sustainable energy future is both achievable and economically viable. With sustained commitment and collaboration, Morocco can fully realize its potential as a hub for renewable energy innovation and green growth.

REFERENCES

Abbass, R.A., Kumar, P., El-Gendy, A. (2018), An overview of monitoring and reduction strategies for health and climate change related emissions in the Middle East and North Africa region. Atmospheric Environment, 11, 061.

Accélérer la Transition Energétique Pour installer le Maroc dans la Croissance Verte - CESE. (n.d.), from https://www.cese.ma/docs/accelerer-la-transition-energetique-pour-installer-le-maroc-dans-la-croissance-verte [Last accessed on 2026 Mar 12].

Afonso, A., Blanco-Arana, M.C. (2024), Does financial inclusion enhance per capita income in the least developed countries? International Economics, 177, 100479.

Alfani, F., Ali, A.A., Auclair, G., Baksa, D., Balima, H., Bartolini, D., Benmoussa, C., Bizimana, O., Oumayma Bourhriba, A.B., Cherif, M., Clementi, F., Dua, A., Díaz-Cassou, J., Fabiani, M. (2023), Morocco'S Quest For Stronger And Inclusive Growth. Books and Reports. Available from: https://ideas.repec.org/b/ocp/dbbook/book2306.html

Alfani, F., Molini, V., Pallante, G., Palma, A. (2024), Job displacement and reallocation failure. Evidence from climate shocks in Morocco. European Review of Agricultural Economics, 51(1), 1-31.

Alhamwi, A., Kleinhans, D., Weitemeyer, S., Vogt, T. (2015), Moroccan National energy strategy reviewed from a meteorological perspective. Energy Strategy Reviews, 6, 39-47.

Allouhi, A. (2024), A hybrid PV/wind/battery energy system to assist a run-of-river micro-hydropower for clean electrification and fuelling hydrogen mobility for young population in a rural Moroccan site. Journal of Cleaner Production, 442, 140852.

Altieri, S., Niccoli, F., Kabala, J.P., Liyaqat, I., Battipaglia, G. (2024), Influence of drought and minimum temperature on tree growth and water use efficiency of Mediterranean species. Dendrochronologia, 83, 126162.

Ammari, M., Chentouf, M., Ammari, M., Ben Allal, L. (2022), Assessing national progress in achieving the sustainable development goals: A case study of morocco. Sustainability, 14(23), 15582.

Anoune, K., Laknizi, A., Bouya, M., Astito, A., Ben Abdellah, A. (2018), Sizing a PV-Wind based hybrid system using deterministic approach. Energy Conversion and Management, 169, 137-148.

Assadiki, R., Merlin, G., Buhé, C., Boileau, H., Belmir, F. (2025), Environmental sustainability assessment method for Moroccan residential buildings. MethodsX, 2025, 103438.

Azimi, M.N., Rahman, M.M., Maraseni, T. (2025), Powering progress: The interplay of energy security and institutional quality in driving economic growth. Applied Energy, 378, 124835.

Azzaoui, A., Alami Merrouni, A. (2025), Hybrid CSP-PV combination to enhance the green hydrogen production in Morocco: Solar technologies evaluation and techno-economic analysis. Processes, 13(3), 769.

Bahou, S. (2025), Techno-economic analysis of green hydrogen production from onshore wind for Morocco. International Journal of Hydrogen Energy, 129, 51-59.

Bakkari, M., Bossoufi, B., El Kafazi, I., Bouderbala, M., Karim, M. (2024), A review of wind energy potential in Morocco: New challenges and perspectives. Wind Engineering, 48(1), 101-120.

Belmahdi, B., El Bouardi, A. (2020), Solar potential assessment using PVsyst software in the Northern Zone of Morocco. Procedia Manufacturing, 46, 738-745.

Belmahi, M., Hanchane, M., Mahjoub, A., Najjari, F., Khayati, A., Kessabi, R. (2023), Sustainability assessment of the main cereals market in Morocco: Evaluating production and import. European Journal of Sustainable Development, 12(2), 135-135.

Ben Azzeddine, B., Hossaini, F., Savard, L. (2024), Greenhouse gas emissions and economic growth in Morocco: A decoupling analysis. Journal of Cleaner Production, 450, 141857.

Benbba, R., Barhdadi, M., Ficarella, A., Manente, G., Romano, M.P., Hachemi, N.El, Barhdadi, A., Al-Salaymeh, A., Outzourhit, A. (2024), Solar energy resource and power generation in Morocco: Current situation, potential, and future perspective. Resources, 13, 140.

Bouhal, T., Agrouaz, Y., Kousksou, T., Allouhi, A., El Rhafiki, T., Jamil, A., Bakkas, M. (2018), Technical feasibility of a sustainable concentrated solar power in Morocco through an energy analysis. Renewable and Sustainable Energy Reviews, 81, 1087-1095.

Boulakhbar, M., Lebrouhi, B., Kousksou, T., Smouh, S., Jamil, A., Maaroufi, M., Zazi, M. (2020), Towards a large-scale integration of renewable energies in Morocco. Journal of Energy Storage, 32, 101806. https://doi.org/10.1016/j.est.2020.101806.

Bouramdane, A.A. (2024), Moroccoa's path to a climate-resilient energy transition: Identifying emission drivers, proposing solutions, and addressing barriers. Science and Technology for Energy Transition (STET), 79, 2024021.

Bourzac, K. (2024), COP28 makes it official: Fossil fuels cause climate change. Engineering, 37, 3-5.

Bousla, M., Belfkir, M., Elharrouss, O., Sadki, A., Haddi, A., El Mourabit, Y., Bossoufi, B., Mouradi, A., Elkharrim, A. (2025), Modeling wind energy production forecasting using machine learning: An in-depth analysis of wind farms in Morocco. Engineering, Technology and Applied Science Research, 15(3), 23268-23276.

Bousla, M., Haddi, A., El Mourabit, Y., Sadki, A., Mouradi, A., El Kharrim, A., Mobayen, S., Zhilenkov, A., Bossoufi, B. (2023), Analysis and comparison of wind potential by estimating the weibull distribution function: Application to Wind Farm in the Northern of Morocco. Sustainability, 15(20), 15087.

Chen, Q., Zhang, E. (2025), Economic growth, energy consumption and CO_2 emissions: A replication. Energy Economics, 147, 108538.

Choukri, K., Naddami, A., Hayani, S. (2017), Renewable energy in emergent countries: Lessons from energy transition in Morocco. Energy, Sustainability and Society, 7(1), 1-11.

Coordinator, M.T., Martin, A.P., Suleiman, H., Sainati, T., Rodrigo, J., Cornelio, J. (n.d.), Renewable Energy and electricity interconnection megaprojects in North Africa: Prospects for Euro-North Africa Cooperation; 2024. Available from: https://eprints.whiterose.ac.uk/215111/1/policy-study34-megaprojects.pdf [Last accessed on 2025 Jun 26].

COP28: Global Renewables and Energy Efficiency Pledge. (n.d), Available from: https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge [Last accessed on 2024 Jul 13].

Crow, D.J.G., Balcombe, P., Brandon, N., Hawkes, A.D. (2019), Assessing the impact of future greenhouse gas emissions from natural gas production. Science of the Total Environment, 668, 1242-1258.

Daoudi, M. (2024), Education in renewable energies: A key factor of Morocco's 2030 energy transition project. Exploring the impact on SDGs and future perspectives. Social Sciences and Humanities Open, 9, 100833.

Document PBT 25-27 Version Fr Finale.pdf. (n.d), Available from: https://www.finances.gov.ma/publication/db/2024/document%20pbt%2025-27%20version%20fr%20finale.pdf [Last accessed on 2026 Oct 09].

Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., Castellazzi, L. (2020), Review of 50 years of EU energy efficiency policies for buildings. Energy and Buildings, 225, 110322.

El Asli, H., Azeroual, M. (2025), The long-run anthropogenic incidence on climate change, air pollution, water scarcity, and contribution to global warming in Morocco. Sustainable Futures, 9, 100699.

El Haddadi, M., Lahjouji, H., Tabaa, M. (2025), The nexus between economic growth and water stress in Morocco: Empirical evidence based on ARDL model. Sustainability, 17(15), 6990.

El Hafdaoui, H., Khallaayoun, A., Al-Majeed, S. (2025), Renewable energies in Morocco: A comprehensive review and analysis of current status, policy framework, and prospective potential. Energy Conversion and Management: X, 26, 100967.

El Hafdaoui, H., Khallaayoun, A., Ouazzani, K. (2024a), Long-term low carbon strategy of Morocco: A review of future scenarios and energy measures. Results in Engineering, 21, 101724.

El Hassani, S., Lebrouhi, B.E., Kousksou, T. (2024), A feasibility study of green hydrogen and E-fuels production from a renewable energy hybrid system in the city of Dakhla, Morocco. International Journal

of Hydrogen Energy, 73, 316-330.
El Iysaouy, L., El, N., El Idrissi, A., Tvaronavičienė, M., Lahbabi, M., Oumnad, A. (2019), Towards energy efficiency: Case of Morocco. Insights into Regional Development, 1(3), 259-271.
El Majdoubi, G., El Ayadi, H. (2025), Unlocking potential: A holistic approach to water, energy, and food security nexus in Tangier-Tetouan-Al Hoceima, Morocco. Case Studies in Chemical and Environmental Engineering, 11, 101129.
El Mostafa, J., Zejli, D., Komendantova, N. (2019a), Dynamics of Energy Transition in Morocco: Centralized versus Decentralized Options. Laxenburg, Austria: International Institute for Applied Systems Analysis.
El-Maaroufi, A., Daoudi, M., Laamara, R.A. (2025), Hydrogen production for SDG 13 using hybrid renewables energies in Southern Morocco. Energy, 319, 134986.
Escribano, G. (2019), The geopolitics of renewable and electricity cooperation between Morocco and Spain. Mediterranean Politics, 24(5), 674-681.
Fakhraddine, M., Zerrad, N., Berhili, H., Morchid, M. (2025), Digital transformation in Moroccan agriculture: Applications, used technologies, impacts on marketing, limitations, and orientations for future research. Smart Agricultural Technology, 11, 100978.
Fonds Vert Pour le Climat/FVC, Climate Promise. (n.d), Available from: https://climatepromise.undp.org/fr/donors/fonds-vert-pour-le-climat-fvc [Last accessed on 2025 Oct 09].
Fragkos, P. (2023), Assessing the energy system impacts of Morocco's nationally determined contribution and low-emission pathways. Energy Strategy Reviews, 47, 101081.
Fu, F.Y., Alharthi, M., Bhatti, Z., Sun, L., Rasul, F., Hanif, I., Iqbal, W. (2021), The dynamic role of energy security, energy equity and environmental sustainability in the dilemma of emission reduction and economic growth. Journal of Environmental Management, 280, 111828.
Gargab, F.Z., Kaitouni, S.I., Jamil, A., Kasinathan, P., Saadani, R., Rahmoune, M. (2025), Regional development assessment and policy perspectives on urban residential energy efficiency program in Morocco by 2030. Urban Science, 9(5), 149.
Gasparatos, A., Gadda, T. (2009), Environmental support, energy security and economic growth in Japan. Energy Policy, 37(10), 4038-4048.
Haddadi, M.E., Lahjouji, H. (2025), Exchange rate pass-through effects on food and cereal inflation in Morocco: An asymmetric analysis under climate change constraints using an ARDL model. Journal of Risk and Financial Management, 19(1), 16.
Haidi, T., Cheddadi, B., El Mariami, F., El Idrissi, Z., Tarrak, A. (2021), Wind energy development in Morocco: Evolution and impacts. International Journal of Electrical and Computer Engineering 11(4), 2811-2819.
Huang, S.W., Chung, Y.F., Wu, T.H. (2021), Analyzing the relationship between energy security performance and decoupling of economic growth from CO_2 emissions for OECD countries. Renewable and Sustainable Energy Reviews, 152, 111633.
Ibn Batouta, K., Aouhassi, S., Mansouri, K. (2024), Sustainable energy transition: A steam system optimization case study from a Moroccan food industry. Results in Engineering, 24, 102944.
Ikram, M., Nahdi, R. (2025), Toward sustainable development: Unfolding the nexus among exports, foreign direct investment, capital formation, natural resource rent, unemployment, and low-carbon transition in Morocco. Resources Policy, 102, 105490.
International Labour Organization. (2018), World Employment Social Outlook 2018: Greening with Jobs. Available from: https://researchrepository.ilo.org/esploro/outputs/report/world-employment-social-outlook-2018-greening/995218839002676
International Monetary Fund. Middle East and Central Asia Dept. (2024), Statement by Mr. Mohammed El Qorchi on Morocco November 11, 2024. IMF Staff Country Rep, 2024(324),
Işık, C., Ongan, S., Yan, J., Islam, H. (2025), Towards carbon neutrality and COP29 Baku/Azerbaijan - COP30 Belem/Brazil: Exploring the impacts of economic, environmental, social, and governance (ECON-ESG) factors on climate policy uncertainty (CPU) for sustainable development. Heliyon, 11(3), e41944.
Islam, Z.U., Lipu, M.S.H., Mearaj, S.T., Fuad, A.M., Rahman, T., Islam, M.A., Sarker, M.R. (2025), Hybrid renewable energy systems towards sustainable development in Bangladesh: Configurations, optimizations, applications, challenges and future pathways. Results in Engineering, 2025, 105728.
Job Creation and Skills Development During the Energy Transition - Morocco. (n.d), Available from: https://documents.banquemondiale.org/fr/publication/documents-reports/documentdetail/099012324071522189 [Last accessed on 2026 Mar 12].
Khaldi, H., Mounir, H. (2025), Comparative carbon footprint of electric and hydrogen vehicles: Insights from Morocco, Africa, and global energy transitions. Energy for Sustainable Development, 85, 101685.
Kharbach, M., Chfadi, T. (2022), Economic growth and challenges in achieving NDC targets: A Moroccan perspective. Energy Reports, 8, 7010-7015.
Kuramochi, T., Nascimento, L., Moisio, M., Den Elzen, M., Forsell, N., van Soest, H., Tanguy, P., Gonzales, S., Hans, F., Jeffery, M.L., Fekete, H., Schiefer, T., De Villafranca Casas, M.J., De Vivero-Serrano, G., Dafnomilis, I., Roelfsema, M., Höhne, N. (2021), Greenhouse gas emission scenarios in nine key non-G20 countries: An assessment of progress toward 2030 climate targets. Environmental Science and Policy, 123, 67-81.
Laaroussi, A., Bouayad, A., Lissaneddine, Z., Alaoui, L.A. (2021), Impact study of NOOR 1 project on the Moroccan territorial economic development. Renewable Energy and Environmental Sustainability, 6, 8.
Lahjouji, H., El Haddadi, M., Tabaa, M. (2025), Causal interaction between economic growth, FDI, trade liberalization and CO_2 emission in Morocco: Case study of Morocco with VECM evidence. Management of Environmental Quality, 2025, 1-22.
Lebrouhi, B.E., Lamrani, B., Zeraouli, Y., Kousksou, T. (2024), Key challenges to ensure Morocco's sustainable transition to a green hydrogen economy. International Journal of Hydrogen Energy, 49, 488-508.
Leonard, A., Ahsan, A., Charbonnier, F., Hirmer, S. (2024), Renewable energy in Morocco: Assessing resource curse risks. Renewable and Sustainable Energy Reviews, 192, 114210.
Mahdavi, M., Vera, D. (2023), Importance of renewable energy sources and agricultural biomass in providing primary energy demand for Morocco. International Journal of Hydrogen Energy, 48(88), 34575-34598.
Maka, A.O.M., Ghalut, T., Elsaye, E. (2024), The pathway towards decarbonisation and net-zero emissions by 2050: The role of solar energy technology. Green Technologies and Sustainability, 2(3), 100107.
Marzouk, O.A. (2023), 2030 Ambitions for hydrogen, clean hydrogen, and green hydrogen. Engineering Proceedings, 56(1), 14.
Masen Launches Noor Midelt Ii Solar Farm Tender Process, Masen. (n.d), Available from: https://www.masen.ma/en/masen-news/masen-launches-noor-midelt-ii-solar-farm-tender-process [last accessed on 2025 Jul 01].
Masen. (n.d), Atlas de la Ressource Solaire du Maroc. Available from: https://www.masen.ma
Mekila Mbayam, O., Bounahmidi, T. (2025), Energy optimization of a residential building for electricity, cooling, and heating: A path to Net Zero Energy. Energy for Sustainable Development, 85, 101672.
Meliani, M., El Barkany, A., El Abbassi, I., Moumen Darcherif, A., Mahmoudi, M. (2021), Smart grid implementation in Morocco: Case

study. Materials Today: Proceedings, 45, 7675-7679.
Modarres, A. (2017), Commuting, energy consumption, and the challenge of sustainable urban development. Current Opinion in Environmental Sustainability, 25, 1-7.
Moore, S. (2017), Evaluating the energy security of electricity interdependence: Perspectives from Morocco. Energy Research and Social Science, 24, 21-29.
Morocco - Countries and Regions - IEA. (n.d), Available from: https://www.iea.org/countries/morocco/energy-mix [Last accessed on 2025 Feb 18].
Morocco Energy imports - data, chart, The GlobalEconomy.com. (n.d) Available from: https://www.theglobaleconomy.com/morocco/Energy_imports/?utm_source=chatgpt.com
Morocco Energy Imports: Volume: Annual | Economic Indicators, CEIC. (n.d), Available from: https://www.ceicdata.com/en/morocco/energy-imports/energy-imports-volume-annual [Last accessed on 2025 Jun 25].
Morocco: Hydropower Share in Electricity Production, Statista. (n.d), https://www.statista.com/statistics/1360569/share-of-hydropower-in-electricity-production-in-morocco/?utm_source=chatgpt.com [Last accessed on 2025 Jun 24].
Morocco_NDC_Eng.pdf. (n.d), Available from: https://www.greenpolicyplatform.org/sites/default/files/downloads/policy-database/morocco_ndc_eng.pdf [last accessed on 2026 Oct 09].
Morocco's National Energy and Energy Efficiency Plan, Inequality Solutions. (n.d), Available from: https://www.sdg16.plus/policies/moroccos-national-energy-and-energy-efficiency-plan [Last accessed on 2025 Jul 02].
Moudene, K., El-Oud, R., Ejbari, R., Amedjar, A., Moudene, K., El-Oud, R., Ejbari, R., Amedjar, A. (2023), Renewable energy and economic growth in Morocco. Journal of Human Resource and Sustainability Studies, 11(2), 401-413.
Mouhaya, A., El Hammoumi, A., El Ghzizal, A., Motahhir, S. (2025), Assessment of floating solar photovoltaic potential and water conservation in Morocco: Case studies of four hydroelectric dams. Cleaner Engineering and Technology, 26, 100952.
Moussir, C., Dynamics, A.C.S.C. and E., 2020, undefined. (2020), Structural Change and Labour Productivity Growth in Morocco. Vol. 53. Netherlands: Elsevier. p353-358.
Mulcahy, E., Smith, R. (2024), COP29 must move from stalling to action. The Lancet, 404(10463), 1623-1624.
Nait Abd, C., El Fadar, A., Achkari, O.B. (2025), Energy efficiency improvement of a wood-manufacturing plant in Morocco through energy audit. Energy for Sustainable Development, 85, 101669.
Nakach, I., Mouhat, O., Shamass, R., El Mennaouy, F. (2023), Review of strategies for sustainable energy in Morocco. Polityka Energetyczna, 26(2), 65-104.
Nationally Determined Contributions Registry, UNFCCC. (n.d.), Available from: https://unfccc.int/ndcreg [Last accessed on 2026 Mar 12].
Nikfar, S., Mozaffari, S. (2024), Organization for Economic Cooperation and Development. Encyclopedia of Toxicology. 4th ed., Vol. 9. Paris: OECD. p. 157-165.
Ourya, I., Nabil, N., Abderafi, S., Boutammachte, N., Rachidi, S. (2023), Assessment of green hydrogen production in Morocco, using hybrid renewable sources (PV and wind), International Journal of Hydrogen Energy, 48(96), 37428-37442.
Petrović, P. (2023), Climate change and economic growth: Plug-in model averaging approach. Journal of Cleaner Production, 433, 139766.
Projet de Parc Eolien Jbel Lahdid. (n.d), Available from: https://www.mem.gov.ma/Pages/secteur.aspx?e=2&sprj=140 [Last accessed on 2025 July 01].
Projets. (n.d.), Available from: https://www.masen.ma/fr/projets [Last accessed 2025 Jun 13].
Rasul, M.G., Hazrat, M.A., Sattar, M.A., Jahirul, M.I., Shearer, M.J. (2022), The future of hydrogen: Challenges on production, storage and applications. Energy Conversion and Management, 272, 116326.
Sabry, M.I. (2025), The green transition in Morocco: Extractivity, inclusivity, and the stability of the social contract. The Extractive Industries and Society, 22, 101614.
Sahbani, S., Mahmoudi, H., Hasnaoui, A., Kchikach, M. (2016), Development prospect of smart grid in Morocco. Procedia Computer Science, 83, 1313-1320.
Sakhraoui, K., Agadi, R., Von Hirschhausen, C., Ege, G.S. (2024), Energy policy in morocco: Analysis of the national energy strategy's impact on sustainable energy supply and transformation. Next Research, 1(2), 100072.
Saqib, A., Lean, H.H. (2023), Climate change, natural resources, and economic growth. In: Reference Module in Social Sciences. Netherlands: Elsevier.
Siriwardana, M., Nong, D. (2021), Nationally Determined Contributions (NDCs) to decarbonise the world: A transitional impact evaluation. Energy Economics, 97, 105184. https://doi.org/10.1016/J.ENECO.2021.105184
Situation du Marché du Travail en 2025. (n.d), Available from: https://www.hcp.ma/Situation-du-marche-du-travail-en-2025_a4248.html [Last accessed on 2026 Mar 12].
Slighoua, M., Guennoun, S., Kasmi, S., Tenkoul, A. (2022), The COP22 in the City of Marrakech: A Catalyst for Sustainable Urban Transformation? Mega Events, Urban Transformations and Social Citizenship: A Multi-Disciplinary Analysis for An Epistemological Foresight. Abingdon: Routledge. p153-171.
Slimani, J., Kadrani, A., El Harraki, I., Ezzahid, E. (2024), Towards a sustainable energy future: Modeling Morocco's transition to renewable power with enhanced OSeMOSYS model. Energy Conversion and Management, 317, 118857.
Tao, Z., Ren, Z. X., Chen, Y., Huang, X., Liu, X. (2023), Pathway to sustainable economic growth: Linkage among energy consumption, carbon emissions, climate change and technological innovation. Energy Strategy Reviews, 50, 101253.
Terrapon-Pfaff, J., Fink, T., Viebahn, P., Jamea, E.M. (2019), Social impacts of large-scale solar thermal power plants: Assessment results for the NOORO I power plant in Morocco. Renewable and Sustainable Energy Reviews, 113, 109259.
The Lancet Regional Health - Europe. (2024), COP29: Incremental but insufficient progress on climate finance. The Lancet Regional Health - Europe, 47, 101169.
Wang, L., Pal, S., Mahalik, M.K., Gozgor, G. (2025), Empowering sustainable development in emerging economies: The role of renewable energy and domestic investment. Energy Economics, 148, 108631.
Wang, S.J., Moriarty, P. (2019), Energy savings from smart cities: A critical analysis. Energy Procedia, 158, 3271-3276.
Wei, J., Jiang, T., Ménager, P., Kim, D.G., Dong, W. (2025), COP29: Progresses and challenges to global efforts on the climate crisis. The Innovation, 6(1), 100748.
Weko, S., Farrand, A., Fakoussa, D., Quitzow, R. (2024), The politics of green hydrogen cooperation. Available from: https://www.academia.edu/download/108036239/iass_study_6003183.pdf [Last accessed on 2025 Jul 01].
Yahya, A., Yessef, M., Bennouna, E.G., Lagrioui, A., Boutammachte, N., Zhilenkov, A. (2024), Performance improvement and techno-economic optimization of noor i solar power plant in Morocco using various heat transfer fluids. IEEE Access, 12, 151204.
Zakari, A., Khan, I., Tan, D., Alvarado, R., Dagar, V. (2022), Energy efficiency and sustainable development goals (SDGs), Energy, 239, 122365.
Zhang, X.Q. (2016), The trends, promises and challenges of urbanisation in the world. Habitat International, 54, 241-252.