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Renewable Energy in Morocco: a reign-long project

By Henri-Louis Vedie

Summary

The Kingdom of Morocco, which has no oil and gas, has shifted to renewable energy as early as 1960, giving priority to hydroelectricity and the construction of dams. However, most of the country's power plants were and remain powered by diesel or gas, which has a heavy impact on its balance payments. Since then, the demand for electricity has continued to grow due to the country's development on the one hand and, as a result of the use of desalination facilities on the other hand, which consume a lot of electricity, to meet the constantly increasing drinking water needs. Since 2009, and at the initiative of King Mohammed VI, renewable energy has become a reign-long project, with the objective of covering 42% of the electricity produced by 2020. To achieve this goal, three branches will be used to contribute an equal share of 14% each: hydropower, wind energy and solar energy. This study shows that this objective should be achieved at the cost of considerable investment, with a focus on state-of-the-art technologies. Over and above this statistical success, Morocco will also be able to export the know-how learned, particularly in the solar and wind fields, a success which should give hope to emerging economies deprived of fossil energy, in search of development and sustainable development.

The Moroccan economy is highly dependent on an energy bill which represents a heavy burden on the country's balance of payments. As early as 1960, thanks to the first dams built under the rule of the late Mohammed V, and later on to accelerating their construction during the reign of the late Hassan II, who made it a priority, hydroelectricity developed rapidly. At the same time, the use of biomass, a significant energy niche, has continued. However, the growing demand for electricity from these two renewable energy sources alone cannot be met without continuing to use carbon energies and/or other renewable energies, such as solar and wind energy.

As a first step, we will use and mix all the possibilities and then look for ways to reduce the contribution of carbon energies. This will result, under King Mohammed VI, in strong and quantified objectives, set for the renewable energies that we wish to set up or develop: by 2020, 42% of electricity should come from renewable energies, with an equal distribution of 14% between hydro, solar and wind power. To reach these objectives, renewable energies are set up as a priority, and as a reign-long project.

We will first look at the fate which has been reserved to the renewable energies existing in the country since 1960 (I), then we will look at the conditions under which wind energy (II) and solar energy (III) have become not only a success story, but also an example to be followed by many emerging countries.

I. Developing renewable energy sources that have been around for decades

A. niche energy still very present: biomass

Biomass consists in using all materials of animal or plant origin that can be transformed into energy. Scientific progress will open up new prospects for this sector with biofuels, wood heating, in thermal power stations fuelled by the combustion of wood and waste. In Morocco, the wood reserves are much diversified: vegetable waste from forest undergrowth, wood chips and waste, agro-industry by-products, etc. The efficiency of biomass can be measured in terms of energy balance in « tons of oil equivalent » (TOE). It is currently estimated at more than 3 million TOE per year, despite an insufficiently exploited potential. In order to optimize this sector, the Agency for Renewable Energy and Energy Efficiency (ADEREE) and the German international cooperation agency for development (GIZ) have been called upon. Both will propose and develop an Investment Master Plan in the biomass sector. And ADEREE will identify three regions that can host and develop the first national biomass projects: in Rabat-Salé-Zemmour, Meknès-Tafilalet and the Eastern Region.

This energy niche is often the most widely used in the world. This is true in Morocco. Its energy balance is good and its activity is an important support to local employment. It remains, of course, a niche branch and, while not neglecting it, the Moroccan authorities are demonstrating their willingness to take into account, and even develop, all renewable energies in their widest diversity.

B. Hydropower: a new impulse thanks to PSPPs (Pumped-Storage Power Plants) and micro-power plants

1. Strengthening the hydroelectric facilities

This mainly concerns what has been called large-scale hydraulics, namely the large dams launched under the late King Mohammed V, developed during the reign of the late Hassan II and perpetuated, of course, by King Mohammed VI. Today, the expansion capacity of the large dams is not infinite.

On the other hand, technological innovation, thanks to PSPPs, will make it possible to store the energy produced and regulate their operation.

2. Introduction of PSPPs in the regulation of large hydropower operations

PSPPs are pumped energy transfer stations. This is briefly how they operate: by putting two basins at different altitudes, energy will be stored by pumping water from the lower basin to the upper one, when demand for electricity is low, resulting in a low price of electricity. Conversely, when demand for electricity increases, as does its price, the grid will be supplied by pumping water from the upper basin. A PSPP can, therefore, operate pump-motor or turbine-generator mode, in storage mode or in production mode. This reduces to almost zero the waste of electricity production inherent to large scale hydraulics. Three projects, inaugurated at the end of 2011, for the PSPP of Afourer, in the construction phase, for the PSPP of M'Dez El Menzel, in the design phase, and for the PSPP of Abdelmoumen, 70 kilometres from Agadir.

- The PSPP of Afourer, inaugurated by King Mohammed VI ate the end of 2011, makes it possible to exploit excess energy during off-peak hours, to store it as potential energy, and to pump this water to the lower basin during peak hours. Thus, 100,000 cubic metres are pumped every day, which amounts to 60,000 tons of CO2 savings. Its full and total electrical capacity is 465 MW.

- The PSPP of M'Dez El Menzel, currently under construction, will have a capacity of 170 MW. Located 35 kilometres south-east of Sefrou, it includes the

development of two waterfalls: one at M'Dez, a 120 metre waterfall with a flow rate of 48 cubic metres per second, thus generating an installed capacity of 45 MW, and the other at El Menzel, with a waterfall for an installed capacity of 125 MW.

* The PSPP of Abdelmoumen, located 70 kilometres from Agadir, which began construction in 2018 and is expected to be commissioned in April 2022, is a hydroelectric facility with a capacity of 350 MW.

3. The use of micro hydropower plants (MCH)

Micro hydropower plants are also the outcome of technical progress, making it possible to build "small-scale models" of micro-hydro plants with highly variable production capacity, adapted to circumstances and needs. These models turned out to be particularly efficient and useful in meeting the electricity needs of isolated sites. Their capacity can range from 0.5 MW to 12 MW, which is far from negligible, given that an installed unit of one MW produces 3500 to 6000 kw/year. The objectives of this technology make it possible to meet, for example, the needs of a douar or a village. Twelve projects, spread over the entire country, launched in 2013 and operational since 2018, will give concrete form to this technology:

- A project with an installed capacity of 0.5 MW, in Meknès, in the region of Meknès;
- A project with an installed capacity of 1.5 MW, at Flilou, in the region of Midelt;
- A project with an installed capacity of 3 MW, at Sidi Said, in the region of Midelt;
- A project with an installed capacity of 3.15 MW, at Sidi Driss, in the region of Kelaa Lakhdar;
- A project with an installed capacity of 6.7 MW, at Oued Za, in the region of Taourirt;
- A project with an installed capacity of 8 MW, at Zelloul, in the region of Séfrou/Sebou;
- A project with an installed capacity of 10 MW, at Asfalou, in the region of Taounate;
- A project with an installed capacity of 11.7 MW/ Project Hassan II, at Midelt;
- Four projects with an installed capacity of 12 MW at:
  - Ouljet Es Soltane, in the region of Khémisset/Beht;
  - Boutferda in the region of Azilal;
  - Tilouguite I in the region of Azilal;
  - Tilouguite II in the region of Azilal.

What characterizes these achievements is, first of all, the flexibility of this system which, all facilities taken together, provides a total installed capacity of 92 MW, compared to the 620 MW of large dams. Another feature is that it covers the entire territory.

Micro-power plants are expected to enable hydropower to experience a new upswing. Originally known in the context of large dams, they will provide the solution to specific problems of lack of electrical energy, where dams cannot be the appropriate answer. Either because the configuration of the territories does not allow it, or because the investment cost of a new dam seems totally disproportionate to the number of people concerned. In 2015, the contribution of micro hydropower plants to electricity production was estimated at 15% of that of large hydroelectric power stations, which was far from negligible.

The potential of hydropower production is estimated for Morocco at 3700 MW. By setting the production of electricity from hydropower at 2000 MW by 2020, only 55% of its potential would be used. This is a modest target for two reasons, since it is barely more than 50% of its potential and, it is even more modest if compared to the potential of wind (25 000 MW) or solar (20 000 MW). But, to reach these 2000 MW, new dams, micro power stations, and PSPPs, etc. will have to be built, which will require heavy financial investments: a dam is expensive and the use of new technologies is no less expensive.

However, hydropower is also an investment in terms of employment, and by developing it we also help to support the national economy. We should keep in mind Keynes's proposals to revive the economy and put an end to the 1929 crisis. They focused on investment in large structuring projects, such as roads and dams. President Roosevelt made the move from theory to practice, building numerous electric dams in the state of Tennessee, with proven success.

Finally, one must always be careful in analysing statistics, recalling that hydroelectricity represented 16% of the Kingdom's electrical energy in the years 2000. If they

are accurate, they should not lead one to think that with 14 %, the target set for 2020-25, hydropower is in decline. This is, of course, not the case. During 2020-25, hydropower in the broad sense (dam, micro power plant, PSPP) should offer a capacity of 2700 MW, representing 14% of the total. And 16% of 1700 MW is less than 14% of 2700 MW. These figures only confirm what was known: much had already been done before 2000 in the field of hydropower, leaving a narrow margin of development to this sector.

It should also be noted that, for obvious geographical reasons, this sector, which is highly developed in the northern provinces of the Kingdom, is much less developed in the southern provinces. This is not the case, far from it, for the wind and solar energy sectors.

II. Wind power: a unique potential exploited since 1999

A. Wind resources present in all the territories of the country

With wind speeds varying from 9.5 to 11 m/s and at a height of 40 metres, all the wind conditions were in place to set up and develop this new energy sector in the best possible way. Two geographical zones offer the best conditions for the success and profitability of this sector: a northern zone, from Tangier to Tétouan, and a southern zone, from Tarfaya to Lagouira. Exploitation of these wind sources will go through two periods, before and after Law 13-09 on renewable energy, allowing auto-production of energy with access to VHV/HV/MV networks. More specifically, this means that it is now possible to generate electricity from renewable energy sources for one's own use and, if necessary, to export it if there is a surplus. Over the period 1999-2019, in addition to the wind farms developed by ONEE, IPP (Independent Power Production) farms were set up, also called IPP-ONEE farms, whose characteristic is to be at the origin of private farms, held jointly by a foreign holding company and a Moroccan holding company. Finally, what characterizes this sector is that nearly 60% of its production concerns the southern provinces. This South/South sector will be treated separately.

1. ONEE Wind farms (Office National de l'Eau et de l'Electricité)

Three wind farms benefit from the ONEE label:

- The first wind power programme, inaugurated in 2000, is the «Abdelkhalek Torres Farms», located at Koudia El Baida, between Ksar Sghir and Tétouan. The financial package is typical of ONEE farms, the owner of the farm is ONEE and the concessionaire is the one who invests, and in exchange, produces and sells electricity to ONEE. This is called the BOT formula. The installed capacity of this farm is 50 MW.

- A second farm was inaugurated in 2007, the Amogdoul Farm in Essaouira. With a capacity of 60.35 MW, this farm received funding from the German financial cooperation agency while ONEE directly manages the farm unlike the BOT formula.

- A third farm will be opened in 2009 in Tangier, the Tangier wind farm, which will later be called Tangier I, when Tangier II is put on track. It will benefit from financing from four parties: the European Investment Bank, the German Financial Cooperation Agency, a Spanish financier and ONEE. The operation of the farm will be entrusted to the Spanish company Gamesa Eolica. It is the largest of the three farms, with a capacity of 140 MW.

As can be seen, while the principle is BOT, the actual practice is on a case-by-case basis, which provides more flexibility in attracting potential investors.

2. IPP Wind Farms

Two farms are IPP wind farms: the most important of these farms is that of Tah, about thirty kilometres from Tarfaya, the second being located in the region of Tétouan. Only the wind farm of Tétouan will be discussed here, while the wind farm of Tarfaya is discussed in detail in section B. The wind farm of Tétouan in Koudia Al Baida, the older one, was commissioned in 2000. It is also the smaller, with an installed capacity of 50.4 MW.

3. Wind farms after Law 13-09

Some of them, which are part of the southern Nareva farms, will be analysed under section B (Akhfennir, Foum el Oued and Tarfaya), as will be the auto-production

power plant in Lâayoune. This is not the case for the Nareva farm in Tangier and the auto-production farm in Tétouan.

- The farm of Haouma in Tangier is developed by the company Energie Eolienne du Maroc (EEM), a subsidiary of Nareva and CIMR (Caisse Interprofessionnelle Marocaine de Retraite), under the terms of Law 13-09, with a production of electricity intended for the company's customers. This farm has an installed capacity of 50.6 MW and was inaugurated in 2014.

- Ciments Lafarge's auto-production farm in Tétouan has an installed capacity of 5.25 MW. Present on four sites in Morocco: Bouskara, Meknès, Tangier and Tétouan. The Lafarge cement plant chose the site of Tétouan to set up this farm, enabling it to save MAD 10 million each year on its energy expenses. Another significant advantage is that the cost of energy can be smoothed over time, something that could not be achieved using conventional energy such as diesel.

B. Fifty-eight per cent of installed wind power capacity in the southern provinces

1. The Nareva farms of Tarfaya, Akhfennir and Foum El Oued

In the southern provinces, Nareva Holding has a virtual monopoly, providing more than 95% of the installed wind power capacity. This percentage compares with the 60% under its control of the entire wind energy sector in the country.

- The wind farm of Tarfaya, inaugurated in 2014, is an ONEE-IPP (Independent Power Production) farm, carried by TAREC (Tarfaya Energy Company), in partnership with IPP, equally owned by Nareva Holding and Engie (formerly GDF-SUEZ). The financing was assumed by Nareva and Engie, TAREC and IPP benefiting from an exclusive contract for the purchase of the output (electricity) by ONEE for 20 years. At the end of these 20 years, this private farm will become the property of ONEE. With an installed capacity of 301.30 MW, this site includes 131 turbines, supplied and assembled by the German company Siemens, enabling it to produce around 1080 Gwh, which is equivalent to the current consumption of the city of Marrakech. The giant wind turbines used are 80-metre high towers with 40-metre blades, the largest ever built by Siemens. Although in the middle of the desert, these wind turbines are particularly noiseless.

Interestingly, the rate of Moroccan industrial integration is estimated at 35%: studies, electrical works, civil engineering works and wind towers performed by Moroccan companies. During the two years that these works required, it is estimated that 700 Moroccans, men and women, will have taken part in them. Today, around 100 jobs are maintained on the site.

The wind farm of Tarfaya is a flagship project, not only for Morocco, but also for the continent, and the largest wind farm in Africa in 2020. Nareva Holding's know-how is recognized and can therefore be exported.

- The wind farm of Akhfennir is located between Lâayoune and Tan Tan, 900 kilometres from Casablanca, 196 kilometres from Lâayoune and 112 km from Tan Tan. This wind farm has an installed capacity of 100 MW, based on the operation of 61 Alstom brand wind turbines. One of the specificities of this wind farm is to have two connection systems to the ONEE grid: one to Lâayoune, the other from Tan Tan. Even though wind turbines only give their maximum output in a very precise wind range, below 3m/second they do not rotate, and above 25m/second they do not rotate any more. Thanks to these two connection systems, a large part of the city of Tan Tan will, in all circumstances, be able to benefit from the electricity produced by the wind farm of Akhfennir. As soon as it is commissioned, its success will lead to the doubling of its production capacity to 200 MW.

- The wind farm of Foum El Oued, a few dozen kilometres from Lâayoune, with an installed capacity of 50 MW, is also a Nareva wind farm and a site dedicated to the extraction site of Boucrâa. Managed and developed by EEM, this wind farm of 22 Siemens turbines meets and will, tomorrow, meet up to 95% of the substantial electricity and desalinated water needs of this phosphate mining site, using this water from desalination plants that consume a lot of electricity. With a capacity of 50 MW, this wind farm should be able to generate surplus power that will be exported.

2. The auto-production wind farm of Lâayoune

This wind farm which belongs to « Ciments du Maroc » was inaugurated in 2011 to supply its crushing centre. It has an installed capacity of 5.5 MW, meeting 85% of the group's needs.

Two other wind farms are already on track: Boujdour, with an installed capacity of 100 MW, which could be inaugurated in 2020, and Tiskrad, with a capacity of 300 MW, which is due to be inaugurated in 2021. The energy needs of these provinces are currently estimated at 120 MW, taking into account the overall capacity of the various sites, including those of Boujdour and Tiskrad, estimated at 1150 MW. As a result, a surplus of more than 1000 MW can be connected to the national grid, either from Tarfaya, Boujdour, Dakhla or Lâayoune. This surplus will then be able to meet the other needs of the Kingdom's provinces and/or be exported to Southern Europe, only 14 kilometres from Tangier.

As can be seen with these different wind farms, one of the major assets of wind energy is to be able to offer small, medium, large and even very large facilities. The size of the wind farms is adapted to the needs of large urban centres, clustered or isolated settlements, an industrial group or a farm, etc.

Through these different examples, we can see how low the threshold for entry into the sector can be (5.5 M with Ciments du Maroc). While the wind farms in the north are more numerous than those in the South, the most important in terms of installed capacity are in the South. It is also in these provinces that the wind conditions are the most optimal/sufficient but not too high, unlike the wind conditions from the North, which are often too high.

The advent of the wind energy branch will also contribute to reducing the carbon footprint. For example, it should be remembered that the energy produced by the wind farm of Foum El Oued is equivalent to a carbon-based energy source producing 80 000 tons of CO2 per year. All this requires substantial investment and the use of state-of-the-art technologies and will reduce the cost of energy produced, making this sector more and more competitive.

Finally, it is worth recalling the objective pursued by 2020, which is 14% of wind energy produced in Morocco, i.e. an energy capacity of 2000 MW. This objective should be reached, taking into account that in 2018-2019 the capacity produced was theoretically estimated at 1,700/1,800 MW, all wind farms taken together.

III. Solar energy: high potential and outstanding achievements

Unlike wind energy, Moroccan solar energy is in line with a promising international and national environment: The Desertec Foundation and the Mediterranean Solar Plan, on the one hand, and the Moroccan Solar Plan, on the other.

A. particularly promising international and national environment

1. Foundation and a concept: Desertec

Let's start from an observation: each km2 of desert receives an annual amount of solar energy equivalent to 1.5 million barrels of oil, i.e. a theoretical capacity of all the world's deserts to supply several hundred times the planet's electricity needs. In other words, by covering only 0.3% of the 40 million km2 of the world's deserts with solar thermal power plants, we could, still theoretically, meet the electricity needs of all the continents.

To conceptualize this observation, the Desertec Foundation was created in 2003 with two sponsors: the Club of Rome and the National Energy Research Centre of Jordan. In 2009, the Foundation signed a memorandum of understanding with a German reinsurance company, Munich-Re, to exploit this concept. The MoU involves its exploitation over a vast region including the European Union (EU) and MENA (Middle East and North Africa). In October 2009, the Desertec Industrial Initiative (DII) was created. In June 2011, DII signed another agreement with MASEN (Moroccan Agency for Solar Energy). This agreement is expected to implement a large-scale solar project in Morocco and the possibility of using the Kingdom's electricity grids, linking it to Spain. DII is the facilitator and brings its expertise, while MASEN is the developer in charge, among other things, of identifying the sites likely to host this project.

2. Plan: the Mediterranean Solar Plan

The Mediterranean Solar Plan was the flagship initiative of the Paris Summit of July 2008, within the framework of the Union for the Mediterranean. The objectives of this plan are threefold: build, develop and strengthen.

- Build stands for building 20 000 MW of additional renewable energy capacity, including solar energy by 2020;
- Develop stands for developing electricity interconnections between the countries of the EU-MENA zone, and thus allow for pooling their energy sources and for optimizing the considerable investments made by reducing operating costs;
- Strengthen stands for strengthening the energy efficiency of the various sectors.

More specifically, this plan rests upon the principle of co-development, based on strengthening local industrial activities. As of 2008, it was associated with the creation of three power plants combining gas and solar thermal use, also known today as integrated thermal solar combined cycle power plants. The first plant was Moroccan, in May 2010. Two others followed in 2011, in Egypt and Algeria.

Whether with Desertec or with the Moroccan Solar Plan, Morocco was the first partner to benefit from each other. This is no mere coincidence, but reflects the Royal will to give priority to renewable energy through the Moroccan Solar Plan.

3. The Moroccan Solar Plan

The Moroccan Solar Plan was launched in 2009, with the objective of making the most of the 3000 hours/year of sunlight of a kingdom that has an average irradiation of 6,5KWh/m2/day, which generates a solar energy potential of 20 000 MW. The target set for the contribution of solar energy, by 2020, is 2000 MW, under the 3x14% rule; it represents in fact 10% of its potential. To meet this objective, the Kingdom will have to rely on two advanced technologies, requiring considerable financial investment: photovoltaic solar and solar thermal, also called CSP (Concentrated Solar Power).

- Photovoltaic solar energy refers to solar energy that is directly converted into electricity by semi-conductor materials, such as silicon, which is covered with a thin metal layer. Photovoltaic solar energy implies solar panels.
- Thermal solar energy uses heat released from the concentration of the sun's rays, thanks to articulated mirrors. This heat will then be converted into energy by one or more turbine-generator units.

From 2010, five solar sites have been identified: the site of Ain Beni Mathar, the site of Ouarzazate, the site of Sebkhate Tah, the site of Foum Al Oued and the site of Boujdour. As part of the Moroccan Solar Plan, all these sites have been confirmed in the Finance Law of 2014, with the exception of the site of Ain Beni Mathar, whose water resources have been judged insufficient. It should be remembered that this site already has a thermo-solar power plant with an installed capacity of 20 MW, inaugurated in 2009.

Before the Moroccan Solar Plan, there were experimental power plants, such as the solar fields of Ain Béni Mathar, or the photovoltaic power plant of Tit Mellil, commissioned in 2007 and, at that time, Africa's first solar micro-power plant, with a modest installed capacity enabling it to meet the electricity needs of the 700 inhabitants of this town.

B. Achievements demonstrating the success of an ambitious long-term plan

1. Four sites inaugurated, or in the process of being inaugurated, since 2015

- First achievement of the Moroccan Solar Plan: the Noor/Ouarzazate project. It is divided into four phases: Noor I, Noor II, Noor III and Noor IV. Noor I was inaugurated in 2016. It is a thermodynamic solar power plant with an installed capacity of 160 MW, ranking seventh in the world and, of course, first in Africa historically, but first in the world in terms of installed capacity. Technically, the plant stretches over 480 hectares, with parabolic trough reflectors using CSP technology. At full power, its storage time is 3 hours. Following an agreement between Masen and ONEE, the latter undertakes to buy the electricity produced by Noor I for 5 years at a fixed price.

- The site of Foum Al Oued, which already benefits from a wind farm, also enjoys direct sunlight of 2628 kWh/m2/year, one of the highest on the planet. The plant, constructed on a 2500-hectare site, has an installed capacity of 500 MW, with an annual production of 1150 Gwh, partly intended to supply electricity to a seawater desalination unit.

- The site of Boujdour, which also benefits from exceptional sunlight of more than 2600 kWh/m2/year, plans to mobilize a surface area of 500 hectares, enabling it to develop an installed capacity of 100 MW, mainly for a seawater desalination unit, to meet the needs of the town of Boujdour.

- The site of Sebkha Tah will house a power plant with an installed capacity of 500 MW.

2. Two ONEE projects of medium-sized power plants

These projects are expected to ultimately deliver 20-30MW of capacity, enhancing the security of supply to communities located far from power generation sites. Two projects are in line with this approach and have been confirmed by ONEE since 2010: the project of Noor Tafilalet and the project of Noor Atlas.

- The project of Tafilalet was launched in April 2011. It comprises three photovoltaic power plants with a capacity of 75 to 100 MW, located in the regions of Arfoud-Zagora and Missour. It is an EPC project through turnkey contracts, with a financial package including engineering, procurement and construction of the plant. The electricity produced will be directly connected to the national HV grid.

- Noor Atlas is a project with a capacity of 200 MW, spread over eight power plants located in southern and eastern parts of the Kingdom.

3. Projects confirmed for 2020-2025

Noor II, Noor III, Noor IV and Noor Midelt

a. Noor II, III and IV Projects

- Noor II, which was officially launched at the inauguration of Noor I, on February 4, 2016, is a power plant equipped with parabolic trough technology and an expected power output of 200 MW and an eight-hour storage capacity;

- Noor III, which will follow, has an expected capacity of 100 MW, generated by a solar thermal tower, with an eight-hour storage capacity;

- Noor IV, the last phase of the Noor/Ouarzazate programme, will be a photovoltaic power plant with an installed capacity of 50 MW.

b. Noor Midelt Project

Launched in 2018, the project of Noor Midelt, in the east of the Kingdom, is a project that mixes CSP and PV, with an installed capacity of 600 MW for CSP and 1000 MW for PV. In May 2019, the result of the call for tenders was successful, and the preparatory work has now been completed: construction of 40 Km of road to access the complex and the Hassan II dam, whose water is essential for regular cleaning of the panels, and whose sand is a dreadful enemy. In addition to this work, 50 Km of power lines are under construction to carry the electricity generated to meet the needs of the centres of life and industrial activities.

Unlike Noor Ouarzazate, Noor Midelt is equipped with a fourth PV unit, effectively combining both technologies to improve the efficiency of the complex and optimize the price per kilowatt-hour.

Launched in 2018, the first phase of this extraordinary project is expected to be commissioned in 2022. With an installed capacity of 825 MW, 300 MW of CSP installed capacity and 525 MW of PV installed capacity, the CSP provides 5 hours of storage capacity.

With solar energy, Morocco is pursuing an ambitious plan to develop renewable energy which should enable it, by 2030, to produce more than 50% of its electricity from this renewable energy, of which solar energy is one of the pillars. To achieve this goal, all energies have been taken into account, as evidenced by the inclusion of biomass, while also promoting, at every opportunity, the use of state-of-the-art technologies to make the best of solar and wind electricity.

General conclusion

The 3/14% target expected by 2020 should be met, as we are almost there. The focus on renewable energy is mainly driven by wind and solar energy. For the Kingdom, which has always been highly dependent on coal and diesel for its electricity supply and, indirectly, for its drinking water supply, the success of these renewable energies is changing many things, especially as it is accompanied by a decrease in the cost of the energy produced, and as electricity is becoming increasingly competitive, despite considerable financial stakes.

But beyond reducing the energy bill and improving the Kingdom's balance of payments, Morocco has also been able to acquire know-how and expertise, as shown by the first solar cluster supported by Masen, which contributed to the development of synergies between actors of different sectors.

For emerging economies, it is also an example that should give reason for hope, even for those with few resources, such as Morocco. By formally declaring renewable energy a priority since 2009, King Mohammed VI made it a reign-long project while providing it with the necessary resources to support it. In addition to its benefits on employment, it is also an opportunity of great interest for the southern provinces of the Kingdom, where nearly 60% of the country's solar and wind power production is concentrated, which would allow them to transfer part of it to the northern regions and, tomorrow, no doubt, export some of it to the European Union, via Tangier.

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Holding a doctorate in economic sciences from Dauphine University Paris, and a graduate in Law from Université Paris I, Henri-Louis Vedie is Professor Emeritus at HEC Paris, where he teaches in the Paris campus as well as Moscow, Varsovia, Belgrade, Abu Dhabi, Rabat, and more.

Author of sixteen books, of which the last few concerned Morocco and sovereign funds, hundreds of articles (of which some where translated in English, French, Arabic, Polish and Russian), Henri-Louis Vedie was also a consultant for the European Council and a member of the Economic, Social and Environmental board in Paris.

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