Testing for VECM Granger Causality and Cointegration Between Economic Growth and Renewable Energy: Evidence from MENA Net Energy Importing Countries

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ABSTRACT: This paper employs several techniques to study the relationship between renewable energy consumption and economic growth in Net Energy Importing Countries in the Middle East and North Africa (MENA-NEICs) during the period from 2001 to 2015. Panel cointegration test shows that there is a long-term cointegration relationship between those variables. However, the Granger causality test in VECM shows that this relationship is bidirectional in the short and long term. Thus, MENA-NEICs must encourage the deployment of renewable energies to the detriment of fossil fuels. To this end, an investment incentive is suggested in this sector, which will be medium and long-term market-based. In the short term, a transitional stage of a mixed and dynamic approach consisting of a program of partial subsidies for renewable energy production and partial adjustment of fossil fuel prices that is progressively moving towards a final stage where subsidies to energy will be completely removed is suggested. In this way, these countries can make the trade-off between fiscal sustainability and political stability.

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Introduction

MENA countries own about 57% of world oil reserves and 41% of natural gas reserves; however, there is considerable disparity between the countries of the region in terms of oil wealth. The total volume of greenhouse gas emissions is relatively low compared to other countries and 74% of these emissions come mainly from oil-producing countries, but the region is ranked the third in the world in terms of carbon emissions growth, which exacerbate the risk of climate change.

Volatility in fuel prices, population growth, rapid urbanization and economic expansion are putting pressure on the financial resources of many MENA-NEICs and on the existing energy infrastructure, which requires relatively new large investments. World Bank estimates (2013) indicate that over the next 30 years, the total demand for investment in the energy sector in the MENA region will exceed 30 billion per year, or about 3% of total GDP of the region (3 times higher than the world average).

According to the Director-General of the International Renewable Energy Agency (IRENA) (Jordan Times, 2016), MENA can save up to $750 billion in renewable energy consumption up to 2030, if the target of using renewable energies in the range of 5-15% by the year 2030 is achieved against 36% in the world. It should be noted that the current world consumption of renewable energies is around 16-17%. This strong growth in the consumption of renewable energy will have a positive impact on CO2 emissions, which will fall by the half, resulting in the limiting of global warming to 2 degrees, which is the threshold adopted at the Paris climate conference in 2015 (COP 21).

In this paper we investigate if there is a causal relationship between the consumption of renewable energy and sustainable economic growth in the MENA-NEICs. Otherwise one wonders if it is possible to substitute the energy consumption with clean energy without harming economic growth through the reduction of the energy cost and the indirect gains linked to the carbon emission reduction.

The paper has been inspired by four factors. First, the Paris agreement on climate global warming that follows the negotiations that took place from November 30 to December 12, 2015 in Paris, France, during the organization of the United Nations Climate Change Conference, COP 21. This agreement was approved by all 195 delegations present in the conference and accelerated thereafter policy measures for the substitution of hydrocarbons. The majority of MENA countries have signed the agreement and have submitted plans to adopt renewable energy (Table 1).

The second factor is related to the rapid growth of the MENA-NEICs domestic energy demand and the deficits of their energy balances which tend to worsen from year to year. This has led policymakers to consider renewable energy as a short- and long-term safe haven for the national economy.

The third reason is the divergence in the results of the previous studies on the economic convenience of renewable energies. Finally, the fall in the cost of producing renewable energy using diverse technologies in many parts of the world.

The remainder of this paper is organized as follow: Section 1 gives a general overview of the energy transition in the world, Section 2 investigates literature review; Section 3 presents econometrical methodology and empirical results; and the last section is devoted to conclusions.

1 The energy transition: a general overview

The consequences of climate change on economic growth are severe and its most harmful effects will be most evident in the health and agriculture sectors, with particularly severe damage in Africa and Asia including MENA countries. Indeed, each degree of global warming is expected to cost 1.2 percentage points of GDP and 23% of each person's income by the end of the century (Burke et al., 2015). According to scientists, current projections already lead us to a warming of 4°C; some of the most pessimistic assumptions predict more than 8°C. As a result, several potential cataclysms threaten humanity if nothing has been done to stop ecological degradation such as: permanent airpocalypse, large submerged cities, deadly heat waves, drought, famine, new diseases, etc.

The majority of countries in the world, aware of the danger of global warming, have moved towards circular economies based on renewable energies. This will "reduce the social, economic and environmental issues that are usually among the main causes of instability and geopolitical conflict" (Adnan Amin, director of IRENA, 2019, January). It is especially since the Paris agreement, that the use of renewable energies has found a use more and more generalized which has favored the fall of their production costs. In its 2019 report on the geopolitical consequences of the renewable energy transition, IRENA reports that since 2010, the average cost of photovoltaic and wind solar electricity has dropped by 73% and 22% respectively. This agency adds that the cost of lithium-ion batteries, used in electric vehicles, has fallen by 80% since 2010. The world average megawatt hour price of $ 30 currently, "will be at the lower end of the cost of electricity produced from fossil fuels" (International Renewable Energy Agency, 2016, 2019a,b).

According to the United Nations Environment Program (2019, UNEP), investments in renewable energy in 2018 have reached $ 288.9 billion. A geographical breakdown of this amount shows that China is leading global investment for the seventh consecutive year with $ 91.2 billion, or 32% of total investment. All developing countries (other than China) account for 21% of global investment with $ 61.6 billion. The share of the Middle East and Africa in global investment is 5%, jumped 57% to reach a record of 15.4 billion (Table 2).

Despite the fact that investments in renewable energies have increased by 55% since 2010, this increase remains strikingly insufficient if we look at the evolution of electricity demand; and the world should double its annual investment in low-carbon energy to have a reasonable chance of staying below 2°C warming by 2100 in accordance with the Paris agreement (International Energy Agency, 2019).

Inger Andersen, Executive Director of the United Nations Environment Program, has declared that "Global trends continue to indicate that investing in renewable energy is investing in a profitable future. Investments in renewable energy in 2018 were three times higher than the amount invested in new coal and gas-fired generators. . . While this is encouraging, we need to significantly step up the pace, if we are to meet international climate & development goals."

Regarding the MENA countries, studies show that they are rich in solar radiation at around 6 kWh / square meter per day and the majority of these countries are in the "global sunbelt" with 59% of their surface area is suitable for solar deployment, and 56% for wind (Alnaser, 2011; IRENA, 2015). Despite the fact that this region is rich in renewable energy (Table 3), its deployment remains modest compared to a large part of the world. According to the International Institute for Sustainable Development (2014), renewable energy accounts for only 1% of total primary energy consumption and contributes 3.5% of electricity generation in the MENA region (see Table 4).

2 Literature review

The causal link between fossil energy consumption and economic growth has been widely discussed in previous literature, however, the results of these studies differ and depend on the method and period of the analyzed time used.

In their study of the causal link between energy consumption, CO2 emissions and income in India, Alam and Butt (2002) showed that there is a bi-directional causality between energy consumption and long-term CO2 emissions. However, there was no causality between other variables and incomes. Thus, the authors conclude that energy conservation policies could be implemented without affecting economic growth. Further and due to the absence of causality in any direction, the reduction of CO2 would be less easy in India.

Jinke et al. (2008) showed that there is a positive long-term cointegration relationship between energy consumption, pollution and economic growth in thirty Chinese provinces. The results they have achieved show that a 10% increase in GDP per head leads to a 5% increase in energy consumption and 4.3% in CO2 emissions.

In a study that examines the relationship between economic growth and pollution, Managi (2006) has shown that this relationship satisfies the environmental Kuznets curve (EKC) hypothesis. For him there is an enrichment threshold of a country from which pollution starts to decrease through investment in research and development to replace obsolete technologies with new, cleaner technologies.

By using the Granger causality test and the Variance Decomposition Analysis of Vector Autoregression (VAR), Mallick (2009) has shown that there is one-way causality ranging from economic growth to petroleum demand. This causality will be reversed for the case of coal consumption. In addition, it shows that there is a two-way causality between economic growth and electricity consumption. More recently, Fei et al. (2011) conducted a study of twenty eight Chinese provinces, showing that there is a two-way causality between energy consumption and economic growth. In the long term, CO2 emissions are determined by economic growth and energy consumption.

Regarding the relationship between renewable energy consumption and economic growth, there are few studies on this topic. By studying a sample of 19 developed and underdeveloped Eurasia countries covering the period 1984-2007, Apergis and Payne (2010b,c,a) have shown that there is a two-way causality between renewable energy consumption and economic growth.

Menyah and Wolde-Rufael (2010) analyzed the causality direction between renewable energy consumption, nuclear energy consumption, and CO2 emission for United States during the 1960-2007 period. Their results show, on the one hand, that CO2 emissions Granger-causes renewable energy consumption and that there is a negative unidirectional causality ranging from nuclear energy consumption to CO2 emissions. On the other hand, Granger's causality tests have shown that there is no significant link between renewable energy consumption and CO2 emissions.

Ibrahiem (2015) uses Auto Regressive Distributed Lag (ARDL) bound testing approach over time series data from the period 1980 to 2011, to examine the relationship between renewable electricity consumption, foreign direct investment and economic growth in Egypt. The results show that the studied variables are cointegrated, which shows the existence of a long-run relationship among them. Furthermore, renewable electricity consumption and foreign direct investment have a long-run positive effect on economic growth. Granger causality test shows that there exists unidirectional causality running from foreign direct investment to economic growth; in addition, there is bidirectional causality between economic growth and renewable electricity consumption.

Sadorsky (2009) conducted a study of the G7 countries, relating to the 1980-2005 period and has shown that the long-term movement in the renewable energy per capita consumption is explained primarily by CO2 emissions and GDP per capita. His results also show that when the consumption of renewable energy deviates from its equilibrium trajectory in the short term, it returns to it through movements towards the long-term equilibrium. It should be mentioned that Sadosky used a Panel Vector Error Correction Model (VECM) and Panel Cointegration Techniques.

Through a neoclassical growth function, Dees and Vidican Auktor (2018) have shown that increasing renewable energy production positively affects economic growth in the MENA region. Their conclusion is that investing in renewable energy is beneficial for several countries which they considered in the MENA region, and that this could be an incentive to intensify the existing policy towards renewables in the region.

A review of the previous literature reveals three shortcomings. Firstly, the majority of these studies, which have been interested in renewable energies, have been conducted on individual country cases, with limited applicability to the wider region. Bhutto et al. (2014) have listed all the renewable energy studies in the MENA countries since 2005, he found that only nine out of fifty five studies have a regional approach and are limited to country-rich oil resources such as the Gulf Cooperation Council countries (GCC). Secondly, these studies have not proposed a short- and long-term framework to ensure a successful energy transition in this region, but they are limited to providing only passive narrative econometric results. Thirdly to my knowledge, no serious study has been carried out on a panel of MENA-NEICs. In this paper, we will try to enrich the existing literature on renewable energy and the circular economy, using advanced econometric methods based on a panel of MENA-NEICs.

3 Empirical evidence

3.1 The data

This study uses a balanced panel annual data for MENA-NEICs from 2001 to 2015. All variables are transformed into natural logarithms for analysis purposes:

- $lnEC$, the logarithm of electricity consumption from renewable sources measured in million kilowatt hours, such as Hydraulic Energy (may be hydroelectric), Solar radiation and Wind;
- $lnGDP$, the logarithm of real gross domestic product in constant 2000 US$;
- $lnCF$, the logarithm of real capital formation in constant 2000 US$;
- $lnJOB$, the logarithm of the number of jobs in millions of people;

The sample is composed of 5 Non-Oil MENA countries: Tunisia, Morocco, Egypt, Jordan, and Lebanon. All data are obtained from the World Bank (2016) World Development Indicators (WDI) online database. We have used Eviews 7.1 to conduct the analysis.

3.2 The model

Following recent work mainly from Stern (2000) and Lee and Chang (2008), it would then be possible to test the long-run relationship between economic growth on the one hand, and renewable energy consumption, real capital formation and labor on the other hand, using the following production function after linear logarithmic transformation:

$$lnGDP = f(CF, JOB, EC(P)),$$

$$\frac{\partial GDP}{\partial CF} \succ 0, \frac{\partial GDP}{\partial JOB} \succ 0, \frac{\partial GDP, \partial EC}{\partial EC, \partial P} \succ 0, \frac{\partial GDP}{\partial EC} \succ 0 \tag{1}$$

EC is the energy consumption which is itself a function of energy prices (Costantini and Martini, 2010). In order to find the long-run relationship between variables, the following linear logarithmic form is proposed:

$$lnGDP_{it} = \alpha_{1i} + \alpha_{2i} lnEC_{it} + \alpha_{3i} lnJOB_{it} + \alpha_{4i} lnCF_{it} + \varepsilon_{it}, \tag{2}$$

where, ε_{it} is the error term.

3.3 Unit root test

To check the stationarity of the data series, we will use 2 types of unit root tests in panel:

- Levin, Lin et Chu test (LLC, 2002). The panel proposed by these authors is based on the ADF test (Augmented Dickey-Fuller test) which assumes homogeneity in the dynamics of the autoregressive coefficients for all panel units with transversal independence. They consider the following equation:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \delta_i t + \sum_{j=1}^{k} \gamma_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \tag{3}$$

  where Δ is the first difference operator, y_{it} is the dependent variable, ε_{it} is a white-noise disturbance with a variance of σ_ε^2, i indexes country, and t indexes time. The null and the alternative hypotheses of the test are as follows:

$$\begin{cases} H_0 : \beta_i = 0 \forall i \\ H_0 : \beta_i \prec 1 \forall i \end{cases}$$

- Im, Pesaran, Shin test (IPS, 2003): Unlike Levin, these authors proposed a nonrestrictive test since the coefficients are heterogeneous. The hypothesis test becomes:

$$\begin{cases} H_0 : \beta_1 = 0 \qquad \forall_i \\ H_1 : \begin{cases} \beta_i \prec 0 & \text{for} \qquad i = 1, 2 \ldots, M \\ \beta_i = 0 & \text{for} \qquad i = M + 1 \ldots N \end{cases} \qquad M \prec N \end{cases}$$

It is clear that in the null hypothesis all individuals have unit roots whereas the alternative hypothesis allows some of the individuals to have unit roots. In practice, the average of the individual unit roots is used to perform this test:

$$t = \frac{1}{N} = \sum_{i=1}^{N} t_{\beta_1}$$

Table 5 below presents the results of the LLC and IPS unit root tests. The results of the two unit root tests used show that all the variables are not stationary but they become stationary in the first difference.

3.4 Pedroni cointegration test

Since the variables are integrated of order 1, then the existence of the long-term relation between these variables is therefore possible. In the case where the constant and the slopes are heterogeneous, the Pedroni test is applied. By referring to Apergis and Payne (2010a), the following co-integration equation will be estimated:

$$lnGDP_{it} = \alpha_i + \delta_i t + \beta_i lnEC_{it} + \gamma_i lnJOB_{it} + \lambda_i lnCF_{it} + \varepsilon_{it}, \tag{4}$$

where:

- α_i indicates the fixed effect;
- δ_i is the trend coefficient;
- β_i, γ_i and λ_i are the regression coefficients;
- $\varepsilon_{i,t} = \rho_i \varepsilon_{i,t-1} + w_{i,t}$, and $w_{i,t}$ is the error term.

The null hypothesis in the Pedroni test, according to which that there is no cointegration relationship is as follows: $H_0 : \rho_i = 1$. In Pedroni's (2004) method, there are two cointegration tests based on the within approach which includes four statistics (panel tests) and on the between approach which includes three statistics (group tests). In total, there are seven statistics for the tests of the null hypothesis of no cointegration in heterogeneous panels.

However, all these tests are based on the residual and variants of Phillips and Perron (PP, 1988) and Dickey and Fuller (ADF, 1979) tests.

As shown in Table 6, all the seven statistics are significant at 5% level. We therefore reject the null hypothesis according to which there is no cointegration between the variables and we confirm the existence of a long-term equilibrium panel relationship between economic growth, renewable energy consumption, real capital formation and labor. This means that these four variables move together in the long run.

3.5 Causality test

Since the co-integration relation has been verified, a panel-based error correction model (ECM) followed by the two steps of Engle and Granger (1987) is adopted to investigate the long-run and short-run dynamic relationships. The first step estimates the long-run parameters in equation (4) in order to obtain the residuals corresponding to the deviation from equilibrium. The second step estimates the parameters related to the short-run adjustment. The resulting equations are used in conjunction with panel Granger causality testing. The equations to be estimated are therefore the following:

$$\begin{aligned}\Delta lnGDP_{it} = \beta_{1,i} + \sum_{k=1}^{p} \beta_{1,1,i,k} \Delta lnGDP_{i,t-k} + \sum_{k=1}^{p} \beta_{1,2,i,k} \Delta lnEC_{i,t-k} \\ + \sum_{k=1}^{p} \beta_{1,3,i,k} \Delta lnJOB_{i,t-k} + \sum_{k=1}^{p} \beta_{1,4,i,k} \Delta lnCF_{i,t-k} + \gamma_{1,i} ECT_{i,t-1} + u_{1,i,t}\end{aligned} \quad (5)$$

$$\begin{aligned}\Delta lnEC_{it} = \beta_{2,i} + \sum_{k=1}^{p} \beta_{2,1,i,k} \Delta lnEC_{i,t-k} + \sum_{k=1}^{p} \beta_{2,2,i,k} \Delta lnGDP_{i,t-k} \\ + \sum_{k=1}^{p} \beta_{2,3,i,k} \Delta lnJOB_{i,t-k} + \sum_{k=1}^{p} \beta_{2,4,i,k} \Delta lnCF_{i,t-k} + \gamma_{2,i} ECT_{i,t-1} + u_{2,i,t}\end{aligned} \quad (6)$$

$$\begin{aligned}\Delta lnCF_{it} = \beta_{3,i} + \sum_{k=1}^{p} \beta_{3,1,i,k} \Delta lnCF_{i,t-k} + \sum_{k=1}^{p} \beta_{3,2,i,k} \Delta lnEC_{i,t-k} \\ + \sum_{k=1}^{p} \beta_{3,3,i,k} \Delta lnJOB_{i,t-k} + \sum_{k=1}^{p} \beta_{3,4,i,k} \Delta lnGDP_{i,t-k} + \gamma_{3,i} ECT_{i,t-1} + u_{3,i,t}\end{aligned} \quad (7)$$

$$\Delta lnJOB_{it} = \beta_{4,i} + \sum_{k=1}^{p} \beta_{4,1,i,k} \Delta lnJOB_{i,t-k} + \sum_{k=1}^{p} \beta_{4,2,i,k} \Delta lnEC_{i,t-k} + \sum_{k=1}^{p} \beta_{4,3,i,k} \Delta lnCF_{i,t-k} + \sum_{k=1}^{p} \beta_{4,4,i,k} \Delta lnGDP_{i,t-k} + \gamma_{4,i} ECT_{i,t-1} + u_{4,i,t} \quad (8)$$

where the term Δ denotes first differences, $\beta_{j,i,t}$ $(j = 1, 2, 3, 4)$ represents the fixed country effect, k $(k = 1, \dots, p)$ is the optimal lag length determined by the Schwarz Information Criterion, and $ECT_{i,t-1}$ is the estimated lagged error correction term (ECT) derived from the long-run cointegrating relationship of equation (4). The term $\gamma_{j,i}$ $(j = 1, 2, 3, 4)$ is the adjustment coefficient and $u_{j,i,t}$ is the disturbance term assumed to be uncorrelated and to have zero mean.

The values of the variable ECT are calculated from the cointegration equation:

$$ECT_{it} = lnGDP_{it} - \beta lnEC_{it} - \gamma_i lnJOB_{it} - \lambda_{i,t} lnCF_{it} \quad (9)$$

If the ECT coefficients are significant, there is therefore a long-term relationship between the variables. The results of the Granger test are shown in the following Table 7. Table 7 reports the results of short-run and long-run Granger-causality test. According to equation (5), renewable energy consumption, fixed capital formation and labor have positive and significant short-term impacts on economic growth. It can be said that the policies may stabilize economic growth and income when attempting to consume more efficient energy. The ECT is statically significant. It means that long-run adjustment to equilibrium is important in explaining short run movements in economic growth.

With respect to equation (6), only economic growth has a positive and significant short term-influence on renewable energy consumption, and the same relationship exists in the long term since the ECT is statically significant, implying that renewable energy consumption could play an important adjustment factor as the system departs from the long-run equilibrium.

The seventh equation shows that economic growth, and the renewable energy consumption increase capital formation in the short term, but labor does not have an effect on capital formation. Finally, Equation (8) indicates that economic growth and capital formation have positive and significant effects on labor, but the consumption of renewable energy does not have an impact on the labor.

In the four equations, we note that in the long term, the error correction term is significant at the 5% level; that is, the differences between the real values and the long-term values will be corrected with the ECT coefficients in each period. It also means that long-run adjustment to equilibrium is important in explaining short run movements in economic growth, renewable energy consumption, real capital formation and labor. So the causality test shows that in the short term and long term there is a two-way relationship between economic growth and each of the other variables studied. These results are the same as for Apergis and Payne (2010a,b,c) for 20 OECD countries, for 13 Eurasia countries, and for 9 South America countries.

Thus the dilemma of fossil fuel scarcity and economic growth may find a feasible solution through the transition of MENA-NEICs to a safer and less CO2-emitting energy system without hindering economic and social development. However the question that arises at this stage is, which energy mix should be chosen to follow the path of sustainable development? Otherwise, how can this transition be done?

Three solutions can be formulated for this purpose:

- permanent removal of any fossil fuel subsidies and let the market play its role;
- full subsidy of renewable energy production (next to the fossil fuel subsidy);
- and gradual liberalization of the energy market.

If the first two solutions were not easily applicable given the fiscal and political difficulties, these countries can adopt a dynamic combined incentive approach based on a partial and decreasing subsidy of renewable energies and a partial but increasing adjustment of the price of fossil fuels, which is gradually evolving towards a market-driven incentive offer and without state intervention. This approach ensures a gradual energy transition and a balance between fiscal sustainability and political stability.

4 Conclusion

The main objective of this study is to draw the attention of policy makers in MENA-NEICs and other similar countries to the value of renewable energy development, and to demonstrate the economic and environmental viability of low-carbon development in a number of selected countries. For this, the causal link between renewable energy consumption and economic growth has been studied both in the long term and in the short term for the period 2001-2015.

The unit root tests results of Im-Pesaran and Shin, and Levin-Lin and Chu show that all the variables introduced into the model are not stationary but they become stationary in the first difference. The results of the Pedroni (2000) test indicate that there is a long-term relationship between these variables.

Granger's causality test in VECM indicates that there is a two-way relationship between renewable energy consumption and economic growth in the long term and in the short term.

We can conclude that renewable energy like any other energy influences the macroeconomic variables (unemployment, saving,), because most macroeconomic variables depend on GDP. Renewable energy consumption also influences economic growth indirectly, that is, it has a positive effect on capital formation and the latter increases economic growth. The observation of the two-way relationship shows the importance of the consumption of renewable energy in this region.

Thus, to ensure sustainable economic growth, MENA-NEICs must encourage the deployment of renewable energies to the detriment of fossil fuels. To reach this goal, an investment incentive is suggested in this sector, which will be medium and long-term market-based. In the short term, a transitional stage of a mixed and dynamic approach consisting of a program of partial subsidies for renewable energy production and progressive liberalization of the conventional energy sector, through partial price adjustments fossil fuels that is progressively moving towards a final stage where subsidies to energy will be completely removed, is suggested. In this way, these countries can make the trade-off between fiscal sustainability (subsidizing renewable energies and gradual liberalization of conventional energies) and political stability (the continued provision of affordable priced energy, which underpins the "social contract" with their citizens).

At the end of this paper, it should be noted that MENA-NEICs are more favored countries for the large-scale deployment of renewable energies. Indeed, these countries have exceptional geographical features, including intense sunshine, low rainfall and the existence of flat lands. These favorable geographical factors will make it possible to achieve a yield of Kilowatt (KW) installed better than in other European countries and to largely offset the costs of transport from the south to the north of the Mediterranean. This idea paves the way for a future research focus on establishing a sustainable and regionally integrated development model for these countries based mainly on the production and export of renewable energies to Central and Eastern Europe. This model will later replace current growth models based on domestic demand and the import of fossil fuels, which eventually show their intrinsic limitations.

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Table 1: MENA Domestic Targets on Renewable Energy

Country	Target	Date
Algeria	20% of generation	2030
Bahrain	5% of installed capacity	2020
Egypt	20% of electricity demand (generation)	2020
Iran	5 GW wind and solar capacity	2020
Jordan	10% of electricity demand (generation)	2020
Kuwait	15% of electricity demand (generation)	2030
Morocco	42% of installed capacity by 2020;	2020
	including 2 GW solar and 2 GW wind	
Qatar	1.8 GW solar (16% of generation) by 2020;	2020
	10 GW solar PV by 2030	2030
Saudi Arabia	9.5 GW of renewable energy	2023
Tunisia	25% of capacity	2030
UAE	24% clean energy (including nuclear) in energy mix by 2021;	2021
	Abu Dhabi-7% of capacity by 2020; Dubai-7% capacity by 2020	2020
	and 15% by 2030 (versus 'Business As Usual')	2030
Yemen	15% of generation	2025

Source: IRENA, Mittal, Energy Information Administration (2016)

Table 2: Geographical Breakdown of 2018 Renewable Energy Investment

Country / region	Investment in $ billion	Share in global investment (rounded)	Investment growth rates in renewables 2017-2018
China	91.2	32%	-37%
Europe	61.2	21%	39%
USA	48.5	17%	1%
Asia-Oceania	44.2	15%	6%
India	14.445	5%	-
Middle East and Africa	15.4	5%	57%
America (other than Brazil and USA	9.8	3%	-23%
Brazil	3.155	1%	-
Total	288.9	100%	-

Source: Author's calculation based on UNEP 2019

Table 3: Renewable Energy Resource Indicators in MENA Countries

Country	Global Horizontal Irradiance (KWh/m^2/year)	Direct Normal Radiation (KWh/m^2/year)	Wind-Full Load Hours/year	Geothermal Temperature (°C) at 5000m
Algeria	1970	2700	1789	213
Bahrain	2160	2050	1360	100
Egypt	2450	2800	3015	180
Iraq	2050	2000	1789	100
Jordan	2320	2700	1483	100
Kuwait	1900	2100	1605	100
Lebanon	1920	2000	1176	100
Libya	1940	2700	1912	100
Morocco	2000	2600	2708	281
Oman	2050	2200	2463	100
Qatar	2140	2200	1421	100
Saudi Arabia	2130	2500	1789	275
Syria	2360	2200	1789	0
Tunisia	1980	2400	1789	188
UAE	2120	2200	1176	100

Source: International Renewable Energy Agency. Pan-Arab Renewable Energy Strategy 2030, Road Map of Actions for Implementations.

Table 4: Renewables (Ex-hydro) Electric Installed Capacity in MENA Countries

Country	Wind MW	Solar PV MW	Solar CSP MW	Other Renewables MW	Total Renewables Installed Capacity Megawatts	Renewables as of Total Installed Capacity	Total Installed Capacity Gigawatts
Algeria	10	7.1	25	0	42.1	0.24	17.24
Bahrain	0.5	5	0	0	5.5	0.14	3.97
Egypt	610	15	20	0	645	2.05	31.45
Iraq	0	0	0	0	0	0	13.28
Iran	135	34	0	6.8	175.8	0	70.3
Jordan	1.45	13.6	0	3.5	18.55	0.52	3.56
Kuwait	0	1.8	0	0	1.8	0.01	14.99
Lebanon	0.5	1.6	0	0	2.1	0.08	2.5
Libya	0	5	0	0	5	0.10	5.15
Morocco	750	15	20	0	785	10.21	7.69
Qatar	0	1.2	0	40	42.2	0.47	8.75
Saudi Arabia	0	19	0	0	19	0.03	61.87
Syria*	0.15	2	0	0	2.15	0.04	4.80
Tunisia	245	20	0	0	265	6.12	4.33
UAE	0	33	100	1	134	0.46	29.96
Yemen	0	3	0	0	3	0.35	0.85
MENA	1750	155	165	41	1856	1.0	283

Note: * limited data availability. Source: RCREE/AFEX, MEES

Table 5: Panel Unit Root Test Results

Variables	**LLC**		**IPS**	
	Level	**First difference**	**Level**	**First difference**
$lnPIB$	-0.45 (0.0919)	-5.21* (0.0000)	-0.62 (0.0721)	-6.01* (0.0000)
$lnCF$	-4.23 (0.1721)	-5.14* (0.0000)	-5.13 (0.1511)	-5.12* (0.0000)
$lnJOB$	-0.74 (0.0812)	-2.64* (0.0000)	-6.50 (0.0913)	-6.51* (0.0000)
$lnEC$	-0.99 (0.2110)	-7.10* (0.0000)	-0.76 (0.0875)	-8.76* (0.0000)

Note: * denotes a statistical significance at the 5% level. The null hypothesis is the non-stationarity hypothesis. Lag selection (Automatic) based on Schwarz Information Criteria (SIC)

Table 6: Cointegration Test

	Test statistic	**Probability**
Within dimension test		
Panel υ-statistic	6.3245*	0.0000
Panel ρ-statistic	-8.0442*	0.0001
Panel PP-statistic	-14.7825*	0.0000
Panel ADF-statistic	-15.1231*	0.0000
Between dimension test		
Panel ρ-statistic	-2.1210*	0.0000
Panel PP-statistic	-7.3658*	0.0000
Panel ADF-statistic	-7.2514*	0.0004

Note: critical value at the 5% significance level denoted by *. The test includes intercept and trend. The null hypothesis is that the variables are not cointegrated. Lag length selected based on SIC automatically with a max lag of 7.

Table 7: Panel causality test results

	Sources of causation				
Dependent	Short run				Long run
variable	**ΔlnGDP**	**ΔlnREC**	**ΔlnJOB**	**ΔlnCF**	**ΔlnETC**
ΔlnGDP		2.2111 (0.0211)*	0.3124 (0.0032)*	1.0124 (0.0492)*	-0.0321 (0.0121)*
ΔlnREC	2.1230 (0.0322)*		0.9510 (0.1524)	3.0217 (0.3120)*	-01241 (0.0001)*
ΔlnJOB	3.2124 (0.0000)*	0.3251 (0.1421)		0.0111 (0.0321)*	-0.0432 (0.0036)
ΔlnCF	4.2127 (0.0239)*	0.0872 (0.0111)*	0.0941 (0.7451)		-0.0754 (0.0121)*

Note: * indicates that the variables are significant at the 5% level. P-values are reported in parentheses.