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Renewable Energy Growth in Morocco

An Example for the Region

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Morocco is paving the way in the Middle East and North Africa with its national adoption of a renewable energy plan. Utilizing government sponsored programs to link private renewable suppliers with the larger power grid, solar and wind power have transformed from cottage industries to the heart of the country's long-term economic plan. While Morocco has looked both outwardly and domestically to develop its energy infrastructure, the next challenge will be to fully integrate renewables in a way that promotes local involvement and sustainability. If proven successful, such a program could encourage a wider acceptance and use of renewable energy throughout the region.

Key Points

- Morocco's renewable energy goals are the most ambitious in the region, and could potentially provide infrastructural examples for other Middle East states
- Industrialization and a lack of readily available hydrocarbons has created the need for reliable alternative energy sources in Morocco, such as solar power and wind power
- Government policies allow for private entities to integrate solar and wind power into existing energy grids, and remain competitive with larger firms
- The renewable energy sector in Morocco is developing in a way that emphasizes local development, information sharing, and direct involvement
- Morocco has accomplished overhauling older institutional energy frameworks, and now faces the challenge of equipping local communities to utilize renewable energy sources to grow the industry throughout the country

Introduction

Morocco is poised to lead the Middle East and North Africa (MENA) region in renewable energy. Its lack of conventional hydrocarbon resources, high energy import bill and rapidly rising electricity demand have provided Morocco with the impetus to encourage renewable energy development and emerge as a stable destination for power sector investment.

Morocco is not the only MENA country to drive renewable energy development in response to strong electricity demand growth, expensive fuel imports and vulnerability of fuel supply. Jordan, for example, faces similar challenges, and has launched its own renewable energy initiatives. In relative terms, however, Morocco has the most ambitious renewable energy targets in the MENA region, pledging to increase renewable energy capacity to 42 percent of total installed capacity by 2020, and 52 percent by 2030.[1] If successful, the Moroccan model may prove valuable for neighboring countries experiencing similar challenges.

Demand Growth

Morocco's ambitious targets reflect the nation's rising energy demand, with electricity demand projected to increase by 250 percent from 2015 to 2030, and primary energy demand forecasted to double in the same period.[2] Demand has been driven by economic growth, an increasingly wealthier Moroccan population and the nation's industrial sector, which includes electricity intensive activities like mining and car manufacturing.

Increased electricity access has also contributed to rising demand. In 1990, less than half of Morocco's population had modern electric services, yet a 1995 rural electricity program extended electricity access to tens of millions of people, with 98 percent of the population covered by 2014.[3] Accordingly, electricity demand has grown at an average yearly pace of 7 percent since 2002, with residential and industrial residential classes growing fastest, at 8 and 7.4 percent per year, respectively.[4] Together, these two customer classes make up more than 75 percent of electricity consumption.

Demand growth has helped lead to an increasingly large energy import bill, which cost Morocco approximately $8 to $10 billion annually from 2011 to 2013.[5] Crude oil and petroleum products have historically

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Figure 1: MENA Electric Generation Installed Capacity and Renewable Energy Targets

Sources: CIA, IEA, Regional Center for Renewable Energy and Efficiency, National Ministries of Energy

made up the majority of the country's import bill, with coal, natural gas and electricity imports contributing to a lesser extent.

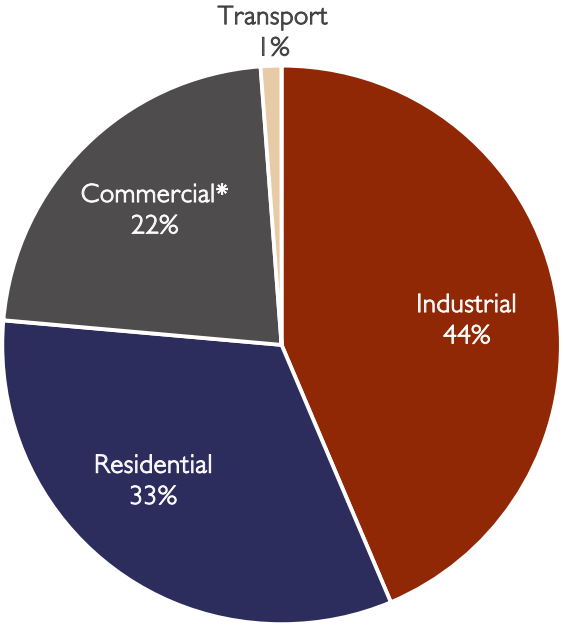
Renewable Energy Regulatory Framework

To manage demand growth, Morocco's contemporary renewable energy plans began to take form in 2009, through renewable energy law 13-09. The law develops the legal framework for renewable energy development, and partially opens the electricity market to competition for the production and commercialization of power from renewable sources.

The law allows private entities to develop renewable electricity generation projects, and sell power to directly to large consumers, while providing guaranteed access to the power grid in order to transport electricity. It also permits renewable energy generators to develop transmission lines if existing transmission capacity is insufficient, and established a framework for these generators to export electricity (Morocco's grid has international connections with both Spain and Algeria).[8] As a result of this regulatory structure, Morocco experienced an addition of 2,760 MW of wind and solar capacity between 2009 and 2015,[9] increasing the share of wind and solar installed capacity from two percent to more than 12 percent.[10]

Since the original law, legislation has developed further to include a net metering scheme for solar photovoltaics (PV) and onshore wind generation, in which private generators connected to the high voltage network can sell up to 20 percent of generation back to the grid.[11]

Figure 2: Electricity Consumption by Customer Class



Source: IEA

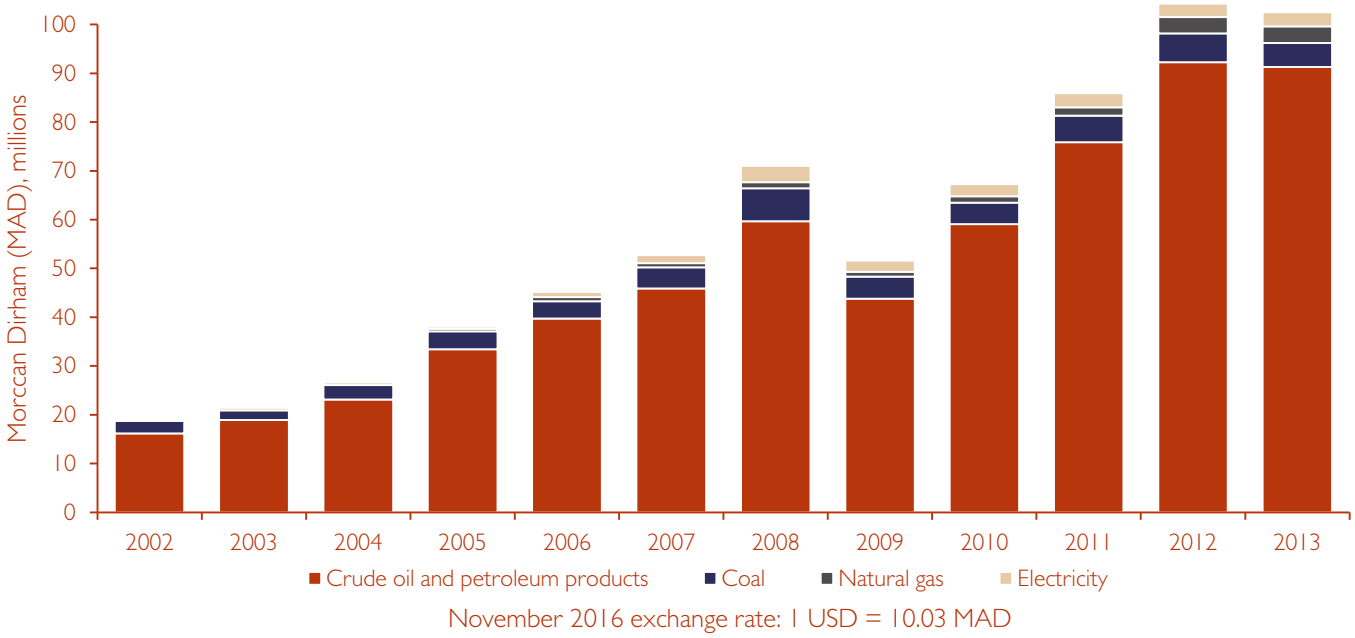
Morocco's renewable energy industry, however, is in the early stages of development. To comply with targets, an additional 10,100 MW of renewable energy capacity must be developed by 2030, with 4,560 MW planned for solar, 4,200 MW for wind, and 1,130 MW for hydro.[12] To fund projects, $30 billion of investment will be required, according to the Moroccan Ministry of Energy, Mines, Water and Environment.[13]

Competitive Tenders

Morocco awards contracts for electric generation projects through competitive reverse auctions, in which independent power producers (IPPs) bid a price at which they will produce each megawatt hour (MWh) of electricity, with the lowest prices favored to win the auction. Used globally, competitive tenders provide a familiar framework for international project developers. In the case of wind, power purchase agreements (PPAs) that result from auctions are signed between the IPPs and ONEE (Morocco's state-owned electric utility and market operator). In the case of solar, PPAs are signed between the IPP and MASEN (Moroccan Agency for Solar Energy); MASEN then signs a second contract to sell its purchased power to ONEE.[14] To date, PPAs for durations have been between 20 and 30 years; long-term contracts for renewable generation output provide investor confidence and facilitate financing.

Access to financing has helped contribute to the competitiveness of the auctions, which have produced winning bid prices as low as $25/MWh for solar PV and $28/MWH for wind. The prices set record lows globally for competitive renewable generation tenders. While this will help lower the cost of electricity in Morocco and represents a

Figure 3: Morocco's Energy Import Spend



Sources: Moroccan Ministry of Energy, Mines, Water and Environment – Energy Statistics 2014 , Energy Sector Key Figures ; Exchange rate by Xe.com

major win for the government and energy consumers, it reduces the potential return on investment.

MASEN intends to hold two additional solar tenders in the beginning of 2017, with a combined capacity of 800 MW. German development bank KfW will provide approximately $765 million of financing, and additional lenders including the World Bank and the African Development Bank have also agreed to participate.[15]

Renewable Energy Development

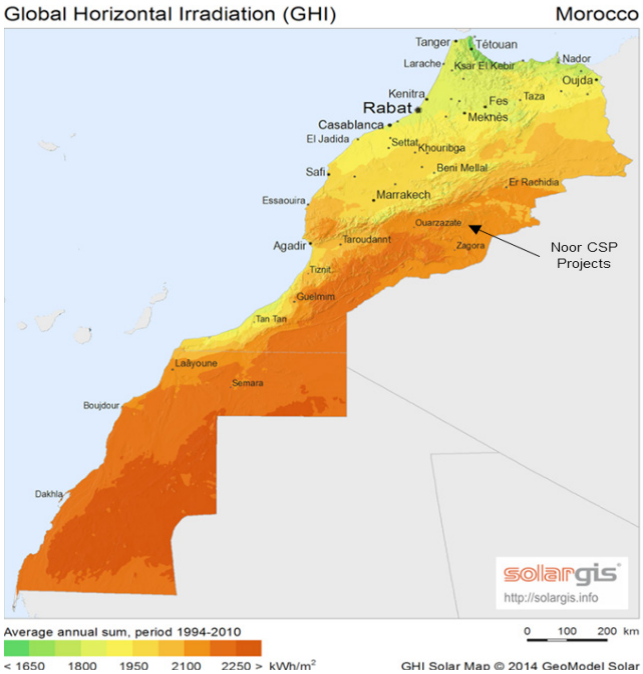
For solar projects, MASEN is not only the offtaker of electricity, but also becomes a minority equity partner for solar projects, and provides debt financing for the IPPs through multilateral agency funds borrowed by the Moroccan government. This arrangement increases the likelihood that projects are built, as securing post-tender financing is often a constraint for project developers. MASEN's many varied roles also helps safeguard the interests of Morocco, by ensuring deep Moroccan involvement and knowledge transfer in the development of solar projects. [16]

Morocco's Solar Plan establishes a target to develop 2,000 MW of solar capacity by 2020, which will be comprised of both solar photovoltaics and concentrated solar power (CSP).[17] Unlike solar photovoltaics (PV), which use solar cells to directly convert sunlight to electricity, the CSP technology in Morocco's case will focus sunlight to heat fluid that is used to propel turbines, which generate electricity.[18]

While CSP solar is more capital intensive than solar PV, its generated electricity can be stored and utilized in the absence of sun. Concessional financing offered by development banks - which can include preferred interests rates and grace periods - helps fund projects with higher capital costs, including CSP.[19] More importantly, electricity storage represents significant benefits for both investors and Morocco's power system. Storing electricity to be dispatched after sundown increases the capacity factor (the percentage of total capacity that is utilized) for the system, as solar PV systems cannot be dispatched without sunlight. Higher capacity factors permit more electricity to be sold, allowing investors to recoup additional dollars for MWhs sold in the evening.

The storage capacity offered by the CSP plants also helps meet peak demand in the evening hours when people return from work; in Morocco, daily peak demand is

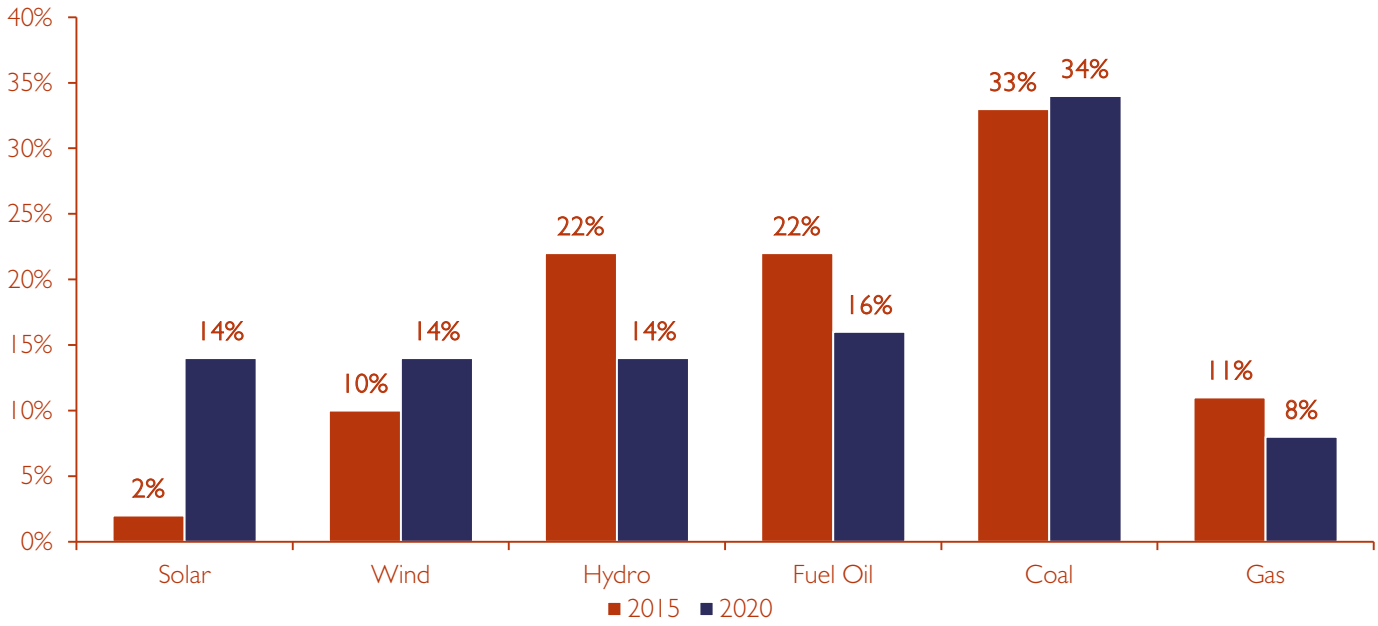
Figure 4: global Horizontal Irradiation



Source: solargis

8:00 – 10:00 PM.[20] Balancing solar supply with peak demand through storage will help Morocco avoid the curtailment of intermittent energy resources (intermittent energy sources may be curtailed by the system operator to avoid the risk of overgeneration).

Figure 5: Installed Capacity 2015 vs. Projected Installed Capacity 2020



Source: Moroccan Agency for Solar Energy

Figure 6: All Currently developed wind projects in Morocco

Source: Moroccan Agency for Solar Energy (MASEN)

Dubbed the Noor Complex, the 580 MW plant is expected to be the largest solar facility in the world. The first phase of the project, Noor I, came online in February 2016, has generating capacity of 160 MW, and is able to store three hours' worth of electricity. Phases two and three of the project are expected to come online in 2017 with a combined capacity of 350 MW, and enjoy seven hours of storage capacity each. The last phase of the project will be solar PV, with 70 MW of capacity.[21]

Combined with the 2017 solar tenders, Noor, which is Arabic for 'light,' will help Morocco meet its target of 14 percent installed solar capacity by 2020, up from less than 2 percent in 2015.

Wind will play an equally important role in helping Morocco meet its renewable energy targets, and is estimated to make up 14 percent of total installed capacity by 2020. Morocco has an estimated 25,000 MW of technical potential for wind generation, yet as of early 2016 only had 800 MW of installed capacity.[22] In a 2016 wind energy tender, a consortium of international companies won the right to build an additional 850 MW of wind generation, which will bring the nation within reach of its 2,000 MW wind energy target for 2020. Gas-fired generation, which is flexible in ramping output up or down, will be critical in responding to the intermittency of both wind and solar energy.

The nation's wind development has been marked by the 301 MW Tarfaya wind facility, Africa's largest wind farm, which began commercial operation in late 2014 just two years after starting construction. Comprised of 131 wind turbines of 2.3 MW each, Tarfaya has a capacity factor of 45 percent, and is located on the coast where winds are strongest. The 301 MW of capacity provide 15 percent of the total required for Morocco to meets its 2,000 MW wind capacity target by 2020. Seventeen kilometers long and six kilometers wide, the plant is able to meet the electricity demand of a city of 1.5 million people.[23]

To further facilitate the nation's wind industry, Siemens, a global technology and engineering company, is building a blade factory for wind turbines in Tangier. The factory, which will serve MENA and European wind markets, is expected to create

700 jobs and begin operations in spring 2017.[24]

As for hydro power, with 1,770 MW currently installed, Morocco is close to reaching its goal of 2,000 MW of installed hydro capacity by 2020. In 2016, 12 small hydro plants totaling 92 MW are expected to be commissioned. With only 3,800 MW of technical potential to develop hydro power, Morocco has almost fully maximized the resource.[25]

The Road Ahead

While Morocco has made enormous progress in creating an economically and environmentally sustainable energy future for its people, the path forward will not be without difficulty. Overhauling the nation's electric generation industry will include serious challenges in integrating intermittent generation sources into the grid. For example, quickly ramping up or down non-variable energy units when intermittent sources come on or offline requires careful long-term planning and a flexible generation fleet. One potential remedy is to expand the interconnection with Spain, which experiences peak electricity demand in the winter, could be mutually beneficial, as Morocco's peak electricity demand occurs in the summer.[26] Additional energy storage, and combined cycle gas generation, which is relatively flexible in terms of adjusting output, would also help renewable integration and grid flexibility issues.

Local opposition to projects could also prove to be a challenge. Some of Morocco's renewable energy generation assets lie in the disputed Western Sahara territory, where local groups complain that the projects will extend Morocco's occupation of their land.[27] Creating opportunities for economic development, consulting local groups regarding potential projects, and equipping Moroccans and Western Saharans with the skills to meaningfully participate in the industry will be a critical criterion for many citizens as they evaluate the soundness of the industry.

Still, Morocco's progress is unlikely to be foreshadowed by these or other challenges. Solar energy, which was minimal prior to 2016 as a percentage of Morocco's generation profile, has already begun to play a significant role. Wind energy alone will help save 5.6 million tons of C02 equivalents by 2020,[28] and the Ministry of Energy aims to reduce emissions by a total of 32 percent by 2030.[29] As a result, using native energy sources, Morocco will likely save billions of dollars on its energy import bill. It seems that Morocco has overcome the most significant challenge of creating institutional and regulatory frameworks that function efficiently, and winning investor confidence. Whether Morocco can maintain the pace remains to be seen.

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