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World Small Hydropower Development Report 2022

Northern Africa

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Table of Content

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Northern Africa

Countries: Algeria, Egypt, Morocco, Sudan, Tunisia

INTRODUCTION TO THE REGION

The electricity sectors of countries in the Northern Africa region are characterized by the dominance of state-owned companies and, with the exception of Sudan, heavy reliance on fossil fuels. In Algeria, two public companies dominate the energy market, with one focusing on hydrocarbon production and trade and the other managing electricity production and distribution as well as gas distribution. Almost all of the country's electricity is generated from natural gas, combined cycle and steam power plants. The electricity sector of Egypt is divided between 16 state-owned companies operating under the umbrella of the Egyptian Electricity Holding Company. Thermal power plays the dominant role in electricity generation in the country, although a significant share of installed capacity and generation is accounted for by renewable energy sources. In Morocco, the electricity sector is dominated by the state-owned National Office of Electricity and Potable Water, which acts as the sole buyer of electricity and also operates some of the largest plants in the country. The primary sources for electricity generation in Morocco are coal and natural gas, while renewable energy sources serve in a supplementary role. In Sudan, the electricity sector is controlled by five companies under the Ministry of Energy and Petroleum. Hydropower and thermal power are both major sources of electricity generation in Sudan and are employed in a complementary capacity. Tunisia operates a partially liberalized electricity market. While the main actor in the country's electricity sector remains a state-owned company, smaller private companies also have a significant presence. Tunisia is heavily dependent on fossil fuels for electricity generation, with thermal power accounting for over 97 per cent of electricity generation in 2019.

The leading hydropower producer in the Northern Africa region is Sudan, where hydropower accounts for the largest share of generated electricity, although the installed capacity of thermal power slightly exceeds that of hydropower. In Egypt and Morocco, hydropower plays an important supplementary role in electricity generation. Egypt and Sudan share the Nile River as their primary source of both hydropower and irrigation, resulting in a complex but generally amicable shared water use relationship between the two countries. Tunisia and Algeria have some hydropower capacity, but its share of the electricity supply of both countries is relatively minor.

An overview of the electricity sectors of the countries in the Northern Africa region is provided in Table 1.

Table 1. **Overview of Northern Africa**

Country	*Total population (million people)*	*Electricity access, total (%)*	*Electricity access, rural (%)*	*Total installed capacity (MW)*	*Electricity generation (GWh/year)*	*Hydropower installed capacity (MW)*	*Hydropower generation (GWh/year)*
Algeria	43	100	100	21,999	87,034	228	152
Egypt	106	100	100	59,530	197,357	2,832	15,038
Morocco	36	100	100	10,677	40,348	1,770	1,654
Sudan	44	55	41	4,137	16,846	1,907	10,210
Tunisia	12	100	100	5,653	20,217	62	66
Total	**-**	**-**	**-**	**101,996**	**-**	**6,799**	**-**

Source: *WSHPDR 2022*[1]

Note: Data in the table are based on data contained in individual country chapters of the *WSHPDR 2022*; years may vary.

REGIONAL SMALL HYDROPOWER OVERVIEW

The definition of small hydropower (SHP) in Northern Africa varies by country. Algeria and Morocco adhere to the up to 10 MW definition of SHP, with additional subcategories for hydropower plants within the 0–10 MW range. By contrast, Sudan has adopted the up to 5 MW definition of SHP. There is no official definition of SHP in Egypt or Tunisia.

A comparison of installed and potential SHP capacities in the region is provided in Table 2.

Table 2. **Small Hydropower Capacities by Country in Northern Africa (MW)**

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (≤10 MW)*	*Potential capacity (≤10 MW)*
Algeria	Up to 10 MW	47.1	47.1*	47.1	47.1*
Egypt	N/A	N/A	N/A	0.0	120.0
Morocco	Up to 10 MW	30.5	300.0	30.5	300.0
Sudan	Up to 5 MW	N/A	N/A	7.2	2,228.6
Tunisia	N/A	N/A	N/A	17.0	56.0
Total	**-**	**-**	**-**	**101.8**	**2,751.7**

Source: *WSHPDR 2022*[1]

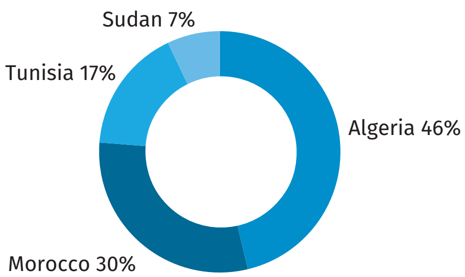
Note: *Based on installed capacity.

The installed capacity of SHP up to 10 MW in Northern Africa is 101.8 MW, while potential capacity is estimated at 2,751.7 MW. Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity decreased by approximately 9 per cent due to more accurate data on the operational status and installed capacities of existing SHP plants in Egypt and Morocco. The estimate of potential capacity for SHP up to 10 MW in the region increased five-fold due to a reassessment of the SHP potential of Sudan and Egypt.

While large hydropower plays an important role in electricity production in Northern Africa, the SHP sector in the region is very small by comparison, accounting for approximately 1 per cent of the total installed hydropower capacity. Little SHP development has taken place in the region over the last decade, with the installed SHP capacities of Egypt, Morocco, Sudan and Tunisia either remaining constant or declining due to the decommissioning of existing plants. The installed SHP capacity of Algeria has increased relative to the *WSHPDR 2019* as a consequence of the inclusion of a previously existing plant in the country's SHP total rather than any new developments in the last few years. SHP development in Northern Africa is hindered by a number of factors common to many countries in the region, including the availability of cheap fossil fuels, lower profitability of SHP relative to solar power and wind power plants and limited water resources in many parts of the region, as well as a lack of detailed data on potential SHP sites.

The national share of regional installed SHP capacity up to 10 MW by country is displayed in Figure 1, while the share of total national SHP potential utilized by the countries in the region is displayed in Figure 2.

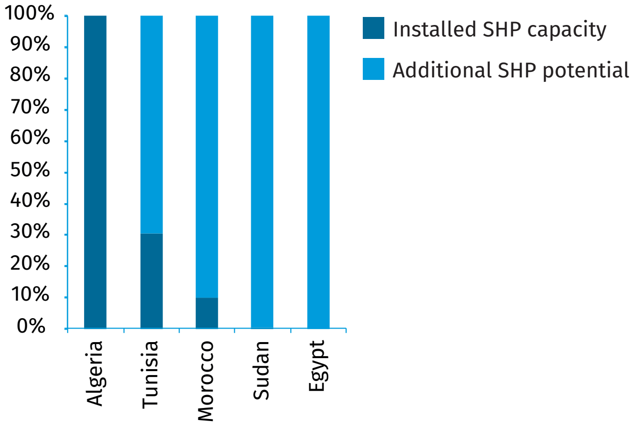
Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in Northern Africa (%)**



Source: *WSHPDR 2022*[1]

Note: Egypt not included due to absence of SHP plants up to 10 MW.

Figure 2. **Utilized Small Hydropower Potential up to 10 MW by Country in Northern Africa (%)**



Source: *WSHPDR 2022*[1]

In **Algeria**, the total installed capacity for SHP up to 10 MW is 47.1 MW. As there are no reliable estimates of the country's potential capacity, it is currently assumed that all SHP potential in Algeria is fully utilized. The installed capacity of Algeria increased relative to that reported in the *WSHPDR 2019* due to the inclusion of the previously unreported Ighzerouftis SHP plant in the country's SHP total. However, no SHP development has taken place in the country in recent years. Furthermore, the Government of Algeria has indicated its intention to phase out hydropower in order to redirect available water for irrigation and drinking water supply, and hydropower development has been entirely excluded from the country's New National Programme for Renewable Energy Development 2015–2030.

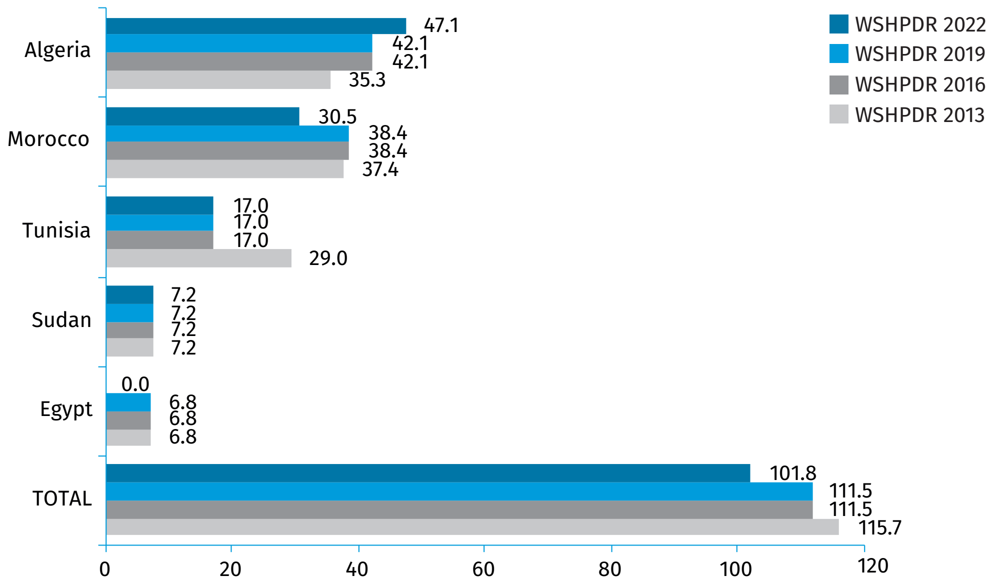
There were no operational SHP plants up to 10 MW in **Egypt** as of 2021, although several plants were in operation in the country in previous years. The potential capacity of SHP up to 10 MW has been recently revised from 51.7 MW to 120 MW. The country plans to develop several SHP sites with capacities ranging between 2 MW and 5 MW, although the project has not yet been confirmed due to concerns over its environmental and social impact.

Morocco has 30.5 MW of installed capacity for SHP up to 10 MW, while the potential capacity is estimated at approximately 300 MW, indicating that approximately 10 per cent of the SHP potential has been developed. As part of the Government's strategy to promote renewable energy sources by 2030, a number of hydropower projects have been approved for development by the private sector, of which 11 projects with a total capacity of 61.5 MW are under construction.

In **Sudan**, the installed capacity of SHP up to 10 MW is 7.2 MW, while the latest estimates put the country's SHP potential at 2,228.6 MW, indicating that less than 1 per cent has been developed. Although Sudan does not have an integrated renewable energy policy document, the country has been making efforts to develop its renewable energy potential and aims to reach at least a 50 per cent share of total electricity generation produced by renewable energy sources by 2031.

The total installed capacity for SHP up to 10 MW in **Tunisia** is 17 MW, while the estimated potential capacity stands at 56 MW, indicating that 30 per cent of the known potential has been developed. There has been no change in either installed SHP capacity or estimated potential capacity of the country since the *WSHPDR 2019*. The renewable energy strategy in Tunisia is focused primarily on solar and wind power. By contrast, the development of SHP has received relatively little interest in recent years, although in 2019 the National Company for the Exploitation and Distribution of Water of Tunisia invited bids for the construction of two micro-hydropower plants. The status of these two projects is currently unknown.

Figure 3. **Change in Installed Capacity of Small Hydropower up to 10 MW from *WSHPDR 2013* to *WSHPDR 2022* by Country in Northern Africa (MW)**



Source: *WSHPDR 2022*,[1] *WSHPDR 2013*,[2] *WSHPDR 2016*,[3] *WSHPDR 2019*[4]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key barrier to SHP development in **Algeria** is weak support for renewable energy technologies and a trend away from hydropower development in particular. Additional barriers include limited financial resources and the low cost of generation from fossil fuels. In light of the Government's decision to not only halt the future development of hydropower but to additionally phase out existing hydropower capacities due to water scarcity, there is little prospect for SHP development in the country.

Barriers to SHP development in **Egypt** include competition from other renewable energy sources, lack of Government interest in SHP and inadequate data on available SHP potential. However, as the Government's policies on renewable energy sources have been formulated fairly recently, the possibility exists that the utility of SHP for diversifying the country's energy mix may be reconsidered in the future. In addition, the country's substantial undeveloped SHP potential, including the large number of irrigation canals and other hydraulic infrastructure, presents many opportunities for SHP development in certain parts of the country.

While **Morocco** has made considerable progress in diversifying its energy mix, SHP development in the country faces stiff competition from wind power and solar power, with returns on investment from SHP projects being less attractive than those from other renewable energy sources. Lack of public interest in SHP and of focused research in the field, as well as concerns over the country's limited freshwater resources, pose additional obstacles for SHP development. Nonetheless, the availability of data on potential SHP sites could serve as the basis for future interest in SHP development in the country.

The development of SHP projects in **Sudan** is hampered mainly by the lack of a comprehensive renewable energy policy, the Government's focus on large hydropower at the expense of SHP, irregular rainfall and low expected returns on investment. At the same time, Sudan possesses the greatest known undeveloped potential in the region for SHP up to 10 MW and emerging renewable energy policies may favour SHP development in light of the country's ambitious renewable energy targets to 2030.

Key barriers to SHP development in **Tunisia** include limited technical capacities and limited specialization to undertake feasibility studies, competition with conventional and renewable energy sources and a lack of stable funding for SHP. At the same time, Tunisia has experienced a marked increase in rainfall in recent years, leading to dramatic increases in annual hydropower generation from existing capacities. If this trend continues, it could make hydropower and SHP in particular a more promising source of renewable energy in the country.

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Algeria

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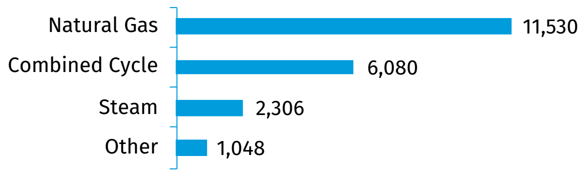
KEY FACTS

Population	43,424,000 (2019)[1]
Area	2,381,741 km^2 [2]
Topography	Algeria is made up of four main topographic zones. To the north, along the Mediterranean coast (1,200 km), stretches the narrow Tell plain, varying in width from 80 km to 190 km. The Tell Plain and the adjoining valleys are home to most of the country's agricultural land. On the borders of the Tell, two mountain ranges are oriented from east to west: the Tell Atlas to the north and the Saharan Atlas to the south, which merge towards the east of Algeria, forming the Aures massif. South of the Saharan Atlas stretches the Sahara Desert, representing 80 per cent of the surface area of Algeria. South of the Sahara stretches a succession of desert highlands, the Hoggar massif, where the highest peak in Algeria, Mount Tahat at 3,003 metres, is located. Approximately half of the territory of Algeria lies at 900 metres or more above sea level and approximately 70 per cent of the area is between 760 and 1,680 metres in elevation.[2,3]
Climate	The north of Algeria is in the temperate zone and its climate is like that of other Mediterranean countries, although the diversity of the relief creates strong temperature contrasts. The coastal region has average winter temperatures of 10-12 °C and average summer temperatures of 24-26 °C. Further inland, winter temperatures average 4-6 °C, with frost and occasional snow on the massifs; summer temperatures average 26-28 °C. In the Sahara Desert, temperatures range from 10 °C to 34 °C, with extreme peaks of 49 °C.[4]
Climate Change	Climate experts estimate that due to global warming, temperatures in Algeria will rise by 4-4.5 °C by 2050. As a result of the increased frequency of torrential rains, in 2009 the highlands of Ghardaïa and Bechar experienced flooding for the first time, and in the south of the country, in 2020 daily rainfall exceeded the normal annual average. Other observed consequences of climate change include high sea levels and destructive waves, causing erosion and even disappearance of beaches to the west of Algiers, demographic pressure, reduction in water run-offs, scarcity of water resources, degradation of hydraulic infrastructure and threat to wetlands.[5]
Rain Pattern	Precipitation patterns in the country can be separated into four key regions. The first region is located to the east in the high plains, and includes the Sersou plateau (Ain-Oussera region, Ksar el Boughari), while to the west it includes the region of Ras el Ma. These territories lie in relatively high altitudes (580–1,194 metres), are sheltered and characterized by low and irregular rainfall with averages of less than 400 mm per year. The second region, located in the west and the centre of the country, is characterized by a position of relative shelter from the rain flows from the west and north-west and low relief. The annual precipitation averages are below 500 mm and are slightly less irregular than in the first region. The third region, encompassing mountainous areas as well as the high interior plains, receives irregular rainfall, with the annual average ranging from 500 mm to just over 800 mm. The fourth region is located in the east of the Tell Atlas and experiences irregular precipitation with maximum rainfall in the cold autumn and winter and minimum in summer, with annual averages ranging from 488 mm to 854 mm.[6,7]
Hydrology	The estimated amount of renewable water resources in Algeria is approximately 19 billion cubic metres per year and approximately 450 cubic metres (m^3) per capita per year. This is below the recommended 500 m^3 per capita per year scarcity threshold, indicating a water crisis in the country. Furthermore, water resources are characterized by high variability. The rivers in Algeria are numerous, but the majority of them have short courses. They mostly rise in the mountains near the coast and flow with great force through deep and rocky channels, presenting the characteristic mountain torrents. The Chelif River, the longest and most important river of Algeria, runs between the Atlas Mountains and Mediterranean Sea, is 725 km long and has an irregular flow, with the longest continuous flow being from November to March. The Djedi River is 479.6 km in length, making it the second longest river in Algeria. Similar to the Chelif, it begins in the Saharan Atlas Mountains at an elevation of 1,402 metres. The Djedi empties into Lake Chott Melrhir, which is located at 3.6 metres below sea level, the lowest point in Algeria.[6,7,8,9]

ELECTRICITY SECTOR OVERVIEW

Total electricity generation in Algeria was 87,034 GWh in 2019 (Figure 1).[10] Of this, 81,526 GWh came from state-owned power plants and independent power producers, while 5,508 GWh came from autonomous production.[10] More than 99 per cent of energy production and consumption, including in the electricity sector, is derived from natural gas and produced from 33 stations located in the southern region of the country.[11] Electricity production growth has been two times slower since 2015 and is almost entirely from gas.

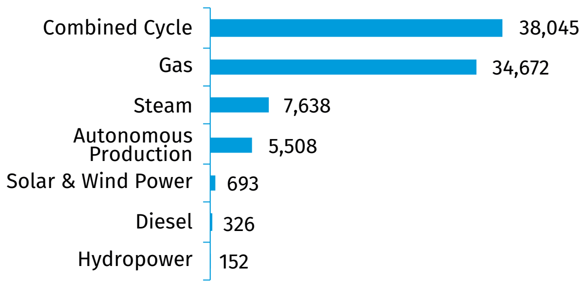
Figure 1. **Annual Electricity Generation by Source in Algeria in 2019 (GWh)**



Source: Ministry of Energy[10]

Algeria had an installed electricity capacity of 21,999 MW as of 2020.[12] This included an installed hydropower capacity of 276 MW and 400 MW of solar photovoltaics (PV), mainly off-grid.[13] According to the International Renewable Energy Agency (IRENA) statistics, in 2019, Algeria had a total renewable energy installed capacity of 686 MW (433 MW of which being off-grid). Of this, 228 MW was from hydropower, 10 MW from wind power and 448 MW from solar power (of which an estimated 25 MW was from concentrated solar power).[14] The most recent data that compare installed capacity from all energy sources are from 2018 (Figure 2).

Figure 2. **Installed Electricity Capacity by Source in Algeria in 2018 (MW)**



Source: Ministry of Energy[15]

Note: The values by source were calculated based on percentage values of the total. The Category "Other" includes installed capacity from diesel, solar power, wind power and hydropower plants.

A further 150 MW of solar PV projects, including seven sites and 15 projects of 10 MW each were released as tenders in 2019.[16] Furthermore, the state oil company Sonatrach has launched a solar expansion programme of 1,300 MW, which is to cover 80 per cent of the electricity needs for its oil facilities, of which 344 MW are already in operation.[17] A further 1,000 MW of solar PV are expected to be released as tenders in June 2021.[18]

The energy sector occupies a predominant place in the Algerian economy; hydrocarbons alone represent 60 per cent of budget revenues and 98 per cent of export revenues.[19] In 2019, following a decision to halt refining its crude oil products abroad, the country's imports of energy almost doubled compared to 2018, while exports dropped by 8.7 per cent.[10] The level of gas exports is decreasing due to rising domestic consumption and, simultaneously, decreased production, hinting at a reduced reliance on hydrocarbons for revenues in the country's future.[20] Algeria plans to reduce its dependence on hydrocarbons through a diversification of its exports and the development of renewable energy sources.[21] In addition, in July 2020 the President announced the plan to stop all imports of fuels and refined oil products by the first trimester of 2021.[22]

In 2016, 99.4 per cent of the population of Algeria had access to electricity, with approximately 400,000 people living without electricity.[23] By 2017, Algeria had reached 100 per cent electricity access.[24]

Two public companies dominate the energy market of Algeria: Sonatrach for hydrocarbon production and trade, and Sonelgaz, former public monopoly, is in charge of electricity production and distribution, as well as gas distribution. The Renewable Energy and Energy Conservation Directorate at the Ministry of Energy and Mines is responsible for the energy policy and supervises the public energy companies. The Hydrocarbon Regulatory Authority regulates the national oil products market by setting prices. The regulatory authority is the Electricity and Gas Regulation Commission (CREG). Forecasts for electricity demand are established by the state electricity and gas utility company Sonelgaz Subsidiary.

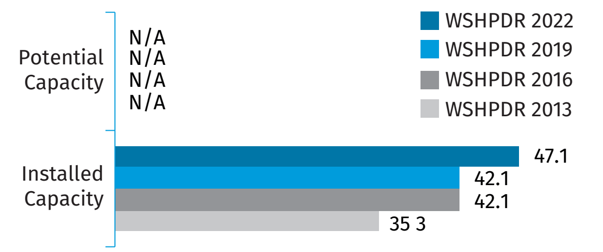
The electricity grid in Algeria has been under stress due to population growth, one-way communication, transmission losses, sudden large amounts of supply and inability of conventional sources to meet the demand.[25] To address the expected increase in electricity demand, the country is actively growing its electricity production. According to the Algerian Programme for the Development of New and Renewable Energies and Energy Efficiency–2030 (PENREE) of 2011, the country aims for an installed capacity of renewable origin of 22,000 MW by 2030, with an intermediary target of 4.5 GW by 2020.[26] The technological developments addressed by this programme include large-scale development of solar PV and wind fields, introduction of biomass fields (waste valuation), cogeneration and geothermal power and, by 2021, also development of solar thermal power (CSP). The long-term goal of this programme is to reach a 20 per cent share of renewable energy in nationwide electricity production by 2030. In contrast, the overall renewable energy target of the country is 27 per cent by 2030.[27] Hydropower is not covered by the PENREE, which favours the development of solar PV, wind power, CSP, cogeneration, biomass and geothermal sources. In fact, in 2014 the Government announced its intention to halt hydropower expansion. More recent plans announce the country's solar PV goal, set at 4 GW by 2024 and 16 GW by 2035.[20]

Electricity tariffs are separated into four categories: 1.77 DZD/kWh (0.013 USD/kWh) for consumption less than 500 kW; 4.17 DZD/kWh (0.031 USD/kWh) for 501–1,000 kW; 4.18 DZD/kWh (0.031 USD/kWh) for 1,001–4,000 kW; and 5.47 DZD/kWh (0.041 USD/kWh) for consumption over 4,000 kW.[28] As of 2021, average electricity tariffs for citizens were 4.01 DZD/kWh (0.030 USD/kWh), which is less than the real price of 5.40 DZD/kWh (0.040 USD/kWh), due to an indirect electricity subsidy.[28]

SMALL HYDROPOWER OVERVIEW

Small hydropower (SHP) in Algeria is defined as any hydropower plant with a capacity of 5 MW to 10 MW, while micro-hydropower is classified as 100 kW – 5 MW and pico-hydropower as plants of less than 100 kW.[29] As of 2020, there was at least 47.1 MW of installed SHP capacity for plants under 10 MW (Table 1). The increase in SHP capacity compared to the *World Small Hydropower Development Report (WSHPDR) 2019* is due to access to more accurate information and the inclusion of the Ighzerouftis plant, which is one of three hydropower plants making up the larger capacity Darguina hydropower plant and which was previously not counted, rather than due to an increase in capacity in recent years (Figure 3). Information on potential SHP capacity in Algeria remains unavailable.

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Algeria (MW)**



Source: *WSHPDR 2019*,[29] *WSHPDR 2013*,[30] *WSHPDR 2016*,[31] Mokrane W. & Kettab A.,[32] Bouraiou A. et al.[33]

Note: Data for SHP up to 10 MW.

The difficulty in finding up-to-date information on SHP in Algeria is likely a consequence of the Government's focus on other sources of renewable energy. According to the Ministry of Energy and Mining, 103 hydropower plants have been recorded and more than 50 plants are in operation.[34] However, an academic source cites only 23 hydropower plants as operational, with the Darguina plant, composed of three hydropower plants (Agrioun of 66 MW, Ighzerouftis of 5.2 MW and Irilemda of 24 MW), being the only one that functions regularly.[32] Approximately 21 per cent of the total hydropower installed capacity consists of SHP, but only 5.2 MW of SHP capacity, from the Ighzerouftis plant, is known to be mostly operational (Table 1).

Table 1. **List of Existing SHP Plants in Algeria (Operational and Non-Operational)**

Name	*Status**	*Location*	*Capacity (MW)*	*Head (m)*	*Launch year*
Souk el Djemaa / Michelet	Operational	Tizi Ouzou	8.1	327.0	1949
Ghrib	Operational	Ain Defla	7.0		1942
Gouriet / Maillot-aval	Needs repairs	Bouira	6.4	111.0	1949
Bouhanifia	Non-operational: no water, control table damaged	-	5.7	46.4	1978
Ighzerouftis	Operational	Bejaia	5.2	171.0	1951
Tizi Meden / Boghni-aval	Needs repairs	-	4.5	254.0	1946
Tessala	Non-operational: evacuation passage obstructed	Oran	4.2	-	-
Beni Behdel	Non-operational: no water	Telemcen	3.3	38.5	1948
Ighzerncheb-el	Needs repairs	-	2.7	-	1934
Foum El Gherza	Reformed**	Biskra	350 kVA + 1 MVA	-	1950
Oum Drou / Pontéba	Reformed in 1980**	-		-	1947
Rhumel	Ruined, non-operational	Constantine	-	-	1910
Total			**47.1**		**-**

Source: Mokrane W. and Kettab A.,32 Bouraiou A. et al.,33 Alger, Algérie: documents algériens,35 Khouchane, F.36

Note: *Status of hydropower plants is based on information from 2005. **Reformed plants are those that have been converted into irrigation facilities and no longer supply electricity.

Hydropower, including SHP, as an energy source plays only a marginal role in Algeria due to limited precipitation, high evaporation and competing uses for potable water. The role of hydropower in Algerian electricity production has been in steady decline since 1973, decreasing by 99 per cent from 1971 to 2015.[37] The contribution of hydropower to the total electricity production in 2019 was 0.19 per cent. The highest proportion of electricity production from hydropower was registered in 1973 at 26.80 per cent, and the lowest value ever recorded, before 2019, was 0.21 per cent in 2002.[37]

In 2014, the Government declared its intention to halt operation of electricity production from hydropower plants and to devote existing dams to irrigation and drinking water supply. The Ministry of Energy and Mining stated that the needs of the population for water supply outweighed the electricity generated by the power plants.[38] This sentiment is echoed in the New National Programme for Renewable Energy Development (2015–2030), which excludes hydropower from its roadmap.

RENEWABLE ENERGY POLICY

The renewable electricity goals of Algeria are set out as percentage values of overall electricity generation. Algeria has one of the highest economic solar power potentials in the world, estimated at 13.9 TWh/year for solar PV and 168,972 TWh/year for solar thermal power.[39] The wind power potential in the country is estimated at 35 TWh/year. Algeria has a nationwide environmental strategy, a national plan for environmental action and sustainable development (Plan national d'action environnementale et de développement durable, adopted in 2002), focusing on reducing pollution and noise, preserving biodiversity and natural spaces, training and raising of public awareness on environmental issues.

Algeria has a public procurement tendering process for renewable energy projects, which was defined by Executive Decree No. 17-98 of 26 February 2017.[40] This tendering process is intended to induce competition among investors, maximize the reductions on price per kWh of electricity produced by renewable energy sources and to avoid the risks associated with excessive profits.[34] In 2019, the Government launched tenders for the installation of solar-diesel hybrid mini-grids.[27]

Key laws pertaining to renewable energy include:

- Law No. 99-09 (28 June 1999), which set out to define the contours of renewable energy development, including hydropower;
- Law No. 02-01 (5 February 2002), which provides the legal basis for electricity management, distribution, transportation and production;
- Law No. 04-09 (14 August 2004), which provides the regulatory basis to promote renewable energy and generalize its uses, protect the environment, fight against climate change by limiting greenhouse gas emissions and preserve fossil fuels;
- Law No. 09-09 on the Finance Bill 2010, which created and determined financing for the National Fund for Renewable Energies as 0.5 per cent of oil royalties;
- Law No. 11-11 on the complementary Finance Bill 2011, which created and determined financing for the National Fund for Renewable Energies and Cogeneration as 1 per cent of oil royalties;
- Executive Decree No. 13-218 (18 June 2013) & Executive Decree No. 17-166 (2 May 2017), which determined the feed-in tariff (FIT) incentive measures to promote investment in renewable energy (premiums for the costs of diversification of electricity production from renewable energy).[41]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

In 2013, the Government of Algeria outlined details for a FIT with the aim of speeding up renewable energy development, diversifying the national energy mix and achieving its ambitious renewable energy targets. It also identified the types of technologies that would benefit from the Government aid, including solar PV, CSP, solar thermal power, hydropower, wind power, cogeneration, waste to energy and hybrid power plants. The scheme uses a premium paid per kWh above the base tariff and is expressed as a percentage of the base electricity tariff. The tariff levels vary across technologies as a function of the bonus value attributed, which is calculated based on the technology type and the percentage of the renewable energy source used in electricity generation.[42] The Government bonuses are equivalent to 100 per cent of the price per kWh of electricity for hydropower, 200 per cent for biomass and 300 per cent for waste, wind power and solar thermal power.[42]

Another financing option is the National Fund for Energy Management, Renewable Energies and Cogeneration (FNMEERC or FNER), which finances actions and projects that promote renewable energy and cogeneration. The fund also provides pre-financing for actions under the promotion of renewable energy and cogeneration.[43] Additionally, 1 per cent of oil royalties are also made available for renewable energy investments.[44] Finally, international funding is also an option. Thus, the European Union has a fund of EUR 40 million (USD 47.6 million) dedicated towards the diversification of the Algerian economy, of which EUR 10 million (USD 11.9 million) is earmarked for renewable energy and energy efficiency projects.[44]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The risks of water scarcity and the likelihood of more intense droughts in the region according to future climate scenarios indicate that further SHP development in Algeria is very unlikely. All forms of hydropower in the region are facing stagnation in potential expansion due to geographical and climatic limitations, which include: limited rainfall in the south of the country, hydropower potential concentration in limited spaces, high levels of evaporation and quick evacuation of water resources to the sea. Moreover, the Government intends to halt the production of electricity from hydropower plants, to dedicate the dams producing electricity to irrigation and to providing the population with drinking water.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Many of the hydropower dams in Algeria were built in the colonial era and have been neglected over the past years. This has led to a 99 per cent decrease in the share of hydropower in electricity production in Algeria. The key barriers to SHP development in the country include:

- Access to financing from international banks until 2015 was restricted by the Government, which led to a lack of access to financing institutions;
- Ageing and poor maintenance of existing power plants;
- Weak support for renewable energy technologies and limited knowledge resources available;
- Lack of institutional support and unstable trajectory of renewable energy policies;
- Low prices for conventional energy;
- Lack of local expertise for the realization of SHP projects.[32,33,43]

There are currently no clear enabling factors for SHP development in Algeria.

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Egypt

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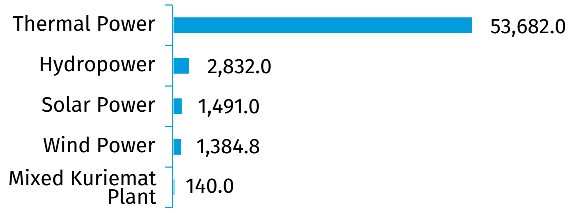
KEY FACTS

Population	105,785,785 (2022)[1]
Area	1,001,450 km² [2]
Topography	Egypt is divided into four major parts: the Nile Valley and Delta, which extends from the north of the valley to the Mediterranean Sea; the Western Desert, which extends from the Nile Valley to the border with Libya and from the Mediterranean in the north of Egypt to the southern borders; the Eastern Desert, which extends from the Nile Valley to the Red Sea, the Suez Canal and the Suez Gulf in the east and from Lake Manzala to the Border with Sudan; and the Sinai Peninsula, which extends from the Mediterranean in the north to the Gulf of Aqaba to the east, the Gulf of Suez and the Suez Canal to the west and Ras Mohammed to the south. The highest peak in the country is Mount Catherine, which elevates to 2,642 metres, and the lowest point is the Qattara Depression at 134 metres below sea level.[3,4]
Climate	Egypt has a dry and hot climate. It has a hot and dry season from May to September and a rather mild winter season from November to April. In coastal regions, temperatures can range between the average winter minimum of 14 °C and the average summer maximum of 30 °C. Temperatures also vary considerably in inland desert areas, particularly during the summer months when they can range from 7 °C at night to 43 °C in the morning. In winter months, the fluctuations are less dramatic, though temperatures can reach 0 °C and 18 °C in the morning. Hot wind storms, called Khamsin, sweep across Egypt between March and May carrying sand and dust and can last for days increasing the temperature by 20 °C in as little as two hours.[5]
Climate Change	Egypt has been affected by climate change and is expected to experience further increases in temperature and decreases and variability in rainfall patterns. Temperatures have been observed to increase by 0.1 °C per decade on average between 1901 and 2013 and by 0.53 °C per decade since the 1980s. Warming has been observed to increase more during the summer months than in winter by 0.31 °C and 0.07 °C per decade, respectively, since the 1960s. The daily and nightly minimum temperatures have increased throughout the country as well. Annual total precipitation has been observed to decrease by as much as 22 per cent since the 1980s, with most of the decrease observed during the winter and early spring months.[5]
Rain Pattern	Due to the arid nature of the climate, there is naturally little rainfall throughout the year with most of the rain falling along the coast, particularly in the city of Alexandria. In addition to receiving approximately 200 mm of precipitation per year, Alexandria enjoys high humidity with sea breeze-modulated moisture. The capital city of Cairo, on the other hand, receives approximately 10 mm of precipitation per year, with rainfall decreasing southwards, but enjoys humidity in the summer. The country sometimes experiences extreme sudden rainfall resulting in flash floods.[5]
Hydrology	In Egypt, the main water resource is the Nile River, which provides the country with approximately 97 per cent of the country's water requirements. The Nile is the longest river in the world, with a length of 6,650 kilometres and enters Egypt through the southern borders with Sudan and reaches to the Mediterranean. Other important water systems are the Suez Canal, the Alexandria-Cairo Waterway and Lake Nasser. The country's riverine and coastline basins can be divided into four main parts: the North Interior Basin, which covers 52 per cent of the country in the east and south-east; the Central Nile Basin, which covers 33 per cent of the country as a broad north-south strip; the Mediterranean Coast Basin, which covers 6 per cent of the country; and the North-East Coast Basin, which covers 8 per cent of the country along the Red Sea coast.[6,7]

ELECTRICITY SECTOR OVERVIEW

The main sources of electricity in Egypt are thermal power, hydropower, solar power and wind power. In 2019/2020, electricity production in the country amounted to 197,357 GWh, of which thermal power accounted for approximately 88 per cent, hydropower for less than 8 per cent, solar power for slightly more than 2 per cent, wind power for 2 per cent and isolated units and power purchased from independent power producers (IPP) accounting for less than 1 per cent (Figure 1).[8]

Figure 1. **Annual Electricity Generation by Source in Egypt in 2019/2020 (GWh)**

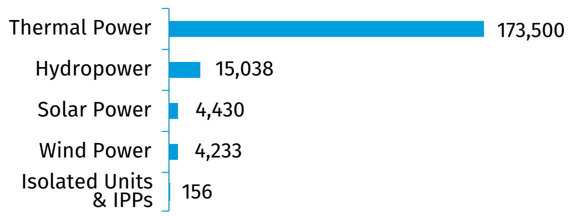


Source: EEHC[8]

In 2016, in order to meet an increasing energy demand, the Government of Egypt launched the Integrated Sustainable Energy Strategy (ISES) to 2035, an energy diversification strategy that aims to guarantee safe and stable energy supply in the country. The ISES also aims to ensure an increase of the share of renewable energy in the country's generation mix as well as to establish Egypt as a focal point of the energy map linking Africa, Europe and Asia by strengthening the interconnection of the electricity network both in the Arab region and beyond.[9]

There are six currently operational hydropower plants in Egypt, amounting to approximately 2,832 MW of installed capacity, or a 5 per cent share of the total installed capacity of approximately 59,530 MW. Thermal power, solar power and wind power account for approximately 90 per cent, 2.5 per cent and 2.5 per cent of the total installed capacity, respectively (Figure 2). Hydropower accounts for almost 5 per cent, while the joint solar/natural gas Kuriemat plant accounts for less than 1 per cent of the total installed capacity.[8]

Figure 2. **Installed Electricity Capacity by Source in Egypt in 2019/2020 (MW)**



Source: EEHC[8]

The main institutions defining energy policy in Egypt are the Ministry of Electricity and Renewable Energy (MOERE) and the Supreme Council for Energy (SCE). The MOERE regulates the generation, transmission and distribution of electricity in the country, while the Electric Utility and Consumer Protection Regulatory Agency (EgyptERA) is responsible for licensing and sector monitoring. The Egyptian Electricity Holding Company (EEHC), with its 16 companies, is responsible for system studies and planning for grid expansion and power plant projects. In terms of generation, subsidiaries are divided by regions of responsibility with the addition of the Hydro Plants Generation Company. The Egyptian Electricity Transmission Company (EETC) is responsible for the countrywide transmission of electricity to regional and local distributors with distribution companies depending on the region.[9]

The Government of Egypt has been making progress towards the development of nuclear power as part of the ISES, with plans to launch the first nuclear power plant in the country already underway as of 2021. Regulation of the nuclear power sector is to be undertaken by the Nuclear and Radiological Regulatory Authority (NRRA). The first studies on nuclear capabilities in Egypt were conducted by the Nuclear Power Plants Authority (NPPA) with technical support from the International Atomic Energy Agency (IAEA). In order to respond to the growing energy demand and accommodate the future nuclear power plants, the Government of Egypt drafted a new law, the new Electricity Law of 2015.[9]

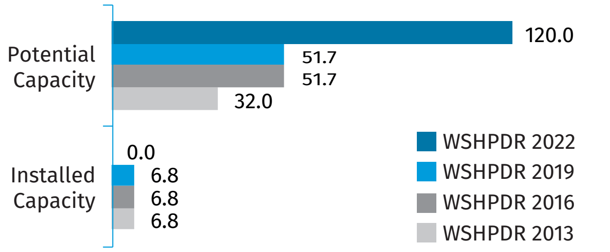
Under the New Electricity Law of 2015, the EETC is to be separated from the EEHC into an independent transmission system operator (TSO) and new companies are required to obtain a permanent licence from EgyptERA before carrying out any electricity-related activity.[10]

The electricity tariffs for residential users in Egypt in 2020/2021 ranged from USD 0.075 per kWh for low consumption (less than 100 kWh/month) to USD 2.260 per kWh for high consumption (more than 1,000 kWh/month).[8] The electrification rate in the country was 100 per cent in 2019.[11]

SMALL HYDROPOWER SECTOR OVERVIEW

In Egypt, there is no official definition of small hydropower (SHP). For this chapter, SHP will be defined as hydropower plants with a capacity of up to 10 MW. Currently, there are no operational SHP plants in Egypt, whereas the total potential capacity is estimated to be at least 120 MW.[12] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, potential capacity increased based on more accurate data and installed capacity decreased taking into account the non-operational status of the plants (Figure 3).

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Egypt (MW)**



Source: Eshra,[12] *WSHPDR 2019*,[13] *WSHPDR 2016*,[14] *WSHPDR 2013*[15]

Table 1. **List of Selected Potential Small Hydropower Projects in Egypt**

Name	*Average potential capacity (MW)*
Damietta	9.00
Rosetta	5.30
Zefta	3.53
El-Tawfeki	2.02
El-Menofi	1.83
Tamia	1.10
El-Azab	0.80
Mokthalat	0.50

Source: Eshra et al.[16]

In Egypt, SHP started in the 1890s with the launch of the 1.1 MW Tamia plant and the 0.8 MW El-Azab plant. They were followed by the 5 MW Old Nag Hamadi plant installed in Upper Egypt and after a long period of time by the 5 MW El-Lahoun plant in Fayum Oasis. All these plants stopped operating due to different problems.

In 2019, studies by Eshra et al. identified eight potential sites for the development of SHP in the Nile Delta and Fayum Oasis (Table 1). The sites have an estimated 24.08 MW of combined potential capacity and an estimated generation capacity of 15.6 GWh.[16] A 2019 study of the same area by the Hydroelectric Power Plant Executive Authority (HPPEA) identified at least seven potential sites for the development of SHP. The Ministry of Electricity plans to develop sites with an estimated potential capacity of 2–5 MW. The construction of the plants is to be funded by the German development agency KfW with a budget of approximately USD 32,620,950. As of 2020, the project had yet to be validated by the Ministry of Irrigation due to concerns over the environmental and social impact of the project in the region.[17]

RENEWABLE ENERGY POLICY

The Government of Egypt issued an environmental law in 1994 to accord special attention to environmental concerns in its energy policy. Following the adoption of this law, the Egyptian Environmental Affairs Agency (EEAA) was created to develop, monitor and implement pilot energy projects. The EEAA is endowed with authority to review and approve all environmental impact assessments (EIA) that must be submitted before licensing power plants in Egypt.[9]

In 2015, partly due to a need for a more competitive and less centralized system, the Government of Egypt adopted the new Electricity Law 87/2015, which emphasized the importance of renewable energy. This new law came after the adoption of the Renewable Energy Law (REL) 203/2014, which aimed to encourage the private sector to invest in renewable energy. Provisions made to specifically address the private sector and facilitate its involvement in renewable energy are outlined in Article 2 of the REL, which includes feed-in tariffs (FITs), competitive bids and independent power production through third party access.[10]

In 2014, the Government of Egypt announced a FIT programme aiming to add approximately 4.3 GW of generation capacity from renewable energy sources. Divided into two rounds, the FIT programme was introduced by the Cabinet Decrees No. 1947 of 2014 and No. 2532 of 2016 for rounds 1 and 2, respectively. These rounds set tariffs for the electricity generated from wind and solar power to be applicable for two years for round 1 and one year and a half for round 2 on power purchase agreements (PPAs) concluded after the issuance of decrees. The PPAs should not exceed 20 years for wind power projects and 25 years for solar power projects.[10]

Under the competitive bid scheme outlined in the REL, the New and Renewable Energy Authority (NREA) issues tenders to private companies that are to install renewable energy power plants, including SHP plants, via an Engineering, Procurement and Construction (EPC) contract. The electricity produced shall be sold to ETTC at a price suggested by Egypt ERA and approved by the Cabinet.[10]

Though there are no government incentives that specifically target hydropower, the African Development Bank's Electricity and Green Growth Support Program (EGGSP) to the Government of Egypt offered a loan of approximately USD 244,698,750 to the country to support its renewable energy and climate change mitigation initiatives. This loan could apply to the hydropower development efforts currently undertaken by the HPPEA.[18]

As part of the Government of Egypt's support for the development of renewable energy, the new Investment Law No. 72 of 2017 was adopted to offer incentives and tax reductions for investors in renewable energy projects. The incentives for renewable energy projects include flat custom duty rates on all machines and equipment for renewable energy projects, registration fee waivers, discounts for project investments, value-added tax (VAT) exemptions for renewable electricity activities and reductions for imported renewable energy equipment, flat electricity rates until 2025, waste-to-energy tariffs and a net-metering scheme. There were also plans for lifting electricity subsidies adopted by the Prime Ministerial Decree 1257/2014, which was delayed due to the COVID-19 pandemic and instead expected to be achieved in the fiscal year 2024/2025.[10]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The development of new SHP projects in Egypt is hampered mainly by:

- The lack of government interest and the favouring of a renewable energy policy based largely on wind and solar energy. Without any financial incentives being given specifically to SHP, it will be difficult to attract investment over other more favourable renewable energy options;
- More studies of the SHP potential should be carried out. The lack of interest in SHP stems from a general consensus that some 85 per cent of the Nile River has already been developed for hydropower, meaning that the NREA stands to make better marginal gains and garner better financial support by looking into other untapped non-hydropower resources. Nonetheless, this assessment is largely based on a perspective from large hydropower projects. More accurate studies on SHP may reveal the existence of significant undeveloped potential.

Enablers for SHP development in Egypt include:

- The Government's strategy to position Egypt as an energy hub that connects Africa, Asia and Europe involves the increase in the share of renewable energy in the generation mix;
- Relatively recent laws and policies that centre renewable energy could lead the Government to consider alternative ways of generating electricity, including SHP;
- The relatively recent emphasis on renewable energy incentives as well as encouragement of international investors and the private sector's involvement in the energy sector could attract actors interested in SHP development;
- Significant SHP potential remains undeveloped and is especially high in parts of the country with a developed irrigation network and various types of hydraulic constructions.

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Morocco

Bilal Amjad, International Center on Small Hydro Power (ICSHP)

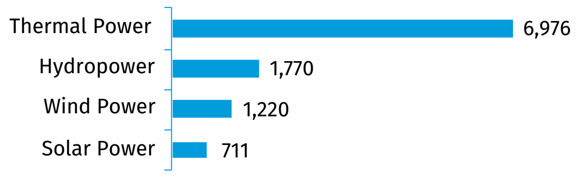
KEY FACTS

Population	36,280,141 (2021)[1]
Area	446,550 km^2 [2]
Topography	Morocco has four mountain ranges. The Rif Chain extends in an arc parallel to the Atlantic Ocean in the west. The High Atlas, approximately 80 kilometres in breadth, extends eastwards for 700 kilometres. Mount Toubkal is the highest point of the massif (4,165 metres). The Middle Atlas and Anti Atlas are the other two massifs. Beyond the chains of the Atlas, lie the pre-Saharan and Saharan zones of the country, where large hamadas form rugged desert plateaus covered with pebbles or dunes.[2]
Climate	Morocco is characterized by a diverse climate. In the northern coastal regions, temperatures are generally mild, reaching an average of 14 °C. In the highlands and mountains, temperatures are usually below 0 °C but can reach -20 °C, causing frost on the plateaus and significant snowfall in the mountains. Summers are hot and dry with mean temperatures of 24 °C on the coast and above 35 °C, sometimes exceeding 40 °C, in the country's interior.[2]
Climate Change	The climate in Morocco is very vulnerable to the global temperature rise, particularly on the north-eastern coast where the sea level is predicted to rise by up to 59 centimetres by the end of the 21st century, causing flooding and storm surges. According to the National Meteorological Directorate of Morocco, by 2100 the average temperature can increase by 2–5 °C and rainfall can decline by 20–30 per cent. These shifts will have a big impact on the country's water resources, leading to less precipitation and more frequent droughts.[3] The year 2020 was recorded among the country's four driest years since 1981. The annual mean temperature across the country in 2020 was 1.4 °C warmer than during the period between 1981 and 2010.[4]
Rain Pattern	In the north, winters are generally wet and mild, with the cumulative annual rainfall decreasing from north to south (from 1,000 to 200 mm/year) and peaking in the mountainous regions (2,000 mm/year in the Rif and 1,800 mm/year in the Middle Atlas). In the southern regions, rainfall is very rare and irregular. Most regions on average receive less than 130 mm of rain per year, with the exception of rare humid, tropical air surges, which give rise to rainfall in the form of showers.[2]
Hydrology	The most important and permanent rivers of Northern Africa are in Morocco: Loukos (100 km), Sebou (500 km), Bouregreg (250 km), Moulouya (450 km), Daraa (1,200 km), Oum Rbia (600 km), Tensift (270 km) and Ziz (270 km).[2]

ELECTRICITY SECTOR OVERVIEW

Compared with other countries in the Middle East and Northern Africa, Morocco is characterized by a lack of conventional hydrocarbon resources and a high reliance on energy imports.[5] In 2019 electricity generation in Morocco totalled 40,348 GWh, of which approximately 67 per cent was from coal, almost 12 per cent from natural gas and wind power each, 4 per cent from hydropower and solar power each and the rest from other sources (Figure 1).[6] National electricity production in 2019 accounted for nearly 99 per cent of total electricity demand, while the remainder was imported through interconnections with neighbouring countries including Spain and Algeria. The same year 1,453 GWh of electricity was exported, which was more than three times higher than the year before.[6]

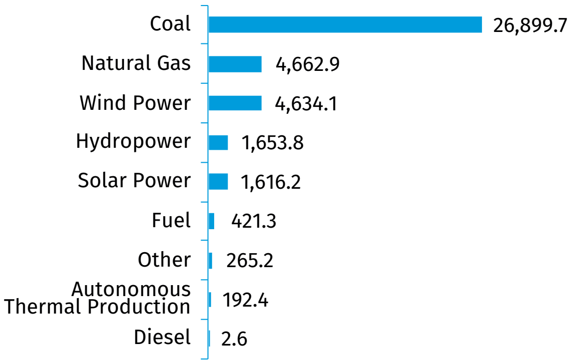
Figure 1. **Annual Electricity Generation by Source in Morocco in 2019 (GWh)**



Source: ONEE[6]

In 2019, the installed electricity capacity of Morocco was 10,677 MW. Of the total, thermal power plants accounted for 65 per cent, hydropower plants for 17 per cent, wind power plants for 11 per cent and solar power plants for 7 per cent (Figure 2).[7]

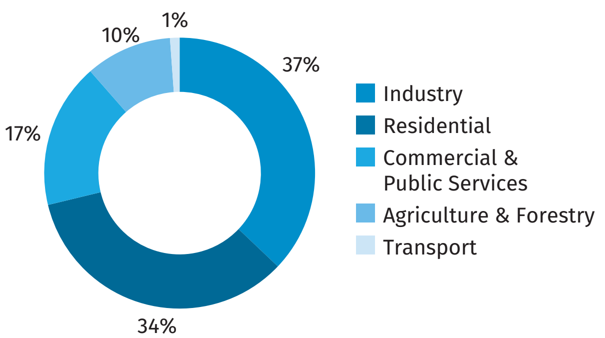
Figure 2. **Installed Electricity Capacity by Source in Morocco in 2019 (MW)**



Source: ONEE[7]

Total energy consumption in Morocco has significantly increased in recent years. Thus, in 2019, it grew by 9 per cent compared to 2018, driven by growth in electricity consumption, which increased by 15 per cent due to the progress achieved in rural electrification and economic growth.[6,8] Between 2015 and 2030, primary energy consumption in the country is projected to double and electricity demand is expected to increase 2.5 times.[5] Overall, since 1990, the electricity sector of Morocco has developed impressively by diversifying generation, improving security of supply and reaching almost universal access to electricity.[9] Currently, electricity consumption in the country is dominated by the industrial and residential sectors (Figure 3).[10]

Figure 3. **Electricity Consumption by Sector in Morocco in 2018 (%)**



Source: IEA[10]

The electricity sector in Morocco is dominated by the state-owned operator, the National Office of Electricity and Potable Water (ONEE). It has the status of the single buyer of electricity produced in the country, except for generation from renewable sources, for which a specific law allows private-to-private electricity transactions.[11] ONEE owns the entire transmission network and much of the distribution network and can give concessions to private operators through purchase guarantees.[12] As the sole buyer, ONEE supplies the national market through its own plants, those of independent power producers (IPPs) and through a number of private industrial producers. IPPs include some of the largest plants in the country such as Jorf Lasfar Energy Company (JLEC) (coal), Safi Energy Company (SAFIEC) (coal) and Electrical Energy Company of Tahaddart (gas, combined cycle).[13]

The Moroccan electricity grid is linked with the Spanish grid through a 400 kV double underwater alternating current line under the Strait of Gibraltar with a capacity of 1.4 GW. Since 1988, Morocco has also had a synchronous interconnection with the Algerian grid via a 400 kV transmission line. Initially its capacity was 1.2 GW, but increased to 1.7 GW with the installation of a second and third lines in 2009.[13,14]

Until 1995, only 18 per cent of the Moroccan population had access to electricity and over the last 20 years approximately 12 million citizens received access through the Global Rural Electrification Programme. Today the electrification rate in Morocco is close to 100 per cent. The country adopted a utility-lead electrification programme where ONEE was responsible for achieving rural and remote area electrification targets. Strong political support, involvement of local stakeholders, funding and engagement of the private sector have enabled ONEE to provide sustainable electricity from solar power to 200,000 households in remote rural communities.[6] In 2019, 373 villages were electrified, providing electricity access to 10,113 households.[6,11]

Electricity tariffs are not uniform in Morocco. The customers are subject to tariffs that are set and reviewed by the Ministry of General Affairs and Governance, on the advice of an Inter-Ministerial Pricing Committee. The latest review process was undertaken between 2014 and 2017. The tariffs are applied to distribution companies by ONEE and to final costumers by distribution companies and depend on the consumer category.[15] Tariffs applied to households are incremental based on monthly consumption, ranging from 0.10 USD/kWh for consumption below 100 kWh to 0.18 USD/kWh for consumption above 500 kWh.[16] A bi-hourly tariff aiming to reduce the evening peak demand is implemented by ONEE on the national level to all low-voltage consumers (including domestic, industrial and agricultural users) with monthly electricity consumption exceeding 500 kWh.[17] Electricity consumption for public lighting and by administration buildings is subject to a fixed price tariff.[15] Rural populations are subjected by ONEE to pricing based on a prepaid meter. These rates, depending on the type of use and consumption bracket, fluctuate between 0.12 USD/kWh and 0.20 USD/kWh.[18]

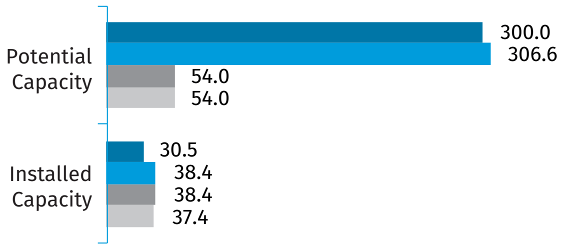
Multiple changes have been experienced in the electricity sector of Morocco over the past years due to the competitive production and commercialization of electricity from renewable energy sources, for very high-voltage/high-voltage/medium-voltage (MV) customers, in accordance with Law 13-09 on renewable energy. The creation of a regulatory agency, National Energy Regulatory Agency (ANRE), was announced by Law 48-15 adopted in 2016.[19] ANRE is responsible for ensuring equal access to the national electricity grid, setting tariffs for the use of the transmission and transportation grids, approving rules and tariffs for access to electricity interconnections and accompanying the implementation of the national energy transition strategy.[20]

SMALL HYDROPOWER SECTOR OVERVIEW

In accordance with the classification established by the International Union of Electric Power Distributors, four categories of hydropower plants are distinguished in Morocco: pico- (less than 20 kW), micro- (20–500 kW), mini- (500–2 MW) and small hydropower plants (SHP) (2–10 MW).[21] The current chapter uses the definition of SHP as all hydropower plants up to 10 MW.

As of 2021, the total installed capacity of SHP up to 10 MW in Morocco was estimated at 30.5 MW (Table 1).[22,23,24] The decrease compared to the *World Small Hydropower Development Report (WSHPDR) 2019* is due to access to more accurate data (Figure 4). The potential capacity is estimated at 300 MW, which is also slightly lower than reported in the *WSHPDR 2019*, with the decrease also being based on a more accurate estimate.[25]

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Morocco (MW)**



Source: ONEE,[22,25] Saad Alami,[23] Government of Morocco,[24] *WSHPDR 2013*,[26] *WSHPDR 2016*,[27] *WSHPDR 2019*[28]

Note: Data for SHP up to 10 MW.

Table 1. **List of Existing Small Hydropower Plants in Morocco**

Name	*Installed capacity (MW)*	*Launch year*
Masser	0.10	2008
Askaw	0.20	2002
Oum Er Rbia	0.22	2004
Sefrou	0.26	1929
Taza Rass El Oued	0.64	1929
Flilou	1.60	2015 (1933)
Fes Aval	1.89	1934
Taurart	2.00	1954
Bouareg	6.40	1969
Kasba Zidania	7.20	1935
Mansour Eddahbi	10.00	1972
Total	**30.51**	

Source: ONEE,[22] Saad Alami,[23] Government of Morocco[24]

In the 1990s, the Development Centre of Renewable Energies (CDER) identified 153 potential SHP sites in the regions of Haouuz, Khenifra and Chefchaouen. The combined potential capacity of these sites was estimated at 6.7 MW, with individual sites having capacities up to 500 kW.[29] More recently, the ONEE has identified 125 sites suitable for SHP development in the basins of the Oum-Errabia, Sebou and Moulouya Rivers, with individual capacities ranging between 100 kW and 1.5 MW and a total potential capacity estimated at 300 MW.[25] Due to the unavailability of lists of the sites identified in these studies, it is not possible to establish whether any overlaps between the two exist, therefore, the current chapter uses the findings of the more recent study as the SHP potential estimate.

Large hydropower has played an important role in the country's energy mix since the 1960s, however, a large share of the available potential has been developed. Therefore, as part of the Government's strategy to promote renewable energy sources by 2030, the main focus for hydropower lies with pumped-storage hydropower as well as small-scale projects.[30] Furthermore, many studies show concern about the impact of climate change on the availability of water in Morocco, which may affect the SHP potential in future.[31] Under Law 13-09 on renewable energy, a number of hydropower projects were approved for development by the private sector.[30] One of these projects consisted of the rehabilitation of an SHP plant at Flilou by the private company Energie Terre; the project was commissioned in 2015.[23] A further 11 SHP projects up to 10 MW with a combined capacity of 61.5 MW are currently under development (Table 2) as well as 10 other projects with capacities between 11.7 MW and 30 MW.[32]

Table 2. **List of Small Hydropower Projects under Development in Morocco**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Developer*	*Planned launch year*
Sidi Chahed	Oued Mikkès, Mèknes	1.3	–	Voltalia Maroc	2019
Sidi Said	Commune Zayda, Midelt	1.89	Reservoir	Energie J2 Terre	2019
Tameslouhte	Lalla Takerkoust Dam, Marrakech-Safi	2.5	Reservoir	Energie J2 Terre	2021
Sidi Driss	Oued Lakhdar	3.5	–	Energie J2 Terre	2019
Machraa SFA	Machraâ Benabbou	6.0	–	Energie J2 Terre	2022
Merija	Machraâ Benabbou	6.0		Energie J2 Terre	2022
Wirgane	Lalla Takerkoust Dam, Marrakech-Safi	6.6	Reservoir	Energie J2 Terre	2020

Name	*Location*	*Capacity (MW)*	*Plant type*	*Developer*	*Planned launch year*
Oued Za	Commune Oued Za, Province de Taourirt	6.7	–	Energie J2 Terre	2022
L'Oum Er-Rbia	Beni Mellal-Khénifra	7.2	–	Voltalia Maroc	2021
Bougemaz	Beni Mellal-Khénifra	9.8	–	Voltalia Maroc	2021
Asfalou	Asfalou Dam, Taounate	10.0	Reservoir	SGTM	2019
Total		**66.35**			

Source: MEME[32]

ONEE has also initiated a project for the rehabilitation of existing hydropower capacities with an estimated cost of approximately EUR 35 million (USD 41 million) to be financed through a loan from the European Bank for Reconstruction and Development (EBRD). The project includes rehabilitation of such SHP plants as Taurart, Bouareg, Taza, Askaw, Sefrou, Tabant and Fes Aval as well as a study of the generation potential of the country's hydropower fleet, including the impacts of the climate crisis.[33]

RENEWABLE ENERGY POLICY

In 2009, Morocco adopted a National Energy Strategy (NES) as a roadmap for the transformation of the energy sector towards greater sustainability, efficiency and financial stability. The NES sets five key objectives for the country's energy policy, including: 1) diversification of the energy mix, 2) national resource development including renewable energy resources, 3) improvement of energy efficiency, 4) integration with international and regional (European and African) energy markets and 5) industrial integration of renewable energy and green technologies.[34]

The climate action strategy of Morocco is defined by the Climate Change Policy (March 2014), the National Sustainable Development Strategy (November 2017) and the Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) (2016). On 21 September 2016, Morocco signed the Paris Agreement, committing to cut its greenhouse gas emissions by 17 per cent by 2030, with an additional reduction of 25 per cent on the condition of international support.[34] The country intends to raise the share of renewable energy sources in its total installed capacity to 52 per cent by 2030. The 2016–2030 period will therefore see the development of 10,100 MW of renewable energy, with solar power to account for 20 per cent of the 2030 energy mix, wind power for 20 per cent and hydropower for 12 per cent. Moreover, Morocco is committed to achieving 15–20 per cent energy saving by 2030 through energy efficiency programmes for the industrial and transport sectors. These strategies are aiming to ensure the country's energy independence, reduce its greenhouse gas emissions and diversify the energy mix.[9,31]

Since 2008, Morocco has experienced a period of rapid change in its power sector, focusing on harnessing its huge renewable energy potential. In order to ensure meeting the energy transition targets, the renewable energy sector of Morocco has been undergoing liberalization. In 2008, Law 16-08 raised the threshold for the allowed self-generation capacity from 10 MW to 50 MW and allowed operators to sell ONEE their occasional surpluses. Law 13-09 promulgated in 2010 set out the legislative framework for the promotion of renewable energy sources. The law allowed renewable electricity producers to feed electricity into the medium- and high-voltage grid or sell it to users. It also removed the power limitations for certain types of energy and introduced three licensing regimes for renewable energy projects depending on the size: a free regime for capacities below 20 kW; a declaration regime for capacities between 20 kW and 2 MW; and an authorization regime for projects above 2 MW. This law was amended by Law 58-15 and Law 13-09, allowing independent renewable energy producers (including hydropower plants above 30 MW) to sell electricity surpluses to ONEE or a distribution system operator. These measures will enable clients from the tertiary and residential sectors to develop renewable energy capacities and feed any excess production into the low-voltage network.[31] At the moment of writing of the current chapter, two further draft laws were under consideration — draft Law 40-19 and a draft law on self-generation. These aim to improve the legislative and regulatory framework for renewable energy and self-generation projects.[35]

In line with the national energy transition strategy, in 2021 the Ministry of Energy, Mines and Environment agreed to collaborate with the International Renewable Energy Agency (IRENA) on accelerating the energy transition and advancing the national green hydrogen economy, as Morocco intends to become a major producer and exporter of green hydrogen.[36]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

There are multiple barriers to SHP development in Morocco. Some of the most important ones are the following:

- SHP projects are less attractive in comparison to other renewable energy sources such as solar and wind power, for which the investment returns are higher;
- Lack of public awareness about the benefits of SHP;
- Low level of interest in research and development (R&D) projects on SHP at universities;
- Impact of the climate crisis on the availability of water resources.

Despite the above barriers, opportunities for SHP development in Morocco exist due to the following factors:

- Availability of data on potential sites for SHP development;

- The policy, legislative and regulatory frameworks favour renewable energy projects, including hydropower.

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Sudan

International Center on Small Hydro Power (ICSHP)

KEY FACTS

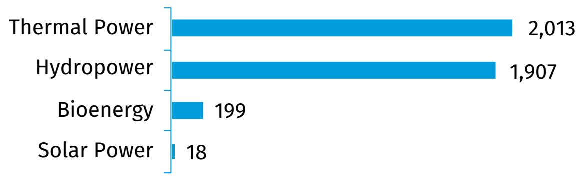
Population	43,849,269 (2020)[1]
Area	1,849,234 km[2 2]
Topography	Sudan is a large country mainly composed of plains and plateaus drained by the Nile River and its tributaries. Northern Sudan is largely covered with a sandy desert diversified by steep-sided granite hills. South-central Sudan is marked by isolated hills that culminate in the Nuba Mountains. The north-east of the country borders the Red Sea, while the Darfur Plateau in the west carries the Marrah Mountains culminating at 3,042 metres above sea level.[3]
Climate	Sudan has a hot, desert climate with strong winds prevailing all year long in the north, bringing dry and cool air in the winter. In the summer, temperatures often exceed 43 °C in the north. the southern regions are slightly cooler. The mean annual temperatures in the country are between 26 °C and 32 °C.[3,4]
Climate Change	Sudan has been experiencing the effects of global warming including increasingly frequent extreme climatic events. Droughts are more common and rainfall has become even more erratic. Temperatures were observed to increase by 0.2-0.4 °C per decade between 1960 and 2009, while precipitation decreased by 20-30 mm per decade in the same time frame. By 2050, temperatures are projected to increase by as much as 3 °C and the Red Sea levels are expected to increase by 30-50 cm.[5]
Rain Pattern	Sudan has a rainy season from March to October, with most of the rainfall occurring between June and September. Rainfall in the country is generally unpredictable and unreliable, with the northern regions experiencing little to no rainfall (less than 50 mm of rainfall). Central regions receive between 200 mm and 700 mm of rainfall a year, while the southern regions enjoy more rainfall at over 1,500 mm per year.[4]
Hydrology	Sudan enjoys considerable water resources primarily from the Nile River and its tributaries, as all rivers and streams of the country drain into or towards the Nile. The White Nile and the Blue Nile enter the country from the south-east and join at Khartoum and after the confluence flow northwards as the Nile.[4]

ELECTRICITY SECTOR OVERVIEW

The main sources of electricity in Sudan are hydropower and non-renewable thermal power. Of the total 16,846 GWh generated in Sudan in 2019, hydropower accounted for almost 61 per cent and thermal power for 39 per cent. Bioenergy and solar power accounted for 109 GWh and 22 GWh, or 0.7 per cent and 0.1 per cent, respectively, of the total electricity generation (Figure 1).[6]

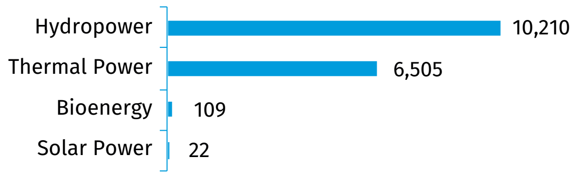
Sudan has one of the largest power sectors in Sub-Saharan Africa and was one of the largest crude oil producers in the region until 2011 when South Sudan gained independence. In addition, South Sudan also retained custody of most of the hydropower plants that once served the former unified country. This meant a significantly reduced installed capacity for the Republic of Sudan.[7,8]

Figure 1. **Annual Electricity Generation by Source in Sudan in 2019 (GWh)**



Source: IRENA[6]

Figure 2. **Installed Electricity Capacity by Source in Sudan in 2020 (MW)**

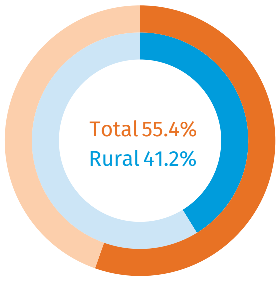


Source: IRENA[6]

In 2020, Sudan had a total installed electricity capacity of 4,137 MW, of which non-renewable thermal energy, hydropower and bioenergy represented almost 49 per cent, 46 per cent and 5 per cent, respectively. Solar power accounted for 18 MW, or 0.4 per cent, of the total installed capacity (Figure 2).[6]

In 2020, Sudan had a total electrification rate of 55 per cent, with a rural electrification rate of 41 per cent (Figure 3).[9,10]

Figure 3. **Electrification Rate in Sudan in 2020 (%)**



Source: World Bank[9,10]

The energy sector in Sudan is overseen by the Ministry of Energy and Petroleum (MoEP) and is composed of five major companies: the Sudan Electricity Holding Company (SEHC), the Sudan Electricity Transmission Company (SETC), the Sudan Electricity Distribution Company (SEDC), the Sudan Thermal Power Generation Company (STPG) and the Sudan Hydro and Renewable Energy Company (SHREC). These companies do not have financial autonomy and are integrated into the MoEP. The MoEP also oversees the Electricity Regulation Authority (ERA), which regulates the country's electricity sector.[7]

The electricity generated in Sudan is mostly publicly-owned with the exception of some thermal generation in isolated grids and emergency powership rentals operated by independent power producer (IPPs). With most of the crude oil reserves owned by South Sudan after the separation, Sudan has had to adapt to meet its ever-growing electricity demand. This includes international agreements for the importation of electricity from neighbouring countries.[7]

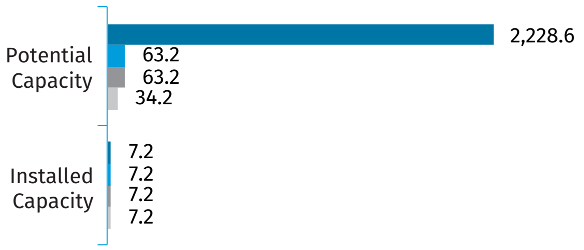
Sudan has one of the lowest electricity tariffs in the region. In January 2021, the average tariff was 0.023 USD/kWh, with the bill collection rate standing at 93 per cent.[7]

SMALL HYDROPOWER SECTOR OVERVIEW

The Government of Sudan defines small hydropower (SHP) as hydropower plants with an installed capacity between 500 kW and 5 MW. Mini-hydropower is defined as 50–500 kW plants and micro-hydropower is below 50 kW. For the purpose of this chapter, the up to 10 MW definition of SHP will be used.

There is currently one SHP plant in Sudan, the El-Girba 2, which has an installed capacity of 7.2 MW (Figure 4).[11] The estimated technical SHP potential in Sudan is 2,228.6 MW, including 123.2 MW from 352 sites of 0.1–1 MW capacity and 2,105.4 MW from 435 sites of 1–10 MW capacity.[12] The increase in SHP potential compared to the *World Small Hydropower Development Report (WSHPDR) 2019,* is due to the more recently obtained data from a study on SHP potential in Sub-Saharan Africa. The installed capacity has remained unchanged (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Sudan (MW)**



Source: Korkovelos et al.,[12] *WSHPDR 2019*,[13] *WSHPDR 2016*,[14] *WSHPDR 2013*[15]

RENEWABLE ENERGY POLICY

Sudan does not have an integrated renewable energy policy document. However, the country has been making efforts to formulate plans to develop its renewable energy potential. While hydropower represents approximately 60 per cent of the total electricity generated in the country, the Government of Sudan is committed to further integrate other renewable energy sources into the generation mix. Specifically, the Government aims to have at least 50 per cent of electricity generation from other renewable energy sources than hydropower by 2031.[16]

The Government also adopted a National Energy Efficiency Action Plan (NEEAP) in 2013 after becoming a member of the Regional Center for Renewable Energy and Energy Efficiency (RCREEE). The set aims include achieving universal electrification, doubling the rate of energy efficiency improvement and ensuring access to modern and reliable electricity by 2030. The Government is also committed to developing the country's SHP potential for a total installed grid-connected capacity of 50 MW by 2030.[16,17]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

SHP plants are regulated by the same legislation as larger hydropower projects. The main legislation and regulation documents in Sudan concerning hydropower projects are:

- The Water Resources Act (1995);
- The National Water Act (2007);
- The Sudan Electricity Act (2001).

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The development of new SHP projects in Sudan is hampered mainly by:

- Lack of a comprehensive renewable energy policy that addresses SHP;
- The Government's focus on larger hydropower to solve the country's electrification issues;
- Irregularity of rainfall patterns, which affects SHP development, further exacerbated by climate change;
- Lack of comprehensive mapping of renewable energy sources in key areas;
- Most of the electricity generation is state-owned, which might discourage potential private sector investors.

Enablers for the development of SHP projects include:

- The abundant water resources in the country due to the location in the Nile Basin. There is great potential for SHP development;
- The Government's commitment to developing renewable energy sources and the inclusion of SHP in 2030 energy development goals.

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Tunisia

Nouri Chtourou, Emna Omri, Rim Jemli and Soukaina Fersi, University of Sfax

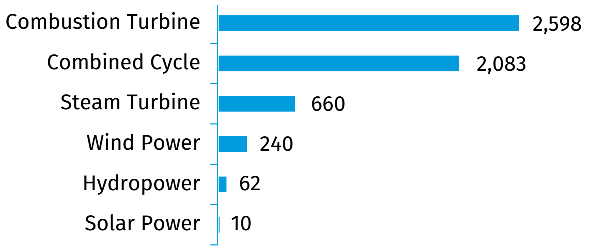
KEY FACTS

Population	11,708,370 (2020)[1]
Area	155,360 km^2 [2]
Topography	The country is divided into three distinct regions. The northern region is characterized by mountains, cork forests and grasslands. The central region is a semi-arid steppe plateau with olive groves. The southern region, which stretches from the border with Algeria to the Mediterranean, contains date palm oases and saline lakes. The extreme south of Tunisia merges into the Sahara Desert. The highest point, Jebel Chambi (1,544 metres), is located near the city of Kasserine.[2]
Climate	The north of Tunisia benefits from a Mediterranean climate, the centre and the Gulf of Gabes have a semi-arid climate and the rest of the country has a desert climate.[2]
Climate Change	The National Institute of Meteorology of Tunisia projects that, based on the climate scenario "RCP4.5", climate in the country by 2050 and 2100 will be characterized by an increase in average annual temperatures and a decrease in annual precipitation. The rise in temperatures will vary between 1 °C and 1. 8°C by 2050 and between 2 °C and 3 °C by the end of the 21st century. In addition, there will be a decrease in annual precipitation of between 5 and 10 per cent by 2050, with a further decrease of between 5 and 20 per cent by 2100.[3]
Rain Pattern	Rainfall is between 400 mm/year in the north of the country and 1,500 mm/year in the far northwest. The central region of Tunisia receives 200–400 mm/year, while in the southern regions of the country rainfall is rare, averaging approximately 50–200 mm/year.[4]
Hydrology	The most important river system in Tunisia, the Medjerda (460 km long), rises in Algeria and drains into the Gulf of Tunis. It is the only river in the country that flows perennially; other watercourses fill only seasonally. In the central Tunisian steppes, after heavy rains, occasional waterways flow southwards out of the Dorsale Mountains, but evaporate in salt flats without reaching the sea.[4]

ELECTRICITY SECTOR OVERVIEW

The electricity sector in Tunisia is characterized by a steady rise in demand and a decrease in the availability of national resources. In 1999, net imports of electricity stood at 6,978 GWh. Since 1999, there has been a steady increase in electricity imports, reaching 72,106 GWh in 2018.[5] Electricity generation rose from 19,245 GWh in 2018 to 20,217 GWh in 2019. Of this total, 17,007 GWh was provided by the Tunisian Company of Electricity and Gas (STEG), 3,071 GWh by the Carthage Power Company (CPC) and 139 GWh by autoproducers.[6] The electricity sector primarily uses natural gas, which accounts for more than 90 per cent of electricity production (Figure 1).

Figure 1. **Annual Electricity Generation by Source in Tunisia in 2019 (GWh)**

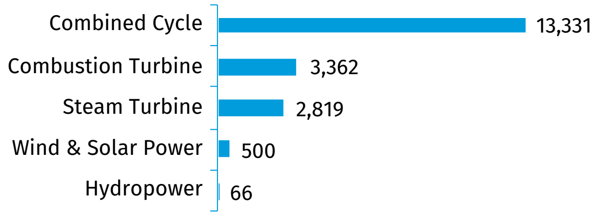


Source: STEG[6]

Note: Includes generation by STEG and CPC only.

Installed electricity capacity in Tunisia increased from 5,076 MW in 2018 to 5,653 MW in 2019. The national generation capacity is composed of steam turbines, gas turbines and combined cycle power plants. The share of wind power, solar photovoltaics (PV) and hydropower in the country's energy mix is very insignificant compared to the available potential of those three resources (Figure 2).[6]

Figure 2. **Installed Electricity Capacity by Source in Tunisia in 2019 (MW)**



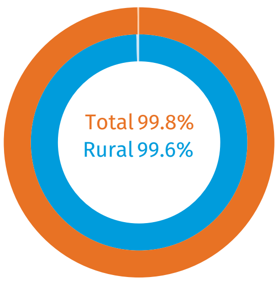
Source: STEG[6]

Note: Does not include installed capacity for hydropower plants not connected to the national grid (approximately 5 MW).

Tunisia is heavily dependent on fossil fuel imports, in particular, imports of natural gas from Algeria. The continuous volatility of fossil fuel prices and the increase of net energy imports have had significant negative repercussions for the country's economy, including massive outflows of foreign currency and an increase in public spending. An important feature of the energy sector of Tunisia are the vast subsidies allocated to conventional energy in order to keep the tariffs for hydrocarbons and electricity at a level that would not deteriorate the purchasing power of the poorest groups of the population. In fact, the budget allocated to energy subsidies tripled between 2017 and 2020, increasing from TND 650 million (approximately USD 239 million) in 2017 to TND 1,880 million (approximately USD 693 million) in 2020.[7]

In 2019, the total length of medium-voltage (MV) and low-voltage (LV) lines in the electricity transmission network of Tunisia reached 180,419 km, with 60,966 km of MV lines and 119,453 km of LV lines. This represented a combined extension of an additional 5,030 km (a 2.9 per cent increase) relative to 2018. The length of the high-voltage network reached 6,985 km in 2019.[6] In 2019, the total national electrification rate was at 99.8 per cent, while the rural electrification rate stood at 99.6 per cent (Figure 3).[8]

Figure 3. **Electrification Rate in Tunisia in 2020 (%)**



Source: STEG[8]

The main actor in the country's electricity sector is the state-owned STEG, which is responsible for electricity generation and distribution. The Tunisian electricity market is partially liberalized. Following Decree 1996-1125 (1996) and Law 96-27 (1996), private generation of electricity is possible through concessions granted by state authorities. This also includes off-grid sources.

Electricity prices at all levels are set at the end of each fiscal year by the Ministry of Industry in collaboration with relevant Government agencies such as the General Direction for Energy (DGE), the Tunisian Enterprise of Petroleum Activities (ETAP), the Tunisian Company of Refining Industries (STIR), the Ministry of Commerce and the Ministry of Finance. Prices are influenced by numerous factors, including the international prices of crude oil and gas, the financial situation of the STEG, ETAP and STIR, as well as the level of Government subsidies. After the STEG's price policies have been approved by the Government, the Ministry of Industry sets consumer gas and electricity prices.

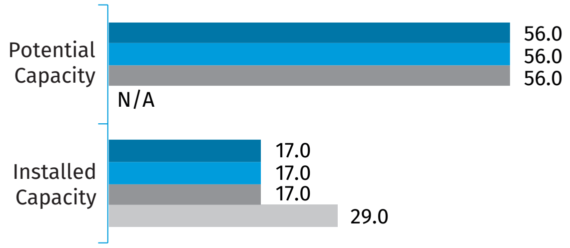
Since June 2019, STEG has applied new electricity tariffs. For low-voltage consumers, tariffs are assigned based on monthly consumption for households and other consumers and according to time slots in the case of pumping for agricultural irrigation. For the category that consumes between 1 and 100 kWh of electricity per month, the tariffs differ between households and other consumers. For households that consume between 1 and 50 kWh/month, the price per kWh is TND 0.062 (USD 0.023). For households that consume between 51 and 100 kWh/month, the price per kWh is fixed at TND 0.096 (USD 0.036). For consumers exceeding 100 kWh/month, the price per kWh varies between TND 0.176 (USD 0.065) and TND 0.414 (USD 0.15) for households and between TND 0.195 (USD 0.072) and TND 0.391 (USD 0.15) for other consumers. For the category of agricultural irrigation, the price varies between TND 0.106 (USD 0.039) and TND 0.391 (USD 0.15) according to three time slots (day, night and evening peak).

The tariffs applied to MV and HV consumers are assigned according to the type of consumer and four time slots (day, summer morning peak, evening peak and night). For MV tariffs, the prices per kWh are assigned according to four categories: regular category (TND 0.251 (USD 0.092)), time slots category (TND 0.188–0.366 (USD 0.069–0.130)), pumping water for agricultural irrigation (TND 0.138–0.195 (USD 0.050–0.071)) and relief supply (TND 0.200–0.407 (USD 0.073–0.150)). For HV tariffs, the prices per kWh are categorized into two types: time slots category (TND 0.160–0.309 (USD 0.058–0.110)) and relief supply (TND 0.168–0.350 (USD 0.061–0.130)). It should be noted that the above-mentioned tariffs do not include the Value Added Tax rate of 19 per cent and the municipal surcharge of TND 0.005/kWh (0.002 USD/kWh).[9]

SMALL HYDROPOWER SECTOR OVERVIEW

There is no official definition of small hydropower (SHP) in Tunisia. For the purposes of this chapter, the definition of up to 10 MW will be used. The installed capacity of SHP up to 10 MW in Tunisia is 16.98 MW, while the potential capacity is estimated at 55.98 MW, indicating that approximately 30 per cent of the known potential has been developed.[10,11] There has been no change in either installed SHP capacity or estimated potential capacity since the *World Small Hydropower Development Report (WSHPDR) 2019* (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Tunisia (MW)**



Source: STEG,[10] *WSHPDR 2016*,[11] *WSHPDR 2013*,[12] *WSHPDR 2019*[13]

Note: Data for SHP up to 10 MW.

Tunisia has a great theoretical hydropower generation potential, which in the mid-1990s was estimated at 1,000 GWh/year, but the technically feasible generation potential is only approximately 250 GWh/year.[14] There is a total installed hydropower capacity of 67 MW in the country, of which 62 MW is connected to the national grid and approximately 5 MW is isolated. The oldest hydropower plant is located in Nebeur (Kef Governorate, northern Tunisia). Built in 1956, it is a reservoir-type plant with a capacity of 13.2 MW. In total, there are seven hydropower plants in Tunisia; of these, the hydropower plant of Sejnane with a capacity of 0.6 MW, is currently not operational (Table 1). Many of the existing hydropower plants were built during the period of French colonization and are predominantly located in the north-western region. The total annual electricity generation of these plants ranges between 50 and 160 GWh.[13]

Table 1. **List of Existing Hydropower Plants in Tunisia**

Hydropower plant	*Capacity (MW)*	*Operator*	*Launch year*
Sidi-Salem	36.00	-	-
Nebeur	13.20	-	-
Fernana	8.50+1.20	Neyrpic	1958-1962
El Aroussia	4.80	Franco Tosi	1956
Bouhertma	1.20+0.62	Alsthom	2003
Sejnane*	0.60	-	-
Kessab	0.66	-	1969
Total	**66.18**		

Source: STEG[10]

Note: *Out of operation.

The two large hydropower plants of Sidi Salem and Nebeur have capacities of 36 MW and 13.2 MW, respectively. Therefore, there are currently five SHP plants in Tunisia, at El Aroussia, Sejnane, Kessab, Fernana and Bouhertma. Their overall installed capacity stands at 16.98 MW.

The renewable energy (RE) strategy in Tunisia is focused on solar and wind power, which receive the support of the Government. Conversely, little interest is given to hydropower, either from the Government or private investors. This would explain the stagnation of hydropower installed capacity in comparison to other sources of RE in Tunisia.

However, in 2019, the National Company for the Exploitation and Distribution of Water (SONEDE) of Tunisia invited bids in separate tenders from qualified contractors to design, equip and build two micro-hydropower plants. These two projects are to be financed by the French Development Agency (AFD). They are located on the water supply network in Montfleury in the north-eastern Governorate of Tunis and at the upper reservoir of Lahirech in the north-western Governorate of Jendouba. The contracts will imply studies of the projects, supply and installation, testing and commissioning of electro-mechanical and electrical equipment, associated civil works, connection to the MV network of STEG, training of technical staff and after-sales service (including provision of spare parts).[15] The status of these two projects is currently unknown. Additional potential SHP sites identified in previous studies are displayed in Table 2.

Table 2. **List of Potential Small Hydropower Sites in Tunisia**

Location	*Potential capacity (MW)*
Barbara	3.00
Sidi Saad	1.75*
Bouhertma	1.20
Sejnane	1.00
Siliana	0.85
Bejaoua	0.75
Khanguet Zezia	0.65
Nebhana	0.50
Medjez el Bab	0.25
Total	**9.95**

Source: *WSHPDR 2019*[13]

Note: *Unconfirmed data.

RENEWABLE ENERGY POLICY

For more than three decades, Tunisia has pursued a proactive policy of energy management. The main axes of this policy are energy efficiency and the development of RE. Despite all the efforts made, the energy situation is characterized by a growing deficit in the energy balance, an increase in the energy bill and an increased dependence on fossil fuels.

In order to address the challenges facing the Tunisian energy system, the Government has committed to a policy of energy transition in the medium and long term. The important elements of this policy have included the creation of the Energy Transition Fund (FTE) in 2013 and the promulgation of the Law on Electricity Production from Renewable Energy Sources in 2015. In the field of energy management, the National Agency for Energy Management (ANME) is the main actor for the implementation of state policy. The ANME has a fundamental role in the energy transition process. The flagship initiatives carried out by the ANME have focused mainly on:

- Elaboration of strategic studies, especially in the areas of rational energy use, RE development and mitigation of greenhouse gas (GHG) emissions;
- Realization of sectoral studies on the energy mix of electricity production and on the Tunisian Solar Plan;
- Conducting specific studies on the financing of energy management initiatives, in particular the restructuring of the National Energy Management Fund (FNME) and the operationalization of the FTE;
- A study on the institutional reform of the ANME in order to enable the Agency to achieve its strategic objectives and to operate in an optimal and efficient manner.

The studies carried out by the ANME represent an essential tool for informing decision-makers on the prospects and challenges of the energy transition in Tunisia. These studies outline the strategic goals and the institutional, regulatory and financial measures necessary to achieve them. The main goals to achieve by 2030 are as follows:

- Reduce primary energy demand by 30 per cent compared to the trend scenario;
- Increase the share of RE in electricity production to 30 per cent;
- Reduce carbon intensity of the energy sector by 46 per cent compared to 2010.[16]

As part of the energy transition plan, Tunisia is striving to engage with international frameworks and agreements on implementing green and sustainable energy policies, including the Paris Agreement of 2015. In September 2015, Tunisia submitted its first National Determined Contribution (NDC), with the objective of reducing the carbon intensity of all sectors of the economy by 41 per cent in 2030 relative to 2010. Energy is placed at the heart of sectoral priorities in the field of emissions reduction, with a significant contribution of 75 per cent in the overall mitigation target of the Tunisian NDC. Energy efficiency and RE are the two main levers to achieve the objective assigned to the energy sector, which aims to reduce carbon intensity by 46 per cent in 2030 compared to the 2010 level. The capacity of the RE sector of Tunisia currently stands at 312 MW (6 per cent of all energy capacity), not including an additional 5 MW of hydropower not connected to the national grid. The aim for the share of RE in the electricity sector is to reach 30 per cent in 2030 (with an installed capacity of 3,815 MW). RE investments in Tunisia are mainly focused on the solar and wind power projects.[17]

The ANME has undertaken the necessary work to meet the requirements of a low-carbon energy transition in accordance with the recommendations of the Paris Agreement. In particular, the ANME has produced a database of GHG emissions of the energy sector over the period of 1980–2012 and an estimate for the period of 2013–2019. In addition, at the beginning of 2020, the ANME carried out a new inventory of GHG emissions in the energy sector covering the period of 2010–2019. The preparation of this inventory is based on the new methodology of the Intergovernmental Panel on Climate Change (IPCC). Furthermore, in 2020, an update of the NDC and elaboration of a National Low Carbon Strategy (NLCS) were initiated. These two elements represent the main instruments of the Tunisian climate policy and an opportunity to accelerate the energy transition and to address both the climate and the energy security issues. Their development defined medium and long-term goals for a changing energy landscape and low-carbon development to meet the energy, climate and socio-economic challenges for 2030 and 2050. Finally, the ANME has developed a monitoring methodology for the NDC in the energy sector, which should enable the assessment of progress towards the achievement of the mitigation target in the energy sector as defined by the NDC. In addition, it serves well to meet the transparency requirements of Article 13 of the Paris Agreement.[18]

In 2019 and within the framework of a partnership with the African Development Bank (AfDB), Tunisia made plans to create the “Fund Establishment and Fund Management Services for A Multi-Investor Equity/Quasi-equity Climate Impact Fund Financing Sustainable Energy Projects and Companies in Tunisia”. In this regard, in 2019 the Fund of Deposits and Consignments (CDC) and the subsidiary of STEG, STEG-ER, launched a call for expressions of interest addressed at investment fund management companies and/or consortiums for the creation, development and management of an investment fund dedicated to the equity/quasi-equity financing of projects with a high environmental impact and oriented towards the energy transition of Tunisia.[19] This Fund aims to promote local currency financing in Tunisian dinars where most appropriate. The AfDB is collaborating with the CDC and STEG-ER in raising financing from a variety of international sources as part of a wider effort to catalyze investment in sustainable energy across the continent. The estimated duration of services is between July 2019 and December 2030. It is important to highlight that the CDC and STEG-ER retain the right to own up to 40 per cent of the fund management company.[20]

The main laws and decrees that regulate the RE sector in Tunisia are the following:

- Law No. 12 of 11 May 2015, which liberalizes the production and export of electricity from RE;
- Law of Investment No. 2016-71 of 30 September 2016 and Government decree No. 2017-389 of 9 March 2017, which provide financial and institutional incentives for investment in the RE sector;
- Law No. 2017-8 of 14 February 2017, which provides tax incentives for investments realized in the RE sector.[21]

The distribution and transportation of electricity remain exclusively the prerogative of STEG, which also sets the purchasing and transportation tariffs. Therefore, investors who self-produce their electricity using RE (and, therefore, are self-consumers) must first sign a contract for the sale of excess electricity produced from RE sources to STEG. Hence, STEG must buy back the surplus according to the established feed-in tariffs (FITs).

The FITs and transmission tariffs for electricity produced by self-consumers or for self-consumption were set by the decision of the Minister of Energy, Mines and Energy Transition of 27 May 2020 (Table 3).[22] The high-voltage (HV) electricity transmission tariff of 0.025 TND/kWh (0.009 USD/kWh; excluding VAT) is only applied for self-consumer organizations benefiting from the right to sell electricity produced from RE and whose production units are connected to the HV network.[23] The tariffs set by this decision apply to the electricity produced from 1 June 2020 on the entire territory of the country.[22]

Table 3. **FITs on Surplus Renewable Energy Electricity Sold by Self-Consumers in Tunisia**

Period	*Price (TND/kWh (USD/kWh))**
Day	0.073 (0.026)
Summer morning peak	0.087 (0.032)
Peak evening	0.077 (0.028)
Night	0.069 (0.025)

Source: STEG[24]

Note: *Excluding VAT of 19 per cent.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

SHP implementation in Tunisia is hindered by several barriers:

- Technical barriers such as: limited access to appropriate technologies in the mini-, micro- and pico-hydropower categories, which pose specific technical challenges; and limited specialization to undertake feasibility studies;
- Energy/electricity sector barriers: mainly the high competition with other RE technologies as well as the maturation of solar and wind power technologies;
- Political barriers: there is limited commitment on the part of the Government to encourage and promote SHP technologies;
- Financial barriers: there is limited participation from the private sector, in part due to a lack of stable funding for SHP and in part due to better investment opportunities with other RE sources.[13]

Recently, Tunisia has experienced a marked increase in rainfall, especially between the years 2018 and 2019. This in turn has led to increased river discharge and a considerable improvement in dam reservoir levels. As a result, electricity generation by the Tunisian hydropower sector as a whole rose to almost 66 GWh in 2019, a 299.4 per cent increase over the previous year. If these weather patterns continue, SHP could become a more promising source of RE for Tunisia in the future.

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