Economic and Social Commission for Western Asia

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United Nations Development Account project on promoting renewable energy investments for climate change mitigation and sustainable development

Case Study on Policy Reforms to Promote Renewable Energy in Morocco

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Preface

This case-study report was prepared for the Energy Section of the Sustainable Development Policies Division (SDPD), United Nations Economic and Social Commission for Western Asia (UN ESCWA) within the framework of the United Nations Development Account (UNDA) project Promoting Renewable Energy Investments for Climate Change Mitigation and Sustainable Development. The project focused on capacity-building for policymakers and project developers in order to promote investments in renewable projects. The project was led by UN ESCWA and implemented in partnership with the United Nations Economic Commission for Europe (UNECE).

The UNDA project included case studies of the experience of renewable energy policy reforms in selected countries from each of the two regional commissions. Four countries were selected from each regional commission: Jordan, Lebanon, Morocco and the United Arab Emirates from UN ESCWA Member States; and Georgia, Kazakhstan, Serbia and Ukraine from UN-ECE Member States.

The present report covers the case study for Morocco, and was prepared by Mr Taoufik Laabi, an expert in renewable energy, who worked for the Office National de l'Electricité et de l'Eau Potable (ONEE), a Moroccan State-owned utility, until his retirement in 2016. During his career of 30 years at ONEE, he held the positions of Director of Renewable Energy (2014–2015) and Director of Strategy and Planning (2013–March 2016), among others. The report was reviewed by Mr Dhamir Mannai (PhD), renewable energy policy expert and member of the UNDA advisory board, and also reviewed by the Energy Section UNDA team of SDPD at UN ESCWA in Beirut.

Executive summary

The present Moroccan case study aims to show the impact of Moroccan policies on encouraging investments in renewable energy by lifting the regulatory barriers and providing an enabling legal and business environment for the development of renewable energy projects and the needed policy reforms.

As the only North African country with no natural oil resources, Morocco is the largest energy importer in the region. The country is faced with the challenging task of meeting rising local demand while keeping its import bill under control.

Environmental constraints (water stress, land degradation, strong energy dependence, vulnerability to climate change, various types of pollution) are the key issues for Morocco, which has made the green economy a strategic focus of its sustainable development policy.

Driven by the rise in energy demand, primary energy supply has been steadily rising in Morocco over the last decade, and reached about **19.5 million tons of oil equivalent (toe) in 2015** while it was only 16.1 million toe in 2010. Oil products account for 54%. Due to economic and industrial development, demographic growth, improved access to electricity (improving from 18% in 1995 to 99.15% in 2015) and the diffusion of household appliances, primary energy demand is expected to continue the rapid growth with a growing rate of 4.3% in the baseline scenario and 3.3% in the energy-efficiency scenario.

With currently no proven gas or oil reserves, Morocco relies heavily on fossil-fuel imports, which represent **93.6%** of the total primary energy supply[1]. The electricity generation balance consists predominantly of thermal generation (coal: 49%, natural gas: 16.5%, oil: 6%) while 15% of the electricity demand is imported from Spain. The renewable energy contribution in the energy mix was about 13.5% in 2015 (including large and small hydro). Total carbon dioxide (CO_2) emissions were estimated at **60 million tons in 2015**, which was dominated by the consumption of oil products.

Facing these challenges, the Moroccan Government developed in 2009 the National Energy Strategy, setting clear and precise objectives. The Strategy covers four main strands: optimize the fuel mix in the electricity sector; accelerate the development of energy from renewable sources, especially wind, solar and hydropower; make energy efficiency a national priority; and promote a greater regional market integration.

In 2009, the corresponding targets for renewable energy were set for **42%** installed capacity by 2020 (or 6,000 MW). These targets were revised in 2015 to become **52%** (or 12,900 MW) by 2030.

Two ambitious programmes were developed to boost Morocco's solar and wind development:

- **The Moroccan Solar Plan (Noor)** that aims to reach **2,000 MW** installed solar power capacity (solar photovoltaic (PV) and concentrated solar power (CSP) by 2020 and approximately **4,800 MW** by 2030 (additional 4,560 MW from 2016 to 2030);

- **The Moroccan Integrated Wind Programme** that aims to achieve **2,000 MW** installed wind-power capacity by 2020 and up to **5,000 MW** by 2030 (additional 4,200 MW from 2016 to 2030).

For easy integration of these renewable capacities into the grid, Morocco intends to spend US$ 700 million for a programme of 1,000 MW pump storage power plants (PSPPs) and US$ 3.5 billion to reinforce the transmission network until 2030. Moreover, Morocco is developing a gas-to-power project consisting of a liquefied natural gas (LNG) terminal of 5 billion m^3 and four combined cycle gas turbines (CCGTs).

CCGTs totalling 2000 MW are to be delivered by 2025. Their flexibility will help to overcome the technical constraints and intermittency generated by the intensive expansion of renewable energy.

In the light of these programmes, multiple large- and medium-scale solar and wind projects were already installed at the end of 2015: **977 MW of wind and 180 MW of solar energy**.

These two programmes were designed to take advantage of Morocco's highly favourable conditions for both wind and solar power, as well as its long-established hydropower sector. Morocco has important renewable energy resources. Wind-energy potential is excellent in vast stretches of the northern and southern regions, with annual average wind speed exceeding 9 m/s at 40 m elevation along its 3,500-km coastline. As far as solar power is concerned, the country enjoys 3,000 hours per year of sunshine, potentially yielding 5.5 kWh/m²/day.

The Moroccan National Energy Strategy has been supported by a comprehensive legal, institutional and regulatory framework including:

- **Law 16-08** (Dahir of 20 October 2008) on self-production, raising the self-production threshold from 10 MW to 50 MW;
- **Law 13-09** on renewable energies (enacted in February 2010) provides a legal framework for the development of renewable energy projects in Morocco. It also allows for the supply and export of the electricity produced to the local market and/or through the national grid and interconnections with other countries;
- **Law 54-14** allows self-producers with a global capacity of more than 300 MW to access the national grid and sell the surplus production exclusively to the National Office for Electricity and Potable Water (ONEE).

Morocco has also demonstrated its commitment by establishing a series of public agencies and institutions which were set up as a means to better organize and structure the promotion of renewable energy development. These include:

- The Agency for the Development of Renewable Energies and Energy Efficiency (ADEREE), which is responsible for the development of energy-management policies;
- The Moroccan Agency for Solar Energy (MASEN), which is a limited company with public funding established in November 2009 when Morocco announced it would install 2 GW of solar capacity by 2020. MASEN was founded to lead and manage this project;
- The Energy Investment Company (SIE), founded in 2010 as an investment fund for the energy sector in Morocco to facilitate the diversification of energy resources, promotion of renewable energy and energy efficiency;
- The Research Institute for Solar Energy and New Energy (IRESEN) was founded in 2009 to promote the research, development and innovation of renewable energy technologies around the country.

In relation to the new renewable energy targets expected by 2030, Law 37-16 reinforcing MASEN's mission was promulgated on 2 August 2016. By this law, MASEN was thereafter in charge of the realization of all renewable energy projects.

On 4 May 2016, Morocco's House of Counsellors adopted Law 48-15 in order to regulate the electricity sector by establishing a National Authority for the Regulation of the Electricity Sector (ANRE). The law was passed by Dahir 1.60.60 on 24 May 2016 and published in the Official Gazette of 9 June 2016. The main mission of ANRE is to ensure the good functioning of the free market for electricity generated from renewable sources and regulate the access of self-producers to the national electricity transmission grid under the opening-up and liberalization of the sector in accordance with renewable energy Law 13-09. ANRE will have many regulatory attributions, the main ones being setting the usage tariff of the national electric transmission network and usage tariffs of the medium-voltage (MV) electric networks of distribution; approval of the multi-year programme of investments of the network's operator and the monitoring of such a programme; and approval of the grid's code.

In terms of financing, Morocco adopted an innovative financial mechanism based on the project finance model within the framework of a public–private partnership (PPP). Financial arrangements combine domestic and foreign public and private funds and refer to concessional and non-concessional financing mechanisms as part of multilateral and bilateral cooperation. This model was crucial in de-risking the large-scale projects, thus securing their financing. For instance, the bidding price for the last wind project of 850 MW, launched in February 2014, reached about US$ 30/MWh, which is the lowest price worldwide till now.

The Strategy also aimed to support local manufacture of renewable energy products. Under the Moroccan Solar Plan and Wind Programme, bidders are encouraged to promote local manufacturing, for instance:

- The 160 MW CSP plant of Ouarzazate (NOOR 1), awarded to ACWA Power, includes a 42% local content portion;

- As the engineering, procurement and construction (EPC) contractor of the last wind programme of 850 MW, which was won by a consortium of Enel and Nareva, Siemens will supply the turbines for the five wind-power plants and has signed an agreement with the Moroccan Government to build a rotor-blade factory for onshore wind turbines with an investment of more than €100 million. As many as 700 jobs are expected to be created.

The transition towards renewable energy adopted will be extremely beneficial for the country in environmental, economic and social terms. Within its Nationally Determined Contribution (NDC), Morocco has set a target to limit the growth of greenhouse gases (GHGs) with support from the international community. The expected reduction in carbon dioxide equivalent (CO_2eq) is about 400 million tons between 2020 and 2030. Meeting this target requires an overall investment estimated at US$ 45 billion between 2015 and 2030.

In term of energy security, the deployment of renewable energy in Morocco increases the diversity of the energy sources and offers a crucial value added in terms of energy resilience, autonomy and stability of the Moroccan economy. According to the Moroccan Ministry of Energy, Mines, Water and Environment (MEMEE), the contribution of renewable resources to the energy balance will increase from 4.8% in 2014 to 12.8% in 2020 and 14.2% in 2025. Moreover, the dependency on fossil fuels will decrease from 94.6% in 2014 to 86.8% in 2020 and 85.2% in 2025.

One important factor that was considered in the National Energy Strategy was job creation: investing and promoting renewable energy will afford major benefits to the local economy. The job-creation potential of the renewable energy sector in Morocco is estimated at 23,000 jobs in 2020 (see the study conducted on behalf of MEMEE concerning the need for renewable energy skills [18]).

In terms of training policy, the study [18] concluded that the minimum training needs in renewable energy by 2020 were estimated to be 4,300 technicians, 4,800 skilled workers and 1,300 engineers.

It is widely acknowledged that all the above-mentioned reforms and investments by the Moroccan Government have proved its considerable commitment to promoting renewable energy. Many barriers to further renewable energy development in Morocco still exist, however:

i) Economic and financial barriers
There is a particular lack of accessible financial support for small-scale projects to enable private consumers to install renewable energy technologies: most financing is directed at large-scale projects. Moreover, economic viability is affected by high initial capital costs due to the lack of confident financial support and high-risk perception related to renewable energy.
In Morocco, major financing for renewable energy development still comes from the Government and from international funds rather than from local private investors and regional banks.

ii) Political, institutional and regulatory barriers
Many laws that were introduced to promote renewable energy such as Law 13-09 still need to be reconsidered. For example, this law tends to facilitate only large-scale projects rather than helping the entry of smaller producers and stimulate the development of more community-based, bottom-up energy initiatives (the decree for renewable energy connection to low voltage has not yet been approved);
The lack of coordination, cooperation and synergetic collaboration between the various stakeholders, political groups and ministries does not help form a common strategic vision for the promotion of renewable energy (distribution

operators that are supervised by the Ministry of the Interior are often against the development of renewable energy in their networks).

iii) Technical barriers

Major technical issues related to the intermittent nature of renewable energies, such as wind and solar power, still remain. Technical complications occur when aiming to ensure large-scale reliability of supply with high penetration of intermittent sources. Many potential investors have not yet been authorized, especially in the south of Morocco, due to insufficient capacity of the grid.

So far, renewable energy has only been incorporated in the electricity sector. There is a lack of cross-sectorial approaches that include the heating/cooling and transport sectors.

A series of wide-ranging actions able to facilitate achievement of the 2030 target for 52% of renewable have still to be undertaken:

- Set up an effective liberalized market for electricity in Morocco with a view to its integration into the European market;
- Set up a suitable legal framework and financial mechanism for renewable energy connected to the low-voltage (LV) grid and a connection code;
- Introduce smart metering and smart grid technologies to reduce waste and inefficiencies in the power system, fully optimize demand-side resources;
- Support for technical measures in order to overcome the major technical hurdles in particular those related to the intermittent nature of renewable energies such as wind and solar power (enlargement and improvement of the network infrastructure, increased generation flexibility and mix of resources, demand-side measurement and increase in efficiency, storage);
- Support for financing mechanisms and national/international microfinancing tools for small-scale renewable energy projects in order to allow adequate adaptation by vulnerable local populations.

Table of Content

List of tables

List of figures

List of abbreviations

ADEREE	National Agency for Renewable Energies and Energy Efficiency
AMDI	Agence Marocaine pour le Développement Industriel
AMISOLE	Association Marocaine des Industries Solaires et Eoliennes
ANRE	National Energy Regulatory Authority
BAU	business as usual
CCGT	combined cycle gas turbines
CDER	Renewable Energy Development Centre
CDM	Clean Development Mechanism
CO2	carbon dioxide
CO2eq	carbon dioxide equivalent
COMELEC	Maghreb Electricity Committee
COP	Conference of the Parties (UNFCCC)
CSP	concentrated solar power
DOP	Directorate of Observation and Programming
EDF	Energy Development Fund
EPC	engineering, procurement and construction
EUR	euro
FEMIP	Facility for Euro-Mediterranean Investment and Partnership
GDP	gross domestic product
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation)
GME	Maghreb-Europe Gas Pipeline
GW	gigawatt
ha	hectare
HV	high voltage
IEA	International Energy Agency
IFI	international financial instrument
IMA	Morocco-Algeria Interconnection
IME	Morocco-Spain Interconnection
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPP	Independent Power Producer
IRESEN	Institute for Research into Solar Energy and Renewable Energies
IWP	Integrated Wind Programme
JLEC	JorfLasfar Energy Company
KfW	Kreditanstalt für Wiederaufbau (German development bank)
km	kilometre
kV	kilovolt
kWh	kilowatt hour
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LV	low voltage
MAD	Moroccan dirham (US$ 1 ≈MAD 9.5)
MASEN	Moroccan Agency for Solar Energy
MEMEE	Ministry of Energy, Mines, Water and Environment
MENA	Middle East and North Africa
MENA-SELECT	Middle East North Africa Sustainable Electricity Trajectories
Mt	million tons
Mtoe	million tons of oil-equivalent
MV	medium voltage
MW	megawatt
NAMA	Nationally Appropriate Mitigation Action
OCP	Sharifian Phosphate office (Office Chérifien des Phosphates)
ONE	National Electricity Agency

ONEE	National Agency for Electricity and Potable Water
ONEP	National Drinking Water Agency
PERG	Global Rural Electrification Programme
PPA	power purchase agreement
PPP	power purchase parity / public–private partnership
PROMASOL	Development Programme of the Moroccan Market for Solar Water Heaters
PSPP	pumped storage power plant
PV	photovoltaic
R&D	research and development
RES	renewable energy supply
SIE	Energy Investment Company
SME	small and medium-sized enterprises
SPC	solar project company
TFC	total final consumption
Toe	ton of oil-equivalent
TPES	total primary energy supply
TWh	terawatt hour
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States dollar
VAT	value-added tax
VHV	very high voltage
W	watt

I. Introduction

As the only North African country with no natural oil resources, Morocco is the largest energy importer in the region. The country is faced with the challenging task of meeting rising local demand while keeping its import bill under control. This has proved to be a major problem as consumption figures and global commodity prices have increased, putting particular pressure on the country's finances. As a result, energy independence, reform and continued liberalization of the sector and its price-setting mechanisms are at the top of the Moroccan Government's agenda.

To reduce dependency on international markets, as well as emissions from energy production, Morocco has established a plan to make renewable sources a central part of its energy mix. By 2020, 42% of the country's power is expected to be generated from renewable energy. There is a strong focus on developing wind and solar power, which are predicted to have an installed capacity of 2,000 MW each within five years. Morocco's growing infrastructure for hydroelectric power generation will also contribute.

Reducing dependency on imports will have a hugely positive impact on Morocco, which imports 91% of its energy. By the end of 2015, the total capacity from renewable energies was **2,747 MW** (1,770 MW from hydroelectric energy, around 797 MW from wind and 180 MW from solar capacity) which represents **36%** of installed capacity in the country.

The present case study aims to provide decision-makers, project developers and other actors involved in the renewable energy sector with an analysis of the RE policy and regulatory frameworks that were applied in Morocco as lessons learned from that experience.

II. Country brief

Morocco is a constitutional, democratic, parliamentary and social monarchy. Its constitutional system is based on the separation, balance and collaboration of powers, as well as citizenship and participatory democracy and the principles of good governance and the correlation between responsibility and accountability.

Politics take place in a framework of a parliamentary constitutional monarchy – whereby the Prime Minister is head of Government – and of a multiparty system. Executive power is exercised by the government. Legislative power is vested in both the Government and the two chambers of parliament – the Assembly of Representatives and the Assembly of Councillors. The Moroccan constitution provides for a monarchy with a parliament and an independent judiciary.

On 17 June 2011, King Mohamed VI announced a series of reforms that would transform Morocco into a constitutional monarchy. According to the new constitution, the king appoints the prime minister following legislative elections and, on recommendations from the latter, appoints the members of the Government.

Key sectors of the Moroccan economy include agriculture, tourism, phosphates, textiles, clothing and their subcomponents. Despite economic progress, the country suffers from high unemployment (9.9% in 2014 (High Commission for Planning (HCP): Key figures 2015), poverty and illiteracy, particularly in rural areas. The Gross Domestic Product (GDP) for 2014 was US$ 102.8 billion and the GDP per capita was US$ 3,036. Compared to 2013, GDP growth was 2.6%. The low rate is due to the slowdown in agricultural activity

Table 1: Key statistics in Morocco for 2015

	Population (in thousand)						GDP by sector				Unemployement rate (%)		
Area (in km²)	Urban	Rural	Total	GDP (billions of USD)	GDP per capita (USD)	GDP growth	Primary sector	Secondary sector	Tertiary sector	Trade balance (% GDP)	Urban	Rural	Total
710,850	20,432	13,416	33,848	1.028	3,036	2.60%	13%	29%	58%	-4.6%	14.8%	4.2%	9.9%

Source: High Commission for Planning-Key figures 2015.

because of low rainfall in 2014. The growth of GDP in agriculture, forestry and fishing was –2.5%. The trade deficit remained around 43 billion Moroccan dirham (MAD) (US$ 4.5 billion), due to rising expenses for energy imports. The dominant sector is the tertiary sector (58%), followed by the secondary sector (29%) and primary sector (13%). Other imported products are processed food, textiles, fossil fuels and other raw materials.

The main trading partners are China, France, Germany, Italy, Russia, Spain, Saudi-Arabia and the USA, which import food and textile products from Morocco. Raw materials and basic components are generally imported, especially metals such as copper, aluminium, steel and electronic components, as there are no local suppliers. Moroccan companies even claimed that around 95% of their products are assembled using solely imported materials and components.

The proportion of the working population is about 48% of the total population, i.e. more than 16 million people. Due to the rising number of women entering the labour market, this rate is expected to grow. At the moment, men comprise 72.4% of the working population.

Morocco's current overall unemployment rate is 9.2%, with unemployment in urban areas (14.8%) significantly exceeding the rate for rural areas (4.2%). This is because 45.1% of the working population is employed in the agricultural sector. Many of them are classified as free family assistance and thus do not receive a fixed wage. The proportion of qualified employees lies at 16%. As jobs for unqualified workers constitute more than half the jobs, unemployment rates rise with higher education and are currently close to 24% for academics. Businesses claim that Moroccan universities do not sufficiently adjust to their needs and demands. Regarding salary structures, more than half the workforce is employed at the official minimum wage of MAD 12 per hour, equal to MAD 1,872 per month. The salary of qualified technicians and engineers starts at 8,000 MAD per month, for engineers it often exceeds MAD 10,000.

Although the Moroccan investment climate is better than in most African countries, the Arab Spring alienated investors. Further events are suspected and long-term political directions cannot be foreseen. With a credit rating in the middle range, between BB and BBB+, access to finance on the international market is rather complicated or expensive. The World Economic Forum rates the access to financing as the most important obstacle to conducting business in Morocco, according to its Global Competitiveness Report [1].

III. Energy-sector characteristics

This section provides an overview of the current energy situation in Morocco with focus on the power sector, in order to identify achievements and future long-term opportunities and challenges.

1. Primary energy supply

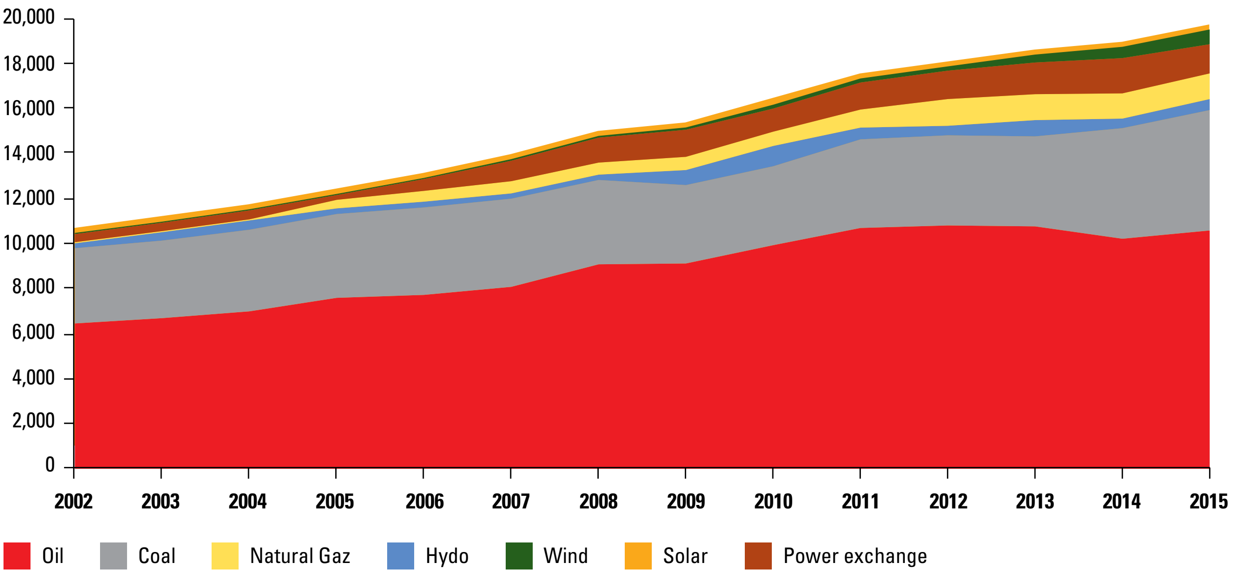
Driven by the rise in energy demand, primary energy supply has been rising steadily in Morocco over the last decade, reacing some **19.5 million toe in 2015** according to the International Energy Agency (IEA). With currently no proven gas or oil reserves, Morocco relies heavily on fossil-fuel imports, which represent **93.6%** of the total primary energy supply [2].

In addition to oil and petroleum products, Morocco imports coal, natural gas and liquid petroleum gas (LPG). Coal is used for power and industry and is imported mainly from producers such as Australia, Colombia, Russian Federation, South Africa and the USA, depending on the results of the international tenders launched by ONEE. Natural gas and LPG are imported from Algeria.

Figure 2 illustrates the increase of primary energy supply by type of fuel over the 13 years 2002–2015. It indicates how Morocco has diversified its energy mix over the last 10 years, first by increasing coal use in the mid-1990s and by introducing natural gas in 2005.

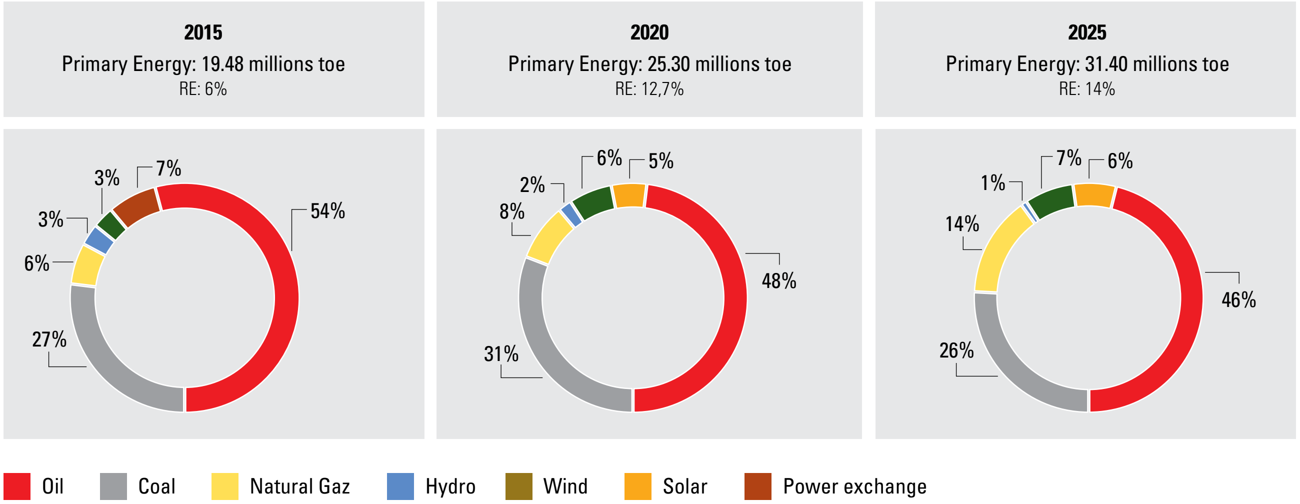
For the future, the Moroccan Energy Strategy focuses on a diversified energy mix with a significant share of renewable energy and natural gas. As shown in Figure 3, the share of renewable energy (excluding hydro) will increase from 2.6% in 2014 to 11% in 2020 and to 13% in 2025. As a consequence, the share of oil products consumed will be reduced from 54.5% in 2014 to 46.1% in 2025.

Figure 1: Total primary energy supply, Morocco 2002–2015



Source: MEMEE

Figure 2: Future evolution of primary energy mix



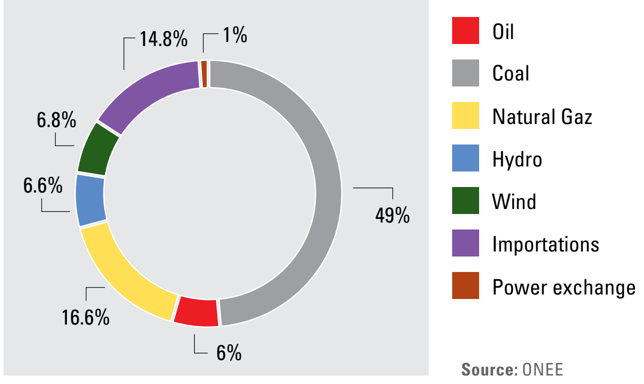
Source: MEMEE

Figure 3 shows Morocco's dependence on fossil fuels with oil still covering 54.5% of its energy needs, compared to 76% in 1990.

2. Characteristics of electrical sector

As of 2015, Morocco's total installed power-generation capacity was 8,160 MW. This consists of 5,412 MW (66%) from thermal power stations, 1,770 MW (22%) of hydropower including 464 MW of hydro pumped

Figure 3: Energy generation in 2015: 34 400 GWh



Source: ONEE

storage. Wind- and solar-generation plants provide the remaining 977 MW (12%).

The electricity generation balance consists predominantly of thermal generation (72%) while 15% is imported from Spain. The renewable energy contribution in the energy mix was about 13.5% in 2015 (including hydro).

With the exception of renewable energy produced under the framework of Law 13-09, ONEE acts as the single buyer in the sector and owns and operates an important share of the generation capacity. ONEE can, however, give concessions to private operators with purchase guarantees (see Electricity-sector organization in Annex 2).

In terms of future development, the total power-generation capacity planned for the period 2016–2030 is estimated at 18,200 MW with more than 56% being renewable energy. Detail of the expansion plan of power capacities are given in Figure 4.

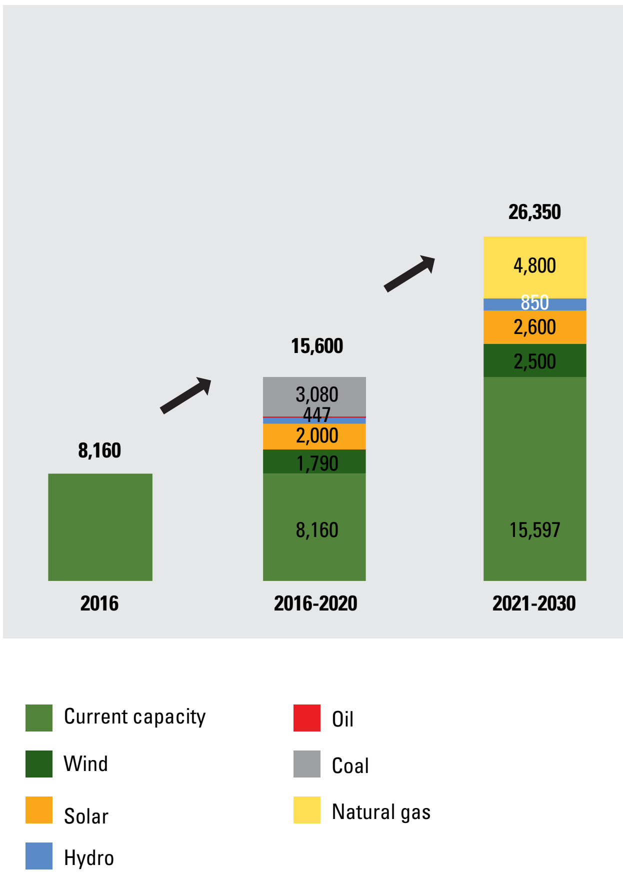
For transmission power, ONEE is responsible for operating and expanding the Moroccan power transmission grid. Aside from a small isolated network in the extreme south of the country, the transmission grid covers the entire country and is interconnected with the European and Algerian power networks. The transmission grid consists of 28,100 km of very-high-voltage–high-voltage (VHV–HV) transmission lines (400 kV, 225 kV, 150 kV and 60 kV). The distribution grid consists of 83,930 km of medium-voltage (MV) lines.

Table 2: Total installed capacity in Morocco by end of 2015

	MW	%
Hydraulic	1,306	16%
Pumped Storage Hydro	464	6%
Total hydraulic	**1,770**	**22%**
Steam turbine	1,065	13%
Gas turbine	1,230	15%
Diesel generators (DG)	201	tal2%
Jorf Lasfar Power Plant	2,080	25%
Combined cycle of Tahaddart	384	5%
Combined cycle of Ain Beni Mathar	452	6%
Total thermal	**5,412**	**66%**
ONEE wind farms	205	3%
Private Wind Farms (Law 13-09)	203	2%
Private wind farms (PPA with ONEE)	352	4%
Wind farms (self-generation)	37	0%
NOOR 1	160	2%
Combined cycle of Ain Beni Mathar (solar part)	20	0%
Total wind & solar	**977**	**12%**
Total installed capacity	**8160**	**100%**

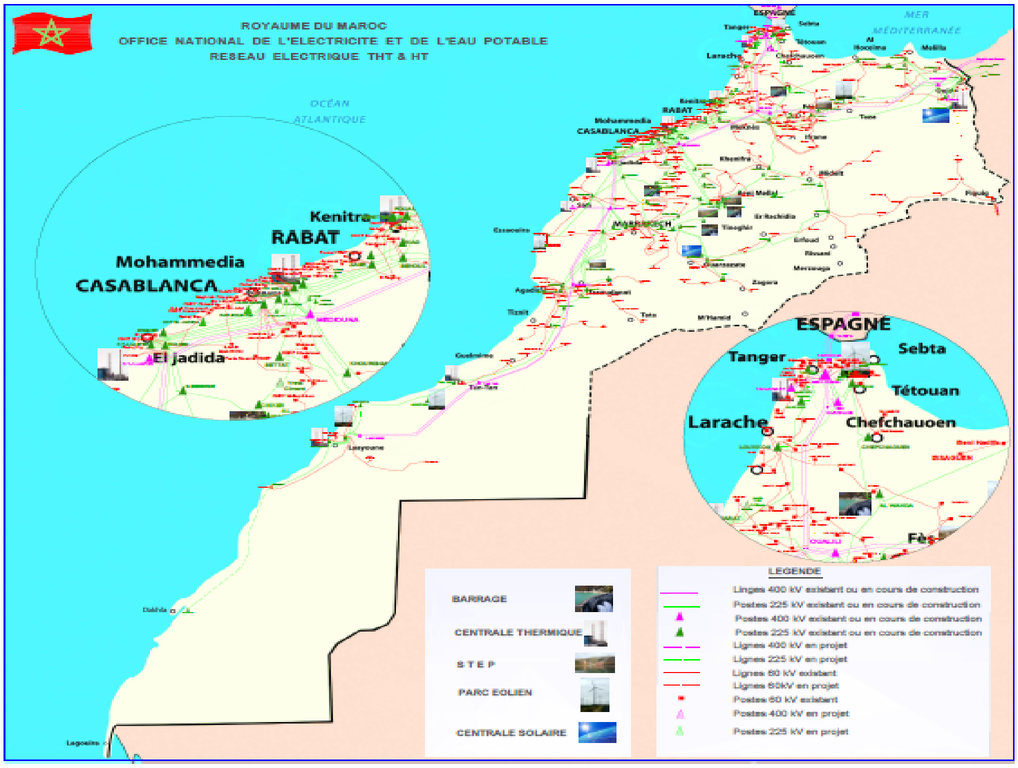
Source: ONEE

Figure 4: Power-generation capacities planned for 2016–2030 (MW)



Source: ONEE

Figure 5: Power transmission map



Source: ONEE

For the period 2016–2020, Morocco intends to extend the transmission grid by building an additional 7,000 km of HV and VHV lines, as well as 9,000 MVA on new transformation capacity. The investment required is about US$ 1.3 billion.

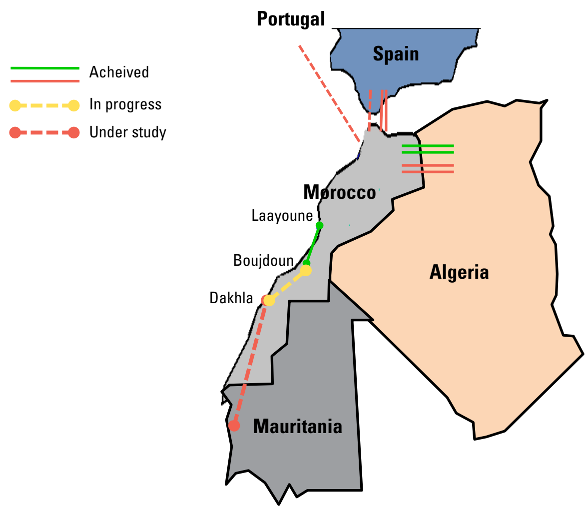
In terms of energy exchanges, Morocco has a special geographical position that allows it to become an important hub in the increasing electricity exchange between the countries around the Mediterranean, thanks to the interconnections it has developed, and is strengthening, with Algeria and Spain.

The 225 kV transmission line to connect the Moroccan power system to the Algerian one was commissioned in 1988 and was extended to 400 kW in 2008.

The main interconnection is through the Morocco–Spain network, which consists of two lines: a 400-kV line commissioned in August 1997 and another 400-kV line commissioned in June 2006.

Figure 6: Moroccan electrical interconnections

Morocco has become a regional crossroads for power exchange between north and south



Morocco-Spain Interconnection
- Commissioning in 1997
- Capacity doubled in 2006
- Exchange capacity: 1,400 MW
- Commercial capacity 900 MW
- ONEE has been the 4th operator in the Spanish market since 1999
- Studies of 3rd interconnection is in progress

Expected Morocco-Portugal Interconnection:
- Under study

Morocco-Algeria Interconnection:
- Commissioning in 1988 (2x 225kv lines)
- 400 kv line in 2008
- Exchange capacity 1500 MW

Expected Morocco-Mauritania Interconnection:
- Under study
- As a first step, Laayoune-Dakhla in Progress (400kv)

Morocco-Algeria Interconnection:
- Commissioning in 1988 (2x 225kv lines)
- 400 kv line in 2008
- Exchange capacity 1500 MW

Source: ONEE

3. Energy-demand characteristics

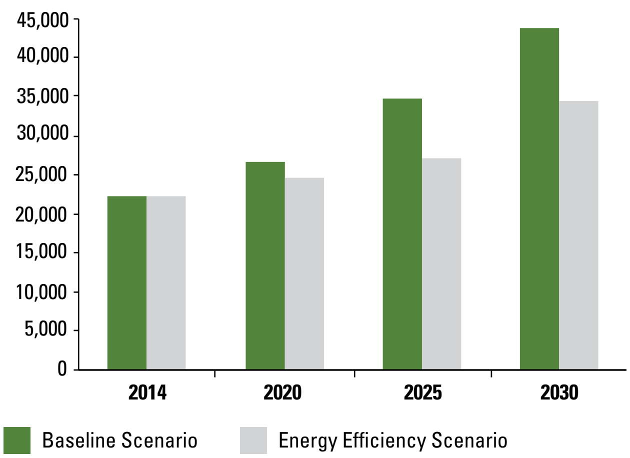
Primary energy demand in Morocco is expected to continue the rapid growth it has experienced in the last decade. The underlying factors explaining this increase are economic and industrial development, demographic growth, improved access to electricity (improving from 22% in 1996 to 99.15% in 2015) and the diffusion of household appliances.

In the framework of the Morocco 2030 prospective programme, several scenarios have been elaborated to estimate energy consumption until 2030. In a baseline scenario with no energy-efficiency policy, energy demand is expected to be around 426 million toe by 2030, with a growth rate of 4.3%. In the energy-efficiency scenario, energy demand is expected to be around 33.8 million toe which corresponds to a growth rate of 3.3%.

Electricity demand grew fast, at an average annual rate of around 6.5%, between 2005 and 2015 to reach **34,413 GWh**. This strong growth is due largely to the country's economic and social growth (widespread access to electricity in rural and urban areas), development of major projects across the country (infrastructure, industry, etc.). Besides economic expansion and a growing urban population, electricity consumption has also jumped due to a rural electrification scheme that has connected over **42,200 villages**, achieving a rural electrification rate of **99.15%** in 2015:

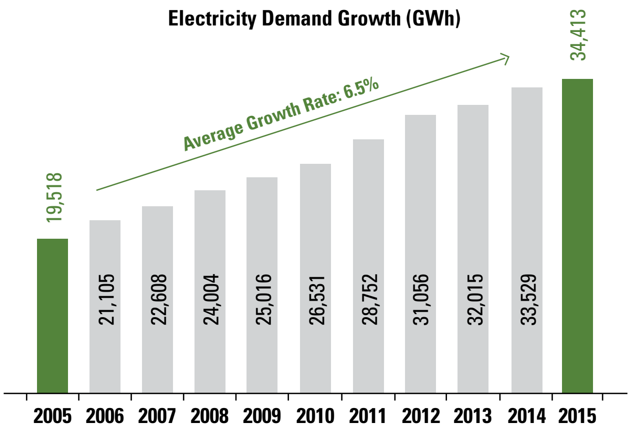
a real achievement compared with the electrification rates of 50% 10 years ago and only 18% in 1995, when Morocco launched its Global Rural Electrification Programme (PERG).

Figure 7: Energy consumption until 2030 (ktoe)



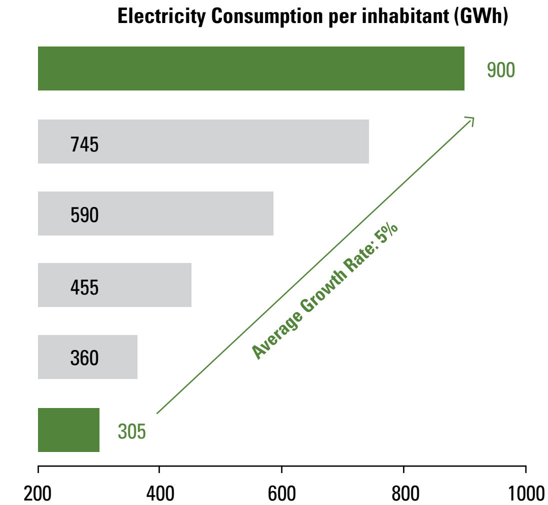
Source: MEMEE

Figure 8: Electricity demand growth (GWh)



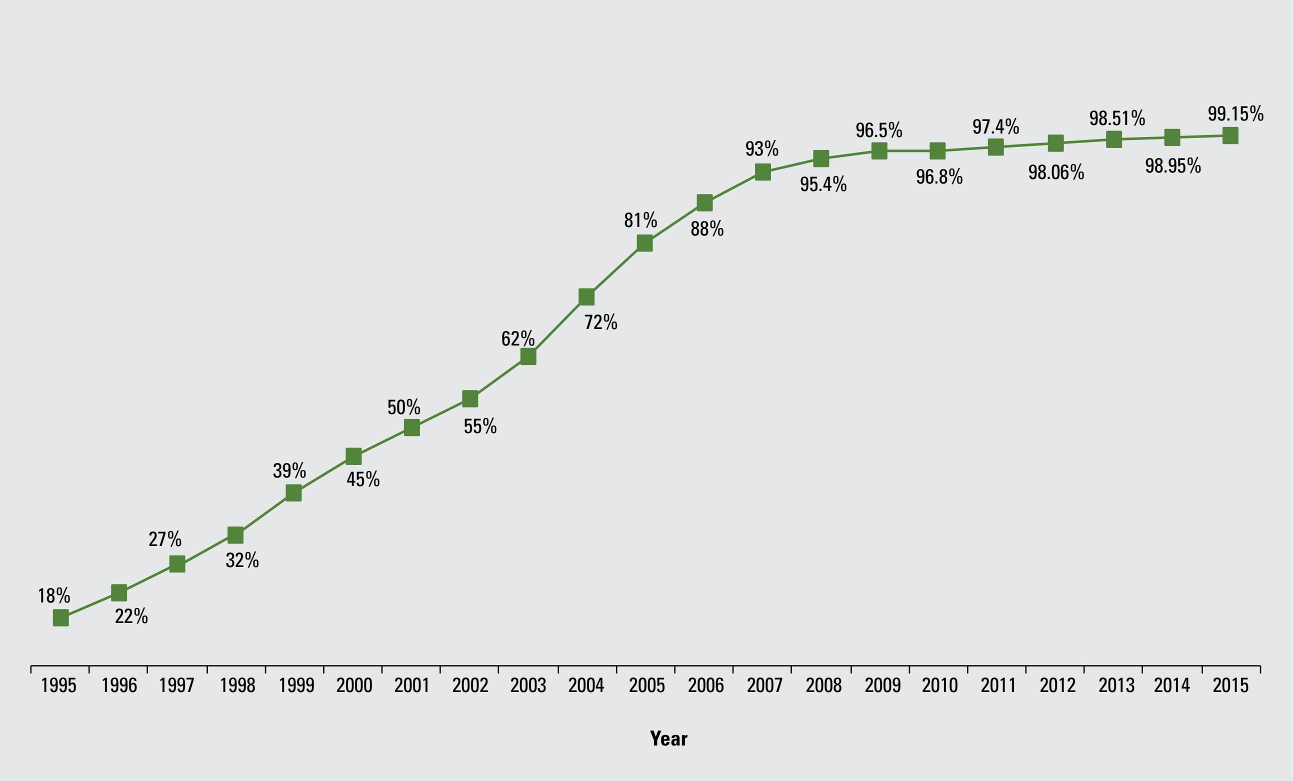
Source: ONEE

Figure 9: Electricity consumption/ha (kWh/ha)



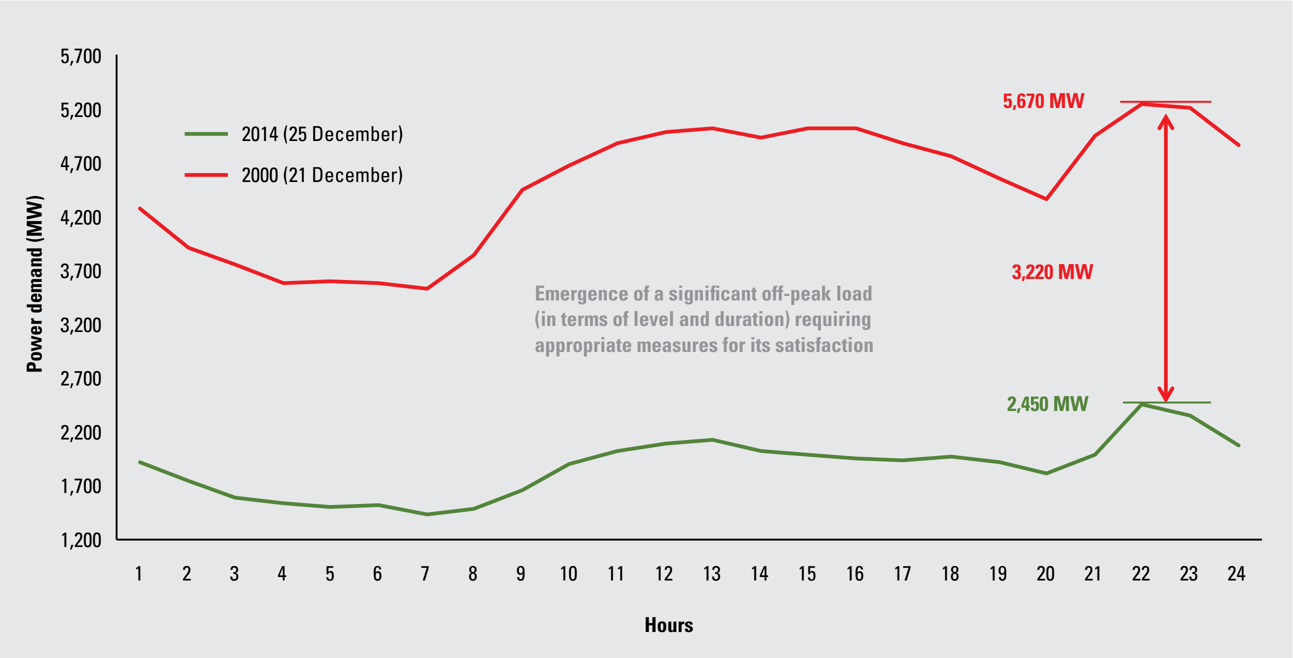
Source: ONEE

Figure 10: Evolution of rural electrification rate



Source: ONEE

Figure 11: Hourly electricity load curve

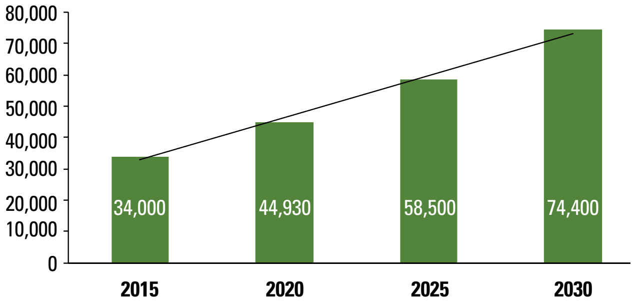


Source: ONEE

In terms of power demand, the Moroccan load curve shifted from a single peak to a double one and from a winter peak to a summer one. The gap between the peak load and the day load became smaller. This is due to economic and industrial development, as well as the modernized life style of the population (air conditioning, etc.).

According to ONEE, future electricity consumption will grow by **5.5%** on average and could reach **45 TWh by 2020**, 58 TWh by 2025 and **74 TWh by 2030**.

Figure 12: Projected future electricity consumption



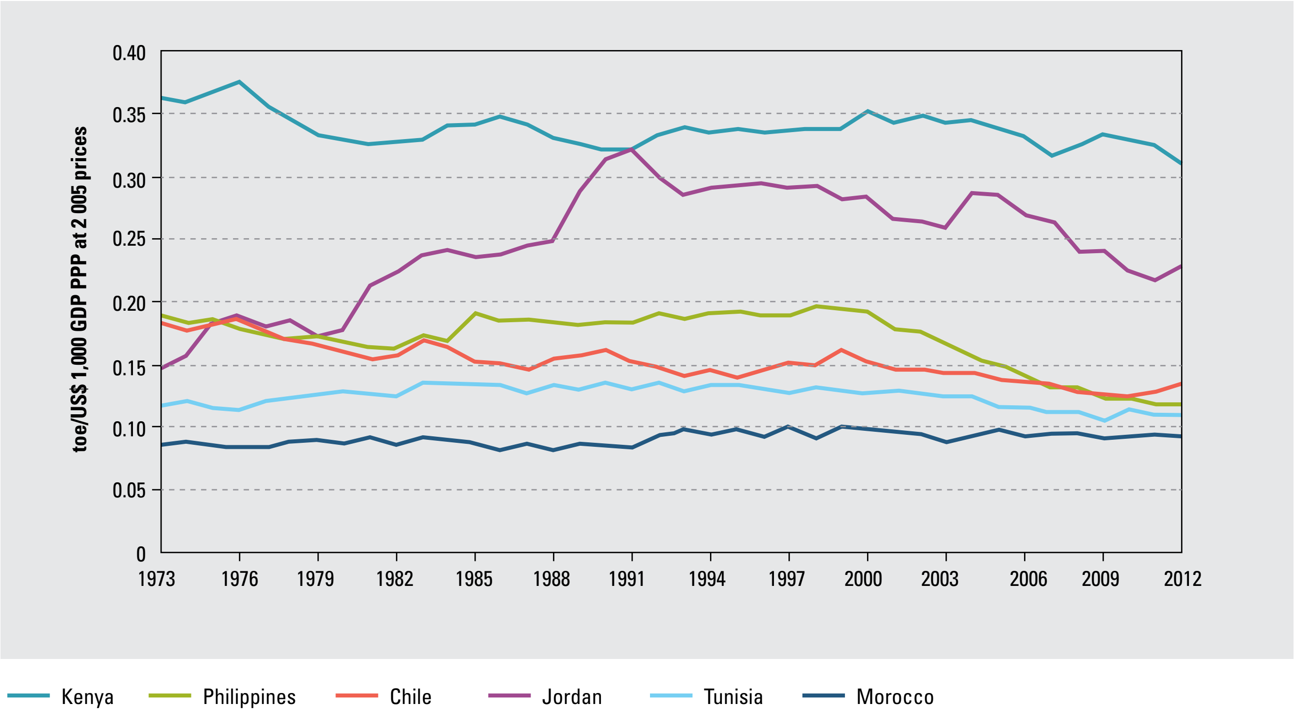
Source: ONEE

4. Energy intensity

Energy intensity, measured as the ratio of energy supply to GDP purchasing power parity (PPP), was 0.09 toe per US$ 1,000 GDP PPP in 2012, lower than the IEA average of 0.14 toe per US$ 1,000 GDP PPP, and at the third-lowest intensity level of IEA member countries.

Morocco's energy intensity has remained relatively unchanged since 2002, with moderate volatility during the decade. Unlike that of its close neighbours, Portugal and Spain and, unlike the IEA average, it has shown no sign of falling in the last five years [3].

Figure 13: Energy intensity of Morocco compared with other IEA non-members

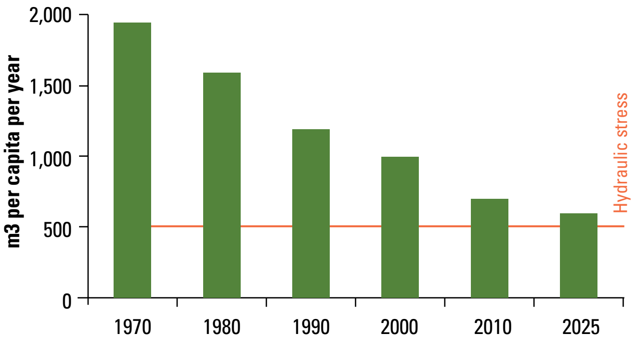


Source: IEA (2013b), *Energy Statistic of Non-OECD Countries 2013*, OECD/IEA, Paris

In this context and in order to improve its energy intensity, the National Energy Strategy adopted by Morocco in 2009 established energy efficiency as a national priority.

From a legislative and regulatory point of view, Morocco adopted in 2011 Law 47-09 (known as the Law on energy efficiency), whose main purpose is to strengthen energy efficiency in the key economic sectors.

Figure 14: Water resources per capita



Source: ONEE

5. Energy–water nexus

Morocco is a semi-arid country: precipitation rates are highly variable and many areas are already facing water shortages.

Due to the water deficit, estimated to be 5 billion m^3 by 2030, Morocco opted for the concept of sustainable management as a strategic choice for its water-management policy. At the end of the 1960s, therefore, Morocco made a strategic decision to build a strong and secure long-term water-supply infrastructure through the construction of more than 130 large dams and a large number of medium and small dams with a combined storage capacity of approximately **18 billion m^3** and a universal access to safe drinking water in urban and rural areas with an access thereto of **100%** and **94%**, respectively.

Nevertheless, water resources per capita are still declining, due to population growth, the significant rate of urbanization and the development of the agriculture, tourism and industry sectors.

To meet future water demand, Morocco launched ambitious plans for desalination and is exploring the possibility of transferring the water from the north to the south. Both these two options require large amounts of energy for pumping and transportation.

In this context, the Moroccan Government began to consider the importance of the energy–water nexus in elaborating public policies for water management, energy production and food security, which it approached in several ways and initiatives:

1. Gathering energy, water and environmental policy management under the same ministry (Ministry of Energy, Mines, Water and Environment);

2. Merging, in a single entity, the two public utilities in charge of water **(National Office for Potable Water)** and electricity **(National Electricity Office)** creating an integrated utility **(National Agency for Electricity and Potable Water (ONEE))**. The objective is to integrate water resources management into energy planning, identify potential areas of future uncertainty and delineate areas where integrated energy–water management may improve the reliability of operating power plants and the viability of schemes.

3. Development of an active coordination action within the Department of Agriculture through the generalization of drip irrigation and water pumping with solar PV, which are having a sound impact on irrigation efficiency and water consumption;

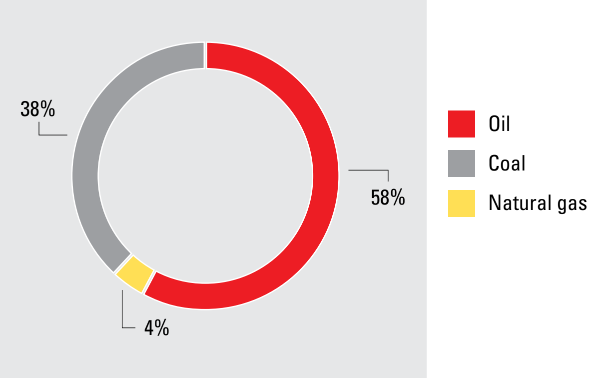
4. Promotion of less water-intensive power generation technologies such as adopting CSP technology with an air-cooling system, and the launch of the national plan of recycling urban water with more than 30 new water-treatment stations.

6. CO_2 emissions

Despite the country's efforts in renewable energy policy-making, its national energy consumption still depends to a great extent on fossil fuels. As a consequence, total CO_2 emissions in 2015 were estimated at **60 million tons**, dominated by the consumption of oil products .

The Moroccan strategy focusing on renewable energy development helped, however, to reduce CO_2 emissions per kWh as seen in Figure 16.

Figure 15: CO_2 Emissions by energy source



Source: MEMEE

Figure 16: CO_2 emission/kWh

Source: MEMEE

IV. Renewable energy potential

1. Assessment methodology

The assessment methodology of renewable potential is based on estimating the theoretical surface that may contain renewable generation facilities, as well as the power density ratio to be considered of each renewable energy technology.

According to the definitions in the study by the German Corporation for International Cooperation (GIZ) [11], the renewable energy potential is assessed in terms of the **theoretical potential** and the **technical potential**.

The theoretical potential is defined as the energy supply that can be physically used in a region and for a limited time, taking into account some important structural restrictions, such as the geographical nature of surfaces.

The technical potential is the share of the theoretical potential that can be developed using current technologies such as "status quo technology". It takes into account other restrictions, including sustainable use of space and other environmental restrictions.

a. Assessment methodology of wind potential

According to the GIZ study, the theoretical wind potential (TWP) is calculated as

TWP = ThS*DW

where
- ThS = theoretical potential surface (km^2)
- DW = power density of wind (MW/km^2)

In this case, ThS is the area where the wind turbine facility can be installed. It is calculated by excluding the areas that:

- are located at altitudes above 2,000 m;
- have a slope of more than 15 °;
- are covered by forests, homes, lakes, etc.;
- have average wind speeds below 5 m/s.

The power density of wind is based on a 5-MW wind turbine with a rotor diameter of 126 m and a tower height of 120 m.

b. Assessment methodology of solar PV potential

According to the GIZ study [11], the theoretical solar PV potential (TSPVP) is calculated as

TSPVP = ThS*DW

where
- ThS = theoretical potential surface (km^2);
- DW = power density of solar PV (MW/km^2).

In this case, ThS is the area where the solar PV can be installed. It is calculated by excluding the areas that:

- are located at altitudes above 2,000 m;
- have a slope of more than 15 °;
- are covered by forests, homes, lakes, etc.

c. Assessment methodology of solar CSP potential

According to the GIZ study [11], the theoretical Solar CSP potential (TSCSPP) is calculated as

TSCSPP = ThS*DW

where
- ThS = theoretical potential surface (km^2)
- DW = power density of solar CSP (MW/km^2)

In this case, ThS is the area where the solar CSP can be installed. It is calculated by excluding the areas that:

- are located at altitudes above 2,000 m;
- have a slope of more than 15 °;
- are covered by forests, homes, lakes, etc.

To identify the convenient zones for setting up future projects of green power production, ADEREE uses an innovative customized solution: the Renewable Energy Atlas of Morocco. It includes dynamic maps and graphs from data generated by the best models of meteorological simulation and correlated with measurements made by ADEREE. The database of the Atlas is coupled with an open visualization Geographic Information System (GIS). Throughout its functionalities, it allows sites to be assessed, comparisons to be made and scenarios to be studied for a rational and sustainable development of the renewable energy industry.

The main objective of the Atlas is to have a powerful, scalable tool that includes all the useful data to make decisions about the development of new projects. The atlas of renewable energies therefore provides assistance to decision-makers and investors in their decision process regarding the establishment of new renewable energy projects in Morocco.

2. Renewable energy potential for power generation

In Morocco, renewable energy is used mainly for power generation. The estimated potential for this purpose is described below.

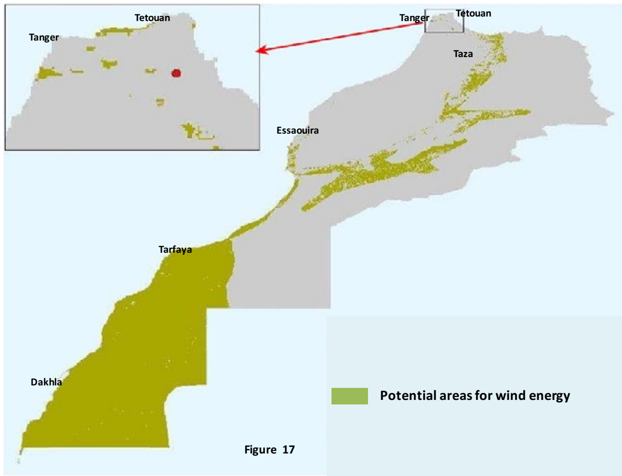
a. Wind potential

The wind-energy potential is important in vast parts in the northern and southern regions, with the annual average wind speed exceeding **9 m/s** at 40 m elevation, due to its 3,500-km coastline. Regions near the Atlantic coast, such as Essaouira, Tangier and Tetouan (with average annual average wind speeds between 9.5 m/s and 11 m/s at 40 m) and Tarfaya, Laayoune, Dakhla and Taza (with annual average wind speeds between 7.5 m/s and 9.5 m/s at 40 m) has excellent wind-power potential.

Based on the GIZ study [11], it is estimated that Morocco's theoretical potential of wind power is about **2,645 GW**, based on an available surface area of 264,531 km^2 and a power density of 10 MW/km^2.

For the technical potential of wind power, it is necessary to consider the environmental constraint which requires servitude of 600 m on either side of the wind turbine. The power density used for the technical potential determination is therefore 2.1 MW/km², giving a technical potential of about **327 GW** based, on an available surface area of 163,200 km².

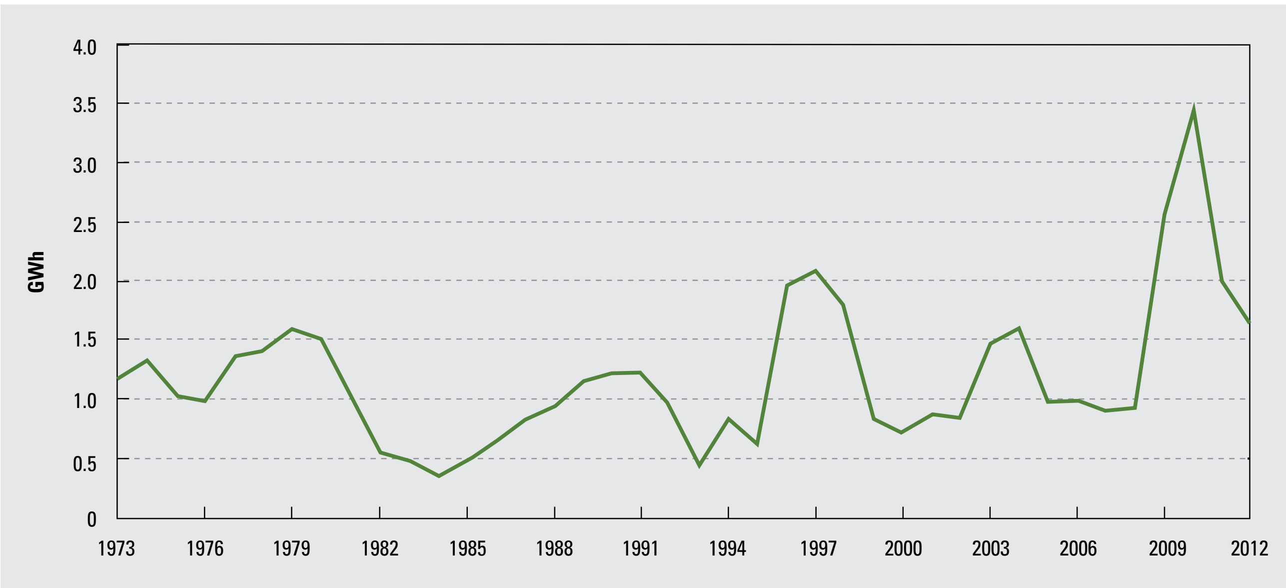
Figure 17: Wind potential map



b. Hydropower

The surface-water resources of the territory overall are estimated at between 20 billion m³ and 30 billion m³ in an average year, but they can range from 5 billion m³ to almost 50 billion m³. Half of these resources are concentrated in the hydraulic basins in the north, which cover less than 8% of the country's total area. Hydro-electricity is only one aspect of Morocco's hydrological management, whose main aim is to provide drinking water, irrigation and protection against floods, thanks to 135 major dams with a total storage capacity of 17 billion m³, a dozen others in construction and some 30 smaller dams. Nevertheless, production of hydropower varies considerably from year to year.

Figure 18: Variability of hydropower generation in Morocco, 1973–2012



Source: IEA (2013b), *Energy Statistics of Non-OECD Countries 2013, OECD/IEA*, Paris

With 27 hydropower plants totaling **1,306 MW** in pure energy, hydraulic energy today remains the main source of renewable energy in Morocco. The potential of this resource is far from being fully tapped, however.

According to ADEREE, the possibility of constructing other storage dams is limited and more than one-third of the water inflow is lost due to the lack of storage infrastructure. For this reason, the hydro potential is evaluated for the mini-hydro only.

In Morocco, annual water inflow from rainfalls are estimated at **30 billion m³**. Geographically, the highest point, the Toubkal, rises to **4,165 m** and the lowest point, SebkhaTah, is located **55 m** below sea level.

Based on this hypothesis, the GTZ study stated that the theoretical potential of mini-hydro is about 26 GW, while the technical potential is estimated at 23 MW.

c. Solar power

Solar power is undeniably the most important source of renewable energy in Morocco. With well over **3,000 h/year** of sunshine – the equivalent of a radiance of about **5.5 KWh/m²/day** – Morocco is a solar power field of excellence. This source of energy represents an even greater potential in areas poorly serviced by the power grid.

i. Solar PV

According to the results of the GIZ study [11], the theoretical potential of solar PV is estimated at **31,200 GW** based on a radiation of 5.5 KWh/m²/day, an available surface area of 152,620 km², a performance ratio of 15% and a power density of 100 MW/km².

The technical potential of solar PV, is estimated at **10,830 GW**, based on an available surface area of 53,000 km².

ii. Solar CSP

According to the GIZ study [11], Morocco's theoretical potential of CSP is estimated at **25,437 GW**, based on a radiation of 5.5 KWh/m²/day, an available surface area of 508,737 km², a power density of 50 MW/km² and a generation potential of 1,600 MWh/MW.

The technical potential of CSP, is estimated at **8,828 GW**, based on an available surface area of 53,000 km².

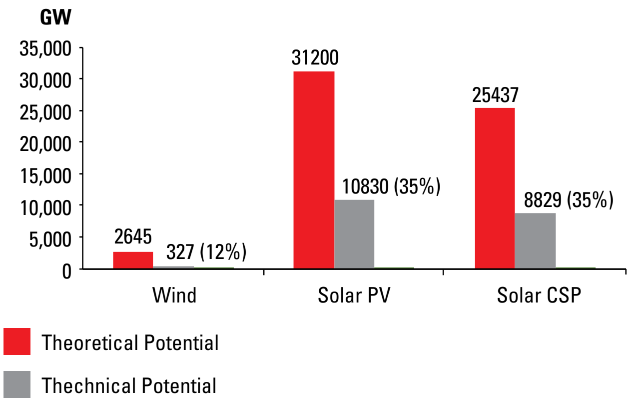
The wind and solar potential are summarized in Figure 19.

It should be stressed that achievable potential is, generally, significantly smaller than the theoretical and technical potential. It takes into account other factors, such as cost, legal and social elements.

3. Renewable energy potential for direct uses

The main renewable energy source for direct uses in Morocco is solar heat. The development programme of the Moroccan market for solar water heaters, PROMASOL, has helped to install **48,000 m²** in 2010 (for a total of 300,000 m²). It is a comprehensive, certified system integrating the technical installation and financing of a solar water heater in the residential sector (which will then be extended to other sectors and solar PV), combined with an investment subsidy and bank loan repayable through the electricity bill. The goal is to reach **1.7 million m²** of installed capacity by 2020, capable of delivering around 1.2 GWh. The goal is a capacity of **3 million m²** by 2030.

Figure 19: Wind and solar power potential



Source: GIZ

According to the GIZ study [11], the theoretical potential of solar heat is estimated at **133 million m²** and the technical potential is **33 million m²**.

There is also great potential – still to be determined precisely – for using solar heat in agriculture, industry and services. Thanks to the amount of direct sunlight it receives, Morocco can obtain good yields of solar heat.

4. Potential for local integration and manufacturing

The deployment of new renewable energy capacities in Morocco brings major challenges in terms of local manufacturing and industrial development.

The strategy to support renewable energy equipment manufacturing is based on the following:

- Under the Moroccan Solar Plan and Wind Programme, bidders are encouraged to promote local manufacturing, for example:

- The 160 MW CSP plant near Ouarzazate (NOOR), awarded to ACWA Power, includes a 42% local content portion. Specialized energy courses have been created within the major engineering schools and universities;

- As the engineering, procurement and construction (EPC) contractor of the last Wind Programme of 850 MW in Morocco won by a consortium of ENEL and NAREVA, Siemens will supply the turbines for the five projects and has signed an agreement with the Moroccan Government to build a rotor-blade factory for onshore wind turbines with an investment of more than 100 million. It is expected that up to 700 jobs will be created in Tangier and the factory will serve the African, Middle Eastern and European wind markets upon its completion, scheduled for spring 2017;

- The Moroccan Association of Wind and Solar Industries (AMISOLE) was created in 1987 to promote the interests of Moroccan professionals and industries involved in the sector of renewable energy (wind and solar). AMISOLE now embraces about 50 Moroccan companies;

- Training of technicians in wind energy by vocational training institutes has been launched;

- ADEREE provides training programmes dedicated to the development of renewable energies;

- The Research Institute for Solar Energy and Renewable Energies (IRESEN) was created to bring together fundamental research and development (R&D) and applied science at national level to encourage innovation and networking.

Solar PV.
The highest potential for local manufacture of PV plants in the medium term is seen in the BOS (balance of system) components of the power plants. The mounting structure, electrical and construction works and installation are usually performed by local companies. Construction and electrical work is similar to other infrastructure and energy projects and the existing local skills can thus be directly applied to PV plants. The manufacture of mounting structures might be targeted by metal-working companies with experience in the forming and welding of steel. For PV modules, while Morocco does not have the necessary infrastructure of know-how for local silicon or cell production, module assembly using crystalline silicone cells or module manufacture using turnkey production lines is thought to be feasible in the medium term, even if this would require large-scale investment.

The solar PV sector remains limited in Morocco, since the local market is only emerging. According to interviews with local players, most of the companies active in the sector are small and medium-sized enterprises (SMEs) focused mainly on the installation of small off-grid devices, as well as on distribution and installation of imported parts and components for solar technologies. Some of these companies have gained experience in supplying, installing and maintaining solar PV equipment through the implementation of PERG, during which small off-grid PV kits have been provided to rural areas with no access to electricity.

The local value-added and job creations therefore remains limited in the sector. Only a few local companies are active in the manufacture of solar panels and in project development and engineering. Over the last few years, two manufacturers of solar panels have been established in Morocco: Droben (10 MW/year plant near Casablanca) and Cleanergy (5 MW/year plant)[4]. These two plants will provide modules based on imported cells. The total manufacturing capacity will be sufficient to provide modules for small projects, but the development of large-scale plants would require new manufacturing capacities.

The following components offer a very promising local capacity potential:

- Morocco can rely on solid mechanical, electrical and electronics industries, especially cable producers, which may be an asset to supply future PV plants in the short-term perspective;

- Construction also offers significant local content potential, with leading EPC companies having both the technical skills and critical sizes to provide civil, mechanical and electrical engineering services;

- Local steel companies could deliver the necessary steel support structure for the PV modules provided there is investment in specific equipment.

Solar CSP.
The required investment and know-how are substantial for setting up the manufacture of specific CSP components, such as mirrors, receivers, tubes and power blocks. Local manufacturing would probably not be feasible in the medium-term. In the long-term, knowledge transfer from abroad would be required.

Regarding pumps and pipes, several companies are currently active in this sector, but the existing competences do not meet the international requirements for CSP solar plants. The majority of Moroccan companies import these products as national production capacities are not sufficient to meet current local market demand. Regarding heat storage, local competences exist for civil engineering work and tanks. A local supply of salt seems critical to develop a local industry.

In the long term, the manufacture and assembly of complex components would be possible in Morocco, as demonstrated in several industrial sectors such as the aircraft industry. Several conditions would have to be in place for this to happen, including the establishment of a local glass industry, greater local and regional market demand and increased capabilities of high-quality manufacturing.

Consequently, upcoming projects to be implemented in the framework of the Moroccan Solar Plan will be critical for knowledge transfer and capacity-building. In the short term, civil works, construction, manufacture of the mounting structure, installation of collectors and some electrical installation works will be the first steps for companies. Later on, the more complex components will follow the market when the project pipeline increases and a market is established.

Based on experiences with projects in Morocco (Ouarzazate), an initial local manufacturing potential of around 42% of the installation costs was already achieved. This amount could be extended to values greater than 60%, if certain favourable conditions are implemented. The winning EPC company of the first CSP project in Ouarzazate (ACWA Power) stated that a local content of more than 40% of the installation costs (even up to 65%) could be possible in this project, resulting not only in a dramatic increase of the local value but also in a decrease of the installation costs.

Wind.
Morocco has a strong potential for the local manufacture of wind-turbine components as several companies have been involved in the last decade in wind projects and have developed know-how in this sector. Local companies would also be able to produce main electrical components, cables and parts of the generator in the short or medium term. Transport, civil engineering work and foundations of upcoming projects could also be performed by local players. Moroccan companies have a great capability for innovation, developing partnerships and technological cooperation with international companies, which would help them to produce blades locally for upcoming projects.

V. Current and prior policy status

1. Renewable energy strategy

In the next 10 years, Morocco will face several challenges, including an exponential demand for electricity to support the economic dynamics triggered in the last decade (in the baseline scenario, the induced energy needs are expected to double by 2030), a dependence of over 95% on export for its energy supply and a strong volatility of energy prices.

Morocco depends on imports for most of its energy needs. Its domestic supply of oil, gas and coal is either negligible or suffers from high per-unit costs of production, resulting in an acute imbalance between domestic production and consumption of energy.

In this context, the Moroccan Government developed the National Energy Strategy, setting clear and precise objectives. The Strategy has four main objectives: optimize the fuel mix in the electricity sector; accelerate the development of energy from renewable sources, especially wind, solar and hydropower; make energy efficiency a national priority; and promote greater regional integration.

Figure 20: Moroccan National Energy Strategy

Main Goals	Strategic Orientations
1- Security of supply	1- A mix diversified and optimized around a choice of reliable and competitive technologies
2- Generalized access to the electricity at moderate prices	2- Mobilization of national resources by increasing renewables share part in the energy mix
3- Demand-side management	3- Energy efficiency as a national priority
4- Environment protection issues	4- Regional integration

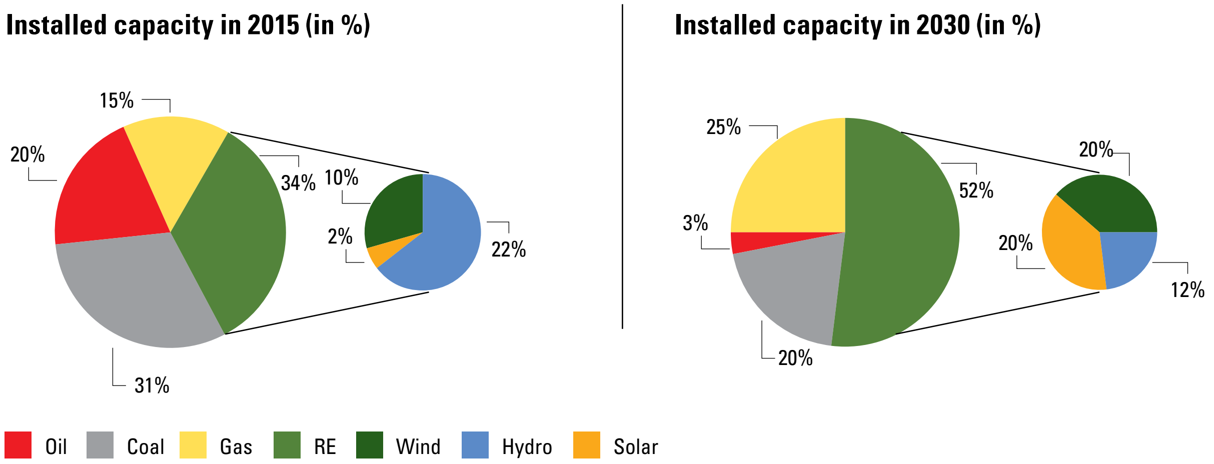
Source: based on ONEE and MEMEE data

2. Renewable energy targets

The renewable energy target set up in the framework of the Strategy was to increase the share of renewable energy to **42 %**, raising the installed capacity to 2,000 MW for solar generation (Moroccan solar plan), 2,000 MW for wind generation (Moroccan Integrated Wind Energy Programme) and 2,000 MW for hydropower.

The new energy roadmap, announced by King Mohammed VI, at COP 21 (Paris, November/December 2015) bolstered this ambition to a target of **52 %** for renewable energy in 2030, comprising 12% hydro, 20% solar and 20% wind generation.

Figure 21: Share of installed capacity in Morocco for the years 2015 and 2030



Source: Authors' calculations based on ONEE and MEMEE data.

Hydroelectric power capacity has been a crucial element of Morocco's energy system for many decades. It is expected to reach 2,000 MW by 2020 and up to 3,100 MW (an additional 1,330 MW from 2016 to 2030) by 2030. Two ambitious programmes were developed to boost Morocco's solar and wind development:

- **The Moroccan Solar Plan (Noor)** aims to reach **2,000 MW** installed solar power capacity (PV and CSP) by 2020 and roughly 4,800 MW by 2030 (an additional 4,560 MW from 2016 to 2030);

- **The Moroccan Integrated Wind Programme** aims to achieve **2,000 MW** installed wind power capacity by 2020 and up to **5,000 MW** by 2030 (an additional 4,200 MW from 2016 to 2030). In the light of these plans, multiple large- and medium-scale solar and wind projects will be installed at different sites.

Given its vicinity with Spain, Morocco has great potential to become a dominant leader in exporting electricity from renewable energy to a major potential importer such as Europe.

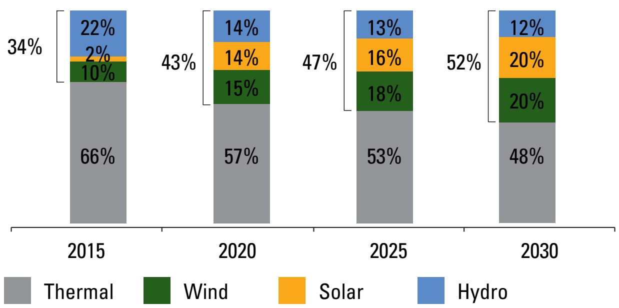
In order to promote renewable energy deployment, Morocco has so far adopted three main pillars of action: the promulgation of actual regulations and laws to favour renewable energy expansion for electricity generation; establishment of institutions with the capacity to manage, supervise and promote renewable energy projects; and the implementation of projects and major financial investments to build the required facilities.

a. Wind target

The first wind farms were commissioned in the 2000s on behalf of ONEE, the off-taker of electricity under a PPA with a private developer.

The installed base for renewables production features a wind farm in Tetouan (54 MW, commissioned in 2000); Lafarge's wind farm at Tetouan (32 MW, commissioned in 2005, 2008 and 2009); Amogdoul's wind farm at Essaouira (60 MW, commissioned in 2007); the Tangiers wind farm (140 MW, commissioned in 2009); the cement plant at Laâyoune (5 MW, commissioned in 2011); and the Tarfaya wind farm (300 MW, commissioned in 2014).

Figure 22: Renewable energy targets (2020–2025–2030)



Source: ONEE

In addition, independent producers developed 420 MW for industrial clients: Akhfennir, 200 MW; Foum El Oued, 50 MW; El Haouma, 50 MW; and JbelKhalladi, 120 MW.

Moreover, ONEE has launched an Integrated Wind Programme (IWP) which will total 1,000 MW upon completion among six wind farms; the first 150 MW capacity is currently under development at Taza.

The five other wind farms planned in this integrated programme are:

- Midelt (Midelt), 150 MW to be delivered in 2018;

- Tanger II (Tangiers), 100 MW to be delivered in 2019 Tiskrad (Laâyoune), 300 MW to be delivered in 2019;

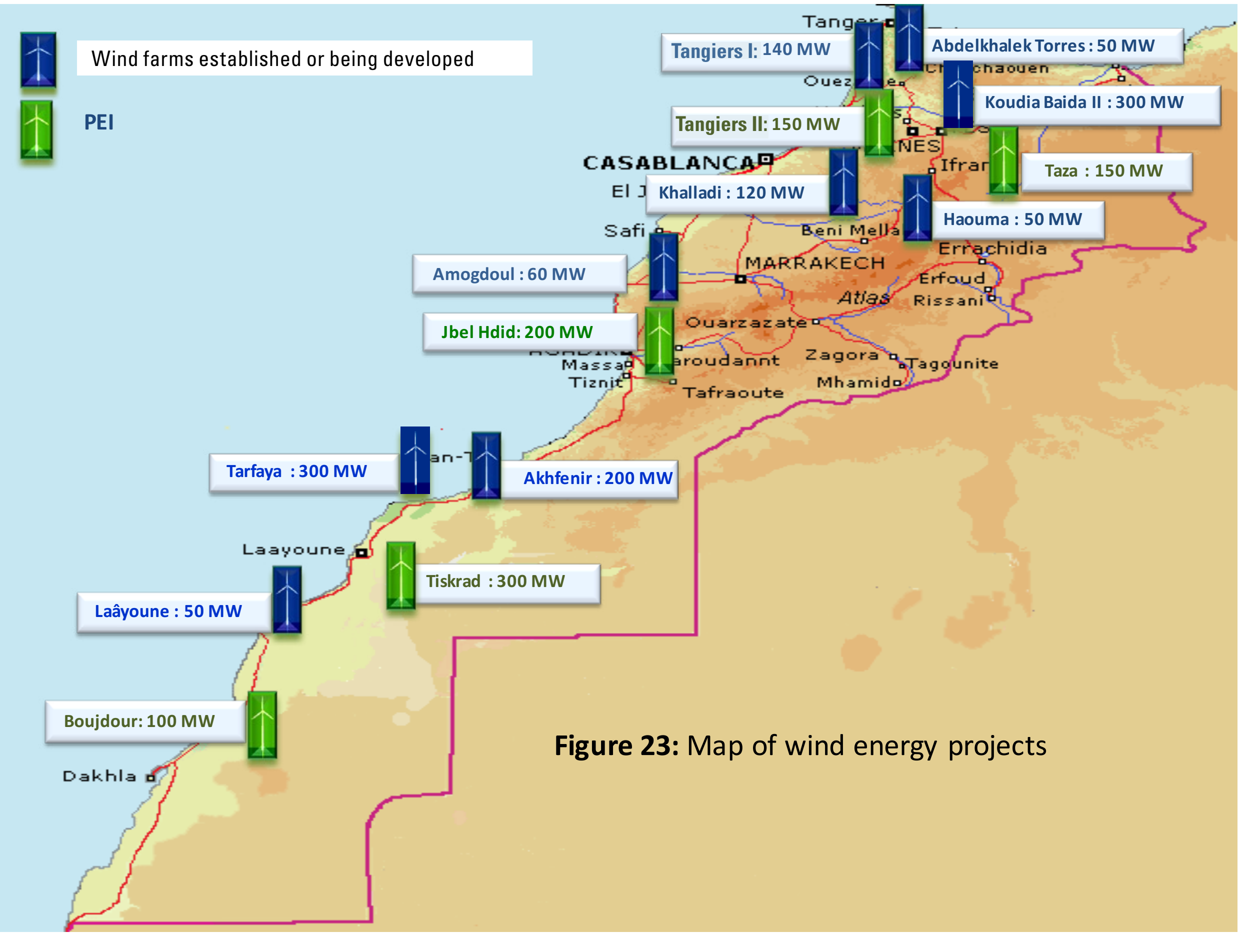
- JbelLahdid (Essaouira), 200 MW to be delivered in 2020;

- Boujdour (Boujdour), 100 MW to be delivered in 2020.

Moreover, ONEE intends to increase the power of the Tetouan (Koudia El Baïda) wind farm to 130 MW or 150 MW.

By 2020, the expected 2 000 MW capacity should generate around 6 600 GWh per year thanks to the exceptional quality of the wind resources on the Moroccan coast, expected to save 1.5 million toe/year and prevent the emission into the atmosphere of 5.6 million tons of CO_2 per year.

Figure 23: Map of wind-energy projects



Source: ONEE

By realizing these projects, the installed wind capacity will be around **2,530 MW in 2020** (largely exceeding the initial target of 2,000 MW) and **5,000 MW in 2030.**

b. Solar target

Since 1995, Morocco has been undertaking the ambitious PERG, entrusted to ONEE. Over 16 years, 42,200 villages – 2 million households – were thus electrified. Of these, 51,000 were equipped with individual (isolated) solar kits with a capacity of 70 kW or 200 kW, totalling some 10 MW of solar PV).

In addition, a CSP power plant with 20 MW capacity, commissioned in 2011 with the support of the World Bank Global Environment Facility, was incorporated in the 450 MW combined cycle gas power plant of AinBeniMathar.

Moreover, the Solar Integrated Project was launched in 2009 in association with the creation of the Moroccan Solar Energy Agency (MASEN). The target of this project is to reach a total installed capacity of 2,000 MW by 2020 with the development of large-scale CSP and PV facilities in five different areas, covering a total of 10,000 ha for a total final production of 4,500 GWh (18% of current national electricity production). Although the investment costs for the project amount to US$ 9 billion, the project should lead to savings of 1 million toe/year and a reduction of 3.7 million tons of CO_2 emissions per year.

This programme will provide 10% of Morocco's electricity needs by 2020 and prevent the emission of 3.7 million tons of CO_2 per year. The first phase of the project will have a total capacity of 580 MW and will involve the construction of a CSP farm in the area of Ouarzazate. The initial construction has been in operation since December 2015 with a capacity of 160 MW.

The second project (NOOR II), also a parabolic trough, with a capacity of 200 MW and seven hours of storage is under construction. The third project (NOOR III) is also under construction, and has a capacity of 150 MW and more than seven hours of storage. In May 2017, the Noor 2 CSP and Noor 3 CSP plants have reached a completion rate of 76% and 74%, respectively [21].

MASEN is currently developing a new programme – NOOR PV I – consisting of three photovoltaic power plants with an aggregate capacity of 170 MW and an annual output of 320 GWh.

In parallel to the development of this PV phase, an additional solar power plant near the city of Midelt will be implemented in various phases. NOOR Midelt Phase I consists of two hybrid PV and CSP projects with storage power plants having a CSP gross capacity of between 150 MW and 190 MW each. The request for qualification relates to the selection of the consortia invited to submit a proposal for the design, financing, construction, operation and maintenance of the project was launched in July 2016.

To further develop the strong domestic solar energy potential, ONEE launched a programme to develop **end-of-line**, mid-sized (20 MW–30 MW) solar PV plants, which will help strengthen the security of the electricity supply in the selected zones.

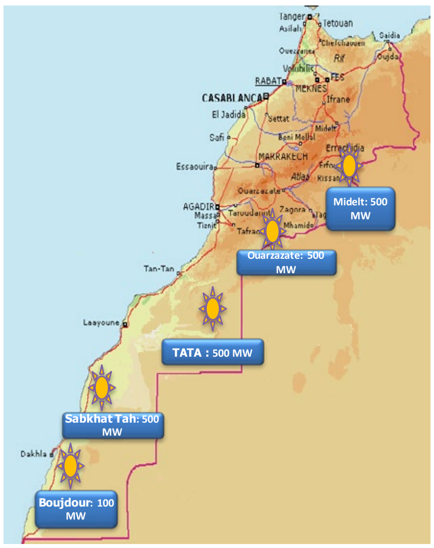
This programme aims for a total installed power of around 400 MW and is seen as a network-management tool, since it is mainly intended to improve the quality of the customer service provided in surrounding regions, particularly during daytime hours. It features the following projects:

- The NOOR ATLAS project is intended to meet the needs of the southern and eastern regions through the deployment of eight solar PV plants with a 200 MW capacity at Guemim, Tata, Tahla, Guenfouda, AinBeniMathar, Boudnib and Boulmane;
- The NOOR Tafilalt project is intended to strengthen the Zagora Arfoud and Misour networks thanks to three solar PV plants with a 75 MW capacity;
- The addition of 100 MW is intended to strengthen the network in other Moroccan regions.

In addition, a national programme promoting solar pumping in water-saving projects for irrigation has been developed. It has a budget of MAD 400 million (US$ 40 million) and foresees the development of 3,000 PV pumping systems with a total peak installed capacity of 15 MW.

Figure 24: Moroccan Solar Plan: 2,000 MW

Installed capacity by 2020	• 2,000 MW • Ouarzazate: The first solar plant in operation in 2015
Generation	• ≈ 4,500 Gwh per year
Estimated investment cost	• US$ 9 billions
Annual fuel saving	• 1 million of Toe per year
CO_2 emissions avoided	• 3.7 million Tons per year



Source: ONEE

The objective is to improve agricultural yield and productivity, while saving on water and energy. It would allow, among other things, savings on the butane-gas subsidy. Savings would cover the subsidy amount, which would be recovered at the end of three to five years. The subsidy granted for the solar pumping component will cover 50% of the installation cost, with a **€7,000 cap**, providing the farmer installs drip irrigation.

By realizing these projects, the solar installed capacity will be around **2,150 MW in 2020** (exceeding the initial target of 2,000 MW) and **4,800 MW in 2030**.

c. Hydro target

By 2020, 520 MW will be installed on the major dams under construction. Under Law 13-09, seven hydraulic microplants with a total capacity of 54 MW are now under development by the private sector. Finally, retention basins have been built, and drip irrigation developed, with a view to separating irrigation needs from energy needs to better satisfy demand.

The increase in the share of variable renewable energies – such as wind and solar power – makes the use of Morocco's flexible hydropower resources even more crucial. Managing this variability will be made easier, thanks to the PSPPs already existing (Afourer, 464 MW, since 2004) or in development (Abdelmoumen, 350 MWh, around seven hours of storage at full power). Two other PSPPs of 300 MW each are under development with an expected commissioning date between 2020 and 2030.

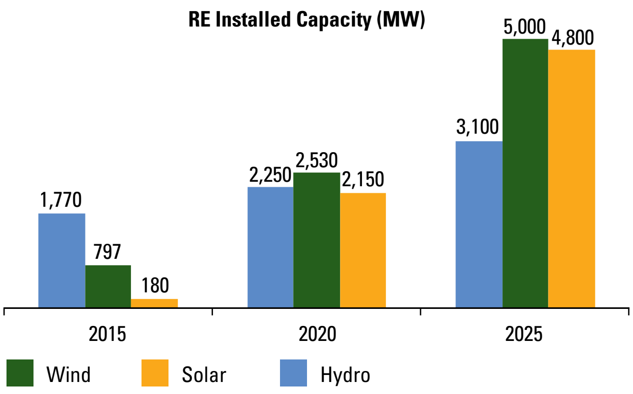
By realizing these projects, the installed hydro capacity will be around **2,250 MW** (exceeding the initial target of 2,000 MW) **in 2020** and **3,100 MW in 2030**.

The renewable energy targets are summarized in Figure 25.

d. Renewable energy integration

As the share of variable renewable energy sources (wind and solar) increases in the energy mix of many countries in the world, power systems will require more and more flexibility. The sources of flexibility are manyfold. They can be found in physical assets (flexible generation, energy storage, transmission, etc.), in grid intelligence, and also in the market model, with the policymakers and regulators playing a key role. There is no one single answer to the question of flexibility. A range of options are available and the appropriate combination is system-specific.

Figure 25: Projected renewable energy installed capacity (MW)



Source: ONEE

Pumped storage power plants are the most cost-effective large-scale energy-storage solution. Detailed modelling of the future Moroccan mix (See the Generation and Transmission Master Plan with renewable energy integration for the Moroccan power system, which was carried out by the Energy Development Fund (EDF) in 2015 [20]) showed that the development of PSPPs is essential to the successful integration of a share of more than 30% of renewable energy supply (RES) in the Moroccan energy system. PSPPs have been found complementary to other flexible sources (flexible CCGT, CSP with storage, interconnection) and regulatory scheme (limited RES curtailment).

With the announcement by King Mohammed VI of the New Energy Roadmap, raising the RES target to 52% in 2030, PSPPs will play a key role in the Moroccan energy transition.

This study concluded that the targeted renewable energy capacities for 2020 and 2030 can be integrated to the electrical system subject to the following measures:

- Realization of a 1,000 MW PSPP programme with an investment of US$ 700 million;
- Reinforcement of the transmission network with an investment of US$ 3.5 billion until 2030.

Moreover, Morocco is developing a Gas to Power Project to be delivered in 2025. It consists of a LNG terminal of 5 billion m^3 and four CCGTs totalling 2,000 MW. The flexibility offered by these CCGTs will help to overcome the technical constraints and intermittency occasioned by the intensive expansion of renewable energy.

3. Present renewable energy policies and institutional framework

a. Regulatory framework

The 2009 Strategy was supported by a comprehensive legal, institutional and regulatory framework including:

- **Law 16-08** (Dahir of 20 October 2008) on self-production;

- **Law 16-08** raised the self-production threshold from 10 MW to 50 MW. It also granted access to the transmission network to power-generation plants, particularly from renewable sources, and allowed direct awards of concession agreements for electricity generation from domestic energy resources. ONEE is in charge of transmission of the generated energy and buys the energy surplus;

- **Law 13-09** on renewable energies (enacted in February 2010). This law allows producers to generate electricity from renewable energy sources on behalf of an individual consumer or group of consumers connected to the MV, HV or VHV grid, under an agreement committing them to consume the electricity generated exclusively for their own use. In particular, Law 13-09, which removed the power ceiling for renewable energy facilities – previously limited to 50 MW – outlined the Government's commitments regarding renewables and, in particular, set the objectives of:

    - Promoting energy production from renewable sources, as well its marketing and export by public or private entities;

    - Subjecting energy-production facilities from renewable sources to an authorization (for capacities more than 2 MW) or declaration regime (for capacities less than 2 MW);

    - Granting an operator the right to produce electricity from renewable sources on behalf of a consumer or group of consumers connected to the MV, HV or VHV grids within the framework of an agreement whereby they commit to consuming the electricity produced exclusively for their own use.

- **Law 54-14** (Dahir of 1 July 2015) modifying the provisions on self-production (for all generation sources). This law allows self-producers with global capacity of more than 300 MW to access the national grid and sell exclusively surplus production to ONEE. An agreement has to be concluded between ONEE and the producer in order to specify provisions regarding technical connection, commercial conditions of ONEE supply to producer if necessary, commercial conditions of surplus energy produced and delivered to ONEE, as well as commercial terms regarding transmission fee. This law applies to all kind of generation sources (renewable and conventional).

b. Establishing new institutions

The Government has also demonstrated commitment by establishing in the past few years a series of public agencies and institutions which were set up as a means to better organize and structure the promotion of renewable energy development. These include:

ADEREE, the Agency for the Development of Renewable Energies and Energy Efficiency, is responsible for the development of energy-management policies. The tasks of ADEREE comprise, among others, the development and realization of national and regional plans for renewable energy and energy efficiency.

MASEN, the Moroccan Agency for Sustainable Energy, initially established in 2010 as the Moroccan Agency for Solar Energy, is a limited company with public funding. The company was created when Morocco announced it would install 2 GW of solar capacity by 2020. MASEN was founded to lead and manage this project. It is a state corporation, jointly owned, in equal proportion, by the Moroccan Government, the Hassan II Fund for Economic and Social Development, the National Electricity Authority (ONEE) and the Energy Investments Corporation (SIE).

SIE, the Energy Investment Company, was founded in 2010 to facilitate diversification of energy resources, promotion of renewable energy and energy efficiency. It is a public investment company established by the Moroccan Government to manage the Energy Development Fund (EDF) with a capital of MAD 1 billion (US$ 100 million).

IRESEN, the Research Institute for Solar Energy and New Energy, was founded in 2009 to promote research, development and innovation of renewable energy technologies around the country. It conducts and finances specific research projects and promotes the building of a network among researchers, projects and universities to strengthen the knowledge of renewable and low-carbon technologies.

c. Financial incentive mechanisms

Before the adoption of the national strategy, Morocco created two incentive programmes. The first focused on a public–private partnership set up to provide rural households with solar PV systems to produce off-grid electricity.

The second programme (EnergiPro) encouraged energy-intensive industrial groups to produce their renewable sourced electricity up to 10 MW.

The current incentive schemes for the private sector contribution to renewable energy include:

- The EnergiPro program was extended by Law 13-09 to allow up to 50 MW of installed capacity. ONEE guarantees the purchase of all energy produced in excess of the company's needs at an incentive tariff. Excess should not exceed 20% of the total generated;

- Competitive bidding contracts: private investors may produce electricity through concessions from ONEE. They build the plants and may obtain contributions towards operating expenses, staff-training costs or investment costs, as well as access to the electricity grid, land, etc. Under the PPA, ONEE buys the electricity from the investor at a fixed tariff for a period of 20–25 years; plant ownership is then transferred to ONEE;

- As part of PERG, home solar PV systems were deployed in areas remote from the electricity grid. A private operator (TEMASOL) implemented the project, while ONEE covered more than 60% of the equipment costs and administration.

For large-scale renewable energy projects, one of the main success factors was the innovative financial mechanism adopted within the bidding process.

The Moroccan approach is based on the project finance model within the framework of public–private partnership (PPP). Financial arrangements combine domestic and foreign public and private funds and refer to concessional and non-concessional financing mechanisms as part of multilateral and bilateral cooperation. This model was crucial in de-risking large-scale projects, thus securing their financing. In the next sections, the way of implementing the PPP scheme will be described.

i.Financial mechanism for large-scale solar projects

To entrust the implementation of solar projects, MASEN was established as the vehicle for mobilizing and blending resources and allocating risks to key players. The activities of MASEN focus on three major solar energy missions, namely to: build power stations; contribute to the development of national expertise; and engage in advocacy activities at the regional and international levels.

For the development of the solar programme, a PPP approach was adopted under the following schemes:

- The developer chosen after a tendering process, enters into a PPA with MASEN for sale of the electricity produced;

- The electricity is re-sold to ONEE at a grid price as part of a PPA concluded between MASEN and ONEE;

- The Moroccan Government pays MASEN the difference between the two contracts. This arrangement guarantees a revenue stream for the solar project company (SPC) that is shielded from the volatility of energy prices;

- MASEN plays the role both of contract holder in the two power purchase agreements and equity partner in the SPC along with the winning bidders;

- MASEN takes stakes in the project company and mobilizes a significant proportion of the concessional debt financing required, which is transferred to the project company;

- MASEN also acts as a consolidator of concessional loans provided by the Clean Technology Fund (CTF) and the main international financial instruments (IFIs), such as the African Development Bank (AfDB), the World Bank and the European Investment Bank (EIB), which reduce the cost of capital for the SPC, and lower the overall cost of energy generated. MASEN blends the terms of the IFI loans and offers a single financial package as part of the development and bidding process. Critically, this ensures adequate financing as part of the tender offer to the SPC, giving potential private investors clear information on the debt package of the project, and ensuring that the cost of capital is reflected in the bidding price.

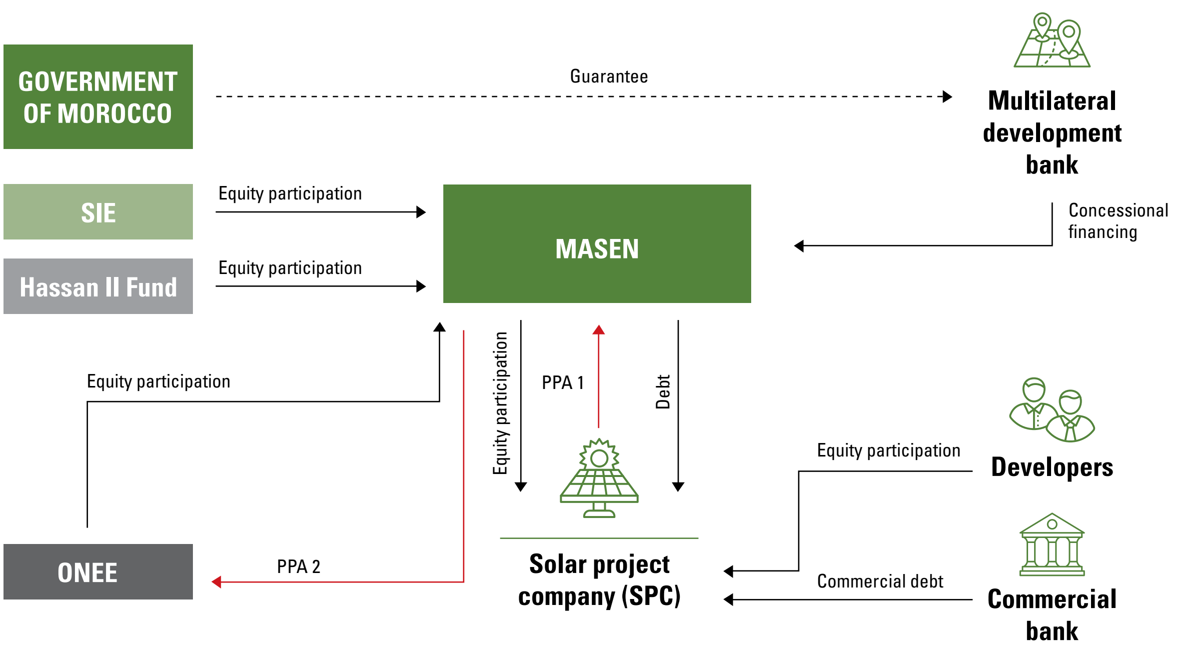
The institutional flow chart is presented in Figure 26. The SPC's share capital is held by MASEN (25%) and the private partner (75%). MASEN, which is the sole purchaser of the electric power generated, acts as intermediary between the developer and ONEE. MASEN signs the first electric power purchase contract with the developer, based on production costs, and a second electric power sales contract with ONEE based on the net rates applicable in the country.

It was therefore necessary to develop a new financing architecture in order to blend domestic public funding with funding from IFIs, whilst effectively aligning risks between public- and private-sector partners.
Built on a partnership between the public and private sectors, the Moroccan Solar Programme (MSP) increased market access to solar energy by reducing market risk and creating attractive investment potential.

Indeed, for the first phase under the MSP (NOOR I, 160 MW), multiple companies bid for the project, and a Spanish–Saudi consortium (ACWA Power/SENER/ACCIONA/TSK) won. At US$ 0.184, the tariff offered by the winning bidder was 25% lower than initial cost projections and, even accounting for public capital subsidies, the plant was one of the least expensive contracted to date. This reduced the required revenue subsidy for the Moroccan Government from the forecast US$ 60 million to US$ 20 million.

For the second phase of MSP which consists of two distinct plants: 200 MW parabolic trough CSP plant (Noor II) and 150 tower CSP plant (Noor III), the

Figure 26: Institutional flow chart for large-scale solar projects



Source: MASEN

tariffs offered were lower than NOOR I at **US$ 0.1601** for Noor II and **US$ 0.1672** for Noor III.

In the longer term, it is expected that such publicly supported projects will enable the technology to mature so that projects can be financed by investors and local banks.

ii. Financial mechanism for large-scale wind projects

For the IWP, Morocco adopted the same financial approach as for the Solar Programme. Indeed, IWP was developed in the context of **public–private partnerships** in which ONEE, SIE and the Hassan II Fund for Economic and Social Development will join the strategic partner selected (ENEL/NAREVA/SIEMENS) to design, build, develop, finance, operate and maintain the five wind-power projects.

In this context, a public–private partnership approach was adopted for the 1,000 MW wind programme, under the following schemes:

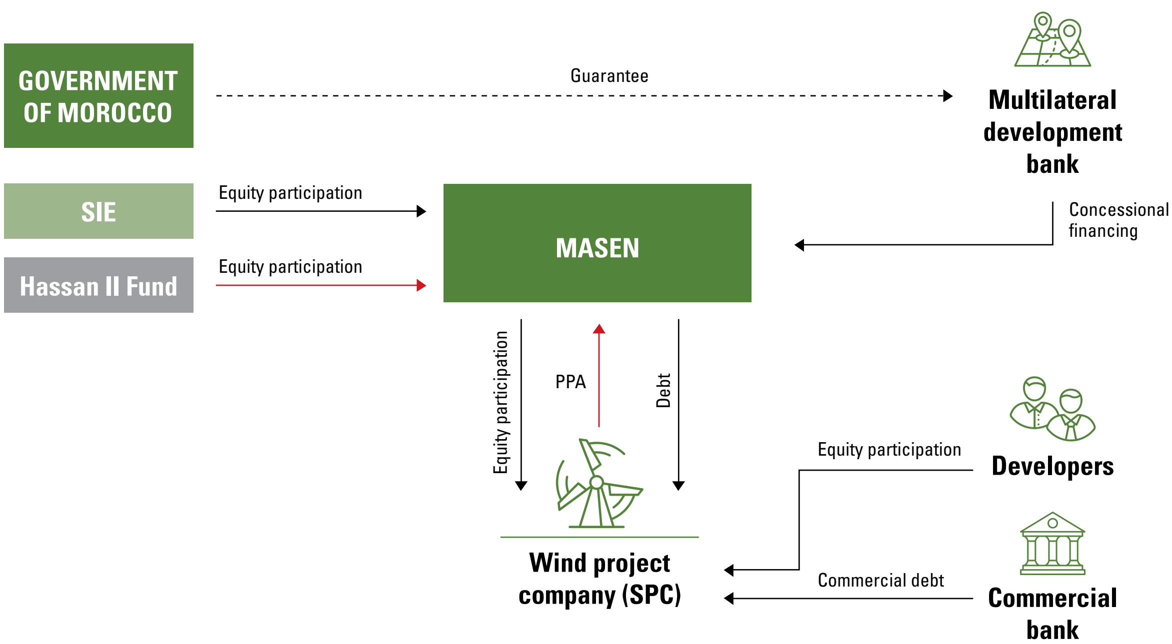
- ONEE, SIE and the Hassan II Fund took a stake in the equity of the created SPCs by the winners of tenders. This reassured donors and gave more credibility to projects;
- Wind projects benefited from concessional loans raised by ONEE and, under the same conditions of financing, transferred to the SPCs. The remaining funding was provided by the winners' developers;
- The developer chosen after a tendering process enters into a PPA with ONEE for the sale of electricity produced.

The expected construction cost is around **€1 billion** and the bidding price was about **US$ 30/MWh**, which is the lowest price worldwide till now. The five wind farms were expected to be completed and start operation between 2017 and 2020.

The institutional flow chart is presented in Figure 27. The SPC's share capital is held by ONEE, SIE and the Hassan II Fund (35%) and the private partner (65%). ONEE signs the electric power purchase contract with the developer based on production costs.

To finance the construction of the wind farms, ONEE mobilized €385 million from a club of multilateral banks including the African Development Bank, European Investment Bank, and KfW, as well as contributions from the European Union and CTF.

Figure 27: Institutional flow chart for large-scale wind projects



Source: ONEE

d. Incentives for local manufacturing and integration

To promote the establishment of local industries of renewables components, Morocco devised the Morocco Renewable Energies Plan, focusing on three areas: infrastructure, human capital and incentives. Within this context, an important land bank (about **2,000 ha**) reserved for industrial activities has been mobilized, with attractive rental prices for the developed plots. Established businesses in these areas are exempt from value-added tax (VAT) and customs duties, as well as from the patent for the first **15 years** and corporation tax for the first five fiscal years (after which a fixed rate of **8.75%** is applied for 20 years). The established industrial projects also have the benefit of measures to support investment and the free repatriation of their profits and capital.

Under this plan, EDF, managed by SIE, finances investment grants of up to **10%** of the acquisition cost of new capital goods, capped at **MAD 20 million (about 2 million)**.

Finally, assistance in staff development, at induction and for long-term training, is also provided to these new enterprises, depending on the profiles of the human resources hired, for a period of three years.

Morocco offers sector-specific incentives for the promotion of its domestic solar industry.
They include:

- Benefits stemming from free-zone status granted to export-oriented solar industries conceding up to **30%** of sales realized in the local market;

- Investment grants funded through the **MAD 400 million (about US$ 48 million)** channelled through EDF. One of the eligibility conditions for these grants is to make new investments in manufacturing parts and components for renewable energy and energy-efficiency technologies. Eligible investment projects can

  benefit from a contribution of 10% of the acquisition cost of new capital goods, up to **MAD 20 million**. Additional direct financial assistance can be attained if investment plans are located in regions or geographical areas where the Government plans to develop clusters;

- Support for training and hiring through the **Agence Nationale de Promotion de l'Emploi et des Compétences**. For hiring, the State provides an annual cost contribution amounting to MAD 15,000 (€ 1,320) for an operator, MAD 20,000 (€ 1,764) for a technician, and MAD 40,000 (€ 3,528) for an engineer. Continuous in-company training measures are supported with MAD 5,000 (€ 441) for an operator, MAD 10,000 (€ 882) for a technician and MAD 20,000 (€ 1,764) for an engineer.

Aside from these incentives, customized for investments in the renewable energy sector, others exist, especially for investments larger than **MAD 200 million (€19 million)**. These incentives address access to land (20% reduction in the cost of acquisition), infrastructure, training, as well as VAT exemption for three years and custom duties exemption for three years (http://www.invest.gov.ma/) [5].

In addition to producing wind power, this wind programme aims to promote Morocco's wind industry, constitute a high-level expertise base and strengthen R&D at the national level in order to master this technological sector, which offers strong potential for furthering Morocco's economic development. In this context, as well as being part of the consortium, Siemens will supply the turbines for the five projects and has signed an agreement with the Moroccan Government to build a rotor-blade factory for onshore wind turbines with an investment of more than **€100 million**. Expected to create up to 700 jobs in Tangier, the factory will serve the African, Middle Eastern and European wind markets upon completion.

4. Suitability of current renewable energy policies and institutional frame work to meet announced strategies and targets

One of the most important steps of the renewable energy policy development in Morocco was the introduction of Law 13-09 which was promulgated in 2010 and was designed to promote and liberalize the renewable energy sector. This law allows electricity to be produced and exported by any private producer as long as renewable energy sources are utilized. Through this policy, the Moroccan Government opened up the energy market by facilitating new entries and by supporting independent renewable energy producers.

The law further regulates the electricity sector and creates an authorization/declaration system, depending on the capacity of the facility: a declaration is required if electricity-generating facility capacity is between 20 kW and 2 MW; an authorization is required if electricity-generating facility capacity is equal to or higher than 2 MW.

In the framework of this law, a total capacity of **623 MW** is already in operation or under financial closure:

- Five wind farms totalling 502 MW developed by Energie Electrique du Maroc;
- One wind farm of 120 MW developed by ACWA Power.

The current renewable energy policy needs to be completed by an appropriate framework aiming to facilitate small and medium investments.

Many barriers to further progress still exist, obstructing further renewable energy development in Morocco:

- Law 13-09 law tends to facilitate only large-scale projects rather than helping the entry of smaller producers and stimulate the development of more community-based, bottom-up energy initiatives;
- Lack of accessible financial support for small-scale projects able to facilitate private consumers to install renewable energy technologies. Most financing is directed to large-scale projects;
- Lack of coordination, cooperation and synergetic collaboration between the various stakeholders (MASEN, ONEE, ADEREE, SIE, MEMEE). For instance, even though MASEN was created to develop solar projects in Morocco, some are also developed by ONEE and SIE, which is confusing to the investor.

In this context, Morocco launched a series of laws and organizational actions in order to achieve the targeted renewable energy goal by 2020 and 2030.

a. Opening of medium-voltage grid to renewable power

Decree **2-15-772 of 28 October 2015, related to accessing the MV grid (5.5 KV and 22 KV)**, specifies the conditions and process of access thereto. According to this decree, distributors should publish the potential of renewable energy to be integrated in their MV grid on a 10-year basis. Moreover, they have to give priority of injection into the grid to energy produced from renewables.

b. Opening of low-voltage grid to renewable power

LawNo 58-15 amending and supplementing **law No 13-09** on renewable energy was adopted by the first chamber of the **Moroccan** parliament dated on October 27th and by the second chamber on December 2015, introduces a net metering scheme for solar- and wind-power plants connected to low-voltage level. In particular, the law calls for regulation detailing the conditions for investors in solar PV to benefit from opening the low-voltage grid to renewable power installations. Private investors in renewable power in general will be able to sell their surplus output to the grid, but no more than 20% of their annual production. The exact terms and conditions of the net metering scheme will be set by regulation.

Also, the new law raises from 12 MW to 30 MW the maximum capacity of private investments in hydropower plants.

c. Creating the regulation authority

The National Authority for Electricity Regulation **(ANRE)**, which was created by **Law 48-15**, in April 2016, will ensure the good functioning of the free market for electricity generated from renewable sources and regulate the access of private producers to the national electricity transmission grid under opening-up and liberalization in accordance with Law 13-09 on renewable energy.

d. Reinforcing MASEN missions

In connection with the new targets to be achieved by 2030, Law 37-16 modifying Law 57-09, concerning the creation of MASEN, was recently promulgated.

The objectives of proposed changes are to:

- Ensure required synergies and institutional complementarities among current institutions: MASEN, ONEE and ADEREE;
- Reinforce MASEN missions in all renewable fields.

MASEN is henceforth in charge of the realization of all renewable energy plants (except PSPPs, facilities dedicated to peak and grid stability and facilities under Law 13-09 generating energy from renewable resources), while ensuring required studies, design, financing, realization, exploitation and maintenance of these facilities.

The Agency is also responsible for renewable resources assessment, as well as identification, design and planning of renewable energy plants.

e. ADEREE focuses on energy efficiency

This proposed law changes the denomination of ADEREE to Moroccan Agency of Energy Efficiency and hence focuses its mission on energy efficiency.

VI. Economic, environmental and policy analysis

1. Overall impact of the policy measures introduced to the renewable energy market in Morocco

Given Morocco's high dependency on external energy resources and the related risks to its economy, the transition towards renewable energy was urgently needed. It will also be extremely beneficial for Morocco in environmental, economic and social terms.

2. Analysis of potential economic and social impacts of the evolution of the renewable energy market in Morocco

The main benefits from renewable energy are summarized as follows:

a. Mitigating climate change and adapting to its impacts

Located on the southern shore of the Mediterranean, at the gates of Europe and northern Africa, Morocco has always been a crossroads of civilizations. Morocco has recently experienced economic and social development within the context of climate change. Consequently, the pressure on natural resources has increased, affecting the resilience of forest ecosystems and the agriculture sector, particularly because of water scarcity. Water availability per capita was more than three times higher in 1960 than it is today.

Aware of this situation, Morocco has voluntarily and resolutely engaged in a progress to combat global warming, progressively outlining its own vision while complying with decisions taken collectively at the international level.

In developing its Intended Nationally Determined Contribution (INDC), Morocco set a target to limit GHG emissions growth that will be reached through its own means, a target that could be enhanced substantially with support from the international community. This ambition rests, to a large extent, on a major transformation of the energy sector, which requires great political commitment and aims to reduce the country's major energy dependency and meet the growing demand for energy to support its development, due in particular to increasing water stress. The main objectives behind this transformation are to:

- Attain more than 50% of installed electricity-production capacity from renewable energy sources by 2025;
- Reduce energy consumption by 15% by 2030;
- Substantially reduce fossil-fuel subsidies, building on reforms already undertaken in recent years;
- Substantially increase the use of natural gas, through infrastructure projects allowing LNG imports.

The targets of the Morocco's mitigation contribution are:

- Unconditional target: a 13% reduction in GHG emissions by 2030 compared to a business-as-usual (BAU) scenario;

- Conditional target: an additional 19% reduction achievable under certain conditions, which would bring total GHG reduction to 32% below BAU emission levels by 2030;

- Expected trajectory: in achieving its unconditional and conditional targets respectively, Morocco expects its emissions trajectory to:

    - Reach 113 Mt CO_2eq in 2020 and 129 Mt CO_2eq in 2025, decreasing by 7% and 10% compared to BAU emissions in 2020 and 2025, respectively;

    - To reach 103 Mt CO2eq by 2020 and 104 Mt CO2eq by 2025, decreasing by 16% and 27% compared to BAU emissions in 2020 and 2025, respectively.

- Financial needs: meeting the conditional target requires an overall investment estimated at US$ 45 billion between 2015 and 2030.

The key mitigation data are given in Table 3, based on the Moroccan INDC report [22].

Even though Morocco is focusing its efforts on the energy sector, its GHG emission-reduction targets will be achieved through economy-wide actions based on strategies and sectoral action plans designed for agriculture, water, waste, forest, energy, industry, and housing.

As the host country of COP 22 in 2016, Morocco was wholly committed to supporting the multilateral action plan for reaching the new climate deal agreed in Paris (COP 21) in 2015.

b. Promoting energy security and resilience

Renewable energy not only provides an effective solution to meet CO_2 reduction targets. Beyond climate change mitigation and adaptation, renewable energy can offer great advantages in terms of energy security and savings on energy imports, as well as great opportunities to spend financial resources within the national economy rather than on fuel imports.

Morocco is in fact highly dependent on imported energy: in 2015, the country imported 93% of its energy needs. Petroleum imports account for 20% of total imports and 50% of the current trade deficit.

Table 3: Expected CO_2 emissions (2020–2030)

	2010	2020	2025	2030	Total 2020-2030
Emissions-BAU (Mt CO_2eq)	94	122	143	171	1,585
Emissions-Unconditional scenario (Mt CO_2eq)	94	113	129	148	1,443
Emissions-Conditional scenario	94	103	104	117	1,184
Expected reductions-Unconditional scenario (Mt CO_2eq)	0	9	14	23	142
Expected reductions-Conditional scenario	0	19	39	54	401

Source: UNFCCC

Imports of electricity in 2015 were close to 5,000 GWh compared with 1,000 GWh in 2005. Morocco spends approximately US$ 3 billion a year on fuel and electricity imports.

Furthermore, Morocco has experienced a considerable growth in electricity demand. Energy consumption has risen at an average annual rate of 6.5% from 2002 to 2015. This is due to economic growth, population increase and rise in per capita energy consumption. This increase in consumption was also due to consistent investments in electrification projects which allowed the country to reach a 99.5% electricity access rate in 2015 (an impressive achievement, considering that the rural electrification level was only 18% in 1995).

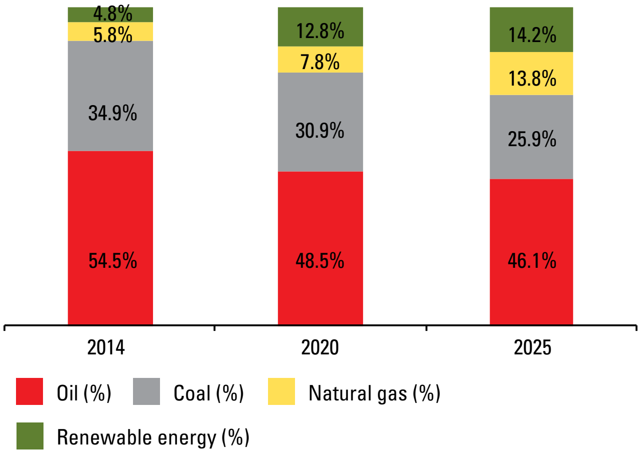
A rapidly growing energy demand in a country so heavily dependent on imported energy, combined with the high volatility of fossil-fuel prices such as those of oil, is a critical factor to be considered for energy security in Morocco.

The deployment of renewable energy increases the diversity of energy sources and offers a crucial value added in terms of energy resilience, autonomy and stability of the Moroccan economy.

The evolution of energy balance is given in Figure 28.

Figure 28: Projected energy balance 2020–2025

Million toe	2014	2020	2025
Production	1,024	3,341	4,574
Oil and Natural gas	100	100	100
Hydroelectricity	426	408	408
Wind	498	1,657	2,272
Solar		1,176	1,794
Consumption	17,520	25,356	31,425
Oil products	10,400	12,300	14,500
Coal	5,080	7,842	8,104
Natural gas	1,116	1,973	4,347
Hydroelectricity	426	408	408
Wind	498	1,657	2,272
Solar		1,176	1,794
Oil (%)	54.5%	48.5%	46.1%
Coal (%)	34.9%	30.9%	25.9%
Natural gas (%)	5.8%	7.8%	13.8%
Renewable energy (%)	4.8%	12.8%	14.2%
Dependency (%)	94.6%	86.8%	85.4%



Source: MEMEE

c. Benefiting the local economy and creating jobs

Investing in, and promoting, renewable energy can offer major benefits to the local economy in Morocco as infrastructure investments are localized and much of the revenue remains within the regional domain rather than flowing out to pay for imported fuel resources.

Socioeconomic effects can be measured along the different segments of the value chain, including project planning, manufacturing, installation, grid connection, operation and maintenance and decommissioning. Further opportunities for value creation exist in the supporting processes such as policy-making, financial services, education, R&D and consultancies or advisory services.

By deciding to promote and invest in local renewable energy, Morocco has huge potential to develop a stronger national economy while demonstrating leadership in paving the way for a sustainable and more prosperous future.

According to a study conducted on behalf of the Ministry of Energy and Mines[18], the job-creation potential of the renewable energy sector in Morocco is estimated at more than **23,000 jobs in 2020**.

As an illustration, during the construction phase of NOOR II and III (350 MW CSP), the project under construction created new income-generating opportunities at two levels, namely: jobs created during the construction works (approximately 2,000 to 2,500 direct jobs) and indirect jobs. The latter stem essentially from an increase in the activities of existing local enterprises that supply materials and equipment needed for the project and daily upkeep of workers, as well as the onsite creation of a company to assemble the solar farm. Labour was recruited mainly locally and infrastructure was constructed in the Ouarzazate area for the accommodation and upkeep of workers. (For Phase 1 of the complex (NOOR I: 160 MW), 1,409 people were recruited on-site, including 587 who were originally from Ouarzazate (42%)). During the operational phase, the number of jobs created will be for between **400 and 500 employees**. Permanent workers will be lodged and will certainly have a positive socioeconomic impact on the region. Furthermore, during this period, local SMEs will provide various services such as maintenance, security, industrial cleaning, etc. Recruitment, especially of unskilled labour, will essentially be done locally, and infrastructure will be established for the accommodation and upkeep of workers. This will help develop industrial activities in the region. In addition, there will be new opportunities to reduce unemployment, thanks to the greater supply of energy (creation of SMEs).

In term of training policy, according to a 2011 study[18], the minimum training needs in renewable energy by 2020 are estimated at 4,300 technicians, 4,800 skilled workers and 1,300 engineers.

The same study estimated the training needs in energy efficiency by 2020 to be 13,600 technicians and 4,000 engineers.

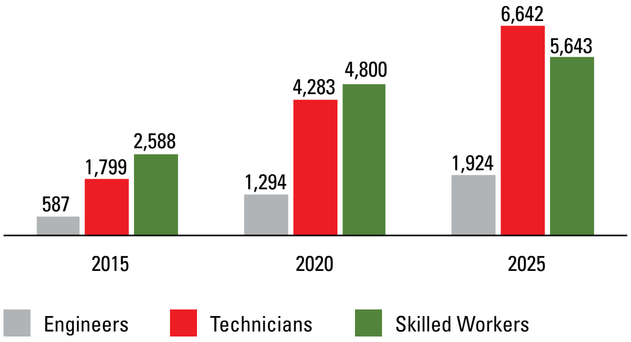
According to the recommendations of the study [18], Morocco launched the implementation of three training institutes specializing in renewable energy and energy-efficiency trades; the combined institutes are known as IFMEREE (Instituts de Formation des Métiers d'Energie Renouvelable et d'Efficacité Energetique). They set up on-site outposts in Oujda in 2015 and in Ouarzazate and Tangier in 2016; these three cities will host Morocco's principal investments in solar and wind programmes.

d. Boosting social development and community participation

The decentralized nature of renewable energy offered an opportunity for Morocco to develop a small-scale, community-based energy system, where people and communities are perceived not only as consumers but also as producers, responsible for, and in charge of, the production of their own energy.

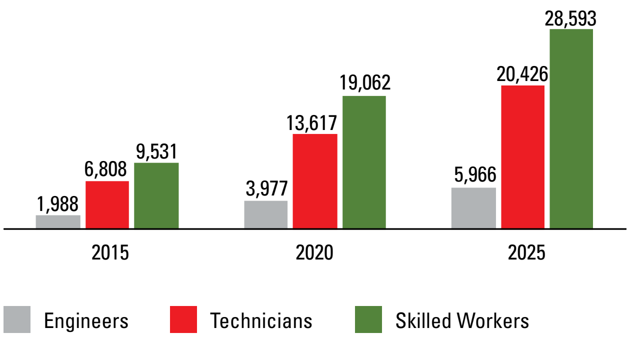
Benefits are enormous, particularly for the poorer rural areas, as renewable energy technologies offer a secure and reliable energy alternative, increasing the standard of living of rural and less developed communities. For example, the establishment of solar panels to provide energy to pump water for a school in a rural area close to the town of **El Jadida** provides the community with a reliable, locally based and viable solution to supplying water by exploiting the abundant solar energy of the region.

Figure 29: Estimated training needs in renewable energy, 2015–2020–2025



Source: MEMEE

Figure 30: Estimated training needs in energy efficiency, 2015–2020–2025



Source: MEMEE

An impact study on the rural electrification programme, conducted by ONEE, demonstrated that the solar PV used for rural areas decreased the migration rate by about **70%**.

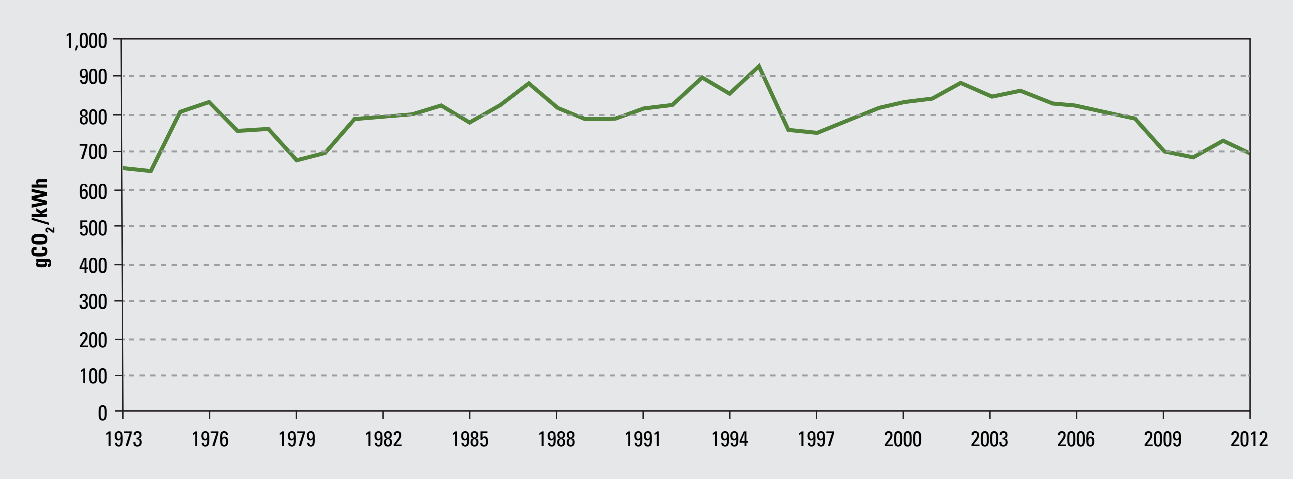
e. Benefiting human health

There is a close interrelation between pollution and human health. For example, renewable energy technologies emit much lower emissions of air pollutants (particulate matter, sulfur dioxide, nitrogen oxides, volatile organic compounds, etc.) compared to fossil-fuel options in terms of grams of pollutants per kWh of energy produced. This can have considerable positive impacts on the quality of air, water and land and consequently on the health of the Moroccan people. For example, a recent study demonstrated how air pollution from the combustion of fossil fuels is a determining cause of asthma and other respiratory diseases among schoolchildren in the city of **Mohammedia** [16].

3. Environmental impacts

Electricity remains the main source of CO_2 emissions in Morocco, compared to other sectors. However, the efforts that have been made in Morocco to develop renewable energies and use cleaner fuels in thermal power plants had a significant impact on the unit emissions rate of electricity production. Figure 31 shows how, beginning in 2009, the sector registered a significant **(11.6%)** decrease in emissions, from **786.7 gCO_2/kWh** in 2008 to **695.5 gCO_2/kWh** in 2012. Except for 2011, which indicated a slight decrease in hydropower, this trend continued until 2012.

Figure 31: CO_2 emissions from electricity generation, 1973–2012

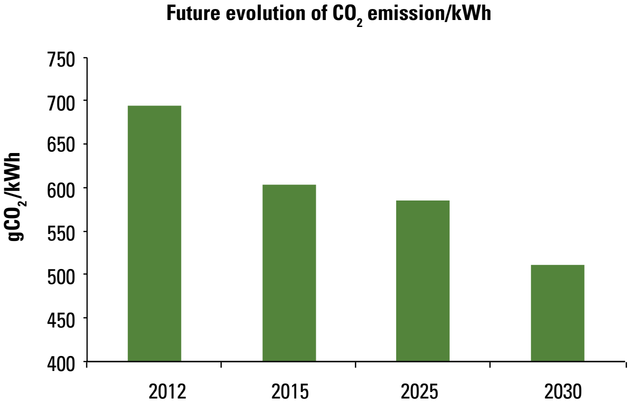


Note: gCO_2/KWh = gramme of CO_2 per kilowatt hour.
Source: IEA (2013a), *CO_2 Emissions from Fuel Combustion*, OECD/IEA, Paris

The wind, hydro and solar development programmes will help reduce GHG emissions significantly by 2020 and 2030.

Based on renewable energy targets, the part of renewable energy generation will grow from 8% in 2012 to 30% in 2030, while CO^2 emissions from electricity generation will register a continued decrease of **26.5%** between 2012 and 2030.

Figure 32: Future evolution of CO_2 emissions from electricity generation



Source: based on the production plan until 2030

VII. Policy design consideration

Morocco has a long tradition in renewable energy and has been a pioneer among developing countries in terms of policy, having developed the first large on-grid wind-power project of 50 MW in 2000.

The main driving factors that are encouraging Morocco to set up renewable energy policies and institutional framework are the following:

Increasing energy demand. In the future, Morocco will face a high demand for electricity to support the economic dynamics triggered in the last decade (induced energy needs are expected to double by 2020 and to triple by 2030 in the BAU scenario;

Energy-import dependence. Unlike some of its neighbours, Morocco is highly dependent on imported hydrocarbons.

Energy price fluctuations. The energy imports affect Morocco's trade balance negatively and make its economy and political stability vulnerable to global price fluctuations. Moreover, electricity prices in Morocco do not represent the real costs as they are below average costs of production and transmission. This creates a significant financial burden on the national budget but efforts to bring prices closer to the cost of power production are deployed. Graduated tariffs are already in place, but these can be increased progressively.

Increasing CO_2 emissions. National energy consumption is still highly dominated by fossil fuels. As a consequence, total CO_2 emissions are anticipated to closely follow the rising energy demand and increase substantially in the mid-long term.

Morocco has several advantages, however, including:

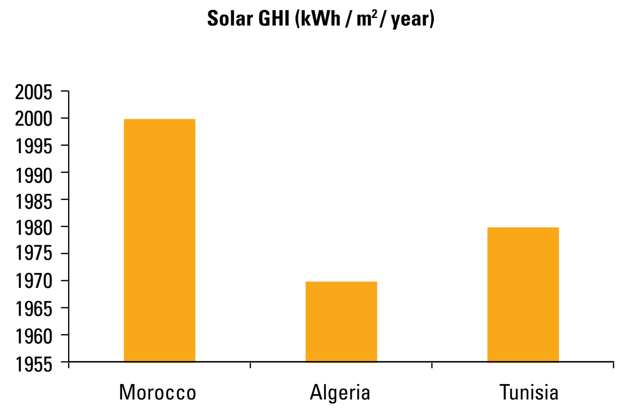
A high potential for renewable energy throughout the territory. Renewable energy resources in Morocco are characterized by a wind full load of 2,708 hours/year and a global horizontal irradiance (GHI) of 2,000 kWh/m²/year, 30% higher than the best European sites. A comparison with some neighbouring Arab countries such as Algeria and Tunisia is given in Figure 33 [19].

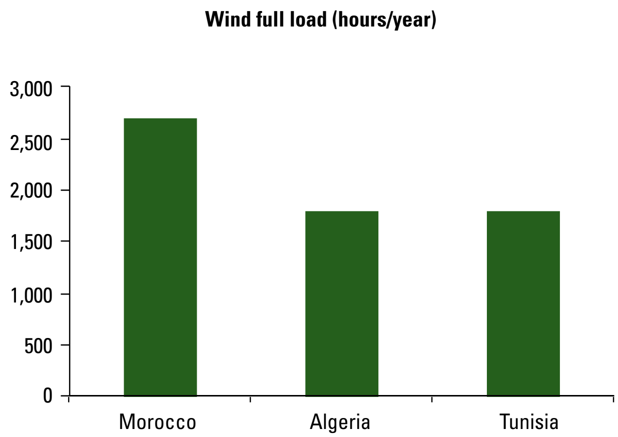
The geographical location of Morocco allows it to play a key role in energy exchanges at the Mediterranean level. By developing electricity interconnections with Algeria and Spain, Morocco has positioned itself as a major player in the energy market in the European-Maghreb area, thus promoting the integration of energy systems and the gradual opening of energy markets, which will greatly help to attract investments in the energy sector (access to networks, cross-border transits, etc.).

Key issues have been considered in the set-up and design of renewable energy programmes that guarantee their success:

- The good set-up and design of renewable energy programmes and the transparency in the tendering process by establishing an interministerial committee to supervise the process;

Figure 33: Comparison of renewable energy resources in Morocco with Algeria and Tunisia





Source: IRENA

- The success in building up strong and effective partnerships between different stakeholders participating in the programmes (State, MASEN, SIE, Hassan II Fund, ONEE, private investors);
- The setting-up of innovative and effective business models of renewable energy projects that helped to attract private investors and then increase competition in the tenders;
- Establishment of a transparent and adequate long-term agenda for the planned projects;
- Setting up local content requirement which is supported by a long-term policy framework that ensures stable and predictable local and regional demand.

Morocco was in a good position to set up an ambitious commitment within its INDC which is to reduce its greenhouse-gas emissions by **32% by 2030** compared to BUA- projected emissions. With regard to adaptation, Morocco made significant efforts during the period 2005–2010, devoting 64% of all climate-related spending in the country to adaptation, which represents **9%** of overall investment expenditure. In the future, the proportion of the national investment budget allotted to adaptation to climate change will be increased to **15%**.

VIII. Barriers for implementing renewable energy

It is widely acknowledged that all of the above-mentioned reforms and investments made by the Moroccan Government proved considerable commitment to promoting renewable energy and taking action against the major challenges that are connected to the energy system in the country. Many barriers to further progress still exist, however, which are significantly obstructing further renewable energy development.

The major barriers are summarized below:

1. Economics and financial barriers

There is a lack of accessible financial support in Morocco for small-scale projects to enable private consumers to install renewable technologies. Most financing is directed to large-scale projects.

Moreover, economic viability is affected by high initial capital costs due to lack of confident financial support and high-risk perception related to renewable energy. In Morocco, major financing for renewable energy development still comes from the Government and from international funds rather than from local private investors and regional banks.

2. Market failures and imperfections

The still relatively low market penetration of renewable energy compared to well-established fossil-fuel options still negatively affects its competitiveness. This is also due to a lack of businesses, entrepreneurs, trained or skilled workers and specialized industries which are able to promote and expand the market and outreach of renewable energy technologies in Morocco.

Furthermore, the externalities such as environmental pollution and climate change costs, health costs, impacts on energy security, etc., are not internalized by the market and are not evaluated in the cost analysis. This obviously distorts a fair cost comparison between renewable energy and fossil-fuel options.

3. Political, institutional and regulatory barriers

Many laws that were introduced to promote renewable energy such as Law 13-09 still present problems. For example, this law tends to facilitate only large-scale projects rather than helping the entry of smaller producers and stimulate the development of more community-based, bottom-up energy initiatives (the decree for renewable connection to the low voltage has not yet been approved).

The lack of coordination, cooperation and synergetic collaboration between the various stakeholders, political groups and ministries does not help form a common strategic vision for the promotion of renewable energy (distribution operators that are supervised by the Ministry of the Interior are often against the development of renewable energy in their networks).

4. Technical barriers

There are still major technical issues related to the intermittent nature of renewable energies such as wind and solar.

Technical complications occur when aiming to ensure large-scale reliability of supply with high penetration of intermittent sources.

So far, renewable energy has only been incorporated in the electricity sector. There is a lack of cross-sectorial approaches that include the heating/ cooling and transport sectors.

IX. Conclusions and recommendations

Morocco has embarked on the sustainable development revolution as the country is engaged in tremendous economic and social development.

Due to some key issues confronting Morocco (water stress, land degradation, strong energy dependence, vulnerability to climate change, various types of pollution) and the limitation of economic growth and social development policies to create jobs and reduce social and spatial disparities, Morocco has made the green economy a strategic focus of its sustainable development policy. The country is committed to mobilizing all stakeholders and building innovative public–private partnerships to increase environment-compliant investments likely to create value-added and sustainable jobs.

In this context, Morocco set up a new energy strategy in 2009 that was supported by five strategic axes: security of supply with diversification of fuel types and origins; availability of, and access to, energy for all segments of the society at affordable prices; mobilization of domestic energy sources, mainly renewable energy and at the same time intensification of hydrocarbon exploration and oil-shale valorization; promotion of energy efficiency; and regional energy integration among the European Mediterranean markets.

Morocco has the required assets to achieve these goals, particularly of developing renewable energies – mainly wind and solar – and realize its integration among the European Mediterranean markets.

In this context, Morocco launched solar, wind and hydro programmes totalling 6,000 MW to be achieved by 2020. When completed, these programmes will have a strong impact on environmental preservation by avoiding **11.2 million tons of CO_2 emissions**. It will also reduce the Moroccan energy dependency from **95% today to 85% by 2020** by saving **3 million toe** of energy imports.

The main message of this case study is that the 2009 National Energy Strategy is being implemented in accordance with the deadlines set at its launch. Major progress has been made, both at the institutional level and in terms of major project development, with credible and achievable targets, while important reforms have been undertaken, giving clear visibility to investors and operators.

Morocco adopted a development model of renewable energy based on a public–private partnership in which the private sector brings its know-how to complete the project and make it operational.

Regionally, Morocco has been a renewable energy pioneer in North Africa, establishing challenging targets and promoting a stable and clear regulatory framework for the development of renewable energy and the Moroccan model can be exported to African and Arab countries. For instance, African countries are turning to Morocco for inspiration from its renewable energy experience.

The previous analysis of this Moroccan case study shows that the importance of policies and regulatory frameworks cannot be overstated. Setting clear policy targets is essential to provide investment security, mobilize stakeholders as well as improve the allocation of resources.

A series of wide-ranging actions able to facilitate the achievement of the 2030 target for 52% of renewable has still to be taken:

Policy reforms

- Set up an effective liberalized market for electricity in Morocco with a view to its integration into the European market.

Connect renewable energy to low-voltage grid

- Set up a suitable legal framework and financial mechanism (renewable energy connected to LV grid);
- Set up a connection code of the renewable energy system to the LV grid;
- Smart metering and smart grid technologies should be introduced to reduce waste and inefficiencies in the power system, fully optimize demand-side resources, while facilitating the addition of more renewables.

Support for technical measures

- Technical and infrastructural changes needed to support an energy system powered by renewable energy sources should be implemented to overcome the major technical hurdles in particular those related to the intermittent nature of renewable energies such as wind and solar power (enlargement and improvement of network infrastructure, increased generation flexibility and mix of resources, demand-side measurement and increase in efficiency, storage);
- Set up accurate forecasting tools of wind speed and solar radiation to reduce the intermittency impacts of renewable energy generation;
- Sizeable capacities of hydro pumped storage and thermal storage should be developed by ONEE.

Support for financing

Mechanisms and national/international microfinancing tools for small-scale renewable energy projects should be developed in order to allow adequate adaptation of vulnerable local populations.

Annex A: Electricity sector organization

ELECTRICITY SECTOR ORGANIZATION BALANCE OF SUPPLY-DEMAND 2015

IPP generation
Capacity: 2,812 MW
Generation: 18,404 GWh
(53.5%)

ONEE generation
Capacity: 4,942 MW
Generation: 10,010 GWh
(29.1%)

Interconnections
Importations
4,919 GWh
(14.3%)

Law 13-09 private generation
Capacity: 203 MW
Generation: 791 GWh
(2.3%)

Auto generation
Capacity: 37 MW
(‹1%)

ONEE-BE
Single buyer (Except Law 13-09)
Transmission system operator

Total Demand 34.4 TWh

ONEE-BE (Direct Seller)
(58%)

Public and private utilities
(42%)

Distribution MV/LV
(43%)

Direct Customers
VHV/HV (15%)

MV/LV Customers
(45%)

Source: ONEE

Annex B: Interviews

Company/ institution name	Private/Private	Participant and Position	Contact details	Home page	Topics discussed	Date of the interview
MEMEE	Public	Mohamed Hajroun Director of Electricity Department	m.hajroun@mem.gov.ma	www.mem.gov.ma	Regualtion and law Energy prospective.	July 2016
MEMEE	Public	Zohra Ettaik Director of Renewable Energy	z.ettaik@mem.gov.ma	www.mem.gov.ma	Regualtion and law RE potential.	September 2016
MASEN	Public	Obaïd Amrane	Amrane@masen.ma	www.masen.ma	Advance in the Moroccan Solar Plan.	August 2016
S.I.E	Public	Ahmed Baroudi	Ahmed.Baroudi@sie.co.ma	www.siem.ma	Financing of Large scale RE project and SIE contribution.	August 2017
ADEREE	Public	Sonia Mezzour General Secretary of ADEREE	sg@aderee.ma	www.aderee.ma	RE potentia, Methodology assessment.	September 2016
ONEE	Public	Tarik Hamane Director of IPP Projects	t.hamane@onee.ma	www.one.org.ma	Current situation of power sector, Planned capacities, Investments in power sector, Advance in the Integrated Wind Programme.	August 2016
AMISOLE	Private	My Ahmed Squali President of AMISOLE and Vice-President of industrial Cluster in Solar Energy	ahmed.squali@nrj.ma	Under construction	Moroccan companies' contribution in the RE programs.	August 2017
EDF Morocco	Private	Adil Lahlou Director of EDF Morocco	a.lahlou@edfmaroc.ma	https://www.edf.fr/	Feedback about the financing model of RE in Morocco.	August 2018

Annex C: Regulation and law texts

All the regulations and laws stated in the case study can be downloaded through:

http://www.mem.gov.ma/SitePages/TestesReglementaires/TRDEER.aspx

Bibliography

[1] The Global Competitiveness Report, World Economic Forum, 2011

[2] 100% Renewable Energy: Boosting Development in Morocco, World Future Council, March 2015

[3] Middle East North Africa Sustainable Electricity Trajectories. MENA-SELECT project

[4] Country Fact Sheet Morocco. Energy and Development at a glance 2016. Background paper. B. Schinke and J. Klawitter, MENA-SELECT project

[5] Study on innovative financing mechanisms for renewable energy projects in North Africa. United Nations Economic Commission for Africa, Office for North Africa

[6] Evaluating Renewable Energy Manufacturing Potential in the Mediterranean Partner Countries, Final report, May 2015. IRENA, FEMIP, European Investment Bank.

[7] Etude prospective de la demande d'énergie à l'horizon 2030, Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement, Direction de l'Observation et de la Programmation du Maroc, 2013

[8] Achieving Inclusive Competitiveness in the Emerging Solar Energy Sector in Morocco. G. Vidican, M.Böhning, G. Burger, E. de Siqueira Regueira, S. Müller, S. Wendt. German Development Institute (DIE), 2013

[9] Morocco 2014, IEA 2014

[10] Chiffres Clefs du Secteur Energie 2015, Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement, 2016

[11] Etude sur le cadre organisationnel, institutionnel et législatif pour la promotion des Énergies Renouvelables, GIZ-CDER, Décembre 2007

[12] Public-Private Partnerships in Morocco: Enabling environment for the realization of RE projects, T. Laâbi and H. Abaâch, Global Energy for the Mediterranean, No. 13, December 2015

[13] Activity Report of ONEE, December 2015

[14] Assessing the Regional Impact of Climate Change on Economics Sectors in the Low-Lying Coastal zone of Mediterranean East of Morocco, V.Tekken, L. Costa and J.P. Kropp, Journal of Coastal Research (2009)

[15] On arms and adaptation: Climate change and pastoral conflict in Northern Kenya. J. Schilling, M. Akuno, J. Scheffran, T. Weinzierl, University of Hamburg Research Group Climate Change and Security, Working Paper, CLISEC-15

[16] Air pollution as a determinant of asthma among schoolchildren in Mohammedia, Morocco. A.S. Houssaini, H. Messaouri, I, Nasri, M.P, Roth, C. Nejjari, M.N. Benchekroun. International Journal of Environmental Health Research, 17(4):243–57, September 2007

[17] Analyse des Indicateurs Energétiques, Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement, Direction de l'Observation et de la Programmation du Maroc, avril 2013

[18] Etude pour la spécification des besoins en compétences dans le secteur des énergies renouvelables et les secteurs impactés par l'efficacité énergétique, Sfere-Co Efficience, novembre 2011

[19] Pan-Arab Renewable Energy Strategy 2030, IRENA, 2014

[20] Generation and Transmission Master Plan with RE integration on the Moroccan power, EDF, 2015

[21] https://www.pv-magazine.com/2017/04/03/morocco-starts-construction-on-70-mw-noor-ouarzazate-iv-pv-plant/

[22] http://www4.unfccc.int/submissions/INDC/

17-00728