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*Ignacio Fuente Cobo*

**Could Morocco become an energy provider for Europe?**


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# Could Morocco become an energy provider for Europe?

## Abstract:

Morocco has made energy independence one of its main strategic axes since the early 2000s. However, Morocco has a two-fold problem in achieving it with conventional means. It hardly produces hydrocarbons and does not have the necessary technology for nuclear energy. The Moroccan energy policy solution in recent years has been to resort to the sun and the wind, which are its strong points. The goal would be to reduce energy imports and substantially increase the share of renewable energy in its energy mix, with its sights set on 2030. If achieved, Morocco would become a major African leader in the field of renewable energy and a powerful supplier for Europe. However, the success of this policy will depend on the capacity of the Moroccan energy network to integrate with the European one, which geographical logic indicates should be done via the Iberian Peninsula. In this way, an important synergistic effect of generating and exporting low cost clean energy would be achieved, benefiting Morocco and Europe, and in which Spain would be called upon to play a significant role.

## Key Words:

Oil, gas, electricity, hydrogen, renewables, Ukraine, opportunities.

# *¿Puede Marruecos convertirse en un proveedor energético para Europa?*

*Resumen:*

*Marruecos ha hecho de la independencia energética uno de sus principales ejes estratégicos desde principios de la década de 2000. Ahora bien, Marruecos tiene un doble problema para conseguirlo con medios convencionales. No produce apenas hidrocarburos y no cuenta con la tecnología necesaria para la energía nuclear. La solución de la política energética marroquí en los últimos años ha sido la de recurrir al sol y el viento que son sus puntos fuertes. El objetivo sería reducir las importaciones de energía y aumentar substancialmente la cuota de las energías renovables en su mix energético, con las vistas puestas en el año 2030. De conseguirlo, Marruecos se convertiría en un importante líder africano en el campo de las energías renovables y en un poderoso suministrador para Europa. No obstante, el éxito de esta política dependerá de la capacidad de integración de la red energética marroquí con la europea, algo que la lógica geográfica indica debería hacerse a través de la península ibérica. De esta forma, se lograría un importante efecto sinérgico de generación y exportación de energías limpias a bajo coste beneficioso para Marruecos y para Europa, y en el que España estaría llamada a desempeñar un papel relevante.*

*Palabras clave:*

*Petróleo, gas, electricidad, hidrógeno, renovables, Ucrania, oportunidades.*

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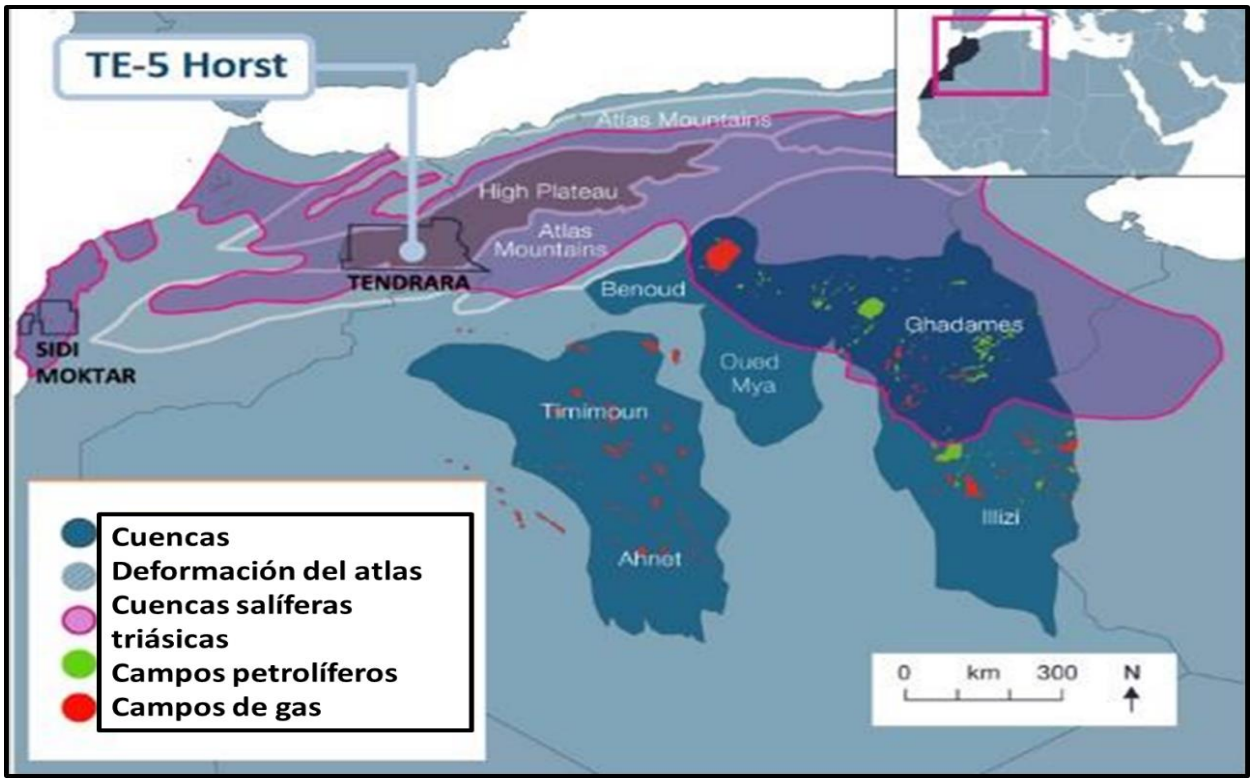
**INTRODUCTION**

In the North African sector, Morocco is an atypical country. Since its independence in 1956, the country has been no more than modest compared to nearby energy powers such as Algeria and Libya. Unlike its North African neighbours, its indigenous production is negligible and produces marginal quantities of oil and natural gas in the Essaouira basin and small quantities of natural gas from the Gharb basin,[1] never having exceeded 5,000 barrels per day. However, the gas discovery in the Tendrara area by the UK's Sound Energy[2] and deepwater exploration offshore are promising developments. These are part of the oil and gas exploration programme managed by the National Office of Hydrocarbons and Mines (ONHYM).



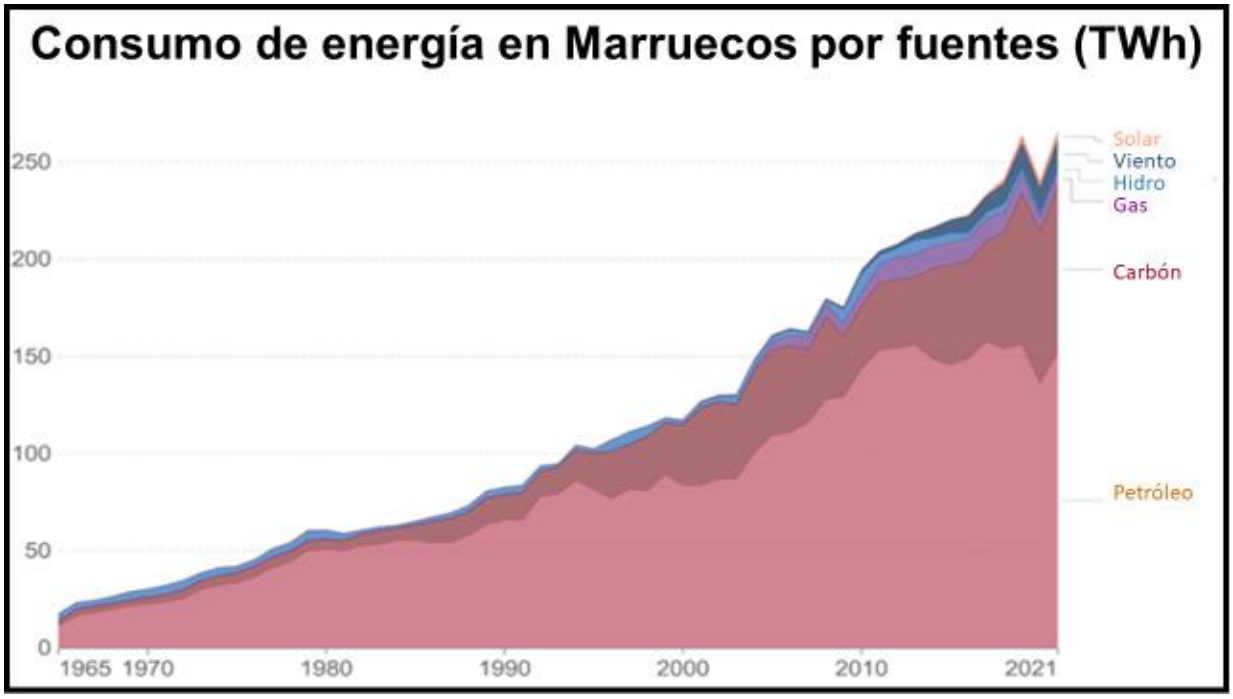

Source: Sound Energy. https://www.energy-pedia.com/news/morocco/sound-energy-announces-tendrara-project-financing-update--%C2%A0-189880

The scarcity of its own hydrocarbon resources makes its economy dependent on imports to meet domestic energy demand, which has made Morocco the largest energy importer in North Africa. Over the period 2017-2020, fossil fuel imports accounted for around 90% of total primary energy supply and 80% of electricity supply.[3]

Morocco's energy mix is mainly composed of fossil fuels, which account for almost 90% of total primary energy supply (TPES) and 80% of electricity supply. In 2020, coal accounted for almost 70% of the energy generated in the country, followed by renewables and natural gas with 18% and 9% respectively. In contrast, oil made a limited contribution to the energy mix, as its share fell substantially from 26% in 2011

[1] U.S. Energy Information Administration (EIA) - Qb. Available at: www.eia.gov
[2] Tendrara Conventional Gas Field, Morocco. Market Data. (23 November 2021). Available at: https://www.offshore-technology.com/marketdata/tendrara-conventional-gas-field-morocco/
[3] Energy policies beyond IEA countries - Morocco. International Energy Agency (2019). Available at: https://www.iea.org/reports/energy-policies-beyond-iea-countries-morocco-2019

to less than 2% in 2020.[4] Coal was also the main source of electricity in Morocco, albeit to a lesser extent, accounting for almost 40% of production in 2019.[5]




Source: BP Statistical Review of World Energy

Heavy dependence on the import of all fossil fuels has clear implications for Morocco's energy security and economy, as was seen with the Maghreb-Europe gas pipeline. Its closure in November 2021 left Morocco without around 15% of the electricity produced at the Tahaddart and Ain BéniMatha combined cycle plants that were supplied with natural gas from Algeria. Fortunately for the Moroccan economy, this damage was quickly alleviated by the reversal of the pipeline, which allowed gas to be imported from Spanish LNG plants and transported to Tangier,[6] but demonstrated the fragility of Morocco's energy system in the face of geopolitical upheavals and accelerated the decision of Moroccan authorities to look for alternative options. Renewable energy was seen as a potential solution to their energy vulnerability, as well as an excellent source of additional income from exporting their surplus.

**The historical fundamentals of the Moroccan energy market**

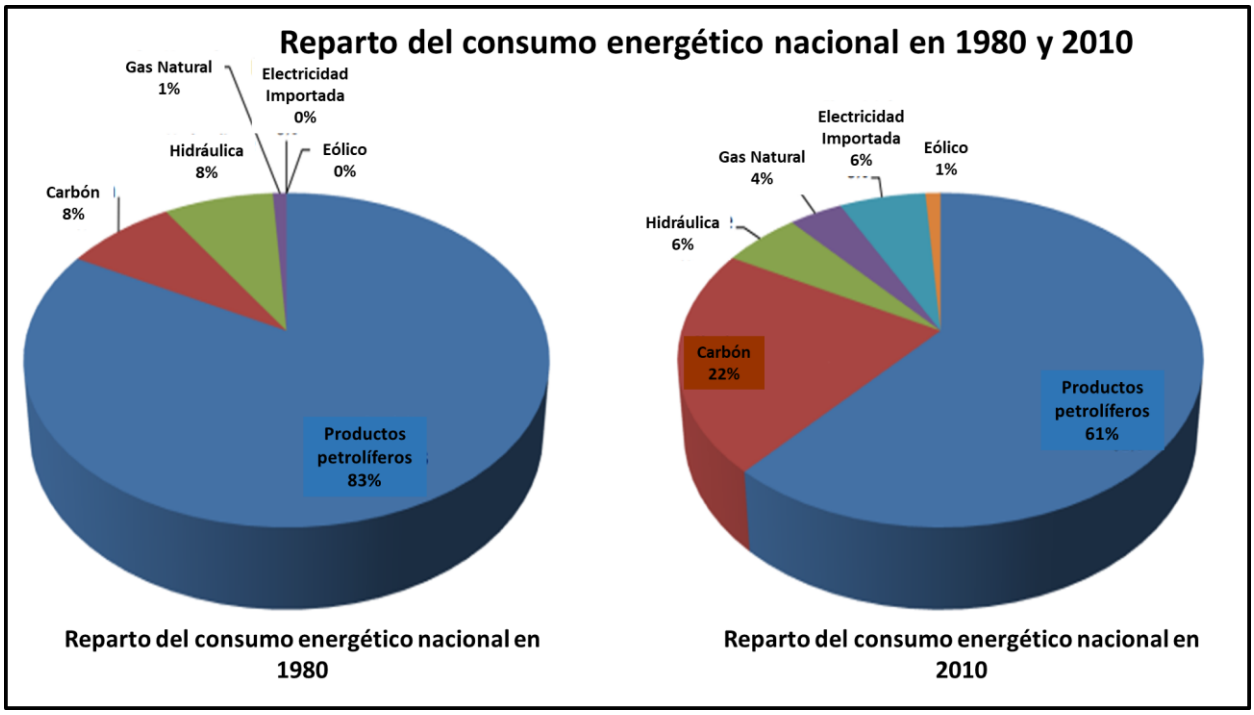
The structure of the Moroccan energy market is rooted in its history. At the beginning of the 20th century, the French colonial authorities sought to increase electricity production in Morocco to extract raw materials, mainly phosphates, and transport them to mainland France. The aim, therefore, was to electrify what was considered the rich area – central Morocco – and ignore the periphery.[7] To this end, large

[4] Share of oil in total power generation in Morocco from 2000 to 2020. Statista. Available at: https://www.statista.com/statistics/1330932/share-of-oil-in-total-power-generation-in-morocco/
[5] Energy Policies Beyond IEA Countries. Morocco 2019. IEA. Available at: https://iea.blob.core.windows.net/assets/138e3195-d0e6-4345-a66c-92ebe4abbeaf/Energy_Policies_beyond_IEA_Countries_Morocco.pdf
[6] Ignacio Urbasos (2022). *Argelia y Marruecos: efectos del cierre del gasoductoMagreb-Europe. [Algeria and Morocco: effects of the closure of the Maghreb-Europe gas pipeline].* The Political Room. Available at https://thepoliticalroom.com/la-crisis-diplomatica-entre-argelia-y-marruecos-consecuencias-del-cierre-del-gasoducto-magreb-europe/
[7] Les représentations politiques de la montagne au Maroc', Revue de géographie alpine 89(2): 141-144. (2001). Available at https://www.persee.fr/doc/rga_0035-1121_2001_num_89_2_4637

concessions were granted to private companies such as the Société Marocaine de Distribution d'Eau, de Gaz et d'Électricité (SMD) in 1912, which was replaced by Énergie Électrique du Maroc (EEM) in 1924.

It was not until 1963, seven years after Moroccan independence in 1956, that the management of the energy sector came under the control of the Moroccan state with the creation of the Office National de l'Électricité (ONE), the public institution in charge of the "public service, production, transport and distribution of electricity".[8]

In the following years, Morocco chose oil as its basic primary energy source, despite the lack of major oil fields, so that by 1980, oil accounted for more than 80% of its energy mix.[9] In the meantime, the oil crisis of 1973 forced the country to rethink this model and it began to focus on increasing the share of coal in its fuel mix. Coal went from 8% in 1980 to 22% in 2010, while oil fell to 61%. ONE's energy strategy proved positive with the extension of the electricity grid to rural areas and the provision of a quality public service, evidenced by the absence of blackouts in the main cities.




Source: Ministry for Energy, Mining, Water and the Environment.

[8]Dahir n° 1-63-226 du 14 rabii I 1383 (5 August 1963) on creating the Office National de l'Électricité, published in the Moroccan Official Gazette No. 2650. (9 August 1963). Available at: https://leap.unep.org/countries/ma/national-legislation/dahir-ndeg-1-63-226-du-14-rabii-i-1383-5-aout-1963-portant

[9] Mohammed Tawfik Mouline, (Managing Director of the Royal Institute for Strategic Studies). Conference on energy security in Morocco: state of play and perspectives. Beijing. 6 March 2012. Available at: https://www.ires.ma/images/pdfs/Forums/Activites_externes/pdf_presentation_dg_ires_energie_vff-2.pdf

In the mid-1980s, the international financial institutions, including the IMF and the World Bank, demanded the implementation of a structural adjustment plan following a debt crisis,[10] including the privatisation of its most profitable public enterprises and the liberalisation of strategic sectors to the benefit of large transnational corporations. The energy sector was one of the first to be affected. The Société Anonyme Marocaine de l'Industrie du Raffinage (SAMIR) was privatised in 1997, coming under the control of the Swedish-Saudi group Corral Petroleum Holding.

This privatisation process was accompanied by intense legislative activity with an enormous impact on the energy sector. Law No. 39-89 of December 1989 authorised the transfer of public companies to the private sector, Legislative Decree No. 94-503 of 1994 put an end to ONE's monopoly and allowed private electricity producers to enter the market, and Law No. 1-95-141 of 1995 liberalised the oil derivatives market.

**The commitment to renewable energies**

With the advent of the new millennium, privatisation fever spread to the field of renewable energies, which began to be considered by the Moroccan authorities as a strategic wager to reduce its energy dependence on foreign suppliers, at a time when Morocco was importing 97% of its energy sources to generate electricity. As Attaurrahman Ojidaram Saibasan, a Moroccan energy analyst, pointed out: "The biggest challenge for the Moroccan government has been to ensure energy security, as its low fossil fuel reserves mean that it must rely on imports to meet its power generation needs".[11]

To solve its energy dependence problem stemming from its limited gas and oil reserves, Morocco decided to use the sun, a natural and inexhaustible resource, as a fundamental element in its energy policy. The strategic logic behind this gamble is clear. On the one hand, Morocco cannot compete in the hydrocarbon sector with countries in the region such as Algeria, Libya or even Egypt; however, its geographical location and favourable climatic characteristics make Morocco one of the leading African countries in terms of potential renewable energy capacity.

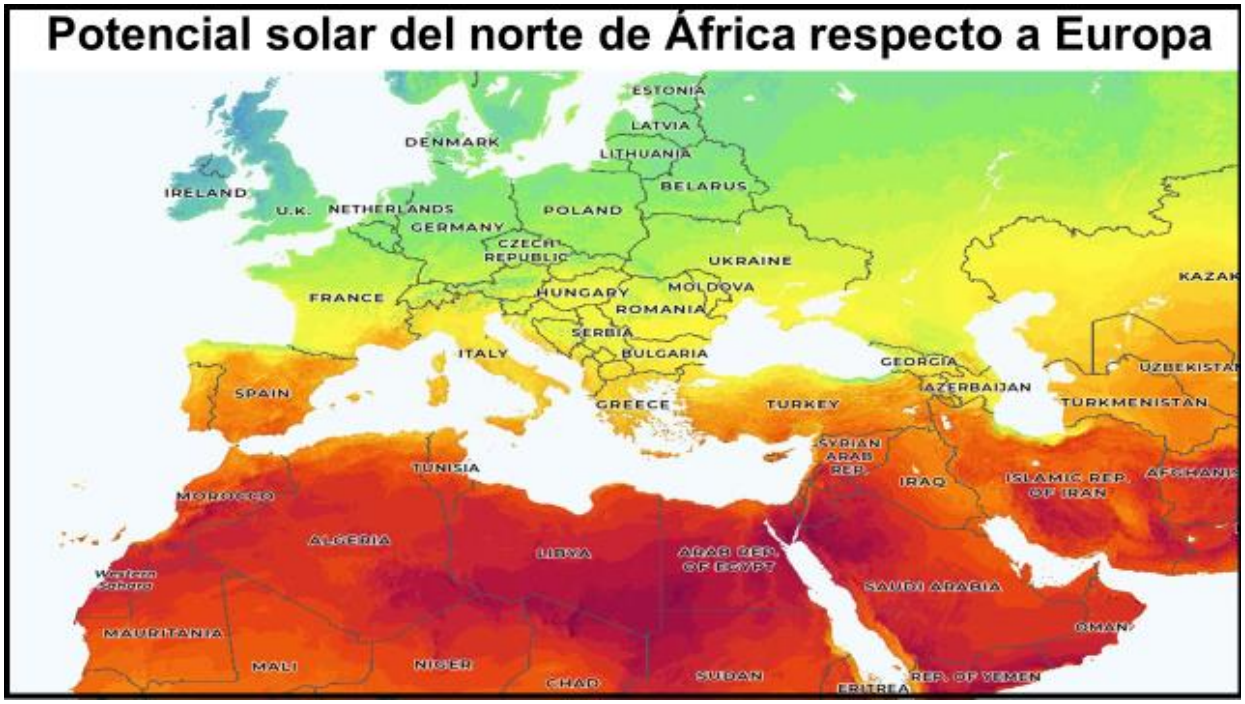
With more than 300 days of sunshine a year in its vast and unpopulated desert landscapes, which can be exploited with solar panels, and a wind power potential with a high yield due to its regularity, Morocco can take advantage of its privileged location to move towards energy independence, thus increasing its energy security and, at the same time, producing surpluses for export to Europe at a very competitive cost.[12]

The comparative advantage provided by its climatic characteristics means that the performance of solar panels is higher in Morocco than in any European country, as can be easily appreciated by visiting the platforms that collect sunshine data from all over the world and which indicate that the sun can be exploited optimally in almost two-thirds of the Moroccan territory.

[10] Akesbi, N. (1985). *IMF "structural adjustment" programmes', Africa Development / Afrique et Développement 10(1/2): 101–21*. Available at: http://www.jstor.org/stable/24487208

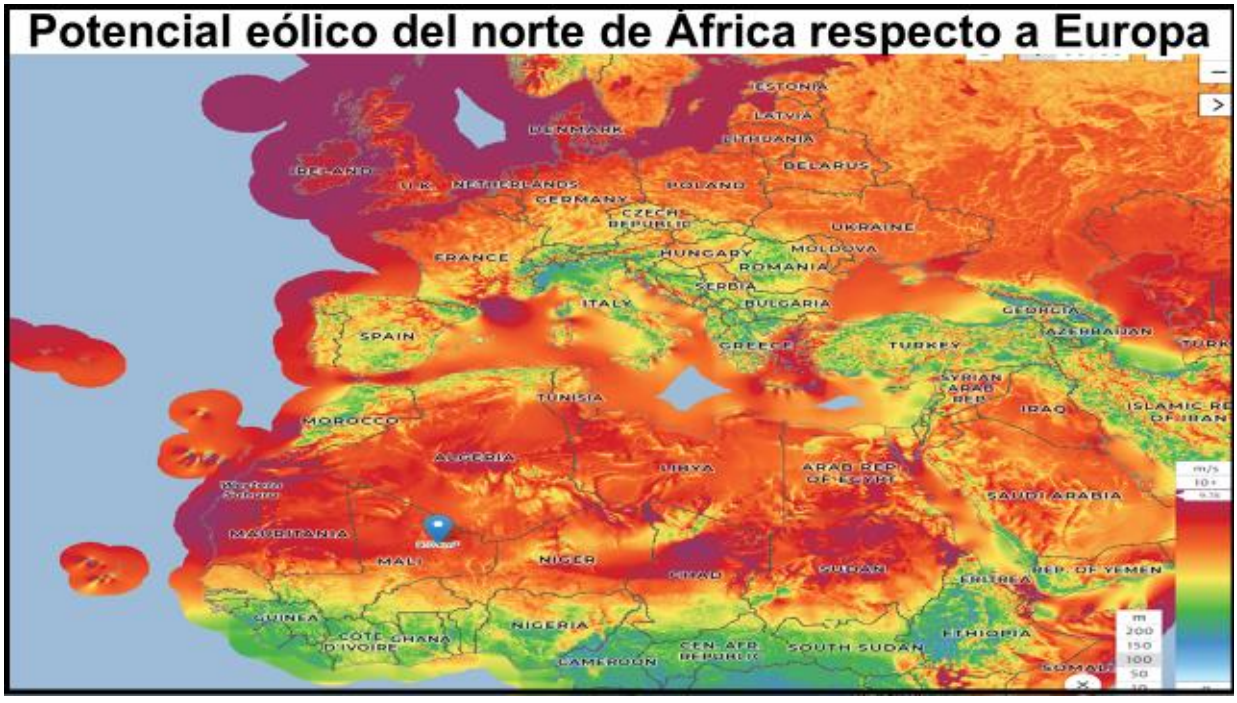
[11] José A. Roca (22 March 2022). *Morocco's renewable capacity will reach 20.6 GW by 2035*. El periódico de la Energía. Available at: https://elperiodicodelaenergia.com/la-capacidad-renovable-de-marruecos-alcanzara-los-206-gw-para-2035/

[12] Víctor De Elena. Morocco arms its renewables to become a supplier to Europe. La Información. 16 October 2022. https://www.lainformacion.com/economia-negocios-y-finanzas/marruecos-arma-sector-renovable-vender-energia-europa/2875128/




Source: https://globalsolaratlas.info/map?c=40.747257,12.128906,4

With regard to wind energy, the whole of southern Morocco has exceptional potential as one of the world's major wind corridors, making it the African country best positioned to generate this type of energy. In addition, its low population density due to its desert conditions favours the installation of huge wind farms with little interference in the lives of its inhabitants. All this differs from Europe, where the windiest regions are in the heavily populated northern regions of the continent and in the British Isles.




Source: https://globalwindatlas.info/en

The economic opportunities that would result from turning Morocco into a Mediterranean renewable energy platform would be colossal[13] and Morocco seems to have realised this. For example, the commissioning in 2021 of the Erfoud photovoltaic plant alone, one of the three plants that make up the 120 MW Noor Tafilalet solar photovoltaic complex, has made it possible to provide a source of renewable energy production at a very competitive cost of €0.03/kWh compared to the €0.35/kWh[14] it cost in 2009, or the €0.20/kWh it cost Spain in January 2023,[15] which makes it a potential renewable energy electricity supplier for Europe.

Morocco shares this solar-based characteristic with other North African countries that have similar climatic conditions. However, Morocco has the advantage of political stability – despite tense diplomatic relations with neighbouring Algeria, or periodic crises with the European Union – and the greater ease with which foreign companies can invest in the country. This makes it, along with South Africa and Egypt, the best country for investment in Africa.[16] Is it any wonder that they are the three countries with the highest renewable capacity in Africa?

**Liberalisation of the Moroccan energy market**

To exploit these energy features, Morocco enacted Law No. 13-09 on 11 February 2010. This legislation liberalised the renewable energy sector, allowing private companies to compete both in the production of renewable electricity and its export through the national grid.[17]

The law came into force in August 2015 with the goal that 42% of electricity would be generated from renewable sources by 2020, thereby paving the way for reducing the country's energy dependence from 97% in 2018 to 82% in 2030. This ambitious target called for the installation of two gigawatts (GW) of solar-powered capacity.[18]

The target of 42% solar-powered capacity by the end of 2020 was not achieved, although it was close, as 36.8% of the 10,600 megawatts (MW) of installed capacity at the end of 2020 came from renewable energy.[19] Nevertheless, Morocco achieved a first push towards green, sustainable energy, while consolidating a "public-private participation" model that proved very favourable to private international operators. The law allowed operators to position themselves as independent power producers, through advantageous power purchase agreements (PPAs) that obliged the state (ONE) to buy the electricity produced at an agreed price for a period of 25 to 30 years.

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[13]Aïda del Puech, Arianna Poletti (27 November 2022). *The race for solar mega-projects in North Africa is attracting Europeans. El País*. Available at: https://elpais.com/planeta-futuro/2022-11-27/la-polemica-de-los-megaproyectos-solares-en-el-norte-de-africa.html

[14]NisrineZaoui (30 September 2021). *Erfoud: the 40MW photovoltaic solar power station is now in service*. Le360. Available at: https://fr.le360.ma/economie/erfoud-la-station-solaire-photovoltaique-de-40mw-bientot-en-service-246631

[15]Electricity tariffs in Spain are available at: https://tarifaluzhora.es/

[16] Investing in Africa: which are the best countries? CESCE. 27 November 2021. Available at https://www.cesce.es/es/w/asesores-de-pymes/invertir-en-africa

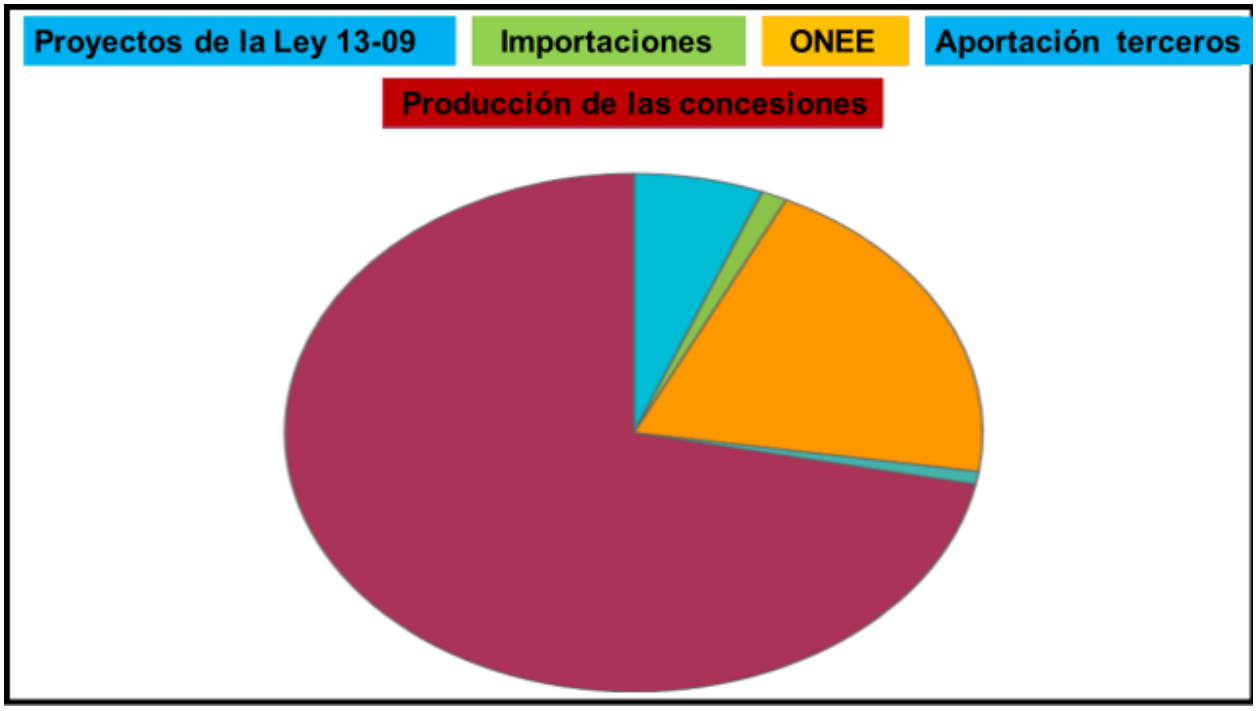
[17] Law no. 13-09 on renewable energy, enacted by Dahir no. 1-10-16 of 26 Safar 1431 (11 February 2010) published in the Official State Gazette no. 5822 of 1 rabii II 1431 (18 March 2010). Available at: https://www.fellah-trade.com/ressources/pdf/loi-13-09-energies-renouvelables-2.pdf

[18]Moncef Ben Hayoun and Moncef Ben Hayo (28 October 2021). *Renewable energies: Morocco powers up*. Le Matin. Available at: https://lematin.ma/journal/2021/energies-renouvelables-maroc-monte-puissance/366567.html

[19] Ibid.

This type of energy contract, whether fossil or renewable, holds priority over energy produced by public power plants. In this way, private operators secure a guaranteed income for the duration of the contract. At the same time, it protects them from possible price fluctuations and/or a drop in energy demand, despite the damage to the public purse.

The result has been increased participation of private businesses in electricity production, so that by the end of 2021, the private sector controlled more than two-thirds (71.8%) of electricity production in Morocco.[20]




Source: "Energy sector - Key figures - April 2021", Ministry for Energy, Mining, Water and the Environment.

This policy has made it possible to create a relatively large renewable energy market in Morocco. In 2020, renewable energy production in the country reached around 7,000 GWH (gigawatt hours), considerable growth compared to 2,700 GWH in 2011. In addition, the share of renewables in total energy generation increased from around 11% in 2011 to 18% in 2020.[21]

The main beneficiaries of private production licences, whether fossil or renewable, have been French (Engie), Spanish (Gamesa), Saudi (Acwa), Emirati (Taqa) and German (Siemens) transnational companies, usually in cooperation with national companies owned by the royal family (Nareva, now Al Mada)[22] or politically connected (Green Africa).

In the coming years, Morocco will continue to develop new projects to reach a renewable capacity of 12 gigawatts by 2030. The strategic objective would be to have renewable energy account for 52% of the total fuel mix by then, compared to 40% today, and to do so at a very competitive price of less than 3

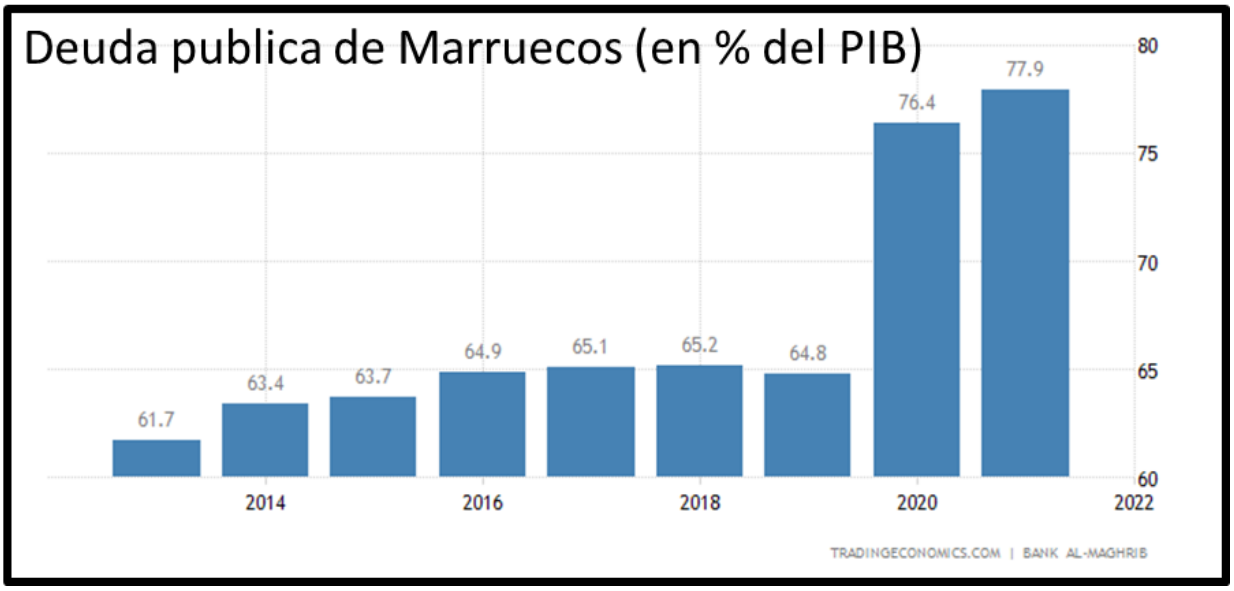
[20] Jawad Moustakbal (7 December 2021). *The Moroccan energy sector: A permanent dependence.*CADTM. Available at: https://www.cadtm.org/The-Moroccan-energy-sector-A-permanent-dependence
[21] Energy sector in Morocco - statistics & facts. Statista. Available at: https://www.statista.com/topics/9843/energy-sector-in-morocco/#topicOverview
[22] Francisco Peregil, Trinidad Deiros Bronte (11 November 2021). Mohamed VI, the king of the wind in Western Sahara. *El País*. Available at: https://elpais.com/internacional/2021-11-11/mohamed-vi-el-rey-del-viento-en-el-sahara-occidental.html

cents per kilowatt hour for wind and between 2 and 3 cents for photovoltaic.[23] This would allow the North African country to meet its growing electricity needs and create a clean energy export capacity.

The main problem holding back Morocco's ambitious plan is funding. All recent power generation projects have been financed by loans from international private banks, the International Monetary Fund, the World Bank, the African Development Bank and French, German and Japanese development agencies. The Moroccan Solar Energy Agency (MASEN) takes on this debt that is guaranteed by the Moroccan state.

The international lenders are therefore the ones who have the final say in all strategic decisions on these projects. So long as the lenders consider that the Kingdom of Morocco has the solvency to guarantee the repayment of the loans and the companies involved in the various projects, whether as operators (France's Engie, Germany's Siemens, etc.) or as equipment suppliers (France's Alstom, Japan's Mitswi, etc.), correspond to the nationality of the lenders, Morocco will be able to continue to develop its ambitious plan.

But, in the end, these loans have added to a public debt that, at the end of 2021, was 77% and is estimated to have exceeded 83% by 2022.[24] Servicing this debt absorbs more than a third of the state budget and represents a significant burden on Moroccan public coffers at a time of unfavourable global market conditions.




Source: Trading Economics. https://es.tradingeconomics.com/morocco/external-debt

**Morocco's mega renewable energy projects**

The main company in the sector is Nareva, created in 2005 as a subsidiary of the holding company SNI, and since March 2018 called Al Mada (perspective). It has established itself as a leader among Moroccan companies, particularly in the field of wind turbines. The company, through its subsidiary Énergie Éolienne du Maroc (EEM), has been specialising in wind farm development and has also led consortia that have won major public-private partnership contracts.

[23] As a reference, grey hydrogen is produced in Spain at a cost of €1.50-€2.50 per kilogramme. https://felipebenjumeallorente.com/el-coste-del-hidrogeno-verde/

[24] Morocco's public debt could be over 83% of GDP. Journeax.ma.16/01/2023. https://www.journaux.ma/journal/opinion/la-dette-publique-marocaine-devrait-depasser-83-du-pib/

Nareva got its start in the renewable energy sector in a very ambitious way in 2014 when in conjunction with the French company ENGIE (formerly GDF Suez) they founded the equally owned Tarfaya Energy Company (TAREC) for the construction and operation of a huge wind farm located 20 km southeast of the city of Tarfaya (southern Morocco). Seventeen kilometres long and six kilometres wide, the Tarec wind farm is the largest on the African continent with an installed capacity of 301 MW (1,100 GWh/year) enough to light a city like Marrakech (1.5 million inhabitants) for a whole year and at a very competitive price. This farm, which cost €460 million, became operational in December 2014 and is an excellent example of how public-private partnerships work in Morocco. The energy produced is sold exclusively to ONE under a 20-year power purchase and supply contract at a price fixed from the outset.[25] At the end of this period, which is considered more than enough to make Nareva and its partner Engie's investment profitable, ONE will recover the infrastructure.[26]

In May 2015, Nareva won the tender for an even more ambitious wind farm project. This involved the construction, operation and maintenance of five wind farms, from Tangier (100 MW) to Boujdour (100 MW) via Midelt (150 MW), Essaouira (200 MW) and Laayoune (300 MW): 850 MW in total at an estimated project cost of almost one billion euros. To do so, Nareva teamed up with Germany's Siemens and Italy's Enel Green Power, in competition with big names in the sector such as France's EDF, Spain's Acciona Wind Power, Japan's Mitsiu&Co, Britain's Engie Energy International (a subsidiary of France's Engie) and Saudi Arabia's Acwa Power[27].

In 2016, Nareva was awarded the huge 850 MW Integrated Wind Project, consisting of Midelt (210 MW), Boujdour (300 MW), Jbel Lahdid (270 MW) and Tiskrad (in Tarfaya) (100 MW). Nareva won this project in partnership with wind turbine manufacturer Siemens Gamesa Renewables (Germany-Spain).

But perhaps the most interesting project is the Noor plant, the largest solar thermal plant in the world with an installed capacity of 580 MW. Located in the municipality of Ouarzazate, a region with one of the highest amounts of sunlight in the world (2,635 kWh/m2/year), it is a four-phase project covering 3,000 hectares in the south of the High Atlas Mountains and has the strategic objective of making Morocco a new supplier to Europe.[28]

Noor Ouarzazate was the first major project of the Moroccan Solar Energy Agency (MASEN) with 60% of its funding coming from Europe. Spanish companies have played an important role in its construction. In 2016, the first phase of 160 MW built by a consortium of Spanish companies (TSK, Acciona and Sener) was inaugurated, covering the electricity consumption of 600,000 people. The second and third phases, which began operating in January and December 2018 respectively, were also built by the Spanish company Sener, this time in partnership with the Saudi company Acwa and with Chinese technology.[29] The fourth phase is a 72MW photovoltaic power project, which will also be the first large-scale photovoltaic power plant in Morocco[30].

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[25]TARFAYA WIND FARM. NAREVA. Available at: https://www.nareva.ma/fr/projet/parc-eolien-tarfaya
[26] Mehdi Michbal (31 May 2015). *The Tarfaya Wind Farm brings a new breath of fresh air to Morocco*. Jeune Afrique. Available at: https://www.jeuneafrique.com/236416/economie/reportage-le-parc-eolien-de-tarfaya-apporte-un-nouveau-souffle-au-maroc/
[27] Fahd Iraqi (10 December 2015). *Morocco: Nareva wins the bid for 850 MW of wind energy*. Jeune Afrique. Available at: https://www.jeuneafrique.com/286034/economie/286034/
[28] Available at: https://marruecoshoy.com/central-noor-ouarzazate/
[29] Victor de Elena (16 October 2022). *Morocco arms its renewables to become a supplier to Europe*. La Información. Available at: https://www.lainformacion.com/economia-negocios-y-finanzas/marruecos-arma-sector-renovable-vender-energia-europa/2875128/
[30]Ouarzazate Solar Power Plant, Draa-Tafilalet. NS Energy. Available at: https://www.nsenergybusiness.com/projects/ouarzazate-solar-power-plant-draa-tafilalet/

The Noor Ouarzazate complex consists of four solar power plants using different technologies: Noor Ouarzazate I and II use cylindrical parabolic mirror technology. Noor Ouarzazate III is a solar power plant consisting of a 250-metre-high central tower, the largest in the world, which generates solar thermal energy from the reflection of sunlight by mirrors placed around it in concentric circles. It also stores this energy for several hours thanks to molten salt storage technology. The power plant is completed by Noor Ouarzazate IV, a typical solar PV power plant. In total, the Noor complex is capable of reaching an output of 580 MW, powering the entire south of the country.

The momentum that the renewable energy sector is experiencing in Morocco has led MASEN to start up or plan a total of 20 solar plants, together with several wind farms, which will allow it to reach 2,000 MW per year, in addition to the country's existing hydroelectric dams capable of generating an additional 1,300 MW.

The Moroccan government's strategy to generate 52% of its electricity from renewable sources by 2030 includes Noor Midelt[31] with 800 MW planned for the first phase (almost the equivalent of a 900 MW nuclear power plant), located in the highlands between the Middle Atlas and High Atlas mountain ranges. Considered the world's first hybrid plant of its kind for this power level, Noor Midelt started in 2019 and combines concentrating solar power (CSP) and solar photovoltaics (PV).

At a cost of $2.3 billion, financed mainly by the World Bank ($125 million), the African Development Bank ($265 million), the European Investment Bank ($420 million), the French Development Agency ($185 million) and KfW ($852 million), Noor Midelt will be one of the world's largest solar projects combining CSP and photovoltaic technologies. The project will also provide thermal storage for a minimum of five hours.

The agency carrying out this project is the Moroccan Agency for Sustainable Energy (25%) in partnership with a consortium of EDFEN (35%), Masdar (30%) and Green of Africa (10%) that was selected to build and operate the facility for a period of 25 years. For its part, TSK, an engineering and construction company based in Spain, is responsible for the design and construction of the first phase of Noor Midelt, which will provide clean electricity to more than one million people at a price estimated at a quarter of what it costs in Morocco to obtain electricity from oil.

But the great technological innovation of Noor Midelt is that it will be the first solar project in the world to include thermal storage of PV (photovoltaic) and CSP (concentrated solar power). Unlike traditional solar PV projects where storage is done with batteries, in Midelt the solar energy from both the CSP plant and the PV plant will, for the first time, be stored in the CSP part of the project.

In total, Morocco has built or planned 28 wind farms and 19 solar power plants. This has allowed the creation of a relatively large renewable energy market in Morocco. In 2021, the installed capacity of renewable energy in the country reached 3,950 MW, increasing the share of renewable energy to 37% of the country's total electricity production compared to 11% in 2011[32].

[31] *Noor Midelt Solar Power Project, Morocco*. NS Energy. Available at: https://www.nsenergybusiness.com/projects/noor-midelt-solar-power-project-morocco/
[32] Available at: https://www.mem.gov.ma/Pages/secteur.aspx?e=2

| WIND FARMS | SOLAR POWER PLANTS |
|---|---|
| ABDELKHALEK TORRES WIND FARM 50 MW | SOLAR PHOTOVOLTAIC POWER PLANT (10 MW) "Morocco Photovoltaic". |
| AKHFENNIR I (101.87 MW) WIND FARM | SOLAR PHOTOVOLTAIC POWER PLANT (30 MW) "GREEN POWER MOROCCO". |
| AMOUGDOUL ESSAOUIRA WIND FARM | SOLAR PHOTOVOLTAIC POWER PLANT IN SELF-PRODUCTION (1 MW) - Golden Logistics |
| KHALLADI WIND FARM 120 MW | SOLAR PHOTOVOLTAIC POWER PLANT IN SELF-PRODUCTION (1 MW) "Ocp Group". |
| LAFARGE WIND FARM 32 MW (TANGIER TETOUAN AL HOCEIMA REGION) | SOLAR PHOTOVOLTAIC POWER PLANT FOR SELF-PRODUCTION (1 MW) |
| TANGIER I WIND FARM 140 MW | SOLAR PHOTOVOLTAIC POWER PLANT IN SELF-PRODUCTION (1.69 MW) "SAFRAN NACELLES". |
| TARFAYA WIND FARM (300 MW) | SOLAR PHOTOVOLTAIC POWER PLANT IN SELF-PRODUCTION (2.5 MW) "Nexans Morocco". |
| FOUM EL OUED WIND FARM (50.6 MW) | SOLAR PHOTOVOLTAIC POWER PLANT IN SELF-PRODUCTION (18MW) |
| HAOUMA WIND FARM (50.6 MW) | MULTI-SITE SOLAR NOOR PV II PROGRAMME - Phase 1 - (400 MW) |
| PLANNED OUALIDIA I WIND FARM (18 MW) | PLANNED NOOR ATLAS (200 MW) |
| PLANNED AKHFENNIR II WIND FARM EXTENSION | PLANNED NOOR BOUJDOUR I (20 MW) |
| PLANNED AFERKAT WIND FARM (80 MW) | PLANNED NOOR BOUJDOUR II (350 MW) |
| PLANNED AKHFENNIR III WIND FARM (50 MW) | PLANNED NOOR LAAYOUNE I (85 MW) |
| PLANNED AM WIND FARM (100 MW) | PLANNED NOOR MIDELT PHASE I (800 MW) |
| PLANNED CAP CANTIN WIND FARM (108 MW) | PLANNED NOOR OUARZAZATE I (160 MW) |
| PLANNED DAKHLA WIND FARM (40 MW) | PLANNED NOOR OUARZAZATE II (200 MW) |
| PLANNED AFTISSAT I WIND FARM (200 MW) | PLANNED NOOR OUARZAZATE III (150 MW) |
| PLANNED AFTISSAT II WIND FARM (200 MW) | PLANNED NOOR OUARZAZATE IV (72 MW) |
| PLANNED BIRANZARANE WIND FARM (200 MW) | PLANNED NOOR TAFILALET (120 MW) |
| PLANNED BOUJDOUR WIND FARM (300 MW) | |
| PLANNED MIDELT WIND FARM (210 MW) | |
| PLANNED TANGIER II WIND FARM (70 MW) | |
| PLANNED TAZA WIND FARM (150 MW) | |
| PLANNED JBELLAHDID WIND FARM | |
| PLANNED KOUDIATBAIDA WIND FARM (REPOWERING) 120 MW AND EXTENSION TO 200 MW | |
| PLANNED TISKRAD WIND FARM (100 MW) | |
| PLANNED GHRADJRAD WIND FARM (80 MW) | |
| PLANNED OUALIDIA II WIND FARM (18 MW) | |

Source: Ministry for the Energy Transition and Sustainable Development. https://www.mem.gov.ma/Pages/secteur.aspx?e=2

The result of this ambitious energy policy is that the initial target of 42%, which was planned for 2020, will finally be reached in 2023, which will make it easier to reach 52% in 2030. This will mean a total installed renewable power of 12 GW, double the current rate,[33] which, if achieved, would represent a major step forward in Morocco's energy autonomy process and in its strategy to become a supplier to Europe.

**The XLINKS project**

The success of these Moroccan energy projects in recent years has led several private European companies to see Morocco as a land of new economic opportunities. The best example of this is the UK's XLINKS project, which aims to produce electricity from renewable sources with a total capacity of 10.5 GW from photovoltaic and wind generation together with 25 GWh (gigawatt-hours) of battery storage near Tan-Tan in southern Morocco and deliver it via an undersea cable to the UK.

[33] Morocco aims to double its renewable energy capacity to 12 gigawatts by 2030. Moroccan Agency for Energy Efficiency. 16 January 2023. https://www.amee.ma/fr/node/1195

The project responds to an obvious economic rationale, given that "solar generation in the UK is very low during the winter, when energy demand is highest, and wind output can vary greatly from week to week... the obvious solution is to locate solar and wind generation in the Sahara... which benefits from high levels of solar irradiation all year round".[34]

However, the objective of this project is fundamentally geopolitical. The aim would be to reduce energy dependence on the European Union within the context of Brexit. As Tesco CEO Dave Lewis pointed out in reference to the UK, "We need a power supply made in Britain, for Britain, and that's what this plan is all about".[35]

This is not a new idea and as early as 2003, an organisation called the Trans-Mediterranean Renewable Energy Cooperation tried to produce renewable energy in the Sahara for export to European markets. However, the enormous cost of €400 billion to obtain 100 GW of generation capacity prevented the project from getting off the ground.

Subsequently, in 2016, the rising cost of nuclear power in the UK led renewable energy company Nur Energie to propose investing in Sahara's concentrated solar power capacity, so that by 2020 the company could begin supplying power to the UK, which has not happened to date.[36]

Xlinks' current goal is basically the same as Nur Energie's: to mass-produce renewable energy in Morocco and bring it to the UK to power seven million homes by 2030. The advantages are lower costs, which is much appreciated in the face of rising demand and which Xlinks aims to achieve by focusing on photovoltaics as a form of renewable generation, rather than the relatively expensive concentrated solar power that was Nur Energie's proposal. In this way founder and CEO Simon Morrish thinks he can distribute electricity at around $15 per megawatt-hour in North Africa.

The second major difference between Xlinks and previous generation proposals concerns transport. Until now, the aim has been to send electricity via interconnectors to continental Europe and from there via the European grid to Great Britain. Xlinks now plans to run 3.6 GW of submarine cable capacity from Morocco, skirting the continental shelf around Portugal, Spain and France to the UK. The ultimate goal would be to provide up to 7.5% of the UK's electricity at a price of around $70 per megawatt-hour, compared to the $125 (at current rates) per megawatt-hour agreed in 2012 for Hinkley Point C, the UK's most recent nuclear power plant.

While the project appears very attractive to Morocco and the UK, it nevertheless has serious drawbacks. The first is technical and concerns the installation of two 1.8 gigawatt HVDC submarine cables between Morocco and the UK at a length of 3,800 km. This is a particularly arduous undertaking that has never been done to date and neither Morocco, nor Britain, has sufficient HVDC manufacturing capacity.[37]

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[34] *The world's longest undersea power cable will connect a wind-solar complex in Morocco to the UK.* Ecoinventos (25 April 2022). Available at: https://ecoinventos.com/xlinks/

[35] Mark Kleinman (29 April 2022). *Clean energy start-up Xlinks eyes investor backing for revolutionary £16bn project.*SkyNews. Available at: https://news.sky.com/story/clean-energy-start-up-xlinks-eyes-investor-backing-for-revolutionary-16bn-project-12601045

[36] Brett Prior (3 August 2010). *Desertec Update: Coordinating 40 Countries, 200 Km of Undersea Cables, and €400B in Funding*. GreenTechMedia. Available at: https://www.greentechmedia.com/articles/read/desertec-update-funding

[37] The cable would be six times longer and have 2.5 times the capacity of the planned Viking Link between Denmark and Great Britain. This latest connection, to be completed in 2023, will be the world's longest high-voltage submarine cable and is expected to cost almost USD 2.2 billion.

The second problem, which will be more difficult to overcome, concerns the estimated funding of $21.6 billion[38] (half of it for the undersea cabling) which would require a commitment from a UK government that is reluctant in the current economic climate and even more so given the history of past projects. Nor is this costly project helped by what Jenny Chase, head of solar analysis at Bloomberg NEF, has described as "the political feasibility of relying on pipelines from North Africa",[39] something that the current situation of geopolitical tension with its Algerian neighbour is not conducive to.

**Morocco's energy commitment to green hydrogen**

Regardless of this somewhat outlandish project, the reality is that Morocco's energy sector is expanding. The country is immersed in the development of an ambitious programme to move its model towards renewable energies, mainly through the exploitation of wind, solar and green hydrogen resources. However, to achieve its strategic goal of becoming an energy supplier to Europe, Morocco needs energy connections to enable it to do so. Geographical logic indicates that these should be routed through the Iberian Peninsula using the shortest route and taking advantage as far as possible of existing infrastructures and those foreseen in European energy plans. This requires stable mutually beneficial agreements with Spain.

The solution is not so simple when it comes to electricity interconnections. Spain is currently an "electricity island" in energy terms due to being a peninsula that cannot easily access electricity from other European countries nor supply them. The European Union recommended reaching a rate of electricity exchanges between neighbouring countries of at least 10% by 2020, with a view to guaranteeing supply; however, Spain's exchanges with the European system only reached 3% of Spain's installed production capacity by this date, the equivalent of 2,800 MW.[40]

The new European targets are to increase the rate to 15% by 2030.[41] However, it will be difficult to bring exchanges with France up to this new threshold, even if the forecasts set out in the Integrated National Energy and Climate Plan (PNIEC)[42] approved in January 2020 are met because it would require an exchange of 8,000 MW by 2030 and involve the construction of new lines.

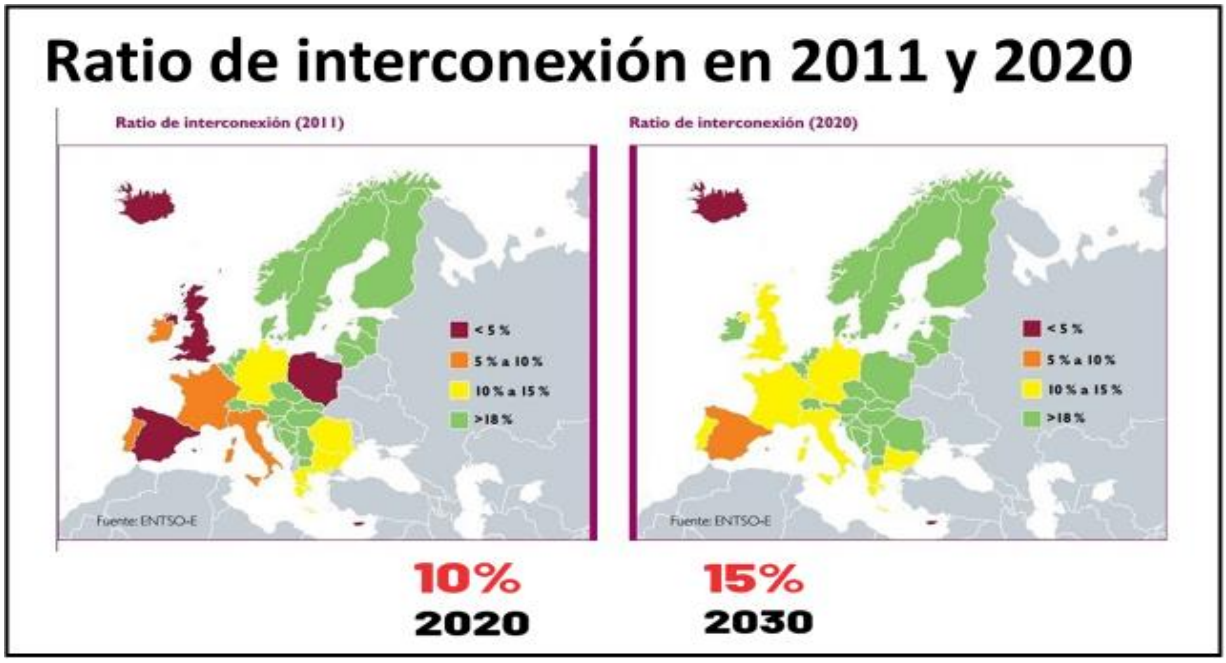
[38] *Abdeslam Ababou provides princely back-up for Xlinks' giant solar power project*. Africa Intelligence. 16 November 2021. Available at: https://www.africaintelligence.com/north-africa/2021/11/16/abdeslam-ababou-provides-princely-back-up-for-xlinks--giant-solar-power-project,109705151-art

[39] Jason Deign (4 December 2020). *Xlinks Revives Desertec's Dream, With a Few Twists. GTM*. Available at: https://www.greentechmedia.com/articles/read/xlinks-revives-desertecs-dream-with-a-few-twists

[40] *Electricity interconnections: a step towards a single energy market in Europe*. REE. September 2012.

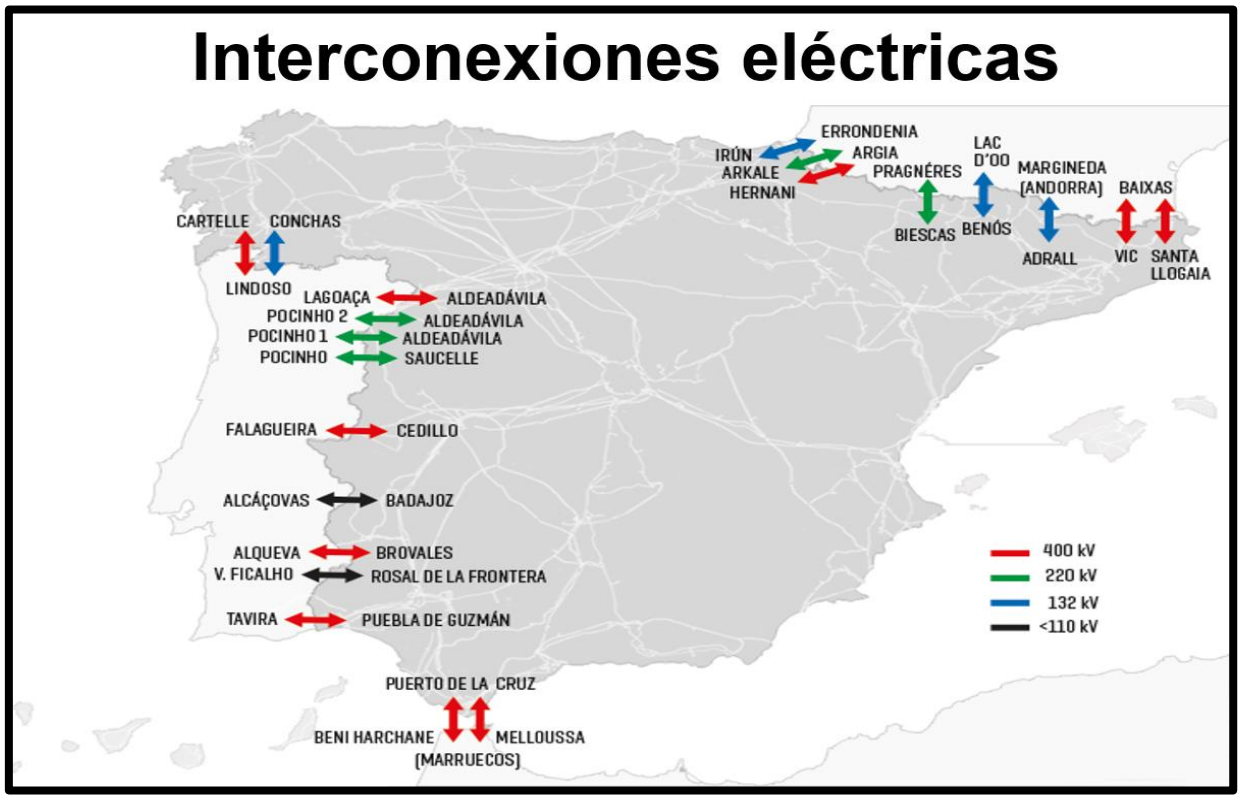
[41] Strengthening interconnections. Red Eléctrica Española. Available at: https://www.ree.es/es/red21/refuerzo-de-las-interconexiones

[42] INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN 2021-2030. Government of Spain. 20 January 2020. Available at: https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf



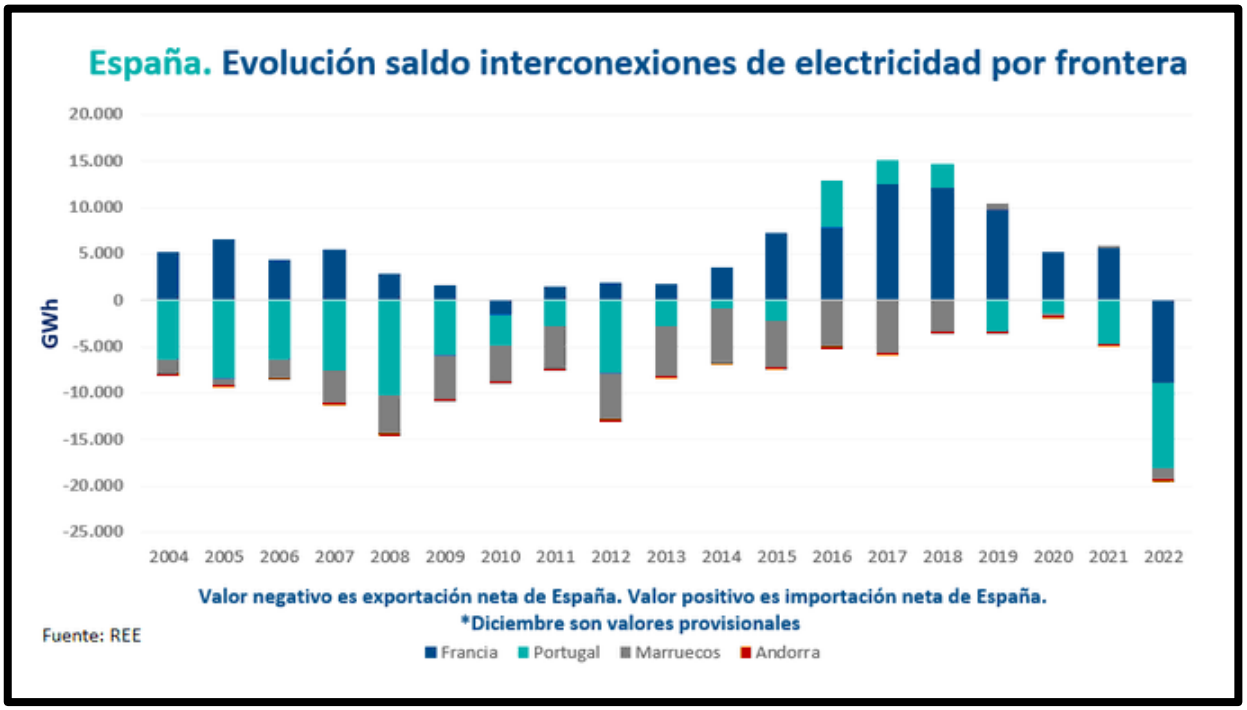

Source: ENTSO-E/REE. https://www.ree.es/es/red21/refuerzo-de-las-interconexiones

This necessarily affects Morocco's ambitious plans to export electricity to Europe. There is currently a Spain-Morocco electricity interconnection via a bi-directional cable across the Strait of Gibraltar. The first 400 kilovolt alternating current line with a technical capacity of 700 MW dates from 1997, to which a second connection of a further 700 MW was added in June 2006, and a third similar connection is planned before 2026. In total the current exchange capacity is about 800 MW.




Source: Red Eléctrica Española (REE). https://www.ree.es/es/red21/refuerzo-de-las-interconexiones

The limited interconnection with Morocco means that, for a country like Spain, which has a demand for electricity that amounted to 22,052 GWh in January 2023 – of which 13,742 GWh was renewably sourced[43] – imports from Morocco, which in the same month amounted to only 19,639 MWh,[44] represent an insignificant amount, so that the price in Morocco has hardly any influence in Spain. Traditionally, it has been Spain that has sold the most electricity to Morocco, although exports have never exceeded 20% of Moroccan consumption and usually account for "between 7 and 17%" of its annual consumption.[45]




Source: Red Eléctrica de España (REE). https://www.ree.es/es/datos/intercambios/frontera-fisicos

The difficulty of substantially increasing electricity interconnections between Spain and France with a view to exporting renewable surpluses and the limited electricity connections with Spain make it unrealistic for Morocco to use the Spanish grid to send its own surplus to the European electricity market. In fact, although there were or are plans to do so, the PNIEC does not foresee an increase in interconnections with Morocco before 2030, which will remain limited to the current 800 MW.

Morocco's response to this bottleneck in electricity connections with the European continent comes in the form of locally produced green hydrogen.[46] Hydrogen enables the transport of renewable energy production over long distances via hydrogen pipelines and sea transport, thus unlocking renewable

[43] *The demand for electricity in Spain fell by 4.1% in January, according to Red Eléctrica*. FORBES/EP. 2 February 2023. Available at https://forbes.es/ultima-hora/227518/la-demanda-de-energia-electrica-en-espana-desciende-un-41-en-enero-segun-red-electrica/

[44] BORDER BALANCES - PHYSICAL (MWh) | BORDER: Morocco. REE. Available at https://www.ree.es/es/datos/intercambios/marruecos-frontera

[45] Guillermo Infantes Capdevila (31 August 2021). *The post that claims Morocco pays "25 times" less for electricity despite buying it from Spain: we explain.* Newtral. Available at: https://www.newtral.es/precio-luz-espana-marruecos-nos-preguntais-por/20210831/

[46] Hydrogen is not a primary source of energy, like the sun or wind, but an energy carrier, i.e. a manufactured product that is capable of storing energy so that it can be released gradually. If renewable energies are used in its production, the hydrogen obtained is considered as "green hydrogen" or "renewable hydrogen".

resources in out-of-the-way locations such as Morocco in relation to Europe. In addition, existing natural gas pipelines could be refitted, with certain technical modifications, to transport hydrogen.[47]

It is therefore a bet on a renewable energy vector that, until now, has been absent from the clean energy puzzle because it is not yet competitive. Nevertheless, it is estimated that it will become so in the next decade and will cover 12% of the world's consumption by 2050.[48] The aim would be to favour local green hydrogen as a technological solution for converting and storing energy, which would at the same time allow it to develop the local economy, increase employment and improve its balance of payments.

This option could be a great opportunity for a country, like Morocco, that lacks fossil fuels but considered by the International Renewable Energy Agency (IRENA) as one of the five best-placed countries to become a major producer of clean hydrogen.[49] This is particularly interesting at a time when rising gas prices in Europe as a result of the conflict in Ukraine are accelerating the transition to a climate-neutral economy by 2050, that is an economy with zero net greenhouse gas emissions.[50]

To this end, Morocco created a National Hydrogen Commission in 2019 and published a green hydrogen roadmap in January 2021. According to it, the North African country expects to capture up to 4% of global demand for green hydrogen by 2030. This would amount to, in 2050, 600 TWh (Terawatt hours) out of a total of 20,000 TWh estimated by a World Energy Council study.[51] In an optimistic scenario, the annual revenues associated with this demand could reach €2 billion in 2030 and €30 billion in 2050 if green hydrogen and its derivatives are valued at the price of their conventional alternatives.[52]

As part of this energy strategy, the company Total Eren – 30% owned by the French oil company Total Energies – has been commissioned to set up a large power plant combining solar and wind energy to produce green hydrogen and ammonia. Requiring an investment of €9 billion, it will be located on 170,000 hectares in the Guelmim-Rio Noun region in the south of the country and will be able to generate up to 10 GWh of energy. By 2030, the country envisages a local hydrogen market of 4 TWh and an export market of 10 TWh, which together would require the construction of 6GW of new renewable capacity, creating more than 15,000 jobs.[53]

Here again, however, Morocco faces the problem of financing, as its own roadmap indicates that the development of the green hydrogen industry in Morocco will require a total investment ranging from

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[47] *Geopolitics of the Energy Transformation. The Hydrogen Factor*. Irena. 2022. Pg. 10. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf?rev=1cfe49eee979409686f101ce24ffd71a

[48] *Morocco now classed a potential green hydrogen exporter*. Medias24. 17 January 2021. Available at: https://medias24.com/2022/01/17/le-maroc-desormais-classe-parmi-les-exportateurs-potentiels-dhydrogene-vert/

[49] Eric Apim (18 January 2022). *Irena sees Morocco as a future green hydrogen giant*. Econostrum. Available at: https://en.econostrum.info/Irena-sees-Morocco-as-a-future-green-hydrogen-giant_a1233.html

[50] *2050 long-term strategy*. European Commission. Available at: https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en#eu-strategy

[51] *Roadmap. Green hydrogen. Energy transition vector. Kingdom of Morocco*. P. 11. https://www.mem.gov.ma/Lists/Lst_rapports/Attachments/36/Feuille%20de%20route%20de%20hydrog%C3%A8ne%20vert.pdf

[52] Ibid. P. 15.

[53] *Geopolitics of the Energy Transformation. The Hydrogen Factor*. International Renewable Energy Agency, Abu Dhabi. P. 48. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf?rev=1cfe49eee979409686f101ce24ffd71a

€12.6 billion to €90 billion to be disbursed between 2020 and 2050, in order to improve its interconnections with Europe and become a reliable supply alternative.[54]

To solve this problem, Morocco has signed an energy trade agreement with the Netherlands and is in talks with Germany and Portugal, among other European actors, to obtain investment support through public-private partnerships, direct financing within the framework of bilateral or multilateral partnerships, as well as preferential tax treatment.

**Morocco and Spain: energy competitors or strategic partners?**

Morocco's commitment would be to develop an export industry for green hydrogen and its derivatives based mainly on the maritime transport of synthetic liquid fuels, the construction of adequate port infrastructure, as well as the creation of production, storage and export infrastructure.

However, international trends point in a different direction. The latest report from the International Renewable Energy Agency (IRENA) indicates that most hydrogen will be produced and consumed locally, although a considerable part will be transported over long distances. By 2050, at least 25% of all hydrogen produced will be sourced outside the borders of consuming countries. This will mean more than 100 million tonnes of green hydrogen and more than 50 million tonnes of blue hydrogen (from natural gas).[55]

However, only half of the hydrogen earmarked for export will be transformed into ammonia for transportation by ship. The high cost of transporting liquid hydrogen at high pressure, due to the required cryogenic conditions of minus 235 degrees Celsius and the significant evaporation losses, makes this form of transport almost residual in the medium to long term.

The other half will be through pipelines by conveniently adapting the pipelines currently used to transport natural gas. The use of these pipelines, which are abundant in Europe, is considered the most efficient and safest way to transport hydrogen and the cheapest at an estimated cost of US$0.08 to US$0.12 per kilogram per 1,000 km. In the case of new installations, the cost per km would increase to between US$0.16 and US$0.24 per kilogram per 1,000 km.[56]

Europe's extensive natural gas grid represents an excellent window of opportunity for the export from Morocco of green hydrogen produced from its abundant high-quality solar and wind resources. Morocco could use European infrastructure to transport green hydrogen to the continent's industrial hinterland by leveraging demand momentum as the price of green hydrogen becomes competitive, which is expected to occur in the mid-2030s, although some studies anticipate it to occur as early as 2024.[57]

But this requires greater coordination with Spain, which is a key element for energy interconnection with Europe, as well as a country that also intends to take advantage of the significant potential of its solar photovoltaic and wind resources and the existence of large free areas that favour the installation of renewable energy production plants, whether solar or wind, to become "one of the European powers in

[54] Ibid. P. 16.
[55] Global Hydrogen Trade to Meet the 1.5°C Climate Goal. IRENA 2022. Available at:
[56] Carlos Noya (5 April 2022). *The future of hydrogen in 2050. Mass production from renewables, pipeline transport and as ammonia in ships*. FCE. Available at: https://forococheselectricos.com/2022/04/futuro-hidrogeno-2050-renovables-transporte.html
[57] Javier López de Benito (10 August 2022). *Green hydrogen will be economically competitive sooner than expected.* Energy News. Available at: https://www.energynews.es/hidrogeno-verde-competitivo-en-2024/#:~:text=Seg%C3%BAn%20el%20%C3%BAltimo%20informe%20de%20Rethink%20Energy%2C%20el,f%C3%B3siles%20utilizados%20en%20la%20producci%C3%B3n%20de%20hidr%C3%B3geno%20gris

renewable energy generation".[58] Spain's "hydrogen roadmap" of October 2020 also stresses Spain's role as a transit country for low-cost hydrogen produced in North Africa, reusing existing natural gas infrastructures and adapting them for the transport and distribution of hydrogen within the peninsula and to centres of demand in Europe.[59]

The GreenH2pipes project,[60] a consortium of eight companies and six research centres, seeks to develop the technology needed to boost hydrogen production and transport through the extensive gas network currently operated by Enagás in Spain, which comprises more than 11,000 km of gas pipelines[61]. This network has six international connections: two with Africa via Tarifa and Almeria (linking with the Maghreb and Medgaz pipelines, respectively); two with Portugal via Badajoz and Tui; and another two with France via Irún and Larrau. In the medium term, the national backbone could be connected to France via the existing connections at Larrau (2035) and Irún (2040). Connections to North Africa can be made from 2035 to supplement domestic supply with imports from the south to meet demand in Central Europe.


Source: ENAGAS. https://www.enagas.es/es/transicion-energetica/red-gasista/infraestructuras-energeticas/red-transporte/conexiones-internacionales/

To this should be added the possibilities offered by the H2MED project to improve energy interconnections with France. This is an underwater corridor designed to exclusively carry green hydrogen

[58] *Hydrogen Roadmap: a commitment to renewable hydrogen*. Ministry for Ecological Transition and the Demographic Challenge. Government of Spain. Madrid. October 2020. P. 24. Available at https://www.miteco.gob.es/es/ministerio/planes-estrategias/hidrogeno/hojarutahidrogenorenovable_tcm30-525000.PDF

[59] Ibid. P. 50.

[60] *Energy companies and research centres join forces in GreenH2Pipes to boost hydrogen*. Europa Press. 6 May 2022. Available at https://www.europapress.es/economia/energia-00341/noticia-companias-energeticas-centros-investigacion-unen-greenh2pipes-impulsar-hidrogeno-20220506115508.html

[61] « Conexiones energéticas con países vecinos ». ENAGAS. Available at https://www.enagas.es/es/transicion-energetica/red-gasista/infraestructuras-energeticas/red-transporte/conexiones-internacionales/

and which will become the world's largest hydrogen pipeline with a route that could reach 450 kilometres and whose cost is estimated at €2.5 billion.[62] H2Med could transport up to 10% of the total renewable hydrogen target set by Brussels in the May 2022 RePower EU plan, which sets a target of 20 million tonnes of renewable hydrogen by 2030.


Source: https://noctula.pt/corredor-de-hidrogenio-verde-h2med/mapa-h2med-corredor-de-hidrogenio-verde/

Although Spain's ambition to become an energy hub and the main supplier of hydrogen in Europe makes it, a priori, an energy competitor of Morocco, the weakening of relations with Algeria due to the change in Spain's position on the Western Sahara conflict would, alternatively, favour the synergy of energy interests with Morocco.

The reality is that forecasts suggest that there is a huge potential market in Europe for two countries that are counting on their significant solar photovoltaic and wind potential to produce green hydrogen on a grand scale. The EU plans to produce one million tonnes of green hydrogen by 2024, rising to 10 million tonnes by the end of the decade, which – at a very competitive price of €1.50 per kilogramme – means a lucrative business worth €1.5 billion s in 2024 and €15 billion by the end of the decade.[63]

The combination of soaring demand and the growing market share held by renewables, coupled with the project to transport energy, which many experts say will be key to achieving the energy transition to totally clean sources, means that this is a historic opportunity for both countries as the decarbonisation process takes hold.

**The risks of competition**

[62] Antón Parada (9 December 2022). *The submarine hydrogen corridor: a project that will make Spain a benchmark in Europe*. Huffpost. Available at: https://www.huffingtonpost.es/entry/el-corredor-submarino-de-hidrogeno-h2med-barmar-un-proyecto-que-hara-de-espana-un-referente-en-europa_es_6392fcf7e4b0169d76d5e6c0.html

[63] *Why Spain can be a world leader in green hydrogen.* Iberdrola. 15 November 2021. Available at: https://www.iberdrola.es/blog/sostenibilidad/espana-lider-mundial-hidrogeno-verde

It is therefore advisable to fine-tune this "win-win" bet and stay ahead of the competition at a time when other alternative projects are emerging forcefully on the immediate horizon. The proposal between Algeria and Italy to increase energy cooperation presents a challenge to Spain and Morocco becoming the trans-Mediterranean platform for the generation and export of green hydrogen to northern Europe, where there is a lack of natural light but a surplus of energy demand. To this end, Italy has agreed to maintain the Maghreb-Europe gas pipeline from Algeria to Spain via Morocco. However, at the same time, it is proposing the construction of a new pipeline through Sardinia that will transport gas, hydrogen, ammonia and electricity in the future from Algeria to Italy.

This alternative proposal to the decision by France and Spain, to connect Barcelona and Marseille with a new corridor for hydrogen exports, seeks to establish Italy as the great hub of southern Europe.[64] If successful, it would severely limit both Morocco's and Spain's objectives of becoming the natural corridor for renewable energy to central and northern Europe.

But ahead of the risks posed by the Italian alternative, there are those coming from France, which has used its weight in Europe to get the so-called "pink" hydrogen from its 56 nuclear plants labelled as "low-carbon", which in practice is equivalent to considering it as green. Behind this euphemism of "pink", which masks its real environmental impact, lies a political decision that affects the future of European energy policy, given that emissions from nuclear energy (66 gCO2/kWh) are significantly higher than those produced by renewable energies such as photovoltaic (30 gCO2/kWh) or wind (9 gCO2/kWh),[65] to which should be added the risks associated with radioactive waste.

The European Commission's approval by delegated act – meaning that only a qualified majority of Member States or an absolute majority of the European Parliament can prevent it from automatically entering into force – has broadened the definition of clean hydrogen, incorporating "pink" hydrogen of nuclear origin and equating it with renewables and other purely sustainable activities.[66] This is a serious setback to Spain's bid to use its comparative advantage in hydrogen production from renewables to become an energy hub in Europe. Evidently, if the French claims were to succeed, Morocco's energy policy of exporting green energy would also be affected.

It is not just a question of Spain and Morocco exporting green hydrogen to the Central European economies through the French corridor, as both countries intend, but of the flow being reversed and France exporting the pink hydrogen from its nuclear power plants to countries in the south. The final result will be reflected in the revision of the renewables directive, known as RED, the draft of which takes into account low-carbon hydrogen from nuclear plants within the renewables targets set out in the directive. According to this draft, by 2030, 42% of the hydrogen produced on the continent must be extracted from renewable or, alternatively, low-carbon sources. A requirement that will increase to 60% just five years later[67].

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[64] Carlos Segovia (23 January 2023). *Algeria announces a second gas pipeline with Italy while keeping the main pipeline connecting it to Spain closed*. El Mundo. Available at: https://www.elmundo.es/economia/2023/01/23/63ceadb7fdddff93288b459d.html

[65] Xavier Bohigas (2017)*Nuclear power plants, CO2 emissions and climate change*. Papeles de relacionesecosociales y cambio global No. 138. P. 118. Available at: https://www.fuhem.es/papeles_articulo/centrales-nucleares-emisiones-de-co2-ycambio-climatico/

[66] Nacho Alarcón (13 February 2023). France prevails: Brussels is open to green hydrogen going nuclear. El Confidencial. Available at: https://www.elconfidencial.com/economia/2023-02-13/francia-impone-bruselas-hidrogeno-verde-nuclear_3575214/

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Regardless of whether nuclear hydrogen is included in the European standard, H2Med will most likely go ahead, otherwise France's veto of any decision contrary to its intentions of becoming a major European hydrogen exporter would jeopardise the economic viability of the project. In the end, the direction of the north-south flow of hydrogen will depend on price and, in the case of the Iberian Peninsula and Morocco, on the construction of a storage infrastructure given the intermittency of green hydrogen, which is not the case for pink hydrogen.

Nuclear reactors have a capacity factor of 90% or more, i.e. they can operate for more than 90% of the year in an uninterrupted, stable and predictable manner. This is higher than the capacity factor of solar (18%), offshore wind (36%) or onshore wind (22%). If the electrolysers are running almost constantly, the price of pink hydrogen could be in the region of €2 per kg of hydrogen produced (a little more if the kilowatt hour costs €0.04, and less than €2 if the cost drops to €0.02 per kilowatt hour).[68].

Compared to pink hydrogen, 1 kilogram of green hydrogen, containing about 33.3 kWh, currently costs between €3.50 and €5, or between €0.10/kWh and €0.15/kWh. However, the price is expected to drop to less than €2/kg by 2030 in Europe,[69] due to the continuing fall in renewable energy production costs, economies of scale and technological advances. In the case of Spain, this price could be around €1.50 per kilogramme as early as 2026.[70]

As a result, green hydrogen would be economically competitive with the nuclear alternative in the short to medium term, although the final outcome in favour of green hydrogen in the competition between the two types of hydrogen will depend on the ability to anticipate these trends and act in time. If this is achieved, and given that the H2Med pipeline should be operational by 2030, it is very likely that, by then, technological advances will allow green hydrogen produced in Spain and Morocco to compete advantageously with French pink hydrogen. This would make the construction of this critical infrastructure feasible and desirable in order to break the Iberian Peninsula's energy isolation and to guarantee the viability of Morocco's energy policy aimed at exporting to Europe.

The question of where to source the minerals needed for the production of renewable plants will have to be resolved first, given that 80% of solar panels are produced in China, a country that seems determined to ban the export of solar panels in order to protect its economy and to prevent and hinder competitors. Large green hydrogen projects will require more minerals to produce turbines and panels. Neither Spain nor Morocco are rich in these and this represents a problem that will have to be solved if the concept of energy independence is to be advanced.[71]

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[68] Javier Costas Franco (28 June 2022). They propose to produce cheap pink hydrogen using nuclear energy, would it work with fuel cell vehicles? Forococheseléctricos. Available at: https://forococheselectricos.com/2022/07/hidrogeno-rosa-y-economico-saldria-a-cuenta-vehiculos-pila-de-combustible.html

[69]José A. Roca (20 July 2020). Green hydrogen will be cost competitive by 2030. El periódico de la Energía. Available at: https://elperiodicodelaenergia.com/el-hidrogeno-verde-tendra-un-costo-competitivo-para-2030/

[70] Victoria Fuentes (12 February 2022). *Spain wants to sell green hydrogen cheaper than petrol through the world's largest renewable hydrogen hub*. Motor Pasión. Available at: https://www.motorpasion.com/futuro-movimiento/espana-quiere-vender-hidrogeno-verde-a-1-5-euros-kilo-a-traves-mayor-hub-hidrogeno-renovable-mundo

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**Conclusions**

Morocco has made energy autonomy one of the kingdom's main strategic focuses since the early 2000s. The scarcity of hydrocarbons and the lack of the necessary technology for nuclear energy, together with geopolitical tensions arising from energy dependence, have forced Morocco to shift its policy towards renewable energy.

Morocco has the capacity to produce a lot of clean energy at very low prices, enough to be self-sufficient and to export the surplus to Europe. Its geographical location in a high-performance wind corridor and its favourable climatic characteristics with more than 300 days of sunshine a year make the wager on green energy a reasonable solution that would increase its energy security by reducing imports and increasing the share of renewable energy in its national mix.

Morocco aims to have renewables reach a 52% share of the national energy mix by 2030, which would allow it to aspire to become an African leader in the field of renewable energies and a potential supplier to the European Union. This would make it easier to move towards energy security; a prospect helped by the war in Ukraine that is gradually but radically reducing Russia's oil and gas trade with Europe and accelerating the continent's decarbonisation and the transition to clean energy.

The combination of the growing presence of renewables in a Europe that has placed energy independence at the top of its agenda, coupled with the fact that renewables will be key in the transition to totally clean sources, means that Morocco has a historic opportunity to become a supplier of renewables as the decarbonisation process takes hold.

To become an energy supplier to Europe, Morocco needs connections that allow it to do so. Geographical logic indicates that these should be done through the Iberian Peninsula following the shortest route and taking advantage, as far as possible, of existing infrastructures and those foreseen in European plans. However, the difficulty of increasing electricity interconnections between Morocco and continental Europe limits the possibilities of direct electricity exports and makes it unrealistic for Morocco to use the Spanish grid to send its surplus to the European electricity market.

From this situation, Morocco is turning toward locally produced green hydrogen as a renewable energy carrier for export to Europe. Its proximity to Europe and the existence of a gas pipeline to the Iberian Peninsula would facilitate Morocco's strategy of producing and transporting green hydrogen to European economies, thereby integrating the Moroccan energy grid with the European one, via the Iberian Peninsula. This would put pipeline transport costs at an advantage compared to sea transport.

This is a gamble on an energy that is not yet competitive, but which is expected to become so in the next decade and which will require Morocco to make progress in the medium term in the decarbonisation of its domestic economy, including the electricity sector currently dominated by coal.

The success of Morocco's renewable energy policy based on green hydrogen, and oriented towards Europe, will require greater coordination with Spain, a key country for interconnection with Europe, as well as a country that also aims to take advantage of its significant solar photovoltaic and wind resource potential to become a European hub for renewable energy.

Although there is currently some controversy over the use of the H2Med hydrogen pipeline to transport green hydrogen to the centre of Europe rather than simply shipping nuclear-derived pink hydrogen from France to the Iberian Peninsula, it is very likely that by 2030, when it should become operational, technological advances will allow green hydrogen produced in Spain and Morocco to compete advantageously with French pink hydrogen.

This would ensure the usefulness of this critical infrastructure for exporting green hydrogen from the Iberian Peninsula – and Morocco – to Europe. In the medium term, a sufficiently large potential European clean energy market can be envisaged for two countries with significant solar photovoltaic and wind potential to produce green hydrogen on a large scale.

Although it does not seem reasonable to expect large volumes of green hydrogen from Morocco in the short and medium term, the European commitment to this energy vector, which has been accelerated by the war in Ukraine, will encourage the Moroccan decarbonisation process and the transformation of its energy sector, orienting it towards exports. Morocco should take advantage of the capacity of Spanish companies that do have the necessary technology to fully leverage the growth of the sector that is expected in the coming years, in order to promote a model of cooperation without fierce competition, in which both countries are able to grow and prosper.

It is therefore important to fine-tune this "win-win" bet and stay ahead of the competition at a time when other alternative projects are emerging strongly on the horizon. If achieved, this would create a powerful synergy through the creation of a "network of shared energy interests", which would serve to cushion potential geopolitical tensions and would ultimately be economically beneficial for Morocco, Europe and Spain.

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