WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online)
Volume 10, Number 8, Year 2026
DOI: https://doi.org/10.62051/ijgem.v10n8.04

Research on Technological Risks and Governance Mechanisms in Morocco's Renewable Energy Transition

Ziyu Lin

HKU Business School, University of Hong Kong, Hong Kong, 999077, China

ABSTRACT

With the rapid depletion of the Earth's natural resources, green development approaches such as low-carbon development and energy transition are becoming major directions for economic development across the world. In recent years, Morocco has introduced a series of incentive measures to support renewable energy, injecting strong momentum into the transformation of its energy structure. However, current technical barriers, talent structure issues, and energy cost pressures continue to constrain the country's energy transition process. Based on a literature analysis method, this paper systematically examines policy documents and publicly available data to investigate the major technological risks and governance mechanisms involved in Morocco's renewable energy transition.

KEYWORDS

Morocco; Renewable Energy Transition; Concentrated Solar Power; Grid Integration; Energy Governance; Technological Risk

1. INTRODUCTION

Across the Middle East and North Africa (MENA), few renewable energy programs match Morocco's in ambition. The Kingdom has been importing almost 90% of its primary energy needs for a long time, and renewables are thus intertwined with three concepts: energy security, fiscal stability and climate commitment [1]. Ideas are embedded in the policy. The National Energy Strategy of 2009, which was reiterated in the country's Nationally Determined Contributions (NDCs), sets a target of 52% of installed electricity capacity by renewable energy by 2030; and further out, the long-term low-carbon strategy sets a more aspirational target to achieve an electricity generation share of about 80% renewable energy by 2050 [3].

At the end of 2024, there is a total of 2,373 MW of wind and 885 MW of solar power (photovoltaic and concentrated) in operation in the country, giving a total renewable power of 5,058 MW [4]. The flagship project of it is the Noor Ouarzazate Solar Complex of 580 MW. But capacity is not Generation. Renewables only generated 26.5% of electricity generated, below their actual contribution and policy direction. Coal still led, at 59.3%, a consequence of lock-in: the 1.4 GW Safi plant that started up in 2018, and the Jorf Lasfar PPA now stretched out to 2044.

The review is structured in the following manner, around two questions. What are the most serious technology risks that pose a threat to Morocco's renewable energy transition? What is the effectiveness of existing governance processes in detecting those risks, allocating them and in controlling them? It uses a narrative review approach [5] to reach the answers and uses peer reviewed studies, grey literature, policy documents, institutional reports, as well as publicly available studies on the energy sector.

2. METHODOLOGY

2.1. Literature Search and Source Selection

The sources were introduced on four routes. One was keyword string searches in databases (Scopus, Web of Science and Google Scholar) for phrases like: “Morocco renewable energy”, “MASEN governance”, “CSP Morocco”, “North Africa energy transition” and “green hydrogen Morocco.” In addition, the second route was the official government one, including the National Energy Strategy, Morocco's NDCs to the UNFCCC, MASEN annual reports, ONEE balance sheets of electricity use. Thirdly, there were reports from multilateral organisations such as the IEA, IRENA, the World Bank and the African Development Bank. The fourth was legislation, including Laws 13-09, 57-09, 58-15, 37-16, and 48-15.

The items that were kept on were judged against three criteria. The source had to be a direct voice to the renewable energy sector in Morocco, had to bring with it relevant evidence, either regarding the technological risks, the governance mechanisms, the capacity, generation, costs or institutional functions; and its information had to be verifiable, and based on an academic, policy, institutional, or legislative origin. Anything that was only talked about in passing, anything that was not very clear, anything that was not evidence based, anything that was like non-peer reviewed promotion was dropped.

2.2. Risk Identification and Thematic Assessment

The technological risks were identified in 2 passes. The first compiled documented the risks reported in the literature and categorized them. The second examined those categories side by side by academic, policy and institutional sources for themes that were repeated and for what they meant for Morocco's transition. Those categories were: grid integration and stability, resource intermittency, energy storage constraints, skills and workforce shortages, climate change vulnerability, technology cost fluctuations, supply-chain reliance, and cybersecurity risks.

The importance of each risk was qualitatively assessed. A risk was deemed more central if it appeared frequently in the literature, if it directly related to the 2030 renewable-energy target, if it related to system reliability, deployment costs, grid flexibility, or implementing it. The following is an analysis-synthesis of the review type rather than a quantitative ranking.

2.3. Governance Evaluation Framework

On the governance side the study applied a functional-analysis framework modified by IEA/OECD Clean Energy Technology Assessment Methodology. It is carried by three dimensions. The first, institutional capacity, is concerned with the clarity of the mandate, the level of resources, and operational autonomy of an institution. This second, policy coherence, is asking whether four agendas - energy efficiency, renewable deployment, industrial development and climate adaptation - are heading in the same direction. The third is implementation effectiveness, measured by actual results, capacity used, costs reduced, investments mobilized and brought on, relative to that which was promised. This was then rated on a simple three-point scale: adequate, partially adequate, and constrained, with supporting documentary evidence and interpretation based on review behind the call.

3. MOROCCO'S ENERGY LANDSCAPE

3.1. Current Generation Mix

Morocco generated 46.43 TWh of electricity in 2024, up 4.8% on 2023 (Figure 1) [6]. Coal did most of the work, at 59.32%. Wind followed at 21.23%, then natural gas at 10.08%, solar at 3.63%, other fossil sources at 4.13%, hydroelectric at 1.53%, and biomass at 0.08%. Renewables accounted for 26.48% of generation when combined.

In 2024, 46.43 TWh of electricity were generated from various sources in Morocco (Figure 1). Source: Office National de l'Electricite et de l'Eau Potable (ONEE) – Bilan Electrique National 2024. The renewable share covers wind (21.2%), solar (3.6%), hydro (1.5%), and biomass (0.1%). Note: national target is a share of installed capacity, not generation, 52% by 2030.

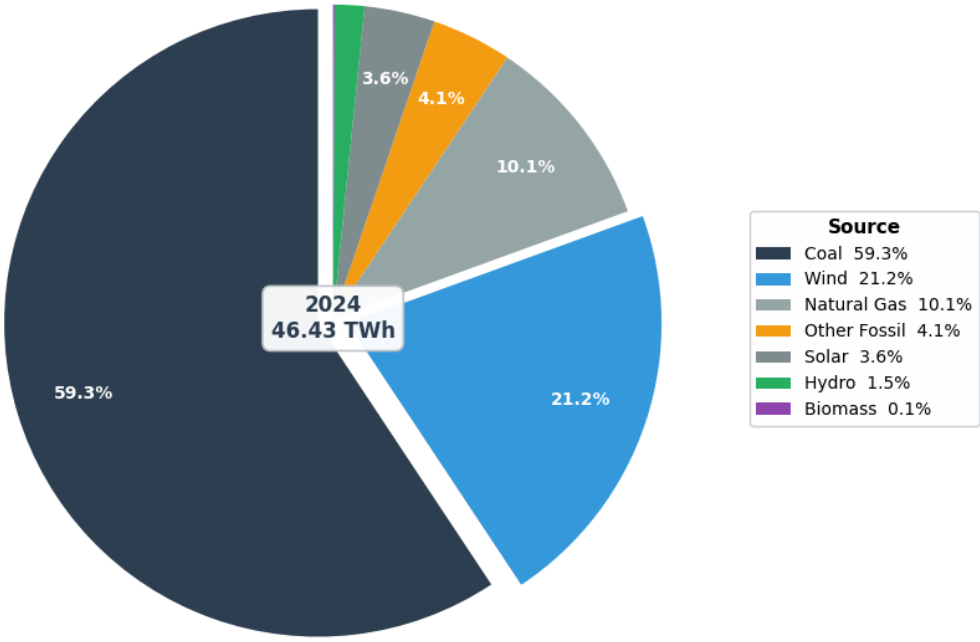

Figure 1. Morocco's electricity generation mix in 2024. Source: ONEE, Bilan Electrique National 2024.

3.2. Installed Capacity and Growth

At the end of 2024, installed renewable capacity reached 5,058 MW. Wind made up 2,373 MW of that, solar 885 MW, the 580 MW Noor Ouarzazate CSP plant included, and hydroelectric power about 1,800 MW [4]. Wind had grown from a mere 487 MW in 2012, compounding at 14.3% a year. Solar's path was bumpier. Betting on CSP gave the country the Noor complex, but it also left PV stranded at around 305 MW.

There are three reasons due to which renewable share of generation (26.5%) lag behind the build-out of capacity. Capacity factors are the first: renewable plants log fewer full-load hours per year than fossil ones. Lock-in is the second. The 1.4 GW Safi coal plant (2018) and the Jorf Lasfar PPA, extended to 2044, both added baseload fossil capacity after the renewable targets were already on the books. Solar is the third, where cost and schedule overruns on CSP projects pushed additions behind plan. Hitting the 2030 goal of more than 10,800 MW would mean adding about 5,700 MW in six years (Table 1).

Table 1. Renewable installed capacity: current status and 2030 targets

Technology	2024 (MW)	2030 Target (MW)	CAGR Needed
Solar (PV + CSP)	885	4,600	28.5%
Wind	2,373	4,200	10.0%
Hydro	1,800	2,000	1.3%
Total	5,058	10,800+	13.5%

Note-CAGR = compound annual growth rate required from 2024 to 2030 [4].

4. TECHNOLOGICAL RISKS

4.1. Risk Assessment and Review-Based Synthesis

The review approach of Section 2.2 yielded eight categories of technological risk. Two stand out as the most pressing for Morocco's transition: grid integration and stability, and resource intermittency. Each strikes at the same thing, the power system's ability to take in variable renewable electricity without losing reliability. Then there is a middle tier of constraints that can slow down deployment, increase system costs, or reduce the capacity of implementing – energy storage limitations, skills and workforce gaps, climate-change vulnerability, technology cost volatility and supply-chain dependency. Cybersecurity is distinct, as it is a new threat. Relatively little is recorded in the literature about it, but as generation assets and grid-control systems become increasingly digital, vulnerabilities are expected to increase.

These risks are collected in a qualitative list of priorities based on a review process, as shown in Table 2. It is not a ranking based on statistics. What it reflects is the frequency at which the risk has been encountered in the literature, how close it is to the 2030 target and what its implications are likely to be with regard to reliability, cost and governance.

Table 2. Review-based synthesis of technological risks in Morocco's renewable energy transition

Risk	Review-based priority	Main Reason
Grid integration and stability	High	Directly affects renewable absorption and system reliability
Resource intermittency	High	Wind and solar output do not always align with demand peaks
Energy storage limitations	Medium	Storage remains insufficient for high renewable penetration
Climate-change vulnerability	Medium	Drought and heat may affect hydropower, CSP cooling, and demand
Technology cost volatility	Medium	CSP, batteries, and imported technologies remain cost-sensitive
Skills and workforce gaps	Medium	Technical capacity is needed for CSP, storage, and grid planning
Supply-chain dependency	Medium	Equipment imports expose projects to external disruption
Cybersecurity threats	Emerging	Risk may grow with grid digitalization and automated control systems

4.2. Grid Integration and Stability

Morocco's fleet bends slowly. A coal plant needs the better part of 12 hours to start from cold, and even a combined-cycle gas turbine wants 30 minutes or more just to ramp up [7]. Variable renewable output does not wait for any of that, least of all at the midday solar peak and the steep drop-off that comes each evening. Drought since 2020 has only made things tighter, eating into what the 460 MW Afourer pumped-storage plant can deliver. By the same reckoning, meeting the 2030 renewable target without endangering stability will take at least 2 GW of additional flexible capacity [7].

4.3. Resource Intermittency

Wind along the Atlantic coast is good, with capacity factors of 35–45%, but its seasonal and daily timing seldom matches when demand peaks. The sun is generous too (2,200–2,800 kWh/m²/year), and yet it has set by the time evening demand arrives. In dry and desert settings, dust that is left uncleaned eats into PV output, and the reported losses swing widely from one site to another and with how often panels are washed [8]. Further ahead, a shifting climate could move these resource patterns in ways the historical record gives little warning of.

4.4. Technology Cost Volatility

If the economics don't add up, then there is a question regarding the gap between CSP and PV prices. Noor I was signed in 2012 at MAD 1.63/kWh ($0.18/kWh); the PV auctions that came later cleared under MAD 0.50/kWh ($0.05/kWh). Without concessional financing, Moroccan CSP would be a lot more expensive [10]. The gap between CSP generation and the market references for PV tariffs has been estimated to be around MAD 800 million ($80 million) annually for Noor I-III.

4.5. Supply Chain Dependency

The hardware is primarily imported from abroad, from China, Europe and the USA. Little progress has been made on domestic value addition (15–25%) with local-content clauses in MASEN tenders. Those supply lines were interrupted by COVID-19 and the geopolitical tension, and it was reflected in the schedules being slipped and costs climbing.

4.6. Climate Change Vulnerability

Rainfall in Morocco is projected to reduce, and drought events are likely to become more frequent, in climate impact studies, which would limit hydropower use and stress any other power source that relies on water [12]. The effect is worse when the weather is hot: Higher temperatures lower generation efficiency, while they increase the demand for electricity from cooling. Combined, these risks suggest that the risks for future electricity systems in Morocco could be higher than what is currently planned for [12].

4.7. Cybersecurity Threats

Cyber security is still a relatively new issue of the transition. As digitalization of electricity system assets, grid-control systems, smart meters and automated dispatch platforms continues to grow, so does the attack surface of the electricity system. To date, no major cyber incident has been publicly documented in the renewable-energy infrastructure in Morocco, but only a part of this should not be overlooked for future plans on grid modernisation and integration of renewable energy.

5. GOVERNANCE MECHANISMS

5.1. Institutional Framework

The renewable sector in Morocco is managed by a multi-layered set of bodies (Figure 4). The direction of the policy is determined at the top, at the ministry of energy transition and sustainable development (METSD). The delivery of the day-to-day work is mainly entrusted to the Moroccan

Agency for Sustainable Energy (MASEN), established in 2010 by Law 57-09. There is also a vertically integrated utility called the National Office of Electricity and Drinking Water (ONEE), which operates the national grid as well as is the sole off-taker of MASEN's projects. Tariffs and oversight of the markets is managed by the National Regulatory Authority for Electricity (ANRE), which was established in 2015 by Law 48-15, but its independence is restricted. The underpinning tier is AMEE (energy efficiency), IRESEN (R&D), SIE (state investment) and ADEREE (rural electrification).

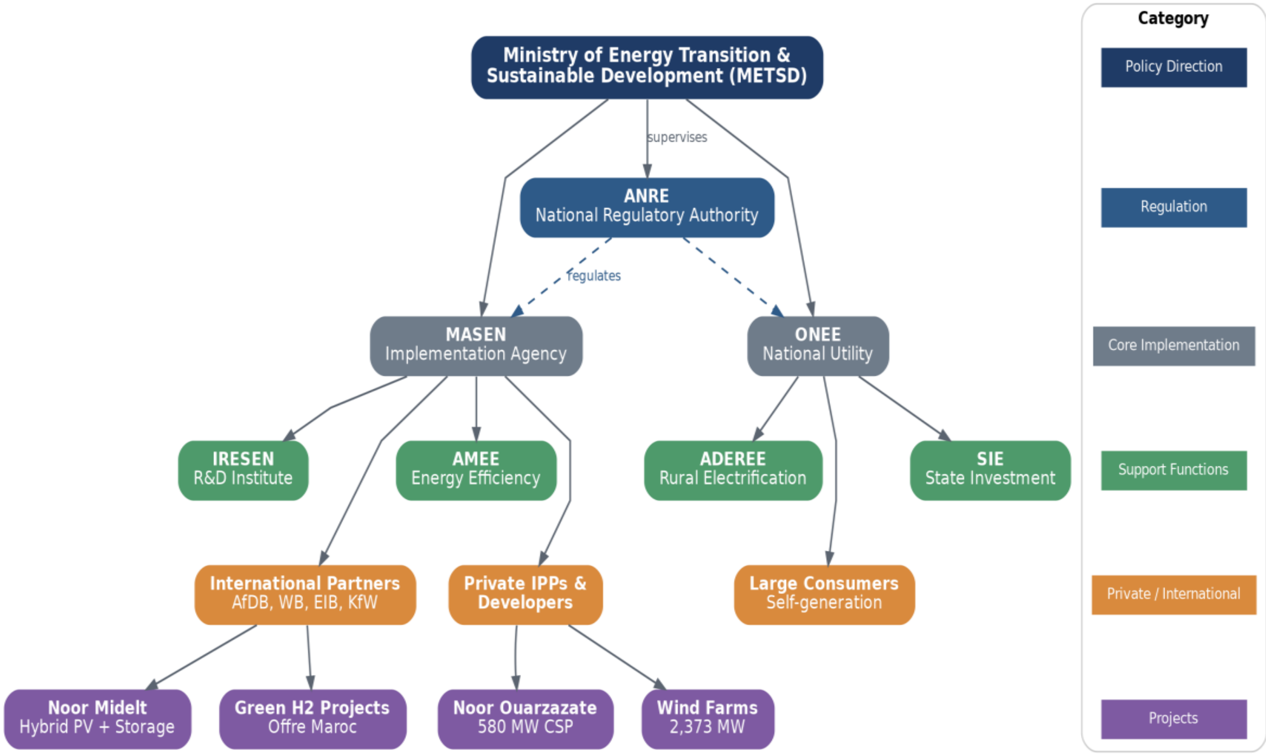

Figure 2. Morocco's Renewable Energy Governance Framework- METSD = Ministry of Energy Transition and Sustainable Development; MASEN = Moroccan Agency for Sustainable Energy; ONEE = Office National de l'Electricite et de l'Eau Potable; ANRE = National Regulatory Authority for Electricity; AMEE = Moroccan Agency for Energy Efficiency; IRESEN = Research Institute for Solar Energy and New Energies; SIE = State Investment Company; ADEREE = National Agency for Renewable Energy and Energy Efficiency Development. Source: Author compilation from Law 57-09, Law 48-15, Law 37-16 [13].

5.2. Policy Architecture

Morocco's law in this area has been built up law by law. Law 13-09 (2010) let private generators into renewable electricity production, Law 58-15 loosened the rules on self-generation, and Law 37-16 (2016) stretched MASEN's remit beyond solar to cover every renewable technology [14]. Then, in September 2024, the Offre Maroc framework set aside up to 300,000 hectares of public land for green hydrogen, overseen by a Steering Committee under the Head of Government, a Green Hydrogen Investment Committee, and a technical secretariat lodged inside MASEN [15][16]. A first batch of hydrogen-related projects has since been reported under Morocco's broader green hydrogen strategy. Recent coordination agreements among the government's energy institutions have, on top of that, aimed to quicken project development and permitting.

5.3. Financing Mechanisms

The financing of MASEN's work is done through a combination of several mechanisms, including concessional loans from multilateral development banks, climate finance (for example, the Clean Technology Fund), bilateral loans (such as the Germany-Morocco PAREMA partnership), and commercial financing. The public-private partnership model takes responsibility for risk. Developers bear the construction and operation costs, while the state bears the political costs and the euro-denominated PPAs bear the currency aspect—recent PV auctions have gone under $0.06/kWh thanks to the state's euro-denominated PPAs. There is a catch. Leaning so heavily on public guarantees to coax in commercial lenders builds up contingent fiscal liabilities, and it may hold back any shift toward market-led procurement [17].

5.4. Governance Evaluation

Table 3 lays five key institutions against the three dimensions from Section 2.3. Scoring remains qualitative: Adequate = adequate resources, autonomy and mandate for effective function; Partially Adequate = enough resources, autonomy and mandate to function effectively but with noticeable constraints; Constrained = noticeable constraints in the ability to function.

Table 3. Governance evaluation of key renewable energy institutions

Institution	Institutional Capacity	Policy Coherence	Implementation Effectiveness	Overall
MASEN	Adequate	Partially Adequate	Adequate	Adequate
ONEE	Adequate	Constrained	Partially Adequate	Partially Adequate
ANRE	Constrained	Partially Adequate	Constrained	Constrained
AMEE	Partially Adequate	Adequate	Partially Adequate	Partially Adequate
IRESEN	Partially Adequate	Adequate	Constrained	Partially Adequate

Source: Author assessment based on Law 57-09, Law 48-15, [4][18], and review-based interpretation

The ratings of the key renewable energy institutions are provided in Table 3 for the year 2024. The dimensions are: Capacity = institutional capacity (mandate, resources, autonomy), Coherence = policy coherence and Effectiveness = implementation effectiveness. The ratings are as follows: Adequate = adequate mandate, adequate resources and adequate autonomy; Partially Adequate = there are some identified constraints on functioning; Constrained = performance is constrained (as defined in Section 2.3).

Three things are worth drawing out. MASEN looks strongest: a consolidated mandate and a delivery record that runs from Noor Ouarzazate to Tarfaya back up its adequate institutional capacity, even as its only-partial mark on policy coherence betrays the strain between its solar-era beginnings and the wider remit Law 37-16 later gave it. ONEE is the opposite case, pulled down on policy coherence by the built-in tension among its jobs as grid operator, fossil generator, and renewable off-taker. ANRE comes out constrained across the board, which says a great deal about how its thin independence from the executive caps regulatory accountability.

6. CONCLUSION

Based on a literature analysis method, this paper systematically examines policy documents and publicly available data to investigate the major technological risks and governance mechanisms involved in Morocco’s renewable energy transition. Morocco has made measurable progress in its renewable energy transition, but it still faces several institutional and technical constraints. MASEN's integrated role in project development, financing, and procurement has helped reduce administrative fragmentation and has supported the formation of more competitive tariff mechanisms through public–private partnership arrangements.

REFERENCES

[1] International Energy Agency. (n.d.). Morocco. Countries & Regions. https://www.iea.org/countries/morocco

[2] Kingdom of Morocco. (2021). Contribution déterminée au niveau national — actualisée. Government of Morocco. https://unfccc.int/sites/default/files/NDC/2022-06/Moroccan%20updated%20NDC%202021%20_Fr.pdf

[3] Kingdom of Morocco. (2021). Stratégie Bas Carbone à Long Terme Maroc 2050. Government of Morocco. https://unfccc.int/sites/default/files/resource/MAR_LTS_Dec2021.pdf

[4] National Authority for Electricity Regulation (ANRE). (2025). Rapport annuel 2024. https://anre.ma/publicationdocs/rapport-annuel-2024/

[5] Ferrari, R. (2015). Writing narrative style literature reviews. Medical Writing, 24(4), 230-235. https://doi.org/10.1179/2047480615Z.000000000329

[6] Office National de l'Electricite et de l'Eau Potable (ONEE). (2024). Bilan Electrique National 2024. Rabat, Morocco: ONEE.

[7] Abi Akl, R. (2025, May 19). Morocco at the energy crossroads: Balancing renewable ambition with grid stability. Wärtsilä Insights. https://www.wartsila.com/insights/article/Morocco-at-the-Energy-Crossroads-Balancing-Renewable-Ambition-with-Grid-Stability

[8] International Energy Agency Photovoltaic Power Systems Programme (IEA PVPS). (2022). Soiling losses: Impact on the performance of photovoltaic power plants (Task 13 Report T13-21:2022). https://iea-pvps.org/wp-content/uploads/2023/01/IEA-PVPS-T13-21-2022-REPORT-Soiling-Losses-PV-Plants.pdf

[9] International Renewable Energy Agency. (2025). Renewable power generation costs in 2024. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Jul/IRENA_TEC_RPGC_in_2024_2025.pdf

[10] World Bank Group. (2018, April 6). Morocco-Noor solar power project additional financing: Project paper. https://documents1.worldbank.org/curated/en/138481528687821561/pdf/Morocco-Noor-AF-project-paper-P164288-May17-clean-05212018.pdf

[11] Eljechtimi, A. (2024, February 27). Moroccan solar plans hampered by dispute over technology. Reuters. https://www.reuters.com/world/africa/moroccan-solar-plans-hampered-by-dispute-over-technology-2024-02-27/

[12] International Energy Agency. (2023). National climate resilience assessment for Morocco. https://www.iea.org/reports/national-climate-resilience-assessment-for-morocco

[13] International Energy Agency. (2016). Clean energy technology assessment methodology pilot study: Morocco (IEA Partner Country Series). OECD/IEA. https://doi.org/10.1787/9789264265851-en

[14] United Nations Economic and Social Commission for Western Asia (UNESCWA). (2018). Case study on policy reforms to promote renewable energy in Morocco. https://www.unescwa.org/sites/default/files/pubs/pdf/policy-reforms-promote-renewable-energy-morocco-english.pdf

[15] Moroccan Agency for Sustainable Energy (MASEN). (2024). Green hydrogen Moroccan offer. https://www.masen.ma/en/green-hydrogen-moroccan-offer

[16] Reuters. (2024, March 11). Morocco to dedicate 1 mln hectares to green hydrogen projects. https://www.reuters.com/sustainability/morocco-dedicate-1-mln-hectares-green-hydrogen-projects-2024-03-11/

[17] Toga Makang, M. N., & Dobrotkova, Z. (2019). The role of the public sector in mobilizing commercial finance for grid-connected solar projects: Lessons learned and case studies. World Bank Group. https://openknowledge.worldbank.org/entities/publication/aafb1a94-aaea-5b35-98f2-9d534e638ad6

[18] International Energy Agency. (2019). Energy policies beyond IEA countries: Morocco 2019. https://www.iea.org/reports/energy-policies-beyond-iea-countries-morocco-2019

[19] International Energy Agency. (2023). Net zero roadmap: A global pathway to keep the 1.5 °C goal in reach (Updated ed.). https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-1-5-0c-goal-in-reach