Renewable Energy in the MENA Region: Key Challenges and Lessons Learned

Fateh Belaid, Elias Boukrami, and Razan Amine

Abstract Many pieces of evidence showing that investments in energy transition can boost GDP and create jobs. Further, national and regional energy transitions can help build resilient economies and societies. Therefore, linking short-term actions to medium- and long-term strategies is vital to achieving the Paris agreement on climate change the Sustainable Development Goals (SDGs). In this context, this analysis aims to explore the key challenges and lessons learned regarding the development of renewable energy. The setting of the current study is the MENA countries, as examples of growing economies, most of them experiencing extensive economic and energy reforms. First, we briefly review the demand for renewable energy and the resources available, before examining some of the challenges that need to be addressed to meet deployment targets. Second, we present some case studies to show what is at stake in some countries, the challenges, and the lessons learned. Aggressive RE policies seem to be vital to achieving key energy-policy goals, and the so-called "multiple benefits" of RE in the MENA region, such as addressing climate change and air pollution, improving energy security, and increasing energy access. Policies should be more ambitious to address national challenges and targets and strengthen climate commitments. However, securing strategic financing, investing in transition-related infrastructure, diverting investment from fossil fuels, and making bailouts conditional on climate action should be a cornerstone of national strategies.

Keywords Renewable energy · Economic development · Economic growth · Sustainability · MENA

F. Belaid (✉)
Faculty of Management, Economics & Sciences, Lille Catholic University, UMR 9221-LEM-Lille Économie Management, F-59000 Lille, France
e-mail: fateh.belaid@univ-catholille.fr

E. Boukrami
Faculty of Business and Management, Regents University London, Inner Circle, Regent's Park, London NW1 4NS, UK
e-mail: elias.boukrami@regents.ac.uk

R. Amine
Johns Hopkins University, SAIS, Washington, DC, USA

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1 Introduction

Energy is an indispensable catalyst for economic activity and a source of comfort and well-being for every individual in the World. In recent years energy demand experiencing a steady increase, well below the usual traditional increase that the world economy has witnessed the last five decades. As a result, reducing energy consumption has been placed on the political agenda of most countries around the world. Demand almost doubled over the period 1990 to 2014 (BP 2017). This demand is driven mainly by economic growth, with an average growth of 2.5%, and significant population growth, which rose from 5.3 billion in 1990 to 7.3 billion in 2014 (BP 2017).

The current trajectory of global economic development is not without consequence on our planet and this is alarming. According to a recent report,[1] anthropogenic emissions of greenhouse gas as a result of human activities are responsible for almost 95% of global warming. In the absence of a reinforcement of the international action in favor of the climate, the rise of the average global temperature could reach 2 °C resulting in even more natural disasters (floods, droughts, degradation of the agricultural yields, accelerated melting mountain glaciers, and polar ice caps, rising sea levels, etc.) and irreversible effects on ecosystems.

To address the underlying problems, the global energy sector is experiencing profound and rapidly accelerating change. Accordingly, investment patterns are changing as a result of a multitude of factors, including changing consumer preferences, technological change, and policy measures. Policies affecting change in this sector are driven by a series of objectives. Besides the high consideration given to climate change, energy policy-makers over the World focus on other priorities, including (i) enhancing energy security; (ii) warranting affordable energy supply; and (iii) ensuring universal access to energy and enhance environmental quality.

The traditional fossil energy system is in deep crisis. Centuries of dependency on fossil fuels have led to severe environmental damage and centralized generation, distribution, and power structures from which only a few countries that benefit. Energy transformation should be part of a fundamental paradigm shift towards a sustainable development model. Socially acceptable and ecologically sustainable solutions have to be sought to improve the energy supply, the overall industrial production, the transport, and the heating sector.

Various ways have been identified to reach a low carbon development path (see Fig. 1), including (i) changing individuals practices and behaviors; (ii) improving energy efficiency; (iii) improving carbon sinks by reducing deforestation and increasing the use of bioenergy with carbon capture and storage; and (iv) enhancing the use of low carbon and non-carbon energy.

The latest instrument, renewable energies, can offer a sustainable, development-promoting, and cost-effective alternative to the current fossil energy system (Tiba and Belaid 2020, 2021; Mongo et al. 2021). In addition, the possibility of creating wealth

[1] IPCC. (2018). Global warming of 1.5 Degrees. Retrieved from https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.

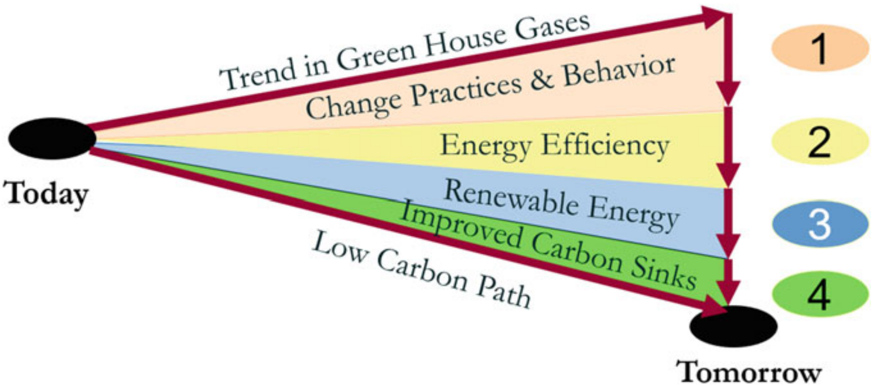

Fig. 1 Key instruments for achieving a low carbon development

and jobs is extremely important, especially as some countries in the Middle East and North Africa (MENA) region have already been struggling with high unemployment for a long time. Moreover, most of the MENA countries if not all of them are rent-seeking economies, with most of the rent is driven and generated by the sale the fossil energy natural resources. On a more complex paradigm, the MENA countries failed to develop a strong industry that takes advantage of the existence of cheap and accessible fossil energy.

In recent years, energy demand in the MENA countries has increased sharply. This trend is mainly due to steady population growth, socio-economic development, and urbanization, driven by both growth-oriented policies and oil and gas revenues.

In recent years, there has been a commitment to stimulating an unprecedented deployment of renewable energy in (MENA) countries. Nevertheless, despite the efforts made and investments in renewable energy, at present, renewable energy sources make a minor contribution to the energy mix, about 0.4%, to the total primary energy in the region (Belaid and Zrelli 2019; Belaïd et al. 2020; Aghahosseini et al. 2020; Omri and Belaïd 2021).

Based on this conjecture, this chapter aims to explore the key challenges and lessons learned in the MENA region regarding the development of renewable energy. First, we briefly review the demand for renewable energy and the resources available, before examining some of the challenges that need to be addressed to meet deployment targets. Second, we discuss the role of Small and Medium-sized Enterprises (SMEs) in driving greed and sustainable inclusive growth in the MENA region.

This chapter will be structured as follows: After an introduction and research background, Sect. 2 provides a brief literature review. Section 3 highlights the potentials and challenges of renewable energy production and challenges in the MENA region, further, this section discusses the situation of some MENA countries and the analysis of their renewable energy policies (Morocco, Lebanon, and Egypt). Section 4 concludes the chapter and provides some policy implications.

2 Literature Review

The investment in renewable energy in the MENA region is a major contributor to setting the region on a path of overall socio-economic and environmental development. The motivation behind increasing renewable energy generation in the MENA region is the improvement of a wide range of sectors in each country's economy. The environmental drivers include limiting pollution by curbing down green-house gas emissions and establishing a secure sustainable source of energy for the region. In terms of economic drivers, the expansion of renewable energy diversifies the economy's sectors will result in the creation of new jobs thus reducing unemployment (Bélaïd et al. 2019; IRENA 2020a, b, c, d, e). A positive economic push is the reduction of technology costs (Smart Energy International 2020).

Renewable energy production capacity installed in the MENA region is approximated to be around 28 GW, 75% of which is hydropower. Nonetheless, renewable energy comprises only 7% of the region's capacity for power generation (Smart Energy International 2020). The most cost-effective and competitive renewable energy resources in the MENA region are solar photovoltaic (PV) and wind energy (Zafar 2020). Energy demand in the MENA region is anticipated to increase steadily at a rate of 1.9% annually (Boyd Anderson 2019). The MENA region has the capacity to expand its renewable energy generation that can comprise 45% of the potential generation for renewable energy in the world (Ramin Jalilvand 2012).

The goals set by governments, in the MENA region, for renewable energy for the next 30 years are ambitious. For example, Dubai's government aims to raise the energy generated from clean sources to 75% of the total energy produced by 2050. The World Future Energy Summit held at the beginning of 2020 in Abu Dhabi confirmed Dubai's new target in massively shifting from unsustainable to sustainable sources of energy (Smart Energy International 2020).

Aghahosseini et al. (2020) investigate whether it is possible for the renewable energy system in the MENA region to constitute 100% of the energy sector by the end of 2030. In the proposed scenario, the Levelized Cost of Energy (LCOE) is estimated to be between 40.3 and 52.8 €/MWh, where the proposed system proves to be 67% on average more affordable than a BAU strategy (Aghahosseini et al. 2020). Future well-being depends on the capacity of the finite resources left for consumption and future generations have, but more importantly on the progress in renewable energy development (Sakmar et al. 2011).

There are several countries in the MENA region that set good examples in the progress towards renewable energy development. Jordan and Egypt have revealed consistent advancement. But Morocco is considered to surpass most other countries in the MENA region, as its government has achieved remarkable progress towards the goal it set: 2 GW for solar PV and 2 GW for wind power by the end of 2020, in accordance with the Nour-1 solar project (Zafar 2020). Moreover, UAE has achieved Dubai's solar park in 2013 and the 100 MW Shams CSP plant is in use since 2014 as well (Zafar 2020). Furthermore, Saudi Arabia's vision for 2030 in the development of renewable energy is promising.

There is no doubt that the MENA region's governments have to overcome a number of challenges, in the transition to more sustainable clean sources of energy. One of the biggest challenges is the reformation of the regulations and the amendment of a wide range of policies. For example, the process of merging photovoltaic solar power into the power grids requires a certain degree of flexibility of the grids, installment of advanced technologies, and setting up well-structured business models. Another challenge is that electricity and water generation are widely linked in the utilities of the MENA region. To successfully expand a system of renewables, this link must be detached (Smart Energy International 2020). In addition, a study revealed that internalizing the externalities (for example, environmental costs like air pollution) that result from using non-renewable energy sources will double the price of electricity for oil and coal (Ramin Jalilvand 2012). Nonetheless, internalizing the negative externalities to be reflected in the cost of electricity of non-renewables is a political obstacle and needs time as well as institutional reform to happen (Ramin Jalilvand 2012).

The governments must increase efficiency in developing renewable energy sources by setting sufficient financial budgets to minimize the LCOE, promoting the infrastructure, and removing fuel subsidies in order to increase incentives to shift toward renewables. There are two types of instruments that the governments can implement to achieve the goals they have set for renewable energy generation: incentivizing renewable energy and disincentivizing non-renewable energy. In other words, subsidizing renewable energy generation instead of non-renewable energy generation is a crucial step that most governments of the MENA region ought to take to move faster on the path of renewable energy development. To incentivize renewable energy, the MENA region governments should pave the way to private organizations to join the renewable energy market by reducing regulative barriers to entry (Abdelrahim 2019). Another tool is price-based subsidies, known as the feed-in tariff would allow access to electricity grids for carriers of renewable energy. Furthermore, a reduction in after-sale tax for producers of renewable energy, easier access to research and development, and lower investment taxes allow producers to earn higher profits thus promoting the expansion and increased generation of renewable energy. To disincentivize non-renewable energy, governments can impose increased tariffs on non-renewable energy and increase investment and sales taxes on non-renewable energy generation (Ramin Jalilvand 2012).

3 Overview of Renewable Energy in the MENA Region: Resources and Potentials

The Middle East and North Africa (MENA) region is considered to be a highly diverse region, with a heterogeneous group of countries, in terms of abundance of distinct resources, trade relations with international countries, technological capabilities, among other features that give each country its unique profile. Compared to the rest of the world, despite the existing wealth of the MENA region in various resources, it is considered still lagging behind the fast progress of renewable energy development. However, there are positive signs that are promising regarding the future of renewable energy expansion in the MENA region, including the availability of technologies and their respective industrial technology providers.

Although the shares of renewable energy are still relatively low compared to countries in other regions, the future of renewable energy seems promising given the optimistic targets set by the various governments in the MENA region. Approximately 80% of non-hydro renewables corresponds to only four countries, making a total of 6% for the renewables out of the total energy generation. But, the fast progress of investment and planning creates optimistic forecasts for the future of renewable energy. For example, across the Arab region, the investment made to renewable energy development increased from USD 1.2 billion in 2008 to USD 11 billion in 2016. According to the established national plans, Variable Renewable Energy (VRE) will contribute to the major part of this development. It's worth mentioning that forecasting international models in local countries is a misleading way of setting targets.

There are several advantages that make the investment in renewable energy a very worthy one. To begin with, the higher is the share of renewable energy of the total energy consumption, the higher proportion of the fuel is saved; this bolsters the countries' energy resources and weakens the risk of facing shortages while meeting the rising demand. Diversifying the energy sources amplifies the energy security and the independence of countries. In addition, renewable energy reduces pollution, particularly greenhouse gas emissions, thus enhancing environmental protection. Besides, this socio-economic growth generates job opportunities and enriches exports.

The key players in the process of renewable energy expansion are ministers, the private sector, transmission system operators (TSOs), utilities, regulators, among other interrelated players. Countries across the MENA region are at different stages in their development process of renewable energy, yet several countries have common concerns. Around six to eight countries in the MENA region are working on orienting the cost projections for the VRE to become better suited to specific corresponding local contexts, by assessing the capacity credits of the VRE of their systems. In addition, some countries are interested in providing flexibility in evaluating the expansion of VRE in terms of costs and progress. Other common concerns include taking action towards the sustainability and stability of the VRE development, seeking improvements in data acquisitions, institution management, and staff training.

Although some targets are common between the countries and many countries welcome cooperation and exchange of plans in developing renewable energy sources, each country still begs specific attention that is best specialized for their respective contexts. Relative to the rest of the MENA countries, Jordan has made good progress regarding the renewable energy development given its relatively high shares of renewable energy infrastructure facilities installed. The National Energy Strategy 2025, which was then amended to 2050 by the National Renewable Energy Action Plan (NREAP) has set a target of 20% for the generated renewable energy out of the total energy generated. Jordan has approximately a current 15.7% of installed renewable energy, targeted to an increase to 20% by 2025, and a current 6.5% of generated renewable energy. Some of the MENA countries have contributed to competitive solar prices. For example, these prices include 17.8 USD/MWh corresponding to the Sakaka project in Saudi Arabia and 29.9 USD/MWh in Dubai (IRENA, MENA 2020a, b, c, d, e). On the other end of the spectrum, Libya and Yemen are examples of the least developed countries in terms of renewable energy in the region.

While the national plans of most of the countries focus on the VRE expansion, Egypt is an exception in the sense that it is more focused on hydro energy which is targeted to an increase of 2.4 GW by 2027. Egypt's current hydro energy is −4.7% and from which the wind energy is −2.3%. In terms of VRE, for the rest of the countries, Algeria has currently 10 MW wind energy produced which is expected to increase to a 23% of the total energy produced by 2030, and 410 MW of solar energy produced, expected to increase to a 62% of the total energy produced by 2030. These targets are very ambitious. As for Bahrain, its solar PV contributed to 5 MW of energy production which is expected to increase to 300 MW by 2035. Iraq's current solar VRE amounts to 37 MW, and the renewable energy target is 5% of generation capacity by 2030. Regarding Lebanon, there are no VRE connected to the grid, but it has a renewable energy share of 1660 MW, out of which 120 MW is from hydro. Renewable energy share is projected to increase to 30% out of the total energy produced by 2030. Morocco has shown significant progress, where a local industry for solar water heaters was built, which is expected to generate 13,000 new jobs. This has further raised expectations of renewable energy development in Morocco, where the target is 53% of Morocco's total installed renewable energy out of total energy generated (IRENA, MENA 2020a, b, c, d, e).

In sum, each country needs a specialized framework with sufficient attention and investment from all its respective interrelated players to fasten the process of renewable energy development. At the same time, encouraging dialogue paves the way towards exchanging country experiences that would provide valuable lessons to all the countries and prevent each country from reinventing the wheel.

3.1 Renewable Energy in Egypt

With oil production of about 588,000 barrels/day, Egypt is the 5th oil producer in Africa. However, with a population of about 98 million, the country is leading the energy consumption in the continent. One of the fastest-growing populations and the economic growth realized in the last years led to a sharp increase in global energy demand. The energy sector is the main driver of the Egyptian socio-economic development, with about 13% of current GDP. According to the 2017 World Bank report, with an electrification rate of about 99.8%, Egypt is near to achieving universal access to electricity. However, the Egyptian electricity Market is characterized by various blackouts and disruption do to some multiple factors, including fuel shortage, the volatility of exported oil prices, sharp population growth, and infrastructure limitations. IRENA reported that, with a peak demand of 28 GW, the Egyptian electricity

Market reached its worst deficit in 2014. The total primary energy supply in Egypt is based, to a large extent, on oil and natural gas (see Fig. 2). In 2014/2015, oil and oil products represented about 50% of the total primary energy supply, and natural gas represented about 45% of total primary energy supply in Egypt. Concerning electricity generation in 2015, about 92% of the electricity was generated from gas and dual-fuel (IRENA 2018).

The total electricity installed capacity was 22,000 MW in 2007, with an expected demand of 74,000 MW in 2030. About 90% of the electricity generation in Egypt is from fossil fuels, mainly by using natural gas (Abdulrahman and Huisingh 2018). In addition, the major energy source (oil and gas) of the country is in continuous depletion. This situation creates major challenges for the country in keeping a continuous and durable energy supply. The growing local energy demand and concern about fossil fuel ongoing depletion, and environmental quality have led Egyptian energy policymakers to think about alternatives to the conventional energy resources use. To achieve these ambitious goals, the Egyptian authorities plan to invest massively in renewable energy sources and to spur the deployment of solar and wind energy across the country. The Egyptian authority's resoluteness to pursue the energy sector diversification is translated into what is called the 2035 Integrated Sustainable Energy Strategy (ISES). This strategy will cost the Egyptian government about 2.5 billion per year until 2030.

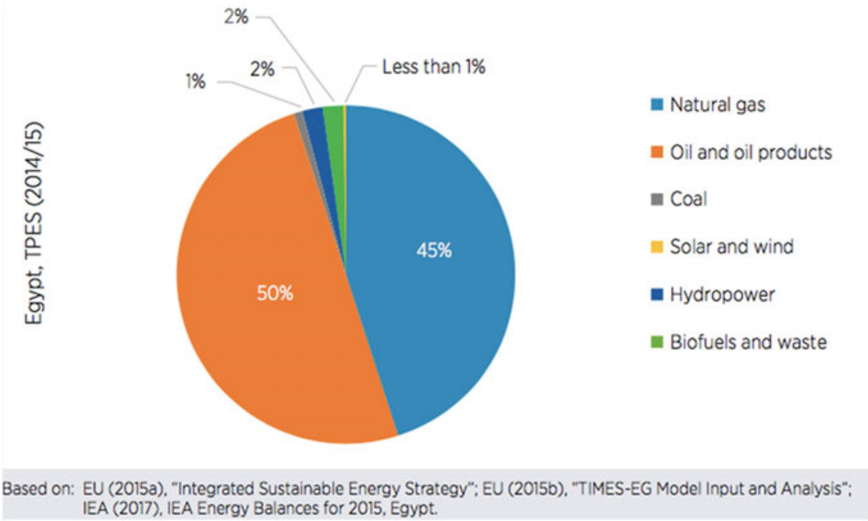

Fig. 2 Egyptian total primary energy supply in 2014/15. *Source* IRENA (2018)

3.1.1 Egyptian Electricity Sector Management

The Egyptian electricity sector is managed by the Ministry of Electricity and Renewable Energy MOERE and supervised by the Supreme Energy Council (SEC). The electricity sector is under the regulation of the Egyptian Electric Utility and Consumer Protection Regulatory Agency, which is in charge of executing policy decisions, setting tariffs, and administering licenses. Historically, generation, transmission, and distribution assets were fully state-owned and operated under the supervision of the Egyptian Electricity Authority (EEA), now known as the EEHC. Transmission, distribution, and generation have been historically under state control via the Egyptian Electricity Authority (EEA), currently known as the Egyptian Electricity Holding Company (EEHC). The private-sector participation started its involvement in the power generation sectors in the late 90s, even though its participation it did not become relevant prior to 2001. The EEHC owns about 90% of electricity generation capacity and the entire state-owned transmission and distribution network. To develop a new competitive power market and end the EEHC on electricity transmission and distribution monopoly, Egyptian authorities introduced in 2015 a new electricity law (No. 87).

3.1.2 Renewable Energy Resources and Potentials

Like other MENA countries, Egypt is richly endowed with renewable energy sources, particularly solar, wind, and biomass. There is a consensus that renewable energy sources represent a viable option for a change in the Egyptian current energy mix, which is still dominated by fossil fuel sources. Increasing the share of renewable energy in Egypt represents a viable solution to address the challenges of the energy sector and improving environmental quality.

Since the late 1970s, the Egyptian authorities have initiated several schemes for testing, demonstrating, and evaluating various renewable energy technology systems and applications in co-operation with several international entities and countries, including Germany, Spain, Italy, Japan, United States, and France. In the last decade, the Egyptian authorities have taken a serious commitment to improving the diversification of energy generation and implementation of energy efficiency measures. Up to now, the renewable energy installed capacity in Egypt around 3.7 gigawatts (GW), in which 2.8 GW is from hydro and 0.887 GW from solar and wind. However, the government aims to generate a supplementary 10 GW from solar and wind power by 2022 (IRENA 2018).

Acknowledging the important role that renewable energy sources could play in addressing this critical situation, the Egyptian authorities created the New and Renewable Energy Authority (NREA) in 1986. In addition to certifications and training programs, the main mission of the NREA was the assessment and promotion of renewable energy in the energy mix through research and development of new technologies. In pursuit of the energy reform agenda, in 2008, the Egyptian Supreme Council of Energy has approved an ambitious strategy and plan to increase the share of renewable sources in the energy mix and reduce the dependency on conventional energy resources. The Egyptian energy diversification strategy is known as the Integrated Sustainable Energy Strategy (ISES) to 2035.

Despite the Egyptian huge solar and wind sources, renewable energy sources are relatively underdeveloped. The renewable energy capacity totalizes 3.7 gigawatts (GW), including 2.8 GW of hydropower and around 0.9 GW of wind and solar power (IRENA 2018). Energy production from renewable sources in Egypt represented about 4% of the global electricity generation in 2009/2010. According to the Egyptian Integrated Energy Strategy plan, the contribution of renewables to energy production in Egypt is predicted to achieve about 8% by 2021/22 and 14% in 2034/35. The evolution of renewable electricity installed capacity for the period 2009–2035 from various renewable sources is displayed in Table 1.

Based on Egypt Vision 2030 scenario, renewable energy is expected to make up 20% and 42% of electricity generation in 2021/22 and 2034/35, respectively. As we can see from the Fig. 3, the average growth rate for renewable energy in the primary energy supply achieves 7.3%.

Table 1 Evolution of renewable energy installed energy capacity for the period 2009–2035 in GW

Type of power station	2009/10	2021/22	2029/30	2034/35
Hydro	2.8	2.8	2.9	2.9
Wind	0.5	13.3	20.6	20.6
PV	0.0	3.0	22.9	31.75
CSP	0.0	0.1	4.1	8.1
Total	3.3	19.2	50.5	62.6

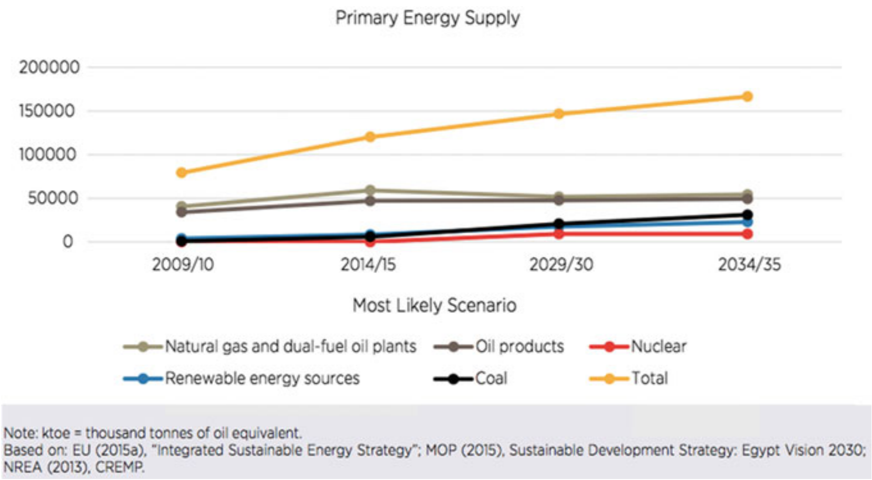

Fig. 3 Primary energy supply (ktoe) in Egypt under the Egyptian Integrated Energy Strategy plan Scenario. *Source* IRENA (2018)

According to this scenario, renewable energy sources, including solar, wind, and hydro, are anticipated to represent about 25% of global installed electricity generation capacity in 2020. Nevertheless, the share of renewable sources in the Egyptian electricity mix is anticipated to reach 42 of the global installed capacity in 2025, following the introduction of nuclear.

3.1.3 Egyptian's Renewable Energy Regulation and Laws

As we stated above, recognizing the role of renewable energy sources in addressing the challenges of the Egyptian energy sector, the Egyptian Ministry of Electricity and Renewable Energy, in line with the Integrated Sustainable Energy Strategy, promulgated a myriad of regulations and laws to accelerate the 2020 and 2035 renewable energy goals implementation. Table 2 displays the key substantial regulations and laws behind the Egyptian energy transition strategy.

Table 2 Overview of the Egyptian energy transition support policies instrument, regulations, and legislation

Regulation	Type
Law No. 102 of the year 1986 establishing the New and Renewable Energy Development and Usage Authority (as amended in 2015)	• Establishes the New and Renewable Energy Authority(NREA) • The NREA has the primary role in promoting and • Developing renewable energy in Egypt
The Constitution of the Arab Republic of Egypt, 2014 (Article 32)	• To gain optimum benefits from renewable energy, promote its investments, and encourage R&D, in addition to local manufacturing
Renewable Energy Law (Decree-Law 203/2014)	• Support the creation of a favorable economic environment for a significant increase in renewable energy investment in the country
Cabinet Decree No. 1947 of the year 2014 on Feed-in Tari	• Establishes the basis for the FIT for electricity produced from renewable energy projects and encourages investment in renewable energy
Prime Ministerial Decree No. (37/4/15/14) of the year 2015	• Regulations to avail land for renewable energy projects
New Electricity Law No. 87 of 2015	• To provide legislative and regulatory frameworks needed to realize the electricity market reform targets
Investment Law No. 72 of the year 2017	• Ensures investment guarantees and amendments as of May 2017 • Establishes a new arbitration center for settling disputes • Codifies social responsibility • Instigates foreign investment in Egypt

Source IRENA (2018)

3.1.4 Egyptian Renewable Energy Potential

Hydropower energy

Up to now, the hydropower is the most mature renewable energy technologies in Egypt. The renewable energy generated from hydropower plants record and average growth of 1.2% per year during the period 2011/2016. Up to now, various hydroelectric stations have been realized. The detail of the hydroelectric capacity and their annual generated electricity in 2015 displayed in Table 3.

Wind energy

Egypt has a huge potential for wind energy resources, notably in the Gulf of Suez. Thanks to its constant wind speed, this region has one of the best locations for mobilizing wind energy in the world. Hurghada station was the first wind farm realized in Egypt in 1993, with a total capacity of 5.2 MW. A number of large-scale wind farms have been realized since that, with a global capacity of 545 M. Table 4 displays information about the Egyptian designed wind farms project until 2023.

Solar energy

Egypt is endowed with high and favorable solar intensity. According to the solar atlas for Egypt, the annual sunshine range between 2900–3200 h, with a direct energy density as 1970–3200 kW h/m^2 per year. The technical electricity-generating potential from solar is about 73.6 Petawatt (pWh) (Aliyu et al. 2018). According to the IRENA report (IRENA 2018), Egypt has one of the most viable regions worldwide for harnessing solar power. Egyptian installed power capacity of small-scale PV totalized about 6 MW in 2013, whereas about 30 MW of off-grid power capacity was installed at the end of 2016. The New and Renewable Energy Authority achieved feasibilities studies for two large-scale PV projects with a generation capacity of 20 MW and 26 MW, respectively. These two plants are expected to be operational in late 2019, with an expected annual production of about 32 GWh and 42 GWh, respectively. Table 5 provides further information on the planned PV project in Egypt up to 2023.

Table 3 Egyptian hydroelectric stations capacity and their annual generated electricity in 2015

Station	Capacity (MW)	Annual generated electricity (GW)
High dam	2100	9484
Aswan 1	280	1578
Aswan 2	270	1523
Esna	86	507
Naga Hamady	64	453
Total	2800	13,545

Table 4 Planned wind farms projects in Egypt until 2023

Project	Technology	Status	Size (MW)	Contract
Gulf of Suez	Wind	Under development	250	NREA-KfW, EIB, AFD EPC scheme
Gulf of Suez	Wind	Under development	250	GDF Suez, Toyota, Orascom BOO scheme
Gulf of Suez	Wind	Under development	200	NREA-Masdar EPC scheme
Gulf of Suez	Wind	Under development	200	AFD-KfW EPC scheme
Gulf of Suez	Wind	Under development	2000	Siemens EPC scheme
Gabal El Zayt	Wind	Under construction	220	NREA-Japan-JICA EPC scheme
Gulf El Zayt	Wind	Under construction	320	Italgen BOO scheme
Gabal El Zayt	Wind	Under construction	120	Spain-NREA
West Nile-1	Wind	Under development	250	BOO scheme
West Nile	Wind	Under development	200	Japan EPC scheme
West Nile	Wind	Tender-bidding Phase	600	NREA IPP scheme

Notes AFD Agence Française de Développement; *EIB* European Investment Bank; *JICA* Japan International Cooperation Agency. Based on: EEHC (2016a), Egyptian Electricity Holding Company Annual Report 2015/16; EU (2015a), "Integrated Sustainable Energy Strategy"; Eversheds and PricewaterhouseCoopers (2016), Developing Renewable Energy Projects: A Guide to Achieving Success in the Middle East, Fourth Edition; MOERE (2017), Full Scale Program for Renewable Energy in Egypt

Table 5 Planned PV projects in egypt until 2023

Project	Type	Status	Size (MW)	Contract
Kom Ombo	PV	Binding	200	BOO scheme
West Nile	PV	Binding	600	Sky Power and EETC BOO
West Nile	PV	Binding	200	EETC BOO
West Nile	PV	Binding	600	BOO scheme
FIT	PV	Operational	50	EETC PPA
FIT	PV	Under development	1415	EETC PPA
Hurghada	PV	Tendering	20	NREA-JICA EPC scheme
Zaafarana	PV	Under development	50	NREA-AFD EPC scheme
Kom Ombo	PV	Under development	26	NREA-AFD EPC scheme
Kom Ombo	PV	Under development	50	NREA-AFD EPC scheme

Note BOO build, own, operate; *EETC* Egyptian Electricity Transmission Co.; *PPA* power purchase agreement; *NREA* New and Renewable Energy Authority (Egypt); *JICA* Japan International Cooperation Agency; *EPC* engineering, procurement and construction; *AFD* French Development Agency (Agence Française de Développement)

3.2 Renewable Energy in Morocco

In 2015, the Moroccan government officially committed itself to the UN's Sustainable Development Goals (SDG), which aims to further reduce poverty and inequality by 2030, thus achieving sustainable, inclusive economic growth as well as promoting social cohesion and innovation. The "Stratégie Nationale de Développement Durable 2030" (SNDD), published by the government in 2017, is based on a national consultation process that was developed in collaboration with relevant international actors. Among others, the strategy describes how the SDGs should be taken into consideration in national planning and budgeting processes. Progress in achieving the SDGs is reviewed by the Haut Commissariat au Plan in cooperation with international actors. The 2009 national energy strategy defined a target of 42% of the total installed capacity to come from renewable energy sources by 2020. This led to the commissioning of new plants to increase the total capacity to 2000 MW of solar, 2000 MW of wind, and 2000 MW of hydropower by 2020 (IEA 2020).

In 2015, at the 21st session of the Conference of the Parties to the UNFCCC (COP21), Morocco announced a further planned increase in renewable energy capacity to reach 52% of the total by 2030 (20% solar, 20% wind, 12% hydropower). To reach the 2030 target, the country aims to add about 10 GW of renewable energy capacity between 2018 and 2030, for example, 4560 MW of solar capacity, 4200 MW of wind capacity, and 1330 MW of hydroelectric capacity (IEA 2020). In accordance with these plans, there are currently several projects organized and being executed for solar and wind energy.

Solar energy project in Morocco

Following the Moroccan's renewable energy plan, there are currently several solar projects planned and being executed as well as the locations of construction are selected under criteria of highest solar irradiance (see Table 6).

One drawback is that the biggest agglomerations are North-West, whereas the strongest irradiation is found South-East. It needs to be mentioned that despite ambitious renewable energy plans back in 2017, two new thermal powerplants were finished (Centrale thermique de Safi and Jerada/ Thermal Power Station with a total

Table 6 Solar power plants specifiactions in Mrocco

Location	Capacity (MW)	dni (kwh/m^2/year)	Area (ha)	Planned commissioning
Ouarzazate	500	2635	2500	2015
Ain Ben Mathar	400	2290	2000	2017
Boujdour	100	2628	500	2020
Sebkhat Tah/Tarfaya	500	2140	2500	2019
Foum Al Ouad/Laayoune	500	2628	2500	2019

capacity of over 1800 MW). In comparison to the energy output of one of the flagship renewable power stations, the NOOR project merely produces 500–580 MW in the final stage. Nor is an ambitious solar power plant that is under construction and of which three phases have already been completed (Fig. 4).

Looking more closely at the business model from an economic point of view, the solar electricity production in the Moroccan desert is internationally not competitive as it is more expensive than electricity generated in conventional gas and coal-fired power plants. At an average of 12 Euro cents/kWh, the production costs will not be competitive and have to be subsidized by the state economic efficiency, as well as the environmental impact, have to be carefully considered as in order to operate the thermal storage which needs to maintain a minimum temperature of above 100 degrees. Back-up fuel is needed for the Ouarzazate complex, estimated to be at 19t/day of gasoil for a capacity of 500 MW (African Development Bank Group 2020)

Additionally, the preferred geographic location for the highest solar irradiance efficiency in the atlas implies that it is far away from the big coastal agglomerations (as can be seen in the table above). This introduces two further inefficiency factors: Electric power transmission and distribution losses. This describes the losses in transmission between sources of supply and points of distribution in Morocco, where

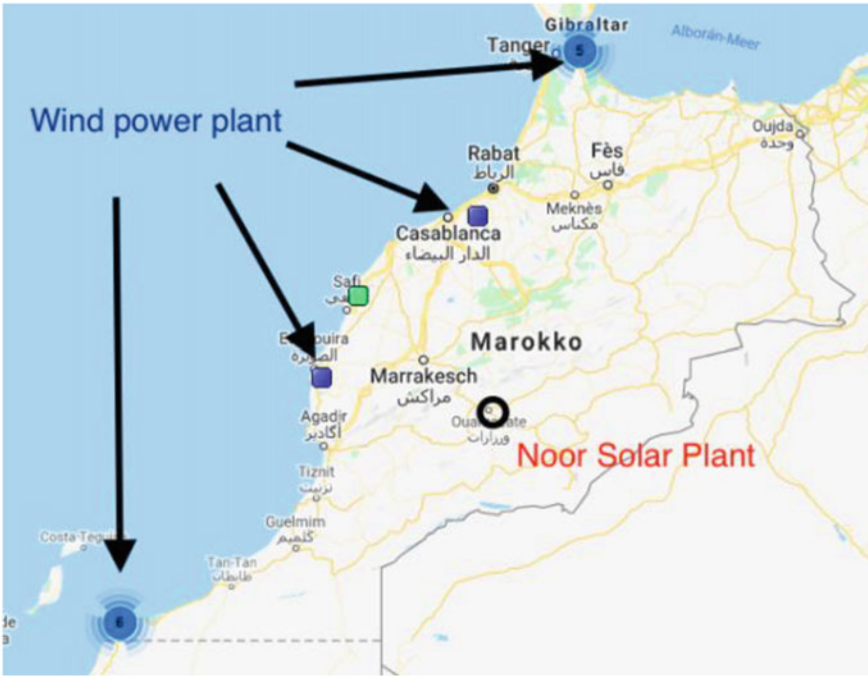

Fig. 4 Wind and solar power stations in Morocco. *Source* The Wind Power (2020)

the average loss was 14.7% of the input. This is of concern, as the biggest central town is Marrakesh (100 km distance) and the other agglomerations are costal.

Wind power in morocco

Table 7 beneath shows the increase in wind energy generation capacity in Morocco.

Besides the already installed capacity, further projects are underway in order to reach the objective of 2000 MW in 2020 (Table 8).

Furthermore, the cost construction, as well as the cost of storage, must be included in the wind power systems in order to meet peak demand. This is mostly done by pumped-storage hydroelectricity. This is an important extra cost that needs to be attributed to the cost of wind power. Besides storage expanding, the network is also a possibility to increase the price efficiency as it means attaining access to new markets. Therefore, Morocco is currently planning to build a third link with Spain. The Spanish government revealed that the new electricity link is designed to promote green energy trading. This agreement will have a strong focus on renewable energy and energy efficiency, in addition to grid integration and by linking regional energy markets. All these elements would favor the renewable energy plan in Morocco. The Moroccan initiative proposed increasing the capacity of the existing interconnections with Spain by 700 MW. Furthermore, Spain and Morocco contemplated building a new 600-MW electric interconnection including Portugal. This would increase the commercial interconnection capacity between Spain and Portugal as well. This option, however, could not be worked out during the negotiations. (Morocco Energy Situation—energypedia.info 2020).

Table 7 Wind energy projects in Morocco

Year	Capacity (MW)	Growth (MW)	Growth %
1998	0	0	–
2000	54	40	285.8
2002	54	0	–
2004	54	0	–
2006	64	0	–
2008	125	0	–
2010	286	33	13.1
2012	291	0	–
2013	495	204	70.2
2014	787	292	59
2015	787	0	–
2016	787	0	–
2017	787	0	–
2018	907	120	15.3
2019	1200	293	32.4

Source The Wind Power (2020)

Table 8 Ongoing wind energy projects

City	Capacity (MW)
Tanger1	140
Tanger2	150
Khallada	120
Haouma	50
Koudia Baida	300
Khallada	120
Taza	150
Midelt	100
Taza	100
Jbel Hdid	200
Akfenir	200
Tarfaya	300
Tiskrad	300
Boujdour	100
Laayoune	50
Amougdoul	60

Source The Wind Power (2020)

3.3 Renewable Energy in Lebanon

Lebanon, the green country at the heart of the Mediterranean, is fortunate with its natural resources and abundance of water, wind, and sun. While citizens enjoy the natural beauty of the country, serious problems like the unsolved problem of electricity cuts leave Lebanon's renewable energy yet far from being well-invested. The year 1970 has marked a new era for renewable energy in Lebanon. Before then, 75% of the produced electricity relied on biomass heating. The development of the renewable energy sector in recent decades has been mostly in the power sector, despite the crucial role that all the sectors play in energy generation. According to the Ministry of Energy and Water in Lebanon, there are around 5 hydroelectric power stations that have been installed between 1931 and 1967, which corresponds to an installed capacity of 286 MW (Ministry of Energy and Water, Lebanon 2019).

In 2010, the electricity reform paper introduced renewable energy foundations. It was then stretched in Lebanon's first National Energy Efficiency Action Plan (NEEAP). The renewable energy targets took their share in the Nationally Determined Contribution (NDC) to the Paris Agreement. The Lebanese government has set several targets on renewable energy as a fraction of electricity consumption, which prior to 2018, was an initial 12% of the total electricity and heating by 2020, increased in 2018 to a target of 30% by 2030. In 2020, the target of renewable energy has been amended to 20% out of electricity and heating, 15% out of which is unconditional and 5% is conditional. This would be considered significant progress compared to a share of renewable energy consumption that amounted to less than 1% in 2014.

As a result of the targets set since 2018, the National Energy Efficiency and Renewable Energy Action (NEEREA) was initiated with the support of the Central Bank of Lebanon (BDL) by lowering the interest rates on the renewable energy projects, providing for each project a loan with a maximum of USD 10 million and an upper period of 14 years to be paid back. In addition, in 2018, Lebanon signed its first power purchase agreement (PPA) for renewable energy consumption which held a total capacity of 226 MW.

Renewable energy forms in Lebanon include hydropower, onshore wind, and solar power. The first form of renewable energy, which has four corresponding sources: reconstruction of existing power plants that would be expected to contribute to an increase of an annual 1000 GMh in energy consumption, a corresponding 358 MW building new ones, 263 MW hydroelectric energy from river flowing water (Sogreah-Artelia 2012), and lastly around 5 MW for non-river energy sources. As for onshore wind, Gharrad Hassan in his publication "The national wind atlas for Lebanon", provided the first mean wind estimation in 2011, which had a potential capacity of 6100 MW (Garrad Hassan 2011). According to the National Renewable Energy Action Plan (NREAP), the targets for the wind energy capacity amounted to 200 MW by 2020 and 45 MW by 2030. The third form of renewable energy which is solar power. The installed capacity of distributed solar photovoltaic solar systems has developed from 1 MPp in 2012 to 56 MWp in 2018 (DREG 2017). Large-scale solar power plants are targeted at 300 MWp by 2030.

The development of renewable energy will require prolonged investment and attention from policymakers to meet the ongoing demands and the arising concerns with the recent pandemic Covid-19. Renewable energy expansion will necessitate more sustainable regulations, better scalable measures, promotion of technology, installment of tools for energy generation from heating and cooling, bolster banking regulation that promotes energy investments, and enhancing the role of private sector financing.

4 Conclusions and Policy Implications

Centuries of dependence on fossil fuels have led to severe environmental damage and centralized generation, distribution, and power structures from which only a few countries benefit. The hunger for energy of a growing population is becoming ever greater and promotes new, extreme forms of energy production. The new needs regarding supply security cannot any longer be satisfied with conventional energy sources. Consequently, it is becoming increasingly problematic to achieve the security of supply, ecological sustainability energy justice, and economic stability. Energy transformation should be part of a fundamental paradigm shift towards a sustainable development model.

MENA countries have one of the greatest renewable energy potentials in the world, and will probably be the most vulnerable to the horrific effects of climate change. Unfortunately, only a few countries have exploited this potential, as non-renewable energy still dominates the total energy mix in most countries. Many pieces of evidence show that investments in energy transition can boost GDP and create jobs (IRENA 2020a, b, c, d, e). In addition, national and regional energy transitions can help build resilient economies and societies. Therefore, linking short-term actions to medium- and long-term strategies is vital to achieving the Paris agreement on climate change the Sustainable Development Goals (SDGs).

There is a consensus among economists that moving away from proven fossil fuel-based development paths requires costly additional investments in the energy system (Leimbach et al. 2018). Moreover, MENA economies are rent seeking-based economies that rely heavily on the declining petro-Dollar rent generated. The shift towards RE business model would imply abandoning wasting, and heavily subsidizing fossil non-renewable energy sources. The shift implies a full economic transformation rather than just an energy transition. Nonetheless, the large potential for renewable energy in the MENA region, especially solar energy, and the international diffusion of technologies could facilitate the transformation to a low-carbon economy and thus the adoption of emission reduction commitments (Belaid and Youssef 2017; Amri et al. 2018; Belaid et al. 2019). The main purpose of this Chapter is to explore the role of renewable energy in shaping energy transition. The setting of the analysis is the MENA region, as examples of growing economies, most of them experiencing extensive economic and energy reforms. Renewable energy is rapidly gaining relevance as the main technology to stifle the increasing demand for energy on the MENA countries, and most of the MENA governments initiated energy renewable energy legislation.

To summarize, aggressive RE policies are vital to achieving key energy-policy goals, and the so-called "multiple benefits" of RE in the MENA region, such as addressing climate change and air pollution, improving energy security, and increasing energy access. Policies should be more ambitious to address national challenges and targets and strengthen climate commitments. Linking short-term actions to medium- and long-term strategies are vital to achieving the Paris agreement on climate change the Sustainable Development Goals (SDGs). However, securing strategic financing, diverting investment from fossil fuels, investing in transition-related infrastructures, and making bailouts conditional on climate action should be a cornerstone of national strategies.

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Fateh Belaid is a Full Professor of Economics at the Lille Catholic University, Director of the Smart & Sustainable Cities research unit, with appointments in Ecole des Ponts & Chaussées ParisTech, and Ecole Nationale des Sciences Géographiques. He is also a Research Fellow at the Economic Research Forum. He received an HDR (Habilitation for Supervising Doctoral Research) from Orléans University, a Ph.D. in Economics and an M.S. degree in Applied Economics & Decision Theory from Littoral Côte d'Opale University, as well as M.S. degrees in Statistics from the National Institute of Statistics and Applied Economics. He is an energy and environmental economist drawing from the fields of applied microeconomics, energy modeling, and econometrics. Dr. Belaïd is already recognized as a productive scholar in a number of fields, the focal point being environmental and energy economics but also in energy policy, decision-making process, and time series econometrics. He has published widely on household energy consumption, energy-saving behaviours, individual preference and investment in energy efficiency, fuel poverty, as well as on renewable energy and energy policy. Outlets for his work have included Ecological Economics, Energy Economics, Journal of Economic Surveys, Journal of Environmental Management, Energy Policy, Structural Changes and Economic Dynamics, Journal of Environmental Science & Policy; Finance Research Letters, Applied Economics Letters; European Journal of Comparative Economics, The Journal of Energy and Development, and Renewable & Sustainable Energy Reviews.

Elias Boukrami is the Head of Programmes' portfolio of Finance, Energy and Trade. His portfolio of programmes includes the M.Sc. Oil and Gas Trade Management a programme that he led during creation and successful development in 2014. More recently he led a team academic and professionals that validated the new MSc Finance and Investment with four specialism pathways, including Banking/Fintech, Wealth Management, Energy Trade and Financial Trading. His team under his leadership was awarded the 2014 Trustees' Prize for Outstanding Service to Regents University London. Dr. Boukrami is the associate director of the Regent's Transnational Centre for Business and Management. Dr. Boukrami is a Fellow member of the Higher Education Academy, a member of Energy Institute, a member of the Westminster Energy Forum and member of the Chartered Management Institute. Dr. Boukrami holds a Ph.D. in Empirical Finance where his area of research was financial derivatives and particularly swaps. His current research is the "Business Models Innovation" arena; he is interested in the causal effects of innovation on business models dynamics, particularly in the financial services sector.

Razan Amine is a Research Assistant at The Johns Hopkins University—Paul H. Nitze School of Advanced International Studies (SAIS). She received a Master of International Economics and Finance (MIEF) From Johns Hopkins University.