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Article

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Reality and Prospect of Electricity Production from Renewable Energies in Arab Countries: Analytical Study (1990–2017)

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ABSTRACT

This study aims to highlight the status of electricity production from renewable energies in some Arab countries due to their potential; that could lead to an increase in the achievement of a significant part of sustainable development if it will be exploited. In addition, this study seeks to highlight the contribution of each renewable energy in producing electricity for every Arab country. One of the results of this study is that there is a very strong correlation (0.995) between electricity consumption and production in the considered countries, that means that the increase in electricity consumption is pushing the production to achieve self-sufficiency. Moreover, there is a weak and low correlation (−0.420) between the electricity production from renewables and CO_2 emissions per capita, which means that the increase in the production of electricity from renewables in Arab countries reduces CO_2 emissions per capita, and this is very logical. It should be noted that some Arab countries have taken rapid steps towards pioneering electricity production through renewables such as Egypt and Morocco.

Keywords: Electricity Production, Renewable Energy, Arab Region
JEL Classifications: O57, Q42, Q48

1. INTRODUCTION

Against the backdrop of the serious and scientifically justified consequences of climate changes such as global warming, flooding … etc, and with the increasing of global fossil fuels' consumption, renewable energy sources and environmentally friendly energy substitutes, such as wind, solar, biomass and geothermal, have had further importance since they are undepleted sources and do not cause any harmful emissions to the environment.

Renewable energies have been increasing in the world since 2009, with an annual growth rate of 8–9% registered at record levels by the end of 2016, with a growth rate 8.7% in 2016.

In addition, the installed capacity of renewable energies reached a record level of 2006 GW -according to the International Renewable Energies Agency (IRENA)- which is mainly derived from solar power (32%) and wind power (12%). According to the International Energy Agency (IEA) outlook in 2017, the installed capacity of renewable energies will know a growth of 43% in 2022 due to new solar photovoltaic (PV) installations in China and India. By the same report, solar PV will enter a new era in the five coming years because of lower prices, the vitality of markets especially in China, and the improvement of the policies for a large-scale solar energy diffusion (Yassaa, 2018).

The production of renewable energies is reported to cover only 20% of electricity consumption despite the efforts of some countries to spearhead the production of renewable energies have been recorded. As China is the lead in the production of renewable energies through wind power, the United States of America is the second in power production through the biomass, the third place is for Germany through its adoption of solar panels.

The Arab countries are striving to keep pace with the sustainable development of the developed countries that produce electricity from renewable energies, especially if it is known that the ingredients of some Arab countries are far superior to those of the developed countries that have pioneered the electricity production from renewable energies. Although, a number of Arab countries such as Jordan and Morocco have resorted to the importation of electricity in the past few years, many of these Arab countries -North Africa- have begun to conclude cooperation agreements to produce electricity from renewable energies, such as Morocco and Algeria due to their potential because of the vast desert areas that can receive huge amounts of sunlight; not to mention, the ingredients of wind energy in other Arab countries such as Egypt, UAE, Jordan according to IRENA.

That is what we will try to highlight through this study by answering the following question: What is the reality of electricity production from renewable energies in the Arab countries? And what are their future strategies in this area?

2. LITERATURE REVIEW

2.1. Electricity Production

2.1.1. Electricity as a secondary energy

Electricity is a form of energy and more accurately an energy vector that has a high flexibility of use. Also, it has virtually no competitors in such applications as telecommunications, computing or lighting. It can be easily transported but difficult to store (Bonal and Rossetti, 2011).

Electricity is by far the most important of secondary energies. Its industrial and commercial development, that has continued since its origins i.e., 120 years, is justified by the intrinsic qualities of this form of energy, in particular the diversity of its modes of production, the flexibility and the convenience of its many uses.

Its success is measured by its penetration rate, i.e., the share that electricity represents in the final energy's balance. It reached about 20% worldwide at the end of the twentieth century, but in the most industrialized countries it exceeded 40%.

Electricity, by its ability to satisfy in every place and at any time multiple energy requirements through a highly branched distribution network, has contributed significantly to the economic boom. Its penetration rate could be seen as an indicator of technical development or an index of a country's standard of living. The electrical system has taken on such importance that it has become strategic and that many governments have wanted to monitor it. But today, this form of energy tends to be considered as an ordinary product to be exchanged freely in the market (Naudet et Reusso, sans date de pub).

2.1.2. Modes of electricity production

One of the reported flexibilities of the electrical system is to be able to have means of production fuelled by the most diverse energy sources, whose technical and economic characteristics are sufficiently varied to satisfy all aspects of demand, and whose geographical locations can be very different, imposed either by the energy source or for the good dynamic balance of the network.

The modes of production are classified in large categories according to the principle of the transformation of the primary energy used into electricity (Naudet et Reusso, sans date de pub).

The production and distribution of electricity are, at present, key issues in the energy field. The list is long-discussed about them: CO_2 emissions, reasoned use of electricity, importance of investments to be made to meet demand, place of nuclear power, development of renewable energies, development and regulation of networks, storage of energy, sale price of electricity etc.

Electricity has the peculiarity of being an instantaneous energy. It is not stored in large quantities. It is, therefore, necessary that at any time its production equals its consumption, although neither is constant. Two situations exist. The easiest way is when there is no network. The consumer can only use what he produces. It can still be serviced by storage. When a network exists it is necessary to ensure a complex work of adjustment to maintain to all users a quality electricity: Frequency, constant voltage, and no break. The adjustment must always take into account changes in production and consumption. The variations in consumption present a daily cycle and a seasonal cycle (Mathis, 2011). In brief, electricity is produced through various primary energy sources that may be depleted or renewable, and each source has its pros and cons. The Table 1 can explain that oil is not listed because its uses are secondary in electricity production.

2.1.3. Electricity production from renewables

2.1.3.1. Electricity production from wind sources

Wind turbines, modern windmills, transform the mechanical energy of the wind into electrical energy. Their benefits compared to windmills are: A better yield, the production of a transportable and usable energy for many applications (Mathis, 2011).

2.1.3.2. Electricity production from hydraulic sources

The principle at work in hydroelectricity involves using the force of water created by a head of water (artificial dam or natural waterfall) to drive a turbine connected to an electricity generator. Some hydroelectric dams are equipped with a pumped-storage plant and therefore must have an upper and lower storage reservoir (Observ, 2013). Hydroelectric installations are classified first according to their nominal power (Naudet et Reusso, sans date de pub):

- Micro-hydropower: Power <100 kW;
- Mini-hydropower: Power between 100 KW and 2 MW;
- Small hydropower: Power between 2 MW and 10 MW;
- Large hydropower: Power exceeding 10 MW.

2.1.3.3. Electricity production from biomass

The biomass sector breaks down into four categories: Solid biomass (wood, wood waste, bagasse, farming waste and animal

Table 1: Advantages and disadvantages of primary energies for electricity generation

Characteristics	Coal	Natural gas (combined cycle)	Nuclear	Renewable energies
Size	Big	Average	Very big	Very small (solar PV) average (ferme wind) big (hydraulic)
Benefit of the scale factor	Yes	No	Yes	No
Investment cost	Big	Average	Very big	Very big for hydraulic average for others
Length of administrative procedure	Long	Long	Long	Long
Construction time	Average	Short	Long	Short, long for hydraulic
Operating and maintenance costs	Average	Weak	Average	High (low for hydraulics)
Fuel cost	Average	Big	Weak	Nil (wind, hydro, solar) big (biomass)
Production of CO_2	Grande	Average	Nil	Nil
Security of supply	Good	Average	Good	Good
Acceptability by the public	Bad	Bad	Bad	Bad
Geopolitical risks	Nil	Average	Nil	Nil

Source: Furfari, 2012

manure), biogas (from landfills, sewage treatment plants or industrial or farm anaerobic digesters), solid renewable municipal waste and liquid biomass (bioethanol, biodiesel, vegetable oil, etc.). Liquid biomass is mainly used as automobile carburation and only marginally for producing electricity (Observ, 2013).

2.1.3.4. Electricity production from solar sources

Two quite distinct technologies are used to produce solar power. PV module technology uses one of the properties of (generally silicon) semi-conductors that generates electrical current when it comes into contact with light. The second technology is solar thermal plant (or concentrated solar power plant) technology that concentrates the sun's rays using mirrors on a focal point to obtain very high temperatures (400–1000°C) to produce water vapour and thus electricity. These concentrating solar power (CSP) plants can operate with another energy source (generally natural gas), in which case they are known as hybrid plants. They can also be equipped with storage systems, to continue producing electricity after sundown or in the temporary absence of sunlight during the day (Observ, 2013).

2.1.3.5. Electricity production from geothermal sources

Geothermal electricity production entails converting the heat of high-temperature aquifers (150–350°C) using AC turbo generators. If the groundwater temperature is 100–150°C, electricity can be produced by using binary cycle technology, in which case an exchanger transmits the groundwater heat to a fluid (isobutane, isopentane or ammonia) that flashes to a vapour at a lower temperature than that of the water. Geothermal power is generally harnessed in volcanic zones and tectonic activity zones (Observ, 2013).

2.2. Current Renewable Energy Status in Arab Region

2.2.1. Renewable energy potencial in Arab region

The energy mix in Arab region is heavily dependent on fossil fuels. This is especially true for the energy exporting countries, with very low penetration of renewable energy sources. On the contrary, renewables are mostly developed in energy importing countries. Historically, hydropower has been the most dominant source.

The region is well suited for the development of renewable energy technologies for different applications. As far as solar energy technologies are concerned, most of the countries lie in the so-called Sunbelt, with global horizontal irradiance values ranging from 1,600 kWh/m²/y in coastal areas of the mediterranean to 2600 kWh/m²/y in the desert, and direct normal irradiance varying from 1800 kWh/m²/y to more than 2800 kWh/m²/y. This is one of the best areas of the world in terms of solar energy, both for PV and CSP applications. The potential for wind is also very high in several countries of the Mediterranean, such as Morocco, Egypt, with more moderate, but still interesting, potential in GCC countries and Iraq. Other sources, such as biomass or geothermal power, hide a huge potential, but they still remain underexplored (Middle East and North Africa Regional Architecture, July 2017).

2.2.2. Installed capacity and electricity production from renewables in Arab region

Since 2014, an impressive scale-up of renewable installed capacity has been observed in many Arab countries. The total installed capacity of all renewables (including hydro) reached around 14 GW in 2015. Excluding hydro, the total installed capacity in 2015 amounted to about 3.0 GW a 150% increase when compared to 2012 where the installed capacity was 1.2 GW excluding hydropower (IRENA, 2016). In 2016, the renewable energy in the region accounted for 6% of total energy generation, approximately 14GW. Mostly, it is in the form of hydropower (4.7%), solar power (0.4%) and wind energy (0.9%) (Alevizos, 2017).

In 2017, the installed capacity of renewables reached around 15 GW, it is in the form of hydropower (68%), wind energy (14%) and solar power (14%). The rest were for other renewables. In general, the installed capacity of renewables has experienced constant increases during the period 2000–2017 (Figures 1 and 2).

In detail, Morocco continues to lead the region in terms of total installed renewable generation capacity (excluding hydropower). As a result of its long-term efforts and successes in implementing its renewable energy action plan, Morocco has increased its share of solar from 35 MW in 2014 to 198 MW in 2015, and wind from 290 MW in 2012 to around 790 MW in 2016.

Egypt also secured its leading position for the region in wind energy, by commissioning the new 200 MW Gulf of El-Zayt project on the Red Sea coast. The total solar PV installed capacity in Egypt reached around 90 MW, predominantly due to the PV rural electrification programme, supported by the UAE, and the feed-in tariff (FiT) small-scale programme.

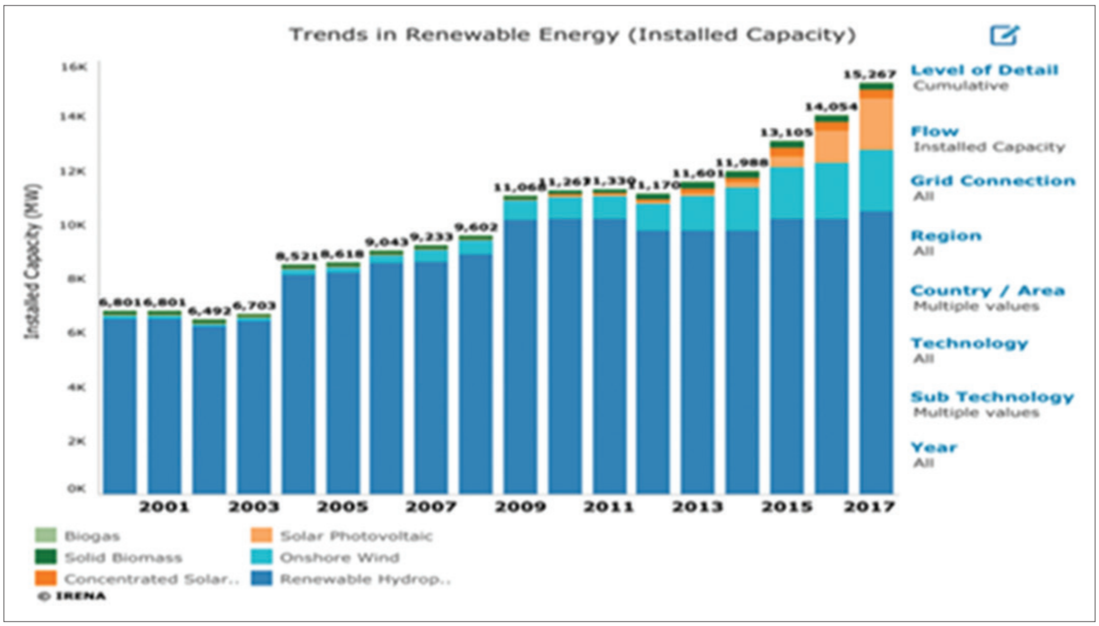
The UAE maintains a prominent regional position in solar installations with a combined 133 MW of operational CSP and PV capacities. Almost all other Arab countries have distributed and utility-scale PV installations.

Jordan has made a substantial leap, with wind and PV projects growing tenfold since 2014, to reach a total capacity of 216 MW (IRENA, 2016).

However, the most remarkable case is that of Sudan. The reason why is that the total installed capacity amounts for 50% of renewable energy share, due to the large hydro capacity, reaching 1.5 GW.

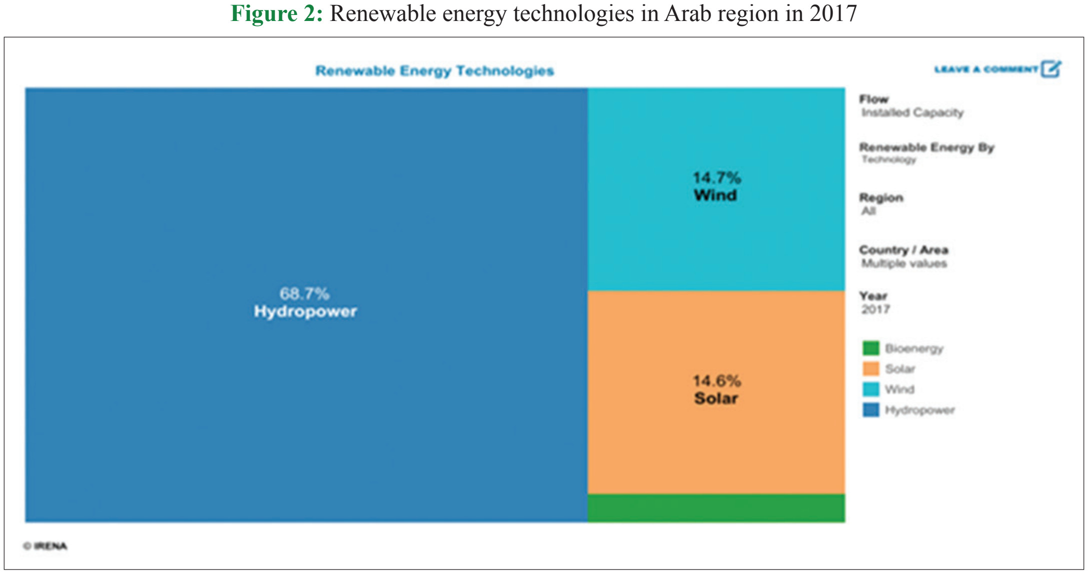
Nevertheless, there is a sad fact about the renewable capacity in the region. There are many countries, like Qatar, Kuwait, Bahrain and Saudi Arabia, which have not installed renewable capacity yet. Although they may find a huge advantage in these sources, they prefer not to do so, having them unused. As of total power capacity, the renewable capacity ranges between 0.05% and 0.6% in these countries. These Arab states do have a strong renewable potential, but they prefer to rely on the fossil fuels or the oil much more than installing the necessary capacity. However, the whole region decided to make this shift and, in the next years, it will experience a huge difference in the energy sector (Alevizos, 2017).

Figure 1: Installed capacity of renewable energy in the Arab Region 2000–2017



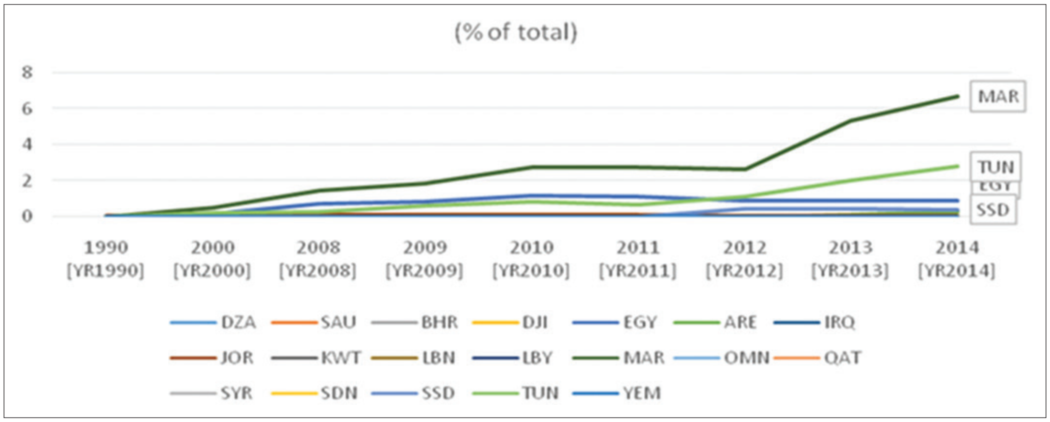
Source: IRENA (2018). Available from: http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=16. (Last retrieved on 2018 July 16).

Figure 2: Renewable energy technologies in Arab region in 2017



Source: IRENA (2018). Available from: http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=16. (Last retrieved on 2018 July 16).

Figure 3: Electricity production from renewables excluding hydropower



Source: The World Bank, IEA Statistics© OECD/IEA. Available from: https://www.iea.org/t&c/termsandconditions/. (Last retrieved on 2018 July 20).

It is noted in Figure 3 that Morocco has a competitive advantage in producing electricity from renewables. In general, its electricity production is based on coal as a raw material, followed by wind, and hydroelectric power.

The curve shows that Tunisia surpassed Egypt in generating electricity from renewables in the last 2 years, after the two countries were in strong competition in the first 20 years studied (1990–2010). Moreover, the effort of the southern Sudan and Sudan in producing electricity from renewables can be considered. It is also necessary to mention the delay of some Arab countries in the production of electricity through renewables -if not a complete lack of production- such as Yemen, Qatar, Oman, Libya, Kuwait and Bahrain.

2.2.3. National renewable energy actions

The primary objective in harnessing the renewable energy potential in the region is to meet the increasing demand for energy and water from growing populations. Renewables can supply secure, clean energy, providing an efficient solution to climate change by abating harmful greenhouse gas emissions.

Policy makers and power producers are increasingly eager to invest in renewable energy in Arab countries, and a number of high-profile projects and targets have been launched in the region.

In general, targets are set at a national level. There is a variety among the region as far as the investment in renewable energy is concerned. There are different plans depending of the deployment year. Other countries in the Arab region have set targets for 2020 (mid-term goals), while others have set targets for 2030 (long-term goals). In many Arab countries, goals have been set in order to meet the domestic demand.

The shift towards renewables is based on the most efficient types of this, which is wind and solar energy. Arab countries focus on these, because they are the most mature and can give tremendous results. However, countries in the region will increasingly start to look at other types of renewables, such as wasteto-waste energy plants or geothermal power. With the necessary technology, waste-to-waste plants help minimize the negative side of waste, and generate this into electricity (Alevizos, 2017).

Table 2: Renewable energy targets by country MW

Country	R.E					
	Wind	PV	CSP	Other	Total (%)	Target
	MW					
Algeria	5.000	13.600	2.000	1.400	22.000 (27)	2030
Egypt	7.200	2.300			9.500 (20)	2022
Jordan	800	1.000		50	1.850 (10)	2020
Morroco	4.200	4.560		1.330	10.090 (52)	2030
Tunisia	1.500	1.900	300		3.700 (30)	2030
UAE-AD		1.500			1.500 (7)	2020
UAE-Dubai		5.000			5.000 (25)	2030
KSA	9.500				9.500 (10)	2023
Kuwait	4.500				4.500 (15)	2030

Source: (APICORP Energy Research, May 2018). CSP: Concentrating solar power

These targets can be summuriezed in the Table 2.

An important milestone for the deployment of renewable energy in the Arab region was the adoption of the "Pan-Arab Strategy for the Development of Renewable Energy 2010–2030." Adopted under the LAS umbrella at the third Arab Economic and Social Development Summit in 2013, the strategy sets long-term targets for electricity production from renewables. To reach those targets, the region must scale-up renewable energy development substantially. In addition to electricity, the strategy also sets out regional aims to scale up renewables for heating and cooling, transportation, desalination and rural electrification (IRENA, 2016).

As net energy importers and exporters operate under different circumstances, progress has been uncertain. To support renewable energy, states such as Jordan and Egypt have introduced FiT, tax abatements and power-purchase agreements (PPA). At the same time, however, energy exporter nations (with the exception of the UAE) have done little to supplement renewable energy, and continue to count on conventional sources with lower extraction costs to meet the growing demand for electricity. However, the situation appears to be about to change: Saudi Arabia, in particular, finally seems ready to call tenders for wind and solar panel farms over the coming year. A fall in the cost of technology has enabled some countries to move towards increasingly competitive renewable energy cost-wise. In the meantime, government support (as in other parts of the world) will become a fundamental tool to develop the renewable sector in the area (Strocchia 2017).

To sum uo, tow crucial factors support the transition to renewables in generating electricity, eventhough in slow steps, which are (Strocchia, 2017).

2.3. The Continual Fall in Costs

In the final analysis, renewable energy will be successful, if costs are competitive. The IEA estimated a 30% decrease in the average, global costs for onshore wind energy, whereas PV solar costs slumped 70% between 2010 and 2015. The agency expects a further fall in PV and wind costs of 25% and 15%, respectively, by 2021. These cost savings are mainly a result of technological developments and of the economies of scale due to increased production in Asia. Constant investments and additional capacities will also result in further cost reductions. Nevertheless, other export countries are finding difficulties in starting up their programmes. Large oil and gas reserves and contained extraction costs have ensured the demand for hydrocarbons continues to grow in countries such as Kuwait, Qatar and Algeria. This slow progress is due mainly to the uncertainty of their policies and lack of an efficient, legislative framework. Kuwait's declared objective is to achieve 5% of renewable energy by 2020, but it only has the 50 MW CSP installation in Al-Shagaya currently in the pipeline. Masdar will construct a 50 MW wind farm in Harweel, Oman. At the same time, the government has put forward proposals to develop 200 MW of PV energy. Other countries, such as Qater and Bahrain, have made minor investments in renewable energy, but nothing significant is envisaged for the near future. A short time ago, the Algerian government announced it wanted to develop approximately 4 GW of PV energy as part of an ambitious programme, which envisages developing 22 GW of renewable energy by 2030.

2.4. New Policies to Support the Development of Renewable Energy

As the nations gradually accelerate their development in the renewable sector, legislation is improving significantly. Jordan was the first country to introduce FiT in 2012. Egypt also has an FiT programme, which appears rather muddled at present. It is still too soon to understand the reaction of potential investors and whether they will be able to ensure an adequate return on investments. Morocco has no FiT policies, even though it launched a similar programme called EnergiPro in 2006. The latter envisaged the opportunity for industrial consumers to invest in renewable energies, whereas the state-owned utility guaranteed it would purchase any surplus power at favourable tariffs. Other economic support mechanisms in the region included tax relief, net metering and capital grants. Legislation, on the other hand, envisages standards for renewable energy and national objectives. However, the main incentives for private promotors will continue to be the government-backed, long-term, PPA contracts. The latter, together with the competitive prices in the area, will be the main spur.

3. DATA AND RESEARCH METHOD

This study relied upon the analytical descriptive method, where the evolution of electricity production from renewable energies in some Arab countries have been described to know the most important renewable source used in these countries. Moreover, the analytical method can be explained in using the method of principal component analysis (PCA) to analyze and compile the variables of the considered countries that are homogeneous in terms of some studied characteristics. These characteristics are electricity production, electricity production from renewable energies, electricity consumption, gross domestic product (GDP), CO_2 emissions. This method of analysis helps to draw a parameter to bring down the best image of the homogeneous countries' grouping in terms of characteristics, and to shorten them into two properties which are the axes of this parameter (Table 3).

This study relied on the IEA data, where the agency provides the information required in it, especially those relating to the production of electricity from renewables in each Arab country. It should be noted that the agency does not provide information about Djibouti even though this country is considered as an Arab one since it has been recently approved by the League of Arab

Table 3: Electricity production from renewables in some Arab countries in 2015

Country	Country code	ELC production in 2015	from RE in 2015	ELC consumption in 2015	GDP (current US) million 2016	CO_2 emissions* In 2015
Algeria	DZA	68.798	203	50.153	159.049	3.29
Saudi Arabia	SAU	338.336	1	292.765	646.438	16.85
Bahrain	BHR	28.484	0	27.814	32.179	21.83
Egypt	EGY	181.977	15.030	154.205	332.791	2.17
UAE	ARE	127.366	296	111.076	348.743	19.68
Iraq	IRQ	68.922	2.572	35.585	171.489	3.63
Jordan	JOR	19.014	176	16.127	38.655	3.13
Kuwait	KWT	67.918	0	43.296	110.876	21.93
Lebanon	LBN	18.396	479	16.603	49.599	3.88
Morocco	MAR	31.216	6.102	29.939	103.606	1.60
Oman	OMN	32.758	0	28.912	66.293	14.32
Qatar	QAT	41.499	0	36.378	152.452	35.77
Sudan	SDN	13.047	8.420	10.580	95.584	0.38
Tunisia	TUN	19.676	772	15.437	42.063	2.28
Yemen	YEM	5.326	0	3.114	27.318	0.42

*CO_2 Emissions from fuel combustion only. Emissions are calculated using IEA's energy balances and the 2006 IPCC Guidelines. Source: IEA Statistics© OECD/IEA (2018). Available from: https://www.iea.org/t&c/termsandconditions/. (Last retrieved on 2018 July 20). GDP: Gross domestic product

States. Also, the absence of Libya in the analysis due to the lack of statistics on its GDP for the year 2016 from the World Bank website as well as Syria and the southern Sudan.

4. RESULTS AND DISCUSSION

4.1. Factorial Analysis Method

Data analysis methods can be used for previous information after using the method of factorial analysis to find the level at which we project the picture that summarizes, in the best way, the real situation of any body, that is, less distorted. We can use the method of PCA which aims to group items with similar characteristics. Following the introduction of these data into the relevant data analysis program XLSTAT2018, we have been able to obtain the information set out successively as follows:

4.2. Correlation Matrix between Variables

Through the correlation matrix in Table 4, we can deduce some of the correlation coefficients between the studied characteristics. The matrix is diagonal symmetrical with the value "1." The matrix also resolves many correlation coefficients between the considered elements (characteristics) where values, whether positive or negative, that approach to "zero, 0" can be ignored. The following conclusions can, therefore, be drawn:

- There is a positive and very strong correlation (0.995) between the consumption and production of electricity in the studied Arab countries, which means that the increase in electricity consumption is pushing the production for more increase to achieve self-sufficiency.
- There is a very strong correlation (0.976) between the GDP and the production of electricity in the considered countries. This means that the increase in electricity production is contributing to an increase in GDP, which is very logical.
- There is a weak and negative relationship (−0.420) between the production of electricity from renewables and CO_2 emissions per capita in the considered Arab countries, which means that the increase in the production of electricity from renewables reduces CO_2 emissions for the Arab individual, and this is also very logical.

4.3. Projection of Elements

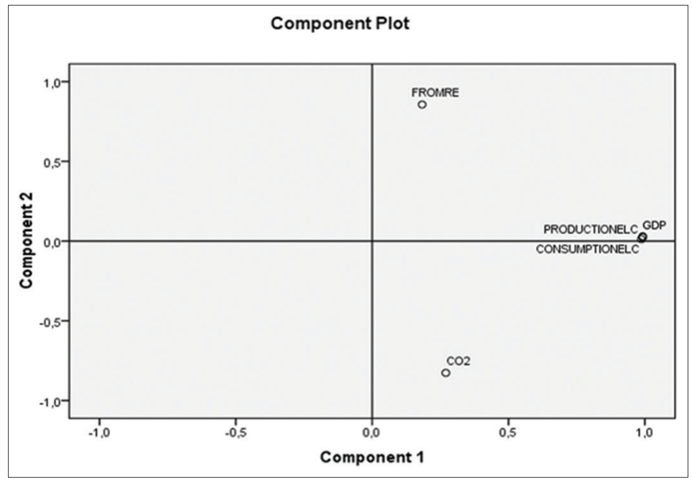
The corresponding figure outlines the projection of elements on the level, and as noted, the cloud of elements has given projections close to the perimeter of the circuit (mathematically [Cos α]^2), which means that the points are well represented and the quality of the representation is acceptable and has high quality. It also shows that the F1 factor contributes significantly to the representation of countries while the second factor F2 contributes less, and the table in the Appendix shows the largest squared of (Cos α)^2 located in F1, F2, respectively(Figure 4).

4.4. Projection of Variables (Countries)

We can watch the spread of the cloud points of the considered countries at the level of the generator of two rays F1, F2 and deduce some observations about the studied characteristics.

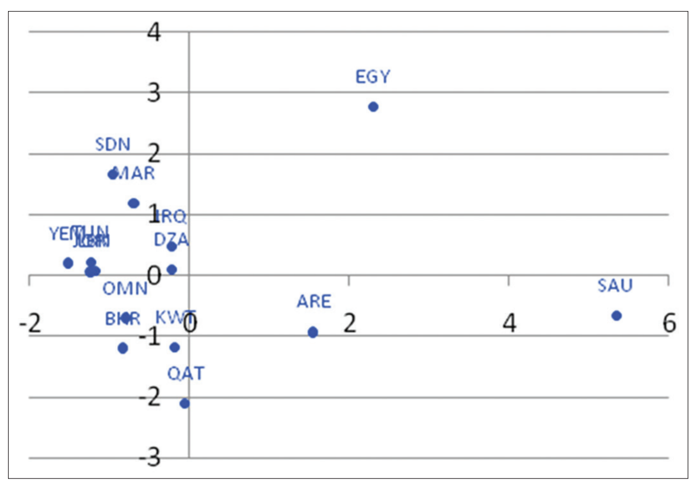
From the Figure 5, we can conclude that the studied countries were divided, according to the calculated, data into four major groups,

Figure 4: The projection of the studied elements which are electricity production, electricity production from renewable energy, electricity consumption, gross domestic product, and CO_2 emissions per capita



Source: SPSS v17 programme output

Figure 5: Projection of studied Arab countries based on the five characteristics studied



Source: XLSTAT2018 programme output

Table 4: Correlation matrix

Correlation	ELC production	From RE	ELC consumption	GDP	CO_2
ELC production	1.000	0.164	0.995	0.976	0.199
From RE	0.164	1.000	0.165	0.165	−0.420
ELC consumption	0.995	0.165	1.000	0.973	0.210
GDP	0.976	0.165	0.973	1.000	0.228
CO_2	0.199	−0.420	0.210	0.228	1.000

Source: SPSS v 17 programme outputs, GDP: Gross domestic product which took into account the proximity of the projection to F1 axis as it is the most representative. It produces by classification method PCA homogeneous core groups in terms of studied characteristics generally which are as follows:

- Group 1: It is Morocco and Sudan where there is considerable similarity in terms of characteristics with significant production of electricity from renewables, small amount of CO_2 emissions per capita in these two countries, and an average GDP.
- Group 2: Qatar, Kuwait and Bahrain, which are homogeneous in terms of their considered characteristics. They have no electricity production from renewables (production of electricity relies mainly on gas, coal and other depleted sources of energy), large amount of CO_2 emissions per capita of these countries, and a considered GDP.
- Group 3: Saudi Arabia, the United Arab Emirates is characterized by almost zero electricity production of renewables, large amount of CO_2 emissions per capita, and an average GDP.
- Abnormal element: Egypt is characterized by a large production of electricity from renewables, very small amount of CO_2 emissions per capita, and an average GDP.
- Group 4: Other Arab countries studied and not previously mentioned are characterized by inconsistencies between the considered characteristics: Algeria, Iraq, Jordan, Lebanon, Oman, Tunisia and Yemen.

5. CONCLUSION

Electricity production in all Arab countries is still dependent on fossil fuels, but in recent years there has been a global trend to produce electricity from renewable sources, especially with increasing demand, and the climate change problem with its negative effects. Through this study we have found that the Arab countries are endowed with great potential of renewable energies, that will enable them to lead the world in the production of electricity if this potential is best exploited.

The main results of this study can be summuriezed as follows:

- The dependence of many Arab countries in electricity production from renewables on hydropower (68%) because many of them have sea views, such as that of North African Arab countries in the Mediterranean, followed by their dependence on both wind and solar energy in roughly equal proportions estimated at around 14%.
- Morocco has a competitive advantage in the production of electricity from renewables. Its electricity production is generally based on coal as a raw material, but it has recently used a second source which is solar energy. Many Arab countries, which aspire to improve their electricity production from renewables such as Tunisia, Egypt, Sudan, South Sudan, Algeria and the UAE, cannot be ignored.
- The use of renewable energies for electricity production is still very low in some Arab countries such as Saudi Arabia, Bahrain and Kuwait despite their potential; as a result of their heavy dependence on fossil fuels, especially oil.
- The continual fall in costs of renewable energies and the policies made in each Arab conutry -according to their nature exporting or importing countries- will help to facilitate the shift towards electricity production from renewables in the Arab region.
- The Arab region has adopted an ambitious strategy -"Pan-Arab Strategy for the Development of Renewable Energy 2010–2030" to develop electricity production from renewable sources, setting targets to 2030.
- From the analytical study we find that there is a positive and very strong correlation (0.995) between the consumption and production of electricity in the studied Arab countries; in addition, there is a weak and negative relationship (−0.420) between the production of electricity from renewables and CO_2 emissions per capita in the considered Arab countries and this is very logical.

In the light of these results, some policies could be proposed to improve the use of renewable energies for electricity production in Arab countries, which could be listed as follows:

- Encouraging investment in solar energy, as a large number of Arab countries contain deserts, that can be used to establish power plants to attract sunlight such as Saudi Arabia, Algeria, Morocco, Libya, Jordan and other Arab countries that have unexploited deserts. In parallel, this can be done through the promotion of patents in this regard, the promotion of scientific research as well as the establishment of research centres and institutes.
- The creation of an "Arab Council for Cooperation on renewable energies" and urging it to revitalize the spirit of cooperation among Arab countries, and to benefit from the experiences in the production of electricity from renewables since there is currently no special apparatus for such stimulation, except for the registration of some initiatives in the field of renewable energies by the "GCC" as accidental and non-essential.
- Encouraging Arab countries in North Africa, in particular, to produce electricity from hydraulic and solar sources, and encouraging them to export such electricity to nearby countries.
- Enhance all Arab countries to adopte renewable energies in the production of electricity in order to reduce CO_2 emissions, which is considered to be very toxic and which is resulting many environmental and health disadvantages on the Arab individual.

REFERENCES

Alevizos, H. (2017), Renewable Sources of Energy: The Pan-Arab Prospect. (Working Paper 6). Greece: Energy and Environmental Policy Laboratory, University of Piraeus.

APICORP Energy Research. (2018), Renewables in the Arab World: Maintaining Momentum. 3(8). Available from: http://www.apicorp-http://www.apicorp-arabia.com/Research/EnergyReseach/2018/APICORP_Energy_Research_V03_N08_2018.pdf. [Last accessed on 2018 Jul 20].

Bonal, J., Rossetti, P. (2011), Energies Alternatives. 2nd éd. Paris, France: Omniscience.

Furfari, S. (2012), Politique Et Géopolitique De l'énergie. Paris, France: Technip.

IRENA. (2016), Renewable Energy in the Arab Region. Overview of Developments. Abu Dhabi, UAE: International Renewable Energy Agency.

IRENA. (2018). Available from: http://www.resourceirena.irena.org/

gateway/dashboard/?topic=4&subTopic=16. [Last accessed on 2018 Jul 16].
Mathis, P. (2011), Les Energies, Comprendre Les Enjeux. Paris, France: Quae.
Middle East and North Africa Regional Architecture. (2017), How can Renewable Energy Help Contribute to the Development of the mena countries? Middle East and North Africa Regional Architecture, 6, 3.
Naudet, G., Paul,R.P. (2008), Énergie, Électricité et Nucléaire. France: EDP Sciences. p127-132.
Observ, ER. (2013), Worldwide Electricity Production from Renewable Energy Sources. 15th ed. Paris, France: Inventory.
Strocchia, G. (2017), Arab World Steps up Renewable Energy. Available from: https://www.aboutenergy.com/en_IT/topics/arab-world.shtml. [Last accessed on 2018 Jul 18].
The World Bank, IEA. (2018). Available from: https://www.iea.org/t&c/termsandconditions. [Last accessed on 2018 Jul 20].
Yassaa, N. (2018), Ce Qui a Marqué Les Activités Du CDER En 2017. Portail Algérien des Energies Renouvelables. Available from: https://www.portail.cder.dz/spip.php?article6288. [Last accessed on 2018 Jul 23].

APPENDICES

Appendices of both xlstat 2018 and SPSS v17 programmes

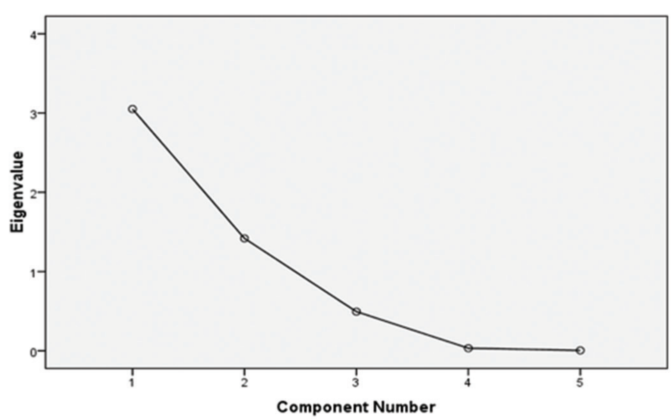
Factor/variables productionelc fromre consumption ELC GDP CO_2/missing listwise/analysis productionelc fromre consumption ELC GDP CO_2/Print Univariate Initial Correlation Extraction Fscore/Format Sort Blank (10)/Plot Eigen Rotation/Criteria Mineigen(1) Iterate(25)/Extraction Pc/Rotation Norotate/Save Reg (All)/Method=Correlation.

FACTOR ANALYSIS

Component matrix[a]

Variables	Component	
	1	2
ELC consumption	0.992	
ELC production	0.992	
GDP	0.987	
From RE	0.183	0.856
CO_2	0.270	−0.827

GDP: Gross domestic product. Source: XLSTAT2018 programme outputs. Extraction method: Principal component analysis. [a]2 components extracted



Scree plot

Squared cosines of the variables

Variables	F1	F2	F3	F4	F5
ELC production	0.984	0.001	0.008	0.004	0.002
From RE	0.034	0.733	0.233	0.000	0.000
ELC consumption	0.985	0.001	0.006	0.007	0.002
GDP	0.975	0.000	0.003	0.022	0.000
CO_2	0.073	0.683	0.244	0.000	0.000

Source: XLSTAT2018 programme outputs. Values in bold correspond for each variable to the factor for which the squared cosine is the largest

Factor scores

Studied Arab countries	F1	F2	F3	F4	F5
DZA	−0.225	0.092	−0.778	0.086	0.044
SAU	5.337	−0.661	−0.913	−0.097	−0.029
BHR	−0.840	−1.195	0.587	−0.300	−0.029
EGY	2.292	2.780	1.161	−0.193	0.021
ARE	1.540	−0.930	0.062	0.381	−0.061
IRQ	−0.229	0.472	−0.352	0.228	0.179
JOR	−1.242	0.066	−0.608	−0.106	−0.028
KWT	−0.182	−1.181	0.472	−0.161	0.139
LBN	−1.186	0.069	−0.513	−0.054	−0.041
MAR	−0.702	1.194	0.188	0.070	−0.066
OMN	−0.795	−0.695	0.059	−0.132	−0.024
QAT	−0.063	−2.103	1.428	0.162	−0.022
SDN	−0.961	1.661	0.546	0.219	−0.039
TUN	−1.229	0.225	−0.569	−0.087	−0.018
YEM	−1.517	0.207	−0.772	−0.018	−0.026

Source: XLSTAT2018 programme outputs