AMERICAN UNIVERSITY OF BEIRUT

ASSESSMENT OF RE DEPLOYMENT POLICIES IN THE MIDDLE EAST

by
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AN ABSTRACT OF THE THESIS OF

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Currently, the Middle East is facing a crisis in the oil and gas industry. Responding to the need of shifting from fossil fuels to renewable energy, several countries across the region started deploying renewable energy technologies. However, different barriers to deployment are taking place. This dissertation presents an overview of renewable energy development in the world embracing hydropower, wind and solar energy, in addition to the implementation of those technologies in several countries in the Middle East. The countries under study in this thesis are Lebanon, Jordan, United Arab Emirates, Saudi Arabia and Egypt. The study also aims to evaluate the deployment policies of renewable energy according to four indicators: effectiveness, efficiency, reliability and institutional capacity. A comparative matrix analytical tool between selected countries in the Middle East is used to facilitate the analysis of the performance of renewable energy deployment. Upon conducting the analysis, it was found that United Arab Emirates is leading the Middle East due to the implementation of the public competitive bidding policy.

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CHAPTER 1

INTRODUCTION

A. General overview

As we see today in this modern world, energy is very essential. Energy plays a significant role in the international economy, security, politics, and most essentially energy is a key tool for the development and growth of a nation. To achieve a better future, the progress of the resources and policies that are related to energy and connected to environmental pollutants should be planned by each country. The advancement of a nation could be expected depending on how much energy is being consumed per person. The reliance on fossil fuels for energy consumption purposes would augment the problems associated with the carbon dioxide emissions. Energy improvements are restricted due to the rising trend of emissions worldwide and global warming; although those improvements are a degree of authority and the level of maturity in future.

Accessibility, affordability, and sustainability of the future energy are three important key features. A trend of increasing energy demand has been observed worldwide, and 80% of this energy consumption is obtained from fossil fuels. Burning of fossil fuels lead to the rise of pollution, and the chance for oil supply depletion continues. Because of the greenhouse gases made by humans with the use of fossil fuels, climate change is threatened by the global warming. This negative environmental influence induced by climate change, encouraged the world energy policy to emphasize on the role of renewable energy as an alternative source for electricity production. As fossil fuels are depleting, countries should use all the rest of the fossil fuels for the domination of renewable energies.

The consumption rate of electricity has increased unexpectedly all over the world with the technological development, infrastructure growth and the increase in energy investment. This resulted in amplifying the bad consequences of carbon dioxide emissions. Thus the anthropogenic carbon dioxide, along with the limited amounts of fossil fuels, stimulated the thought of supporting RE technologies in order to address interests involving “energy security, economic growth in the face of high prices of crude oil, competitiveness, health costs and environmental degradation”. (Tlili, 2015) All of these concerns support the research of using renewable energy, which has many distinctive advantages that should be taken into consideration when building comparison with oil-based substitutes. Moreover, attaining sustainable development is a goal that is now broadly acknowledged as essential to humankind. In this perspective, the use of hydropower, solar and wind as renewable energy resources seems to be the best competent and successful ways to achieve this target since renewable energy is generally rich and holds massive environmental and financial promise.

To diminish the influence of global warming and shortage of energy demand, renewable energy is the solution. Because renewable energy sources are infinite, green and free, they could be the best favorable solution for the energy problem currently.

B. Overview of technologies

1. Wind energy

The kinetic energy coming from the wind is transformed by wind energy technologies into practical mechanical power. To set the generator axe into motion, the axe is connected through a gearbox, which in turn is connected to the drive shaft that is being rotated by the blades of the wind turbine.

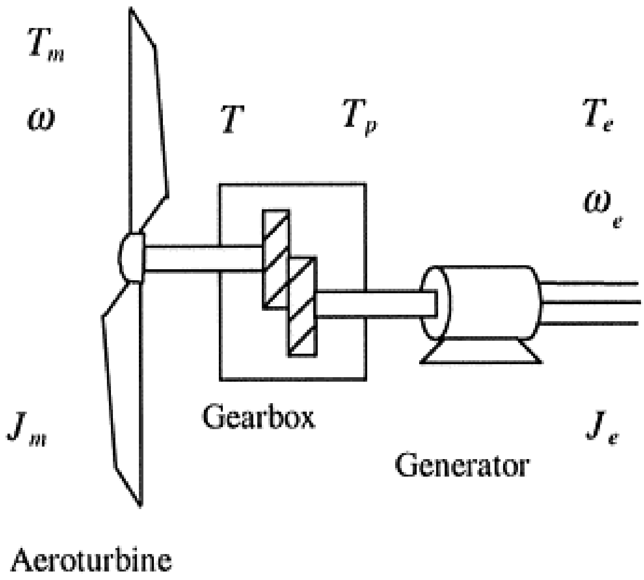

Figure 1. Schematic diagram of wind power system (ELSEVIER, 2000)

From 2005 to 2015, the wind energy industry has shown each year a growth rate of approximately 22.16%, and every three years the capacity of wind energy has doubled on average. On a commercial base, wind power is being used by 83 countries during 2012 and in 2010, 52 countries boosted their overall wind power capacity (REN21, 2011). Compared to any other renewable energy technology, the additional new capacity in 2011 equaled 41 GW (GWEC, 2012). We can conclude from the above changes that at the end of 2011, compared to the end of 2010, the overall wind energy capacity increased by 20% and reached by the end of 2011 238 GW (Figure 2).

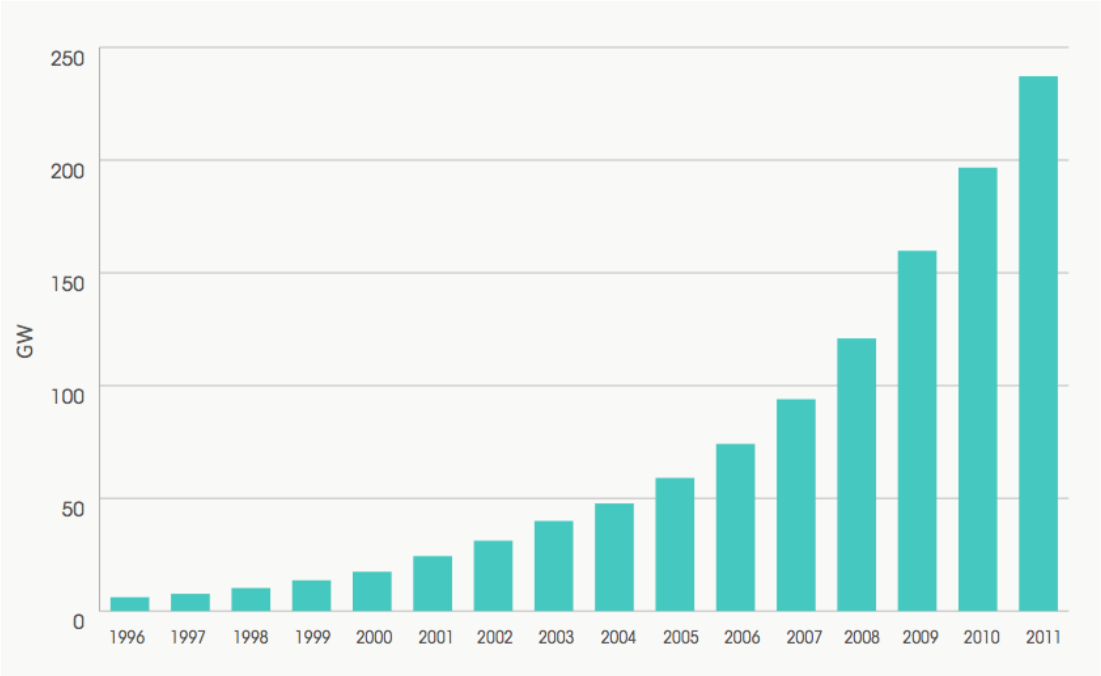

Figure 2. Global installed wind power capacity (GWEC, 2012)

Wind energy is environmentally desirable and it is one of the most required energy sources. Furthermore, wind energy is abundant in nature, infinite, fuel exempted, can produce electricity close to load center, and therefore removes energy costs connected with transmission network. However, wind power imposes negative environmental impacts typically associated with the following three main problems: "visual impact, noise, and wild life impacts". (ELSEVIER, 2015)

Nowadays, many countries use wind energy for the production of electricity. Due to significant development of expertise for the past 30 years, producing electricity through wind energy has shown immense improvement especially in terms of "technological maturity and industrial reliability". (ELSEVIER, 2015) Wind energy is very variable if we compare it to other energy sources although it is one of the most effective sources of energy. Comparing solar energy to wind energy, the latter is very sensitive to changes regarding geography and weather patterns. If the site location of the wind turbine is windy and if adequate selection of the wind turbine's category is made to ensure that it matches with the site's wind pattern, wind energy can be collected at a cost effective level. Thorough information of the wind speed features at a site of attention is very essential in the plan of collecting wind energy.

Complete evidence of the wind characteristics and the allocation of wind speeds of the area are required for the efficient use of wind energy. The installation of wind energy conversion method in a location is necessary for many aspects, such as the speed of wind, the power of wind, the type of generator, and a feasibility study. Researchers in many countries globally conducted several studies of the characteristics of the wind and the potential of wind power.

2. Hydropower

Primarily, water wheels to lift water up from the water base, for example, canal or river, to a water supply system, irrigation, and other mechanical purposes was used precisely for hydropower.

Hydropower is an advanced technology. From the end of the 19th century until the year 2012, the production of electricity in hydropower plants was being made using kinetic energy of dropping water, and usually the development of hydropower was connected with the construction of large dams. In 2012, 160 countries in the world used hydropower. In 2011, the total capacity installed was 1060 GWe (19.4% of the world's electric capacity), the generation of hydropower per year was around 3500 TWh, corresponding to 15.8% of all the electricity production globally. In more than 35 countries, at least 50% of the whole power supply is provided by hydropower plants.

Hydropower plants generate clean energy with fuel-free consumption and carbon dioxide emissions. Hydropower plants are recognized by their excessive productivity and low O&M (operation and maintenance) costs, their consistency, quick accessibility and by the extended life cycle of their producing units (50 years). Nevertheless, a huge investment is needed for large hydropower plants regarding the phase of construction and this may affect negatively the natural environment. Moreover, the production of electricity through hydropower technology is affected by “irregular rain and snowfall”. (ELSEVIER, 2012)

Therefore, in the latest years, a broad concern is focused towards the deployment of energy capacities of small stream, and the construction of SHP (Small hydropower) plants, as well as “towards other natural hydropower sources, such as sea waves”. (JJMIE, 2012)

The installment of small hydropower plants is environmentally friendly and is very valuable to generate power in rural and urban areas: it is an advanced application of RE technologies. Hydropower comprises about 22% of the world total power generation, and most of those are small hydropower plants.

The definition of SHP lacks an international agreement. Nonetheless, in several countries there is a norm that is generally accepted regarding the capacity of hydropower plants to be up to 10 MW total.

Hydropower became a more attractive and significant energy source because of its effect on the environment along with the price increase of fossil fuels.

From all the renewable energy sources, the most profitable and reliable RE technology to be measured for delivering clean power generation is small hydropower plants.

3. Solar

The world's total yearly main energy consumption of 450 EJ (El-Sebaii et al. 2010), is 7500 times less than the total yearly solar radiation dropping on the earth. About 3,400,000 EJ of yearly solar radiation is reaching the globe's surface, which is a direction of magnitude more than all the predictable nonrenewable energy resources. (Shaahid and Elhadidy 1994). That is why a portion of the overall energy network worldwide could be solar energy potential.

Mainly in distant and inaccessible locations that require identified conditions and requirements, solar energy is considered to be a more feasible and applicable solution.

a. Photovoltaic

Photovoltaic is one of the fastest developing RE technologies and it is estimated to play a key role in global power production in the future. The total installed photovoltaic capacity has increased significantly within the past ten years, due to appealing policy incentives (e.g. feed-in-tariffs and tax breaks). PV capacity increased by 37 times from 2000 until 2011, thus recording an increase in capacity from 1.8 GW to 67.4 GW. This is equivalent to 44% growth rate per year (Figure 3) (EPIA, 2012). In 2011, new capacity of 27.7 GW was installed which is two-thirds more than the new added capacity in 2010. In 2011, solar PV produced 118 TWh of electrical energy, which was suggested due to the assumption of the average capacity factor of 0.2.

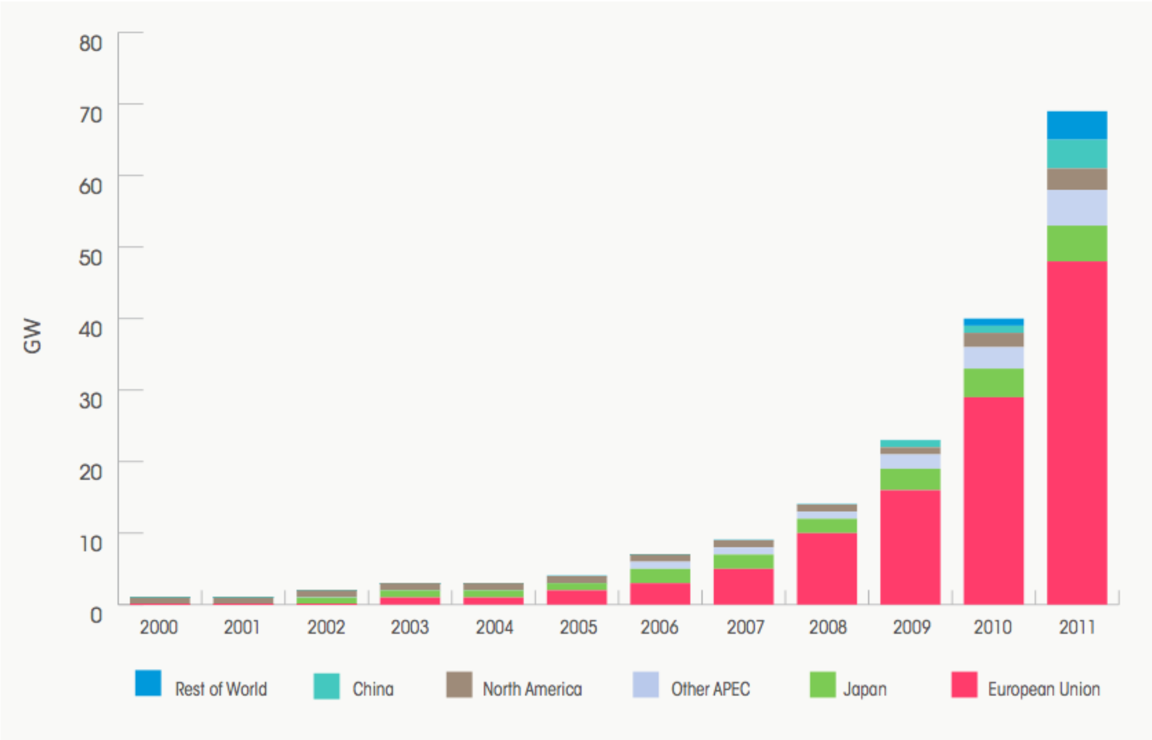

Figure 3. Evolution of global cumulative installed capacity, 2000-2011 (EPIA, 2012)

A cost reduction resulted from this fast expansion in capacity. The estimation of the learning rate for the cost of photovoltaic modules is to be around 20% to 22%, so that every time the cumulative inaugurated capacity has doubled, photovoltaic module prices have dropped by 20% to 22% (EPIA, 2011a and Kersten, 2011).

The operation of the solar photovoltaic systems works in the "presence of direct or diffuse solar irradiation". (IRENA, 2012) LCOE and the level of solar resource are inversely proportional, in which the LCOE is lower when the level of solar resource is higher. The cost of electricity coming from solar photovoltaic will decrease if the site location of the solar photovoltaic systems has high solar resources, which is normally denoted, as yearly mean figures in (kWh/m2/year or as kWh/m2/day).

The global solar resource is enormous. Approximately each year the Earth's surface receives 885 million TWh of solar radiation (IEA, 2011). The solar supply differs considerably "over the day, week and month" depending on local climatic conditions. (IRENA, 2012) Though, most of the yearly difference is connected to the Earth's topography.

Denoted as the global horizontal irradiation (GHI), the global solar resource is represented in Figure 4. The entire quantity of shortwave radiation received from the top by a horizontal surface, is called GHI. This is stated as W/m^2 and contains "both direct normal irradiance (DNI) and diffuse horizontal irradiance (DIF)". (IRENA, 2012) The average solar resource in Europe is about 1200 $Kwh/m^2/year$, whereas in the Middle East it fluctuates between 1800 and 2300 $Kwh/m^2/year$.

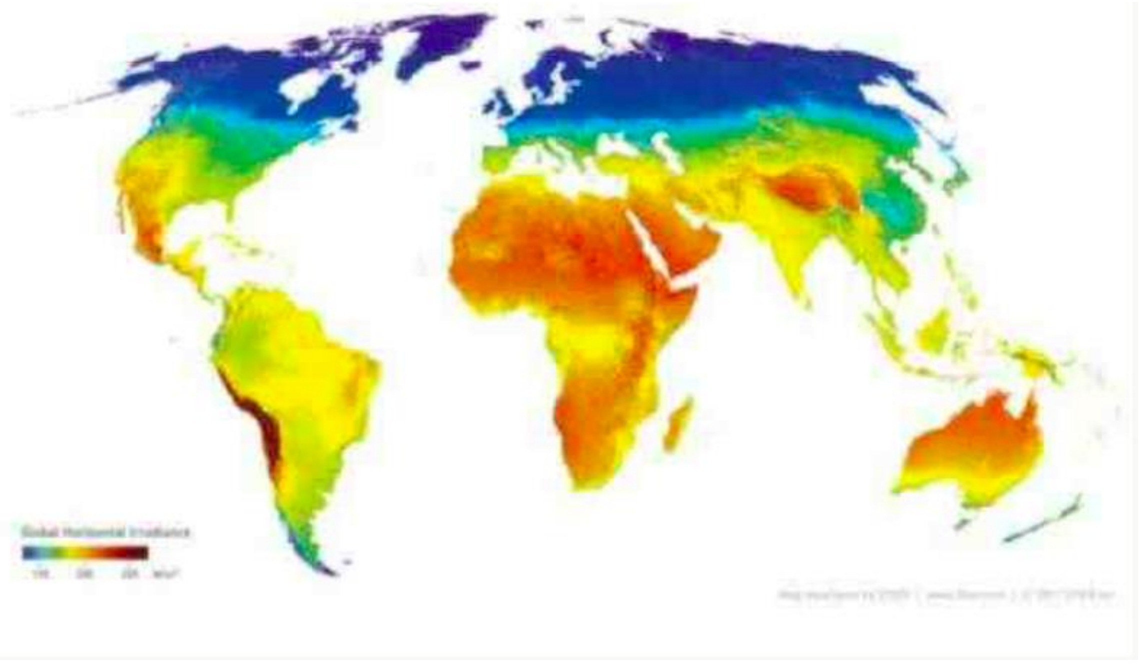

Figure 4. Global mean horizontal irradiance (3Tier, 2012)

b. Concentrated solar power

Concentrating solar power (CSP) is an energy production technology that concentrates the sun's waves through using mirrors or lenses to heat fluid and generate steam. The same mechanism happens in conventional power plants, in which the steam generated drives a turbine and produces energy.

CSP has four technologies, our main focus will be on both: parabolic trough collectors (PTC) and solar tower technologies.

The parabolic trough collectors (PTC) contain mirrors that are called solar collectors, (heat receivers and structures). The mirrors form a parabolic shaped sheet that reflects the sunlight onto a receiver tube located in the center at the main line of the collector.

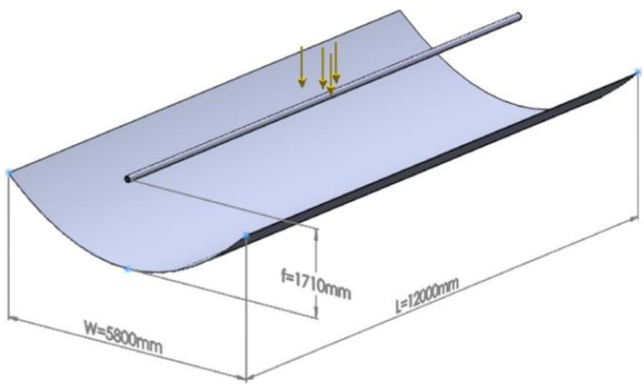

Figure 5. Schematic diagram of a parabolic trough (ELSEVIER, 2017)

Solar tower technologies consist of mirrors that are set on the ground in a field to concentrate direct solar radiation onto a receiver fixed high on a tower set in the center of these mirrors where the light is captured and transformed into heat.

Figure 6. Solar tower in the USA (ELSEVIER, 2010)

In 2012, 94% of concentrated solar power plants installed were parabolic trough systems, which account for a total capacity of about 1.8 GW, while solar tower technologies have a total capacity of about 70 MW.

Some of these both technologies, solar tower and parabolic trough, already have their plants in operation for 6 to 7.5 hours of “thermal storage capacity”. (IRENA, 2012) A rise of their capacity factors took place from 20% to 28% (with no storage) to 30% to 40%, taking into consideration the 6 to 7.5 hours of storage (Emerging Energy Research, 2010).

Instead of using fossil fuels, concentrated solar power has innovative features of capturing and concentrating the sun’s energy to deliver the heat needed in order to produce electricity. Another feature of concentrated solar power plants is that they can have heat storage system for the generation of electricity even at night or when the sky is cloudy. This storage heat system can increase the capacity factor of CSP compared to solar PV, and the most important feature is that it allows the production of dispatchable electricity, “which can facilitate both grid integration and economic competitiveness”. (IRENA, 2012)

Therefore, concentrated solar power technologies are favorable due to the advancements in “solar concentrator and thermal storage technologies”, but other components of the concentrated solar power plants are based on advanced technologies and cannot anticipate seeing fast cost reductions. (IRENA, 2012).

Other renewable energy technologies like wind and solar cells lack the privilege of storage capacity in addition to their strong variability. On the other hand, concentrated solar power plants are able to overcome the variations through thermal storage in “both demand and power inputs into the grid”. (ELSEVIER, 2015)

C. Countries overview

1. Lebanon

As off 2014, Lebanon exploited private funds in order to finance small-scale projects, under its “innovative financing mechanism, National energy efficiency and renewable energy action (NEEREA)”. (RCREEE, 2016) Lebanon suffers from the absence of an adequate regulatory authority that acts independently to provide private developers with power generation licenses. Thus this acts as a bottleneck and presents a major constraint for expanding its capacity of renewable energy. Lebanon has a great potential to develop its market and investment in solar energy projects, since 33% of its power supply is provided by illegal private generators. Therefore, Lebanon should bring up more legal networks in order to give the private sector an incentive to participate in energy generation projects, whether small-scale or large-scale projects, and to shed light on schemes like competitive bidding and net metering.

2. Jordan

Jordan comes in the second place in the ranking. In the past year, Jordan made significant progress for the attraction of private investments for the development of renewable energy. In September 2015, Tafila wind farm, which was developed by Masdar, started its commercial operations at a capacity of 117 MW. With significant performance of its devoted renewable energy fund, Jordan is still the only country to have operated with a full ownership separation of its energy sector in the region. By being the most innovative in creating grid codes and their related technical qualifications for renewable energy producers, from small-scale to large-scale, since last AFEX Jordan has enhanced its Grid Access factor. Jordan has the highest energy prices among the others in the region, which gave the country an incentive to move forward for implementing its net metering scheme. The amendment of the electricity prices, together with the support of policies will continue to appeal investments in RE. The Ma'an Development Area is a special zone identified by the government in Jordan to boost industrial development and innovation. Inside this zone, Jordan has presented specific areas for the expansion of solar projects. Moreover, under the direct proposal system, project developers can easily select locations for projects. In order to permit private-to-private trade of electricity from RE sources, Jordan should also expose its power generation market.

3. United Arab Emirates

UAE comes in the fourth place in the ranking, and the highest among Gulf Cooperation Council (GCC) countries. United Arab Emirates has a very good score regarding the "Governance Quality" factor; Mohammed bin Rashid Al Maktoum Solar Park's third phase that has a capacity of 800 MW, was awarded by Dubai Electricity and Water Authority (DEWA) for scoring the lowest cost of photovoltaic production worldwide. This solar park is based on the IPP model. The advantage of "Shams" Dubai is that its gaining encouragement in promoting small-scale generation systems. United Arab Emirates has "favorable conditions for business operation, including liberal scale and trade policies". (RCREEE, 2016) United Arab Emirates should emphasize to create more choices for the private sector to be exposed to the RE market and it should spread its RE policies to all UAE emirates.

4. Saudi Arabia

"Market size, resource potential, land availability, and high energy demand," are all factors that depict an appealing market for renewable energy. (RCREEE, 2016) Saudi Arabia assigned opportunistic targets, formed an institution that is dedicated for developing renewable energy plans and encouraging stakeholders to contribute towards energy generation from renewable resources; which reveals the country's devotion for renewable energy. In year 2016, Saudi Arabia has inaugurated a total capacity of 23 MW of renewable energy in addition to other small-scale RE projects that are still under construction. Also in 2016, the very first public Independent Power Producer (IPP) competitive bid auctioning was released for a 100 MW, assorted for two 50 MW projects. Hence, this would be a preliminary initiative towards engaging the private sector in the renewable energy market.

5. Egypt

Egypt comes in the third place. Due to its market size, besides its strong renewables potential, Egypt offers an attractive market for the improvement of renewables. Egypt attracted private investors in 2015, and it made significant developments to its RE policy framework. At the beginning of December 2015, 100 turbines wind farm with a capacity of 200 MW were installed by Egypt in Gulf El-Zayt, which will increase Egypt's wind capacity by 35%. This inaugurated wind farm increases the country's wind capacity up to 800 MW. Egypt independent power producer's (IPP's) competitive bids were successful in wind energy in realizing competitive price records. However, the country performance regarding the implementation of the feed-in-tariff doesn't meet the expectations, because of the delays that have been faced in finalizing agreements with skilled developers. Nonetheless, Egypt awarded Siemens an agreement to develop twelve wind farms with an overall capacity of 2 GW on a "parallel direct proposal track". (RCREEE, 2016) Egypt has to put more effort to enrich small-scale generation of RE and to improve the business case for resident's investment in renewable energy.

D. Research objectives

In light of the challenges the Middle East is encountering to solve the crisis of fossil fuels, the aim of this study is to provide a simplified procedure for the analysis of the assessment of the performance of several deployment policies of renewable energy in the Middle East based on different indicators. For this purpose we will compare the selected countries in the Middle East to highlight where they could do better, and what are the lessons learned from the countries that have a good performance regarding the development of renewable energy.

CHAPTER 2

LITERATURE REVIEW

Starting with hydropower, figure 1 shows that Egypt has the highest capacity compared to Lebanon and Jordan, generating a constant output of 2,851 MW from 2010 until 2015. Lebanon and Jordan on the other hand, generated a steady output of 221MW and 12 MW, respectively throughout the years from 2010 until 2015. While UAE and KSA don't have hydropower.

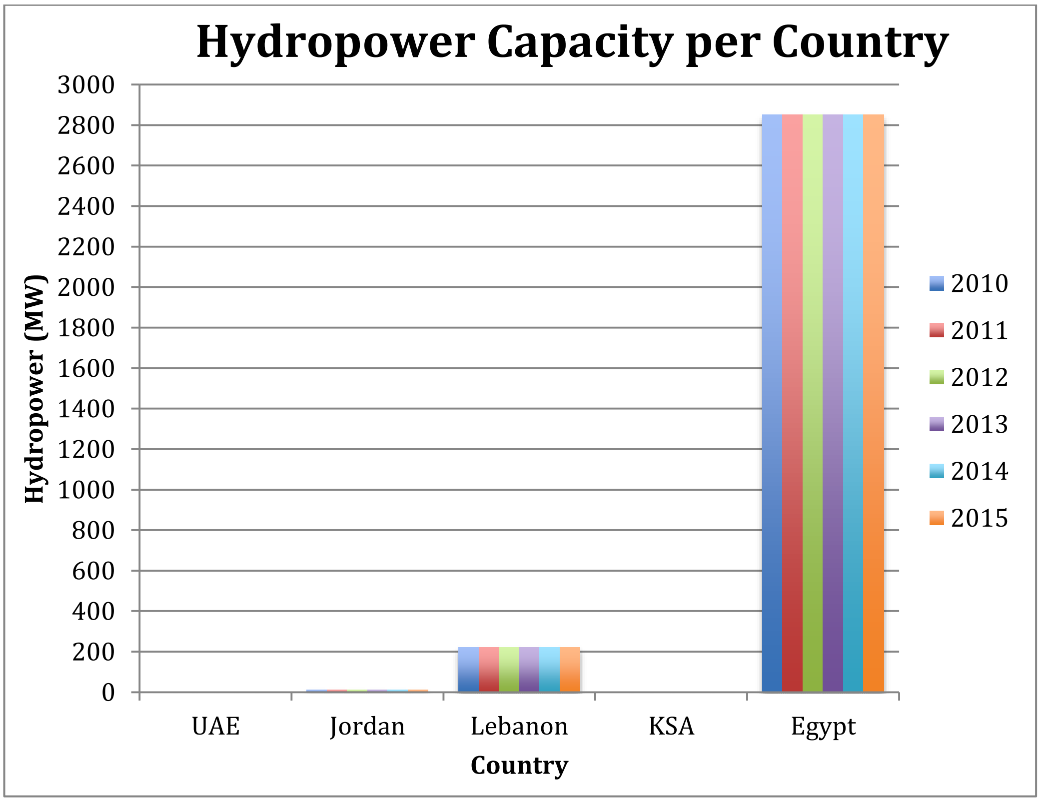

Figure 7. Hydropower capacity (MW) per country

In 2000, 22% of the electricity in Egypt was generated from hydropower. While in 2012, this capacity decreased to 9.59%. This decrease was due to the climate change and the global warming that resulted in a huge fall of the flow to less then a quarter in the River Nile. The 22% of electricity generated in 2000 was distributed among four plants: The Aswan Dam started in 1960-1961 with a capacity of 270 MW. The High-Dam that started in the period 1967-1970 had a total capacity of 2100 MW. The Aswan Dam II began its operation in 1985-1986 with a capacity of 2710 MW. And the Esna Barrage, which was completed in 1995 with a capacity of 80 MW.

As for Lebanon, the country is characterized by warm climate in addition to high and cold mountains. This is advantageous to Lebanon as it profits from the water coming from rain and snow annually (8600 MCM). Though, only 20% of this water is completely used for hydropower.

In total, Lebanon has five hydropower plants located mainly in the Western Mount Lebanon distributed from north to south. And the major plant is the Litani power plant, which is situated at the Litani River in the south of Lebanon.

In 2013, the Ministry of Energy and Water planned for a program to make use of the national water resources for 10 years (2005-2015). Because of the irrigation, which is a priority in the country, only a capacity of 205 MW is planned for hydropower plants.

In addition, a study was published about the potential of hydropower from non-river sources in Lebanon. This study was issued by the UNDP CEDRO project in collaboration with the Ministry of Energy and Water. A total energy of 3.4 MW can be generated from the water dumped back into the Mediterranean along the coastline of Lebanon. This total energy is divided between the irrigation channels (1.27MW) and the drinking water across the country (408KW).

Jordan has small hydropower plants despite their limited resources due to the unimportance of the surface water resources such as rivers and falls. All over the river Zarqa there is the King Talal dam with a capacity of 5 MW. And the Aqaba thermal power station with also 5 MW of capacity. In 2010, the total amount of electricity generated by hydro-units was 61 GWh, which is less than 0.5% of the total national electricity generation.

Moving to wind energy, figure 2 indicates that Egypt has the highest capacity compared to Jordan, Lebanon and UAE generating a constant output of 550 MW from 2010 until 2013 and then an increase of 60 MW for the year 2014 and 2015. As for Jordan, they generated a capacity of 2 MW from 2010 until 2014 and they improved it with a huge increase to become 119 MW in 2015.

Lebanon and UAE on the other hand, generated a steady output of 1MW throughout the years from 2010 until 2015, but UAE started with the wind energy one year later than Lebanon. While KSA don't have wind energy yet.

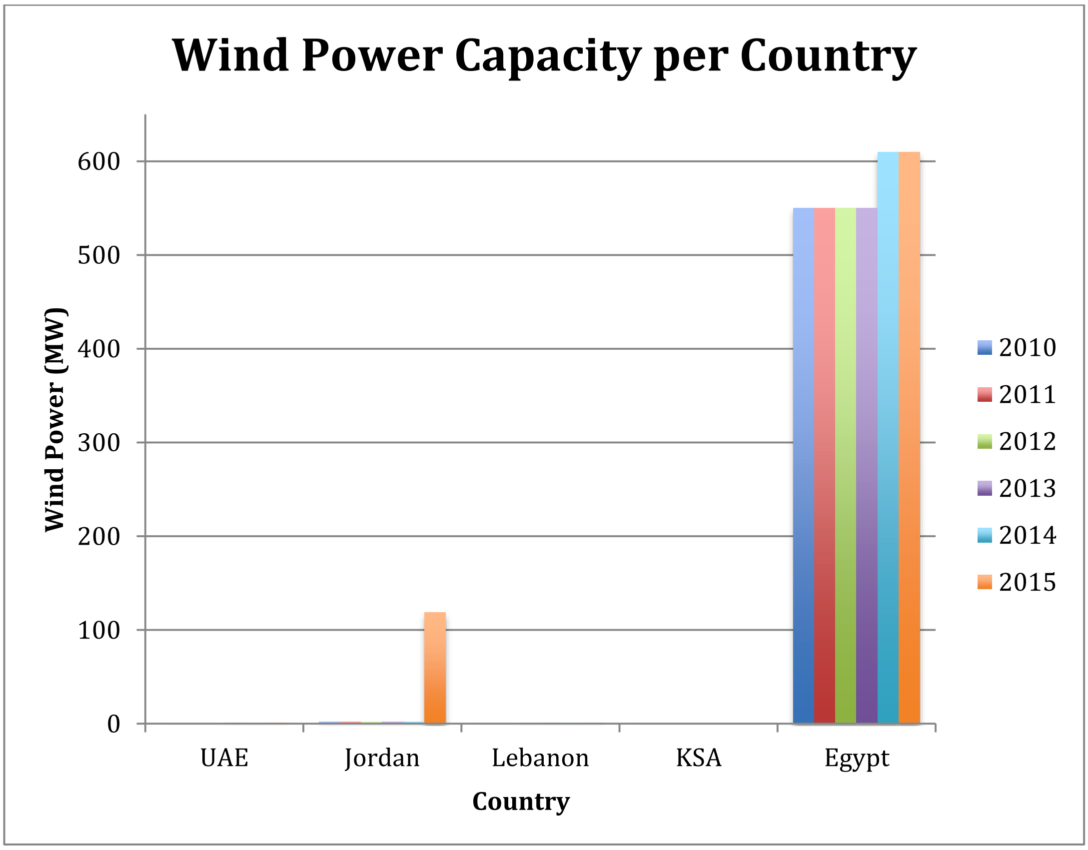

Figure 8. Wind power capacity (MW) per country

Egypt has three areas on the coast that are viable for the construction of wind farms; the east and west coast on the Red Sea and the north coast on the Mediterranean Sea. Ras Ghareb City, which has a suitable siting for large turbines, has also a strong wind potential at 100 m of altitude. Due to its remarkably high power density, Ras Ghareb area can be compared to European countries, America & Canada.

One of the costs that will have to be incurred is the manufacturing cost: importing equipment and expertise. Building wind turbines lacks the availability of industrial manufacture in Egypt.

The energy sector in Egypt set a goal by 2020 to make wind the major renewable energy source in the country and to generate 12% of the electricity need from wind. The total wind capacity installed in Egypt so far is developed by the government via the new and renewable energy authority. But to achieve the target of the energy sector, the private sector should participate in order to realize this goal.

North of Jordan has two wind power plants; the first one is Hofa power plant which consists of five wind turbines with a capacity of 225 KW each, and the second wind power plant is located in the north is Al-Ibrahimyah, which consists of four turbines with a capacity of 80 KW each. In 2008, the energy produced by these plants was equal to the energy produced by a power plant with a capacity of 1.445 MW; on the other hand, the total energy demand needed in that year is 2183 MW. The exploitation of wind as an energy source back to 2008 was 0.07%. In 2013, the Jordanian government increased this rate in order to rise gradually in the next year, which was increased to 3.3%. In addition to this, the availability of the wind power was estimated to be more than 250 MW. Moreover, the south region of Jordan developed large wind power in several areas in the south: Wadi Araba, Maan and Tafileh Governate. These areas can produce hundreds of MW from wind energy. In the Tafileh Governate, two wind energy projects are under construction with a capacity of 150 MW in total and more projects are planned. Other than the south and the north areas, Jordan has a potential in the wind speed in the eastern desert that make them plan for large wind farms.

In Lebanon, wind energy is not yet a renewable source that generates power and this country lacks the availability of a grid-connection to the wind farm. However, wind turbines can be seen in different places for personal use such as home electricity generation and for small private companies like the solitary wind pumps located in Enfeh, which are mainly used to pump water into the salt marshes

Nevertheless, Mourtada, a professor in the faculty of engineering in the Lebanese University, mentioned that there is an effective and real potential of wind power onshore with a capacity of 250 MW and this data was given by the wind atlas. In addition to this, there are high wind potentials in several regions in Lebanon: in the north (onshore and offshore), south, and top of mountains.

According to Siddique et al. and Shawon et al., UAE is the third largest area in the gulf region. It has large coastal area, which is very suitable for the deployment of wind turbines. A study from 2002 measured by the German DLR, the national center for aerospace, energy and transportation research of the Federal Republic of Germany, revealed that the wind speed on the shore line is higher than the wind speed onshore 7.5 m/s and 5.0 m/s respectively.

Wind energy might not be the main renewable energy source in UAE with a 13.4% of full load wind operation, however wind energy can be used in UAE for the support of other renewable energy resources. Wind farms with a capacity that ranges from 130 to 200 MW per year were likely to be installed near Dhadnah, Masafi, and Fujairah city in Fujairah; these figures were taken from the data collection and analysis performed within 18 months period, by Spanish-based wind energy company (EHN) engineers collaborating with the Fujairah Department of Industry and Economics and the UAE University.

Large Vestas wind turbines were installed in the Sir Bani Yas Island and connected to the island's grid with a capacity of 850 KW, this island is located 250 Km southwest of Abu Dhabi.

Masdar Institute is studying the idea of building an onshore wind farm located on Sir Bani Yas Island on the west coast of Abu Dhabi and it is one of the most beautiful natural reserves. It is considered the largest onshore wind turbine farm in the Middle East with a capacity to produce 30 MGWs. Moreover, this wind system would be connected to the Abu Dhabi grid.

Figure 3 reveals that from the year 2010 until 2015, UAE indicated a biggest improvement in the capacity of solar energy (PV and CSP). It started with a capacity of 11 MW in 2010 and it increased to 133 MW in 2015. It has the highest capacity among the others in solar energy. Followed by Egypt with an increase in the capacity from 2010 to 2015, 15 MW to become 45 MW. Then Jordan and KSA recorded 26 MW and 25 MW respectively in the year 2015. And Lebanon started with solar energy in 2011 with a capacity of 1 MW and it increased slightly to 4 MW in 2015.

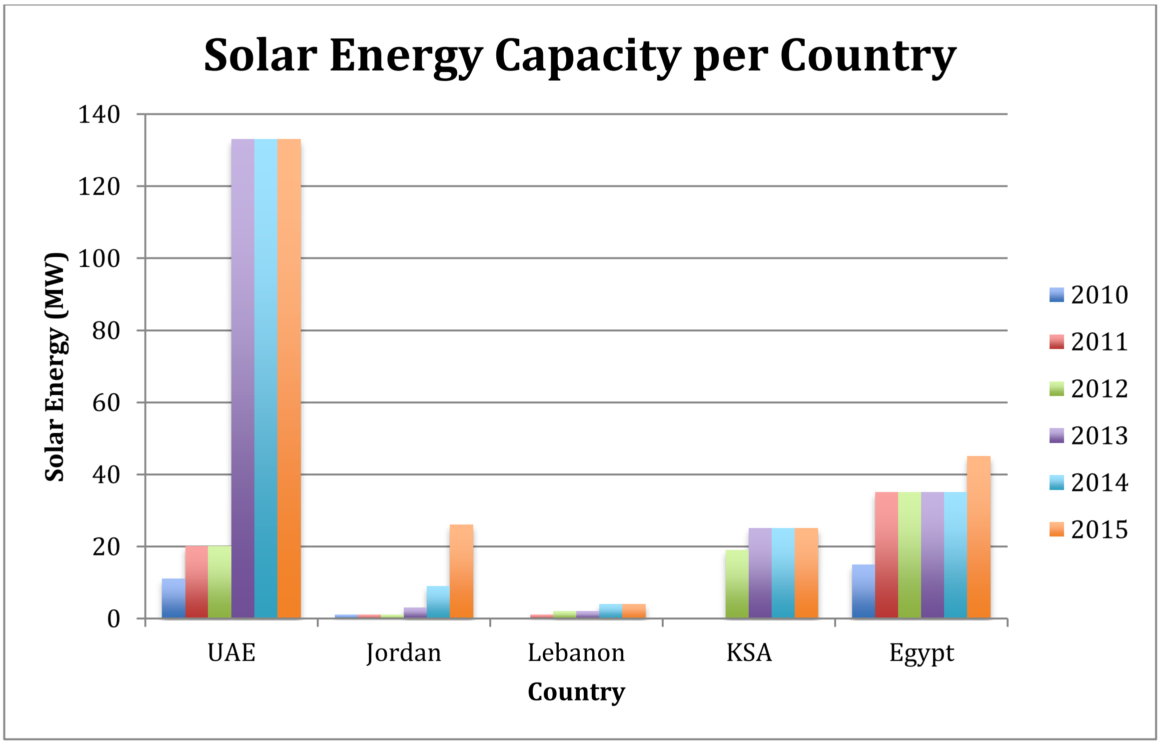

Figure 9. Solar energy capacity (MW) per country

The Dubai Integrated Energy Strategy 2030 is developed by the Super Council of Energy to support the economic growth by ensuring sustainable sources of energy supply as a primary factor. This strategy will lead to the diversification of energy sources in the emirate to increase the total electricity output generated by renewable energy to 1% by 2020 and 5% by 2030.

The solar park under the name of "Sheikh Mohammed Bin Rashid Al Maktoum" is located in Seih Al-Dahal and it is a part of the energy diversification of energy sources in Dubai to meet its target mentioned above. This solar park will be the largest in the region with a capacity of 1000 MW by 2030 using solar PV and solar thermal technology. The first phase, which is a PV plant with a capacity of 13 MW, was completed in October 2013.

Focusing on solar photovoltaic, figure 4 specifies that UAE has the highest capacity compared to Jordan, Lebanon, KSA, and Egypt generating 11 MW (o) in 2010, "(o): which have been obtained from official sources such as national statistical offices" and increased to 33 MW (e) in 2015 "(e): this number have been estimated by IRENA from a variety of different data sources". As for Egypt, they generated a capacity of 15 MW (e) in 2010 to end up with a capacity of 25 MW (e) in 2015. On the other hand, KSA started with investing in solar photovoltaic technology as of 2012 with a capacity of 19 MW and increased its capacity to 25 MW (e) from 2013 till 2015. Jordan was generating a capacity of 1 MW (e) in 2010 and had a major increase of 25 MW throughout the years until 2015. Whereas Lebanon had the lowest capacity of 1 MW (e) in 2011 and this capacity slightly increased to 4 MW (e) in 2015.

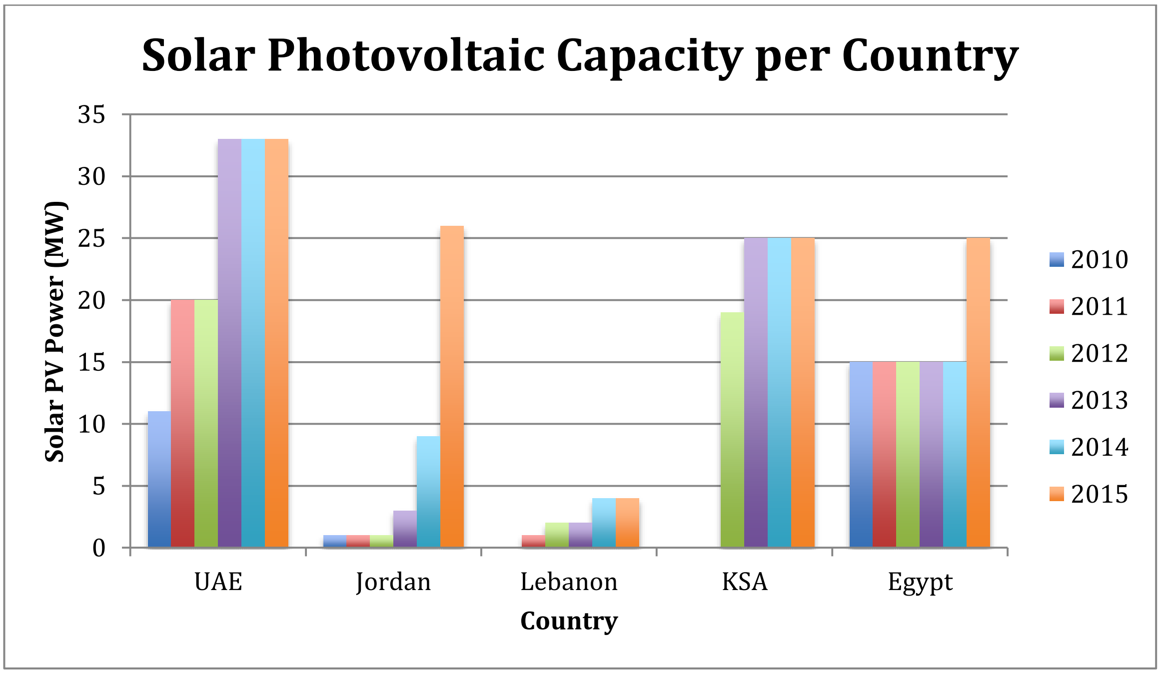

Figure 10. Solar photovoltaic capacity (MW) per country

UAE took the lead in the gulf region in the electricity generation using PV with a total capacity of 22.5 MW. The commissioning of PV cells in the UAE proves that this is one of the most renewable energy technologies that are reliable and promising according to several researches achieved.

A project led by Masdar and Abu Dhabi Water and Electricity Authority (ADWEA) to use solar photovoltaic on rooftops. The government financially sponsored this solar rooftop plan in Abu Dhabi to make it more affordable for the owners of the building to use solar PV. This solar rooftop plan is a step towards reaching the target of Abu Dhabi by 2020 to have 7% of its total electricity output generated by renewable energy. The goal of this plan is to attain within 20 years 500 MW PV on rooftops. A growing rooftop capacity of 2.3 MW fixed on 11 governmental buildings that will generate 4.024 GWh/yr of electricity and this will save 3220 tones of carbon dioxide per year.

Several PV systems are installed on the roof of the shadings to protect the car and outdoor walkways from the sun heat. And these PV are installed for the achievement of a cumulative capacity of 1.65 MW. A project designed and constructed by Enviromena (a photovoltaic system integrator in the Middle East and North Africa region) consists of 105 parking slots in the interim headquarters of Masdar in Masdar city, has a capacity of 204 KW that generates 343 MWh/yr of electricity and save 300 tones of carbon dioxide emissions per year.

Two islands have already solar PV systems, Al Qarneed Island and Marawah Island with a capacity of 0.75 and 0.49 MW, respectively. A total capacity of 291 KW, which produces 450 MWh/yr of electricity and save 400 tones of carbon dioxide emissions per year; this solar PV installation is located on Shams tower in the Yas Marina Formula 1 circuit. This project's target is to shade the cars from the sun heat and to provide for the Yas Marina circuit some energy.

In addition, Masdar 10 MW PV power plant was installed in June 2009, designed and constructed by Enviromena. It produces 17,500 MWh of electricity per year, making it by far, the largest solar PV plant connected to the grid in the Middle East and North Africa.

By mid 2016, the installed capacity of solar PV in Egypt was 90 MW. Local system integrators control the PV market in Egypt and about 25% of the PV modules used in Egypt are locally manufactured.

Saudi Arabia is one of the largest energy producers using solar photovoltaic. The reason for this is its geographical location, which is characterized by clear skies all year round and vast desert land. With the continuous decrease of the photovoltaic solar cells price, the solar energy application in Saudi Arabia is still rising since 1960. Although

Saudi Arabia is the world’s largest producer of oil, it has a great value in installing solar energy, which has several benefits such as, generation of electricity for road tunnel lighting, traffic lights and road instruction signals.

The plan of Saudi Arabia’s solar industry is to achieve 24 GW of solar capacity by 2020 and 41 GW by 2032; 40% of the 41 GW will be generated by solar photovoltaic such as rooftop panels.

The King Abdullah University of Science and Technology (KAUST) has a solar park of 2 MW on the university’s roof since 2010.

In addition, a solar park located in Riyadh within King Abdullah Petroleum Studies and Research Center (KAPSARC) has a total capacity of 3.5 MW for the first phase and the second phase has a capacity of 1.8 MW. It was launched in December 2012 and it is the largest solar power plant in Saudi Arabia.

Moreover, Saudi Aramco has a solar car park of 10 MW, which started since 2011and it is built on the North Park offices of Saudi Aramco in Dhahran and covers 4500 of its parking spaces.

The government of Saudi Arabia is planning for the solar industry to invest more than $108.9 billion in it, and it has also announced incentives involving financing 50% of the project costs and tax breaks.

In Jordan, the National Energy Strategy has a plan to install solar energy with a capacity of 600 MW by 2020.

Solar photovoltaic systems are already discovered in Jordan with two large power plants with a total capacity of 100 MW. They are located in the southern area of Jordan specifically in Maan and Aqaba, and they still under construction.

Quweira/Aqaba solar PV project is currently under re-bidding process, it has a capacity of 65-75 MW and it is funded through a Grant from Abu Dhabi Fund (USD 150 million).

At Azraq, two solar power projects are currently under commissioning, they have a capacity of 5 MW, and they have finished construction in cooperation with the Spanish Government. In addition to this, the Shams Ma'an project is the largest PV plant in the world located in Ma'an area with a capacity of 100 MW.

In Lebanon, the total investment in the solar PV sector by the end of 2015 reached $30.5M, this investment was due to the positive impact NEEREA has on the market. NEEREA stands for National Energy Efficiency and Renewable Energy Action and it is a financial mechanism initiated by the Central Bank of Lebanon with the support of the Ministry of Energy and Water, the United Nations Development Program, and the Lebanese Center for Energy Conservation.

The number of solar PV projects has seen an increase from 18 in 2011 to 94 in 2013 and 259 in 2015. The capacity growth rate increased from 41% in 2011 to 149% in 2015, it has grown by an average rate of 101% per year.

Mount Lebanon, Beirut, and Bekaa are the top 3 Governates leading the Solar PV market in Lebanon with a capacity of 3MWp, 2.4 MWp and 1.8 MWp, respectively. The turnkey price of solar PV decreased over the years from $7,178 per KWp in 2010 to $2,675 per KWp in 2015. In addition, the emissions savings from all the solar PV projects in Lebanon increased from 351 tCO_2 per year in 2010 to 18,000 tCO_2 per year in 2015.

As for the concentrated solar power (CSP), figure 5 illustrates that only two countries among the others have installed CSP. UAE has the highest capacity compared to Egypt, generating a constant output of 100 MW in 2013 and 100 MW (u) in 2014 and

2015, “(u): follows figures that have been obtained from unofficial sources, such as industry associations and news articles”. On the other hand, Egypt started investing in CSP before UAE did, generating a constant output of 20 MW in 2011 and 2012, and the rest of the years until 2015 it was generating a capacity of 20 MW (u).

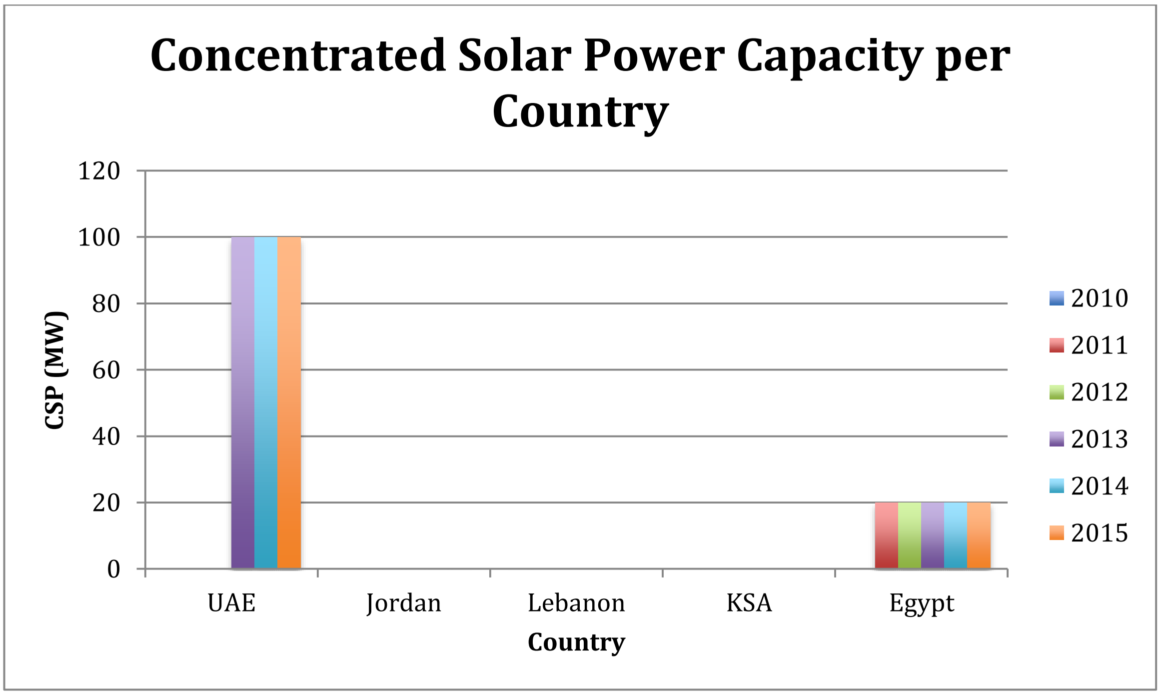

Figure 11. Concentrated solar power capacity (MW) per country

Beginning with UAE, the first CSP, parabolic trough, power plant called Shams 1 located in Madinat Zayed in the desert of Abu Dhabi is one of the world’s largest concentrated solar power plants. It has a capacity of 100 MW and it started operation in the first quarter of 2013. It is a joint project between Masdar (60%), Total (20%), and Abengoa Solar (20%). This CSP plant will offset about 175,000 t of CO_2 emissions per year, which is similar to equivalent to plant 1.5 million trees or removing 15,000 cars from the roads of Abu Dhabi.

In addition to Shams 1, the Masdar institute have a plan by 2020 to build CSP plants each year until the total capacity of 1500 MW is acquired.

Currently, the power generated in Abu Dhabi is approximately 40,000 GWh/year.

The first CSP plant in Kuraymat in Egypt was installed in 2011. 40% of manufacturing CSP plants is locally generated. Egypt has installed a capacity of 20 MW by mid 2016.

Figure 12: Al Kuraymat Hybrid CSP plant, Cairo, Egypt (Ren21, 2013)

CHAPTER 3

METHODOLOGY

Comparative matrix is an effective analytical tool that helps to define an object's essential characteristics. Aggregation method is employed in order for a comparison matrix to define the most typical features of an object without directly deducing a conclusion, but by providing a simplified procedure of analysis.

This tool is used for educational purposes, in which comparison matrices provide an efficient visual aid, and its offers a simple and adequate structure. Therefore, researchers can build in-depth comparisons with the assistance of this high-end invention; taking into consideration several objects properties all at once.

The comparison matrix method will be assessed according to the deployment policies that are evaluated based on four indicators for each country.

Deployment policies are often categorized into four types: "**fiscal incentives**, **public finance**, **regulations**, and **access policies**". (IRENA, 2012)

1. Fiscal incentives policies includes:

- **Grants:** Monetary assistance given by the government for certain purposes to an authorized recipient. It is usually conditional depending on "certain qualifications as to the use, maintenance of specified standards, or a proportional contribution by the grantee or other grantor(s)". Investment costs coupled with preparation, procurement or construction of RE equipment or associated infrastructure can be reduced by the grants (and rebates). In several situations, grants can be used to form concessional financing instruments that are an example of low-interest loans offered by the banks for renewable energy systems. (IRENA, 2012)

- **Energy production payment:** direct payment offered by the government upon each unit of production of renewable energy.
- **Rebate:** The government offers one-time direct payment to a private party in order to cover a percentage or certain amount of the investment cost of a renewable energy system or service. Usually, it is automatically offered to projects that are eligible after completion, and it does not require details for the procedure of the application.
- **Tax credit (production or investment):** An annual income tax credit is provided to the investor or owner depending on the amount of money invested in a certain project or the amount of energy produced during the applicable year.
- **Tax reduction/exemption:** it is not limited to sales; a tax reduction includes "value-added, energy or carbon tax and it is applicable to the purchase (or production) of renewable energy or renewable energy technologies". (IRENA, 2012)

2. Public finance policies contains:

- **Investment:** Where financing in a renewable energy company or project is provided but an equity ownership interest should be given in return. The fund is usually offered by the government that directly invests equity in companies and projects, or a private party can provide the fund.
- **Guarantee:** it is a risk-sharing tool that has a target of activating domestic lending for renewable energy companies and projects which have a perception of high credit (i.e., repayment) risk. A guarantee is usually partial; it covers a percentage of the outstanding loan principal with 50 to 80% being common.

- **Loan:** Funding provided to a renewable energy project or company in return for a debt obligation. Development bank, government or investment authority provides the loan generally on concessional terms, which can be an example of low interest rate or low security requirements.
- **Public procurement:** public entities prefer the purchase of renewable energy services for example electricity and/or renewable energy equipment.

3. Regulations policies covers:

- Quantity-driven:

- **Renewable Portfolio Standard/Quota obligation or mandate:** the minimum renewable energy targets are obliged to be met by designated parties (generators, suppliers, consumers), and they are usually stated as percentages of total supplies or as a total of RE capacity, with costs borne transmitted to consumers. Moreover, this policy creates codes or obligations that require installation of renewable energy heat or power technologies, with the combination of efficiency investments renewable energy heating purchase mandates.
- **Tendering/ Bidding:** Organizing tenders by public authorities for given quota of renewable energy supplies or supply capacities, winning bids will be rewarded at prices mainly higher then standard market levels.

- Price-driven:

- **Fixed payment feed-in tariff (FIT):** it guarantees renewable energy supplies with the priority to access and dispatch, and a fixed price is set depending on technology per unit produced during a specific number of years.
- **Premium payment FIT:** An additional payment is guaranteed for RE supplies,

which is above their energy market price.

- Quality-Driven:

- **Green energy purchasing:** The supply of voluntary renewable energy purchases by consumers is regulated beyond existing renewable energy obligations.
- **Green labeling:** facilitating the purchase of voluntary green energy by using labels sponsored by the government to guarantee "that energy products meet certain sustainability criteria". Labeling on consumer's bills is required by some government with "full disclosure of the energy mix". (IRENA, 2012)

4. Access policies holds:

- **Net metering:** "allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation". (IRENA, 2012) "The meter starts turning "backwards" once excess electricity is fed into the grid". "If the consumer has produced more electricity than consumed the local utility or grid operator has to pay" for excess production. (OSCE, 2009)
- **Priority or guaranteed access to network:** provides renewable energy supplies with easy access to recognized energy networks
- **Priority dispatch:** "Mandates that RE supplies are integrated into energy systems before supplies from other sources". (IRENA, 2012)

Four indicators will be used to evaluate the success of renewable energy deployment policies: **Effectiveness, Efficiency, Reliability and Institutional capacity**

CHAPTER 4

COUNTRIES' RENEWABLE ENERGY TARGETS

A. INDCs targets

Arab countries have produced Intended Nationally Determined Contributions (INDCs) in the Paris conference covering extremely different levels of goals concerning the decrease of green house gases (GHG) emissions and the deployment of renewable energy technologies.

Unconditional targets are accomplished without any intervention; only the country without any external support achieves the targets. Whereas, conditional targets are implemented by an additional international support.

1. Lebanon

Lebanon has unconditional and conditional targets, starting with the unconditional targets:

- A reduction of 15% of GHG emission will be reached in 2030 compared to the Business-As-Usual (BAU) scenario.
- In 2030, 3% of the power demand through energy efficiency will be reduced compared to the demand coming from the BAU.
- The power and heat demand generated by renewable energy sources will be 15 % in 2030.

The conditional targets for Lebanon will be: with an additional international support, the percentage increased from 15% to 30% for the GHG emission. From 3% to

10% for the power demand through energy efficiency, and the 15% to become 20% for the power and heat demand generated by renewable energy sources.

All these conditional targets to be reached in 2030 as well.

2. Jordan

In Jordan, a target of 11% in 2025 has been set for renewable energy share to the total energy mix.

- For the unconditional target, Jordan is aiming to reduce GHGs by maximum 1.5% by 2030 compared to a BAU scenario levels. This target can be achieved by the implementation of several projects.
- For the conditional target, a reduction by at least 12.5% of Jordan's greenhouse gas emissions by 2030, also this reduction is based on the implementation of several projects.

3. United Arab Emirates

The UAE has set a target of increasing clean energy share to the total energy mix from 0.2% in 2014, to 24% by 2021. This target will be achieved through both renewable and nuclear energy.

4. Saudi Arabia

KSA has set a plan to increase the contribution of renewable energy to the energy mix by investing and implementing ambitious programs for RE. The latter will include solar PV, solar thermal, wind and geothermal energy and waste to energy systems. Currently, a competitive procurement process is under preparation and evaluation.

In its Intended Nationally Determined Contributions (INDC), KSA put a target forward to cut 130 $MtCO_2e$ (Million Metric tons of Carbon Dioxide equivalent) each year by 2030, as long the Paris agreement does not affect the capacity of the exportation of oil.

5. Egypt

As for Egypt, several targets were set. Using energy more efficiently, especially by end users. Decrease the use of non-renewable energy sources to shift for the use of renewable energy. Spread the usage of locally appropriate low-carbon energy production technologies.

Commitment to pursue renewable energy and demonstrating political will, are critical to adopt favorable renewable energy investment. Officially adopted and clearly formulated targets represent a significant first step to any renewable energy development strategy, and this way investor’s trust can be gained.

B. Countries’ national targets

The enormous potential and available resources of renewable energy in the Arab region, together with several other factors, has motivated various Arab countries to improve RE projects and announce national targets for the implementation of RE technologies. These factors differ depending on the country, but overall include economic expansion, population growth, rural development, climate change vulnerabilities, urbanization, scarcity of water resources and industrialization. These, in turn, have caused the creation of small but favorable RE markets in power generation in several Arab countries.

Renewable energy targets have been announced in most of the Arab countries for future deployment. General RE targets are important as an initial step in renewable energy planning for a long-term period, as they determine political commitment for the deployment of renewable energy technologies in the future. Targets set for each technology are also important for investors and implementing agencies, since they offer additional details regarding the technologies' types each country finds suitable for its context.

1. Lebanon

In 2009, the ministry of Energy and Water (MEW) defined the commitment launched in the Copenhagen Climate Summit, which was made by the Lebanese Government to develop the capacity of RE production to reach 12%. This political promise was a "major milestone of the Policy Paper for the Electricity Sector". (NREAP, 2016) This policy paper implemented by the Government as the national strategy on June 21, 2010 for the electricity sector, explained the 12% national target of the total electricity by 2020..

Knowing that the expected total electricity in 2020 is about 6,389 ktoe, the implementation of renewable energy projects would be the national objective of Lebanon, which is to produce around 767 kilotonnes of oil equivalent (Ktoe) in 2020, i.e. approximately 12% of 6,389 ktoe.

Three main technologies need to be developed to reach the 12% target. In order to develop these technologies, several targets are set.

The objective for wind energy installations by 2020 is 200 MW. Offshore wind energy is not included in the target set because offshore sites contain very deep waters, in addition to the absence of mature assessment for the offshore wind energy. Moreover, there are areas that have appealing sites for offshore installations and are highlighted by the wind atlas in Lebanon but they are not attractive with respect to the economy when we compare it to the onshore possible installations.

a. Budget needed for the achievement of the wind energy target in 2020

In order to reach the target in 2020, it is estimated to invest a capital of USD 340 million for a low investment costs and USD 490 million for a high investment costs. A range between 31.4% and 38.4% is estimated for the capacity factor. The LCOE of wind power is about 10.3 US cents/KWh, however adding the operation and maintenance (O&M) costs, the levelized cost of wind power will fluctuate between 11.8 minimum cost and 13.3 US cents/KWh for a maximum cost. Based on the production cost by Electrecite du Liban (EDL), which is approximately US 20.2 cents/kWh, the payback period would range between 7.2 and 12.7 years.

Additionally, more hours of supply provided to the consumers would be reflected by the extra electricity production by wind farms. The proposed wind farms that would be installed by 2020 would supply an additional 176 hours of electricity, in order to meet the increasing demand that would reach approximately 29,587 GWh by 2020 compared to 15,934 GWh of electrical demand in 2010.

The target of 150 MW of solar photovoltaic installations by 2020 is assumed by the current NREAP giving the fact that solar photovoltaic farms in Lebanon have high potential for development. This technology is becoming more attractive due to the decrease in prices of solar photovoltaic installations.

<u>b. Budget needed for the achievement of the large-scale solar photovoltaic target in 2020</u>

The installation of 150 MW needs a total investment of approximately USD 225 million in 2020, based on the USD 1.5 million indicative price is used for every 1 MW farm. Moreover, the cost of land is projected at approximately USD 15 million. Therefore, about USD 240 million are needed for a total investment cost.

During a 20-year lifetime, the 150 MW photovoltaic farms will be generating around 4,370 GWh with a 1% of output decrease per year.

This indicates that an average of 5.5 US cents/KWh to which an additional amount of 1 US cent/KWh of the cost of O&M should be added, making the levelized cost of electricity for large scale photovoltaic in Lebanon nearly 6.5 US cents/KWh. This means that the installed photovoltaic farms would be saving around USD 32.9 million each year. Therefore, the whole investment would have a payback period of 7.3 years, "based on the average production cost of EDL (0.202 US cents/kWh)". Also, in 2020 the installed photovoltaic farms would be providing around 71 additional hours of electricity. (NREAP, 2016)

The loan granted by Banque Du Liban, which is a part of the financing mechanism of National Energy Efficiency & Renewable Energy Action (NEEREA), showed that in the first 6 months of 2016 more than 10 MW were under installation. Given the increase of positive momentum and the current market in the Lebanese market, LCEC assumes a very realistic target of 100 MW of solar photovoltaic distributed generation by 2020.

c. Budget needed for the achievement of the solar photovoltaic distributed generation target in 2020

To achieve the 100 MW target over the next 5 years, a total investment between USD 321 million and USD 600 million is needed giving that the cost is between USD 3.21/Wp (Watt-peak) and USD 6.00/Wp.

For 2 main reasons, the cost of USD 3.21/W will be taken into consideration for all type of the decentralized photovoltaic installations in the context of this National Renewable Energy Action Plan.

First, the solar photovoltaic market is observing a steep decrease in Lebanon and worldwide in solar system prices.

Second, most of the installations are close enough to the price of USD 3.21/W which was shown after a full review of the National Energy Efficiency & Renewable Energy Action projects.

However, during a 20-year lifetime the installations of 100 MW will be generating approximately 2,913.5 GWh with a 1% output decrease each year. This shows that an average of 11 US cents/KWh to which an extra amount of 1 US cent/KWh of the cost of O&M should be added, making the levelized cost of electricity for decentralized photovoltaic in Lebanon around 12 US cents/KWh.

The payback period of the entire investment will be around 8.7 years (with approximately USD 36.8 million of savings), knowing that the decentralized photovoltaic systems are being inaugurated as substitution to diesel generators (with a

35 US cents/KWh of average production cost). In 2020, this can supply 47 additional hours of electricity.

Most of the investments will be done by the private sector. So without the need of investment from the public sector in Lebanon, the demand is indirectly decreasing which makes this kind of installation very important.

In the case of concentrated solar power, the action plan remains stable due to some immaturities regarding the development of this technology. However, CSP is still attractive if we compare it with other renewable energy technologies for its storage capability. The target of 50 MW could be attained in 2020 because of the development of concentrated solar power in the country with a steady output until 2030. This conservative statement is made due to the doubts surrounding this technology.

d. Budget needed for the achievement of concentrated solar power target in 2020

The high investment need, is one of the essential reasons for not taking a high share of concentrated solar power in the renewable energy mix. When compared to other renewable energy technologies, the storage capacity available in CSP adds the important measurement of stability.

Nonetheless, for the target of 50 MW with 7.5 hours of storage, an investment of USD 300 million remains needed which was estimated by "CEDRO in their 2012 publication entitled Concentrated Solar Power for Lebanon for 2012: A Techno-economic Assessment (UNDP-CEDRO, 2011)". Concentrated solar power projects in Lebanon have not been applied yet. Though, the estimated levelized cost of electricity for the 50 MW Hermel power plant is approximately 16 US cents/KWh". (NREAP, 2016)

In this case, the savings would be around USD 7.2 million per year comparing it to the cost of production of the power plants of Electrecite du Liban, which lead to a payback period of about 42 years. Nevertheless, CSP has a major benefit, which is the facility to store energy to use it later during peak hours. In Lebanon, the concentrated solar power plant would be replacing Tyre and Baalbeck power plants that have high cost where it is close to 32 US cents/KWh. Drawing a representative comparison, the savings each year would be more than USD 27 million in this case, and the payback period is too close to 11 years. Finally, in 2020 the installed concentrated solar power plant will generate approximately 50.5 additional hours of electricity.

In Lebanon, hydropower is developed in an extremely complicated environment because of several factors; the most main factors are the legal and administrative barriers. Moreover, large hydropower plants are developed only depending on the construction of dams, and this latter is subject to the controversy of nature. The target set by 2020, is to rehabilitate 50% of the current power plants with an effective capacity of 236 MW. Also the implementation of new hydropower plants with 50% of them selling their tariff rate minimum less than 8.1 US cents/Kwh and other 25% selling their tariff rate more than 8.1 US cents/Kwh and less than 12 US cents/Kwh adding up an approximate capacity of 93 MW both.

e. Budget needed for the achievement of the hydropower target in 2020

The construction of new hydropower plants needs an investment of approximately USD 219.5 million. And the cost of the existing power plants that will be rehabilitated can be projected around USD 33 million. The total investment will be approximately USD 252.5 million for an extra production of 571.9 GWh of hydroelectricity. This implies that new hydropower plants have a Levelized Cost of Electricity (LCOE) about 2.4 US cents/kWh for a 20-year lifetime, and the LCOE of rehabilitated power plants is around 1.6 US cents/Kwh.

The total savings of new and rehabilitated hydropower plants are approximately USD 101.46 million/year. In addition, these both types of hydropower plants will increase the electricity to 168 extra hours in 2020.

The basic budget parameters are summarized in Table 1.

Table 4.1. Basic budget parameters

	Needed Investment (USD Million)	Levelized cost of energy (US/KWh)	Yearly Savings	Payback (Years)	Extra Hours
New Hydro	219.50	0.0239	81.90	2.68	136.14
Rehabilitated	33.00	0.0157	19.56	1.69	31.09

2. Jordan

Compared to AFEX 2016, Jordan has a solar photovoltaic target of 800 MW by 2020, and concentrated solar power has a target of 100 MW by 2020. Regarding wind power, Jordan has a target of 1.2 GW to be achieved by 2020.

3. United Arab Emirates

The United Arab Emirates Energy Plan 2050 was approved by the UAE government, which aimed for 70% decrease of CO_2 emissions, 50% increase of the usage of clean energy (renewables and nuclear), and 40% improvement of energy efficiency by 2050.

The United Arab Emirates sets a target by 2050 to cover 20% of the energy it consumes with renewables, 38% accounting with gas, 12% for “clean fossil fuels” and 6% for nuclear. Currently, the country’s energy mix is more than 90% covered by gas. To enhance the integration of renewable, clean fossil energy and nuclear, United Arab Emirates plans to invest by 2050, USD 163.3 billion. The Barakah nuclear power, which is the first reactor, is likely to be commissioned in 2017. When it is ready for operation, it should cover the consumption of electricity in the country by 25%.
A growth rate of 6% per year was expected based on the plan. In an earlier long-term plan, 30% of the generation of electricity with clean sources was planned by United Arab Emirates. Though, Dubai has announced more ambitious targets such as, 7% of the energy consumption will be covered by 2020 with clean energy sources, planning by 2030 to increase this target to 25% and by 2050 to 75%.

4. Saudi Arabia

By 2023, 9.5 GW of installed capacity is set by Saudi Arabia as an impressive renewable energy program, as the country seeks to decrease its dependency on oil.

This means an average of around 1600 MW of new RE capacity yearly. A tender was issued lately by King Abdullah City for Atomic & Renewable Energy (KA-Care) for financial, legal consultants, and technical to advise on 3.5 GW targeted renewable projects for 2020.

By 2040, Saudi Arabia has a target for wind to reach 9,000 MW, solar photovoltaic 16,000 MW and a target of 25,000 MW for concentrated solar power.

The minister at the “World Future Energy Summit in Abu Dhabi” as quoted by local media believed that Saudi Arabia by 2023 will be investing between USD 30 billion and USD 50 billion in waste-to-energy projects and in renewable energy in the country. (IEA, 2017)

The National stated, quoting Khalid Al-Falih that KSA aims to oblige developers to invest in supply chain, which is local as a share of the renewables effort. Saudi Arabia is planning to interconnect with Yemen, Egypt and Jordan, and eventually Europe and also the country is discovering routes to trade green energy in the future. KSA is also continuously thinking for plants of 2 nuclear reactors in total of 2.8 GW.

5. Egypt

The Arab countries are lead by Egypt concerning the 2020 timeframe of installed capacity with the 2022 plan to develop 10 GW of solar and wind projects. This 10 GW target is divided by 7,200 MW of wind and at least 2,300 MW solar photovoltaic. In addition, Egypt has a target for hydropower to reach 2,800 MW by 2020.

CHAPTER 5

RENEWABLE ENERGY POLICIES

The renewable energy targets stated above are very impressive, which is an appreciated initiative for a region that is entirely controlled by fossil fuels. Nevertheless, implementing targets is only a part of encouraging renewable energy; adopting precise procedures to overcome barriers and make favorable conditions for the interest of RE development is more important. A major policy challenge falls in increasing public instruments that are successful in covering the incremental costs of RE, if any, while not devoting to unbalanced public spending levels to future benefits and perceived as politically unsustainable.

For RE projects, several support policies were adopted by Arab governments with or without a RE law. The motivation of private investments in RE and the positive development are composed by these policies.

For the past few years, renewable energy systems have increasingly gained in competitive advantages and cost effectiveness. Although lots of these technologies last in a primary stage of commercialization in the Arab region, and their improvement was blocked by a general shortage of mainstreaming strategies. For these reasons, the support of the policies that reduce commercial risks of lenders and investors combined with deployment and financing of renewable energy projects can only be the reason behind the success of renewable energy targets.

Improving RETs (renewable energy technologies) is achieved by implementing several important policies. Those policies guarantee the investors that produce electricity, a fixed long-term purchased price and ensure the accessibility to the electricity grid. Such policies involve public competitive bidding where the process is not too long and bureaucratic, feed-in-tariff (FiT), and net metering.

Those policies can be categorized into two different groups:

- Price-based market mechanisms, where the policymaker defines the price and the quantity is controlled by the market. This involves net metering and feed-in-tariff.
- Quantity-based market mechanisms, where the policymaker defines the quantity and the price level is determined by the market. This comprises of public competitive bidding (auctions mechanisms).

A. Policy mechanisms

1. Public competitive bidding

Public competitive bidding is the favorite policy option that allows in the region the development of large-scale renewable energy projects.

This policy or mechanism is made by independent power producers (IPP), where the developer signs a power purchase agreement (PPA) after he has been chosen across a tendering process. This successful bidder is chosen based on the bid offer that should be very competitive.

In a power purchase agreement (PPA), investors are requested to produce electricity from RE projects. The bid or tender sets a certain size and period. Contracts that have the lowest cost of production are chosen, and based on the prices and periods that have been agreed on through the tenders, the electricity networks (network operator/carriers) are obliged to be bought from these stations.

A small number of countries have officially launched tenders for few types of renewable energy projects.

In the countries where renewable energy technologies are applied, auctions are main element for the design of renewable energy policy, which encourage the growth and strength of a RE market.

Public competitive bidding remains the most favorite policy instrument for the reason of promoting large-scale RE projects. Nevertheless, the power purchase agreement bidding processes are currently too long in the region and do not allow huge and fast development of renewable energy.

a. Advantages

- In a power purchase agreement, the investor gains a high level of security
- Auctions decrease the risks for investors because provide for fixed periods guaranteed revenues.
- Encourage budget control and volume.
- Increase the expectation of electricity supply from RE resources, if they are applied and well planned.
- Improve cost efficiency because of the competition of prices in developing markets.

b. Disadvantages

- Creation of uncertainties for investors when the government doesn’t provide enough information about the total number of projects that will be developed under the public competitive bidding. In several countries, one or two RE projects are currently planned through the public competitive bidding. For instance, Egypt has announced targets for the development of projects through the bidding process.
- The processes of the public competitive bidding are slow and long.

- The auction approach is threatened because of the nonexistence of direct incentives for RE consumers.
- High administrative costs
- Discontinuous market development
- Not winning projects is a risk that increases finance costs
- Risk of underbidding (absence of target achievement and deployment)

2. Feed-in-tariff

According to Renewable Energy Policy Network for the 21st Century (REN21), the feed-in-tariff is a renewable energy policy that reimburse the power generator that produce electricity form a renewable energy source a guaranteed price. The payment is made based on each unit of electricity exported to the grid by a producer, and normally over a fixed and long-term period (usually 20 years).

In another word, feed-in-tariff is a policy that guarantees a payment for renewable energy generators for the production of electricity.

The tariffs set are higher than those settled for energy production from conventional sources and they guarantee an adequate return for investors in RE production. Usually, each type of renewable energy has a tariff rate.

This policy benefit small power producers and provide them with an additional premium price, which is higher than the electricity market price. And this premium is set for each unit of electricity produced from a renewable energy source.

This policy allows electricity producers to sell electricity from a renewable energy source at a fixed tariff or price for a certain period of time.

Globally, feed-in-tariffs are frequently used and limitless studies guarantee for this mechanism, which they claim is the best efficient policy option to encourage the deployment of grid-connected renewable energy technologies in preliminary phases.

Feed-in-tariff have become the most policy used widely among the others to enhance the development of RE worldwide; 27 states or provinces and 65 countries have applied this policy.

Due to the potential risk of over–compensating investors, this policy might not be the best for the improvement of large-scale projects.

This policy is still important in supporting the projects that have a small and medium-size.

The most successful feed-in-tariff schemes have the features below:

- Low regulatory and administrative barriers
- When a feed-in-tariff is more transparent and simpler, the investor's confidence will be greater and, consequently, the investment security will be higher.
- Certainty of investors is high
- A feed-in-tariff scheme with a long term policy framework and stable would be more friendly for investors than a policy with a short term policy framework.
- High effectiveness at low cost of deployment is achieved when the feed-in-tariff policy is successful.

a. Advantages

- Investment security with a high degree
- Balancing risk is not subject to producers
- Technology-specific method by being able to stimulate costly and new technologies that have a huge mid or long term potential.

- Mature technologies such as, wind energy can be supported in a cost efficient manner.

b. Disadvantages

- Not corresponding to the principle of competition
- Fixing tariffs can also block technological learning
- Gird operation costs increase, and network balancing problems can occur due to the purchase obligation.
- In most of the countries, renewable energy technology costs require extra support because they are still non-competitive.
- The lack of feed-in-tariffs or other price support instruments, currently make the renewable energy investment climate unattractive.
- The investment for consumers in renewable energy is more unattractive when the electricity tariffs are heavily subsidized.

3. Net metering

Similar to the feed-in-tariff policy, net-metering policy also benefit small power producers.

This policy is an extensive billing mechanism used essentially to support residential or small-scale businesses to inaugurate renewable energy (particularly solar photovoltaic), primarily for self-consumption. It permits for prosumers (players who produce and consume electricity) to export their additional electricity generated by renewable energy “into the grid to offset the utility electricity consumption”. (AFEX, 2016)

In another word, it allows RE producers to send additional electricity to the grid at a price settled by the power supplier and in return, they get a deduction of this amount from their following monthly utility bill.

Net-metering policy is regularly perceived as an easier and more flexible alternative to feed-in-tariffs. Usually net metering places the economic load on the utility and is of slight cost to the State. It offers the prosumer with a long-term promise of low electricity bills, especially attractive feature for the countries with high electricity tariffs. The value of the bill-saving is high if the electricity rate structure is distributed in tariff-brackets, since it permits prosumers to cut down their highest consumption and stay away from the peak tariff brackets.

The design of the net metering mechanism is very important for its attractiveness, especially when the net surplus of energy generation is addressed by the end of a payment period. Some systems permit the customers to credit the additional KWh to the following billing period; others have regulation so that any extra KWh at the end of the period is settled to the utility, or otherwise any surplus has to be bought by the utility. Another detailed design is the qualified installed capacity that varies between different net metering system. If the mechanism of a net metering policy doesn't limit the capacity or system size, and permits the extra generation to be added to the next payment period, the net metering scheme will obtain the best results. Because of the limited scope and size of net metering programs, they normally do not influence overall energy mix remarkably but rather generate a niche market for solar photovoltaic distributed on rooftops.

This policy is mostly used for small-scale RE projects.

In Lebanon, net metering is applied where the excess electricity is exported to the grid and it is subtracted from the bill of the following month.

In Jordan, for example the excess electricity exported to the grid is bought at preferential prices.

However, for private developers this policy in the Arab region is still unattractive due to the absence of uninterrupted power supply and low electricity prices.

a. Advantages

- Solar photovoltaic is generated at daytime, which is the highest demand period in most of the countries
- Consumers can get considerable incomes for these mechanisms

b. Disadvantages

- The solar modules cannot be financed because of the incomes that are not high enough, although this is changing
- The net metering policy stimulates small-scale solar photovoltaic systems
- Investment security is low as the effectiveness of a plant lies on the long-term electricity development
- In countries that have low tariff rates of electricity, the policy itself is not enough to create incentive for renewable energy technologies investment without initiating special purchase prices for surplus electricity.
- Lack of motivation for additional gains when implementing net metering policy because of the electricity prices currently, which are too low.

B. Policy implementation in each country

1. Lebanon

a. Public competitive bidding

In Lebanon, public competitive bidding policy is applied for renewable energy projects with a large-scale and for private projects.

Lebanese Center for Energy Conservation (LCEC) was in charge of two public bids out of ten. Those projects were for the photovoltaic technology. One of them was in the ministry of Energy and Water with a capacity of 130 KWp. And the other was in “Moudiriyat Al Handasa for the Lebanese army in Kfarchima with a capacity of 150 KWp.

Currently they are preparing documents for another bid, in four sites, and there will be four systems in the North of Lebanon, Bekaa, Beirut, and ministry of National Defense; besides working on other bids.

b. Feed-in-tariff

Feed-in-tariff doesn’t exist in Lebanon.

c. Net metering

In December 2011, the Ministry of Energy and Water (MEW) launched the net metering policy to be adopted by Electrecite du Liban (EDL). National stakeholders through the creation of the net metering committee involving Lebanese Center for Energy Conservation (LCEC), UNDP-CEDRO, EDL, and national experts developed the idea of the net metering policy, which was initiated by United Nations Development Program (UNDP).

Regarding the net metering method, Electrecite du Liban board published a new decision during the preparation of the National Renewable Energy Action Plan (NREAP) 2016. “Collective net metering allows a group of consumers willing to install a RE system to apply net metering to the individual meters collectively.” (NREAP, 2016) For example, in Kabrikha village, south of Lebanon, a centralized solar photovoltaic system with a capacity of 250-kilowatt peak (kWp) will be installed. Hopefully, the application of collective net metering will be made to the village, permitting all the consumers in the village to decrease their electricity bills depending on the output of the solar plant.

Electrecite du Liban added a new measurement to this policy recently, which is called community net metering. It allows communities to apply to this system. All operational processes for the application of community net metering are currently under preparation. The decentralized renewable energy generation is expected to receive a huge push because of the community net metering.

2. Jordan

a. Public competitive bidding

The public competitive bidding policy is available in Jordan to develop private renewable energy projects on a large-scale.

At Al Quweira in Jordan, the 103 MW engineering, procurement and construction (EPC) over a grant from Abu Dhabi Fund for Development was funded by Jordan’s Ministry of Energy and Mineral Resources. This project was awarded recently through a bidding arrangement for fifteen qualified bidders with an extremely competitive price of $128 million to a group of companies from United Arab Emirates and Spain.

To finance the construction of a 50 MW solar PV plant in the area of the King Hussein Bin Talal Development, which is close to the city of Al Mafraq in the governate of Mafraq, 80 Km in the north of Amman in Jordan, The European Bank for Reconstruction and Development (EBRD) provided a loan of up to USD 27 million in order to finance a 50 MW solar PV plant's construction. This project in Jordan will be the first utility-scale solar PV plants of this size, and it will support Jordan in the increase of RE capacity and the decrease of its dependency on costly hydrocarbon imports.

Al Mafraq solar PV shifted from a feed-in-tariff program to a tender process, where tariff is placed competitively. Therefore, this project in Jordan and the region is going to be one of the cheapest sources of electricity. The successful implementation of the second round will prove the benefits of the usage of a competitive process and will install this as the model of future cycles.

c. Feed-in-tariff

The country's Energy Regulatory Commission initiated FiTs for renewable energy projects at the end of 2012. It was the 1st FiT to be implemented in the Middle East.

A loan of USD 70 million was provided to Green Watts Renewable Energy LLC by the European Bank for Reconstruction and Development (EBRD), for the construction of a wind power plant with a capacity of 86 MW in Ma'an governorate located in the south of Jordan, around 200 Km south of Amman.

This power plant is the first project settled under round 1 of the renewable energy FiT program of Jordan and this plant will increase the installed wind capacity of Jordan by 40%.

Figure 13. Al Rajef wind power plant

d. Net metering

Through the trade of electrical energy obtained from renewable energy systems; net metering is authorized in the Directive governing.

The additional electricity exported to the grid is credited for future consumption, which is under the net metering scheme of Jordan. This credited extra electricity can be used to counterbalance electricity used in another time, in the case where there is no photovoltaic electricity production, for example, at night.

The 2012 Renewable Energy and Energy Efficiency Law No. 13 (REEL) is the legal source for net metering. The Renewable Energy and Energy Efficiency Law No. 13 and its bylaws allow Independent power producers (IPP) to deliver electricity from RE sources to National Power Electric Company (NEPCO) as a share of a long-term PPA. It is allowed up by REEL to 5 MWp for private investors to invest in their own photovoltaic system to consume directly the produced electricity and offset it within a net metering system. The REEL also allows the “Energy Wheeling” system, which is referred to the production of electricity on a different area than the one where the consumer is placed.

More than two thousand applications were received by the companies’ distribution and around 35 MW of rooftop schemes were inaugurated and another 30 MW were accepted for future installations, by December 2015.

3. United Arab Emirates

a. Public competitive bidding

Following the competitive bidding policy, United Arab Emirates have had successes.

The auction of Mohammed bin Rashid Al Maktoum Solar Park’s third phase with a capacity of 800 MW, broke the record of the world when granted to a Masdar-led group with 2.99 US cents/kWh of levelized cost of electricity (LCOE). This happened after the second phase of 200 MW that broke the ground earlier, and it was granted to Saudi Arabia’s Acwa Power-led group with 5.84 US cents/kWh of LCOE.

In United Arab Emirates, thirty-four companies for its 350 MW solar photovoltaic park of in Sweihan has been pre-qualified by Abu Dhabi Water and Electricity Authority (ADWEA), where the deadline of the bid submission was set in September 2016.

The first 200 MW concentrated solar power project was initiated by the Dubai Electricity and Water Authority by receiving formal offer in July 2016 from 4 international finance services companies to deliver advisory supports on the project.

United Arab Emirates does have the public competitive bidding policy for the private renewable energy projects on a large-scale.

Figure 14. Mohammed bin Rashid Al Maktoum solar park

b. Feed-in-tariff

Dubai is currently taking feed-in-tariff into consideration as a potential policy.

c. Net metering

On December 15, 2014, the operation of rooftop photovoltaic systems under a net metering scheme is allowed by the United Arab Emirate's Executive Council. On 15th of March 2015, Dubai Electricity and Water Authority (DEWA) launched the net metering system officially, and it is anticipated through the Shams Dubai framework to encourage residential and commercial building owners to fit solar photovoltaic panels. There is a powerful business case for the installations of rooftop solar photovoltaic for industries on medium to large-scale (above 50 kW). So far, many government and private entities that are showing interest are applying for installations that are received by DEWA. For instance, Dubai Ports authority announced recently that they will be adding a capacity of 30 to 40 MW on their sites under Dubai Electricity and Water Authority’s net metering program.

4. Saudi Arabia

<u>a. Public competitive bidding</u>

In April 10, 2017, qualified companies were shortlisted by the Renewable Energy Project Development Office (REPDO), of Saudi Arabia’s Ministry of Energy, Industry and Mineral Resources for the first round of the National Renewable Energy Program (NREP). The bidders that are qualified have been identified depending on a clear set of measures that guarantees bidders are both capable and experienced of delivering utility scale RE projects.

27 companies for the solar photovoltaic project of 300 MW, and 24 companies for the wind farm of 400 MW located in Sakaka, have been qualified by REPDO.

In April 17, 2017, A second round of the National Renewable Energy Program (NREP) were also exposed under a total capacity of 1020 MW, which is divided between 400 MW wind farm in Doumat Al Jandal and 620 MW of solar photovoltaic projects distributed across different sites.

The close date for delivering the request for proposal (RFP) submission of the Sakaka solar PV will be in September 2017.

A power purchase agreement of 25 years will be backed for the Sakaka solar photovoltaic.

b. Feed-in-tariff

KSA is still discussing a policy for developing a feed-in-tariff program for the producers of small-scale RE projects.

c. Net metering

In Saudi Arabia, net-metering policy doesn't exist.

5. Egypt

a. Public competitive bidding

Egypt has adopted the public competitive bidding policy to develop renewable energy large-scale projects such as wind and solar which are private.

Following the competitive bidding policy, Egypt has had successes. A price of around 4 US cents/KWh was received for a project of 250 MW at Gulf Al Zayt, which is currently under negotiation. Those prices are possible only due to the regions remarkable wind and solar resources, and supported by several measures and concessional finance to encourage investment and reduce different risks.

b. Feed-in-tariff

In October 2014, feed-in-tariff scheme in Egypt was introduced and then revised in September 2016 and employs to both wind and solar photovoltaic projects.

For their feed-in-tariffs Egypt has decided to apply a stable tariff rate.

Some of these stable rates are reviewed during the programs, relying on the type of technology and scheme, but those rates are not revised according to the fluctuations of the market but they are always revised with respect to pre-defined price levels.

This element creates confidence for investors who know how much encouragement they can expect from the beginning. In the region, feed-in-tariff systems vary significantly in tariff structure, duration, tariff levels, and scope; mainly those levels change in the way they have been determined.

For wind, the tariff level is considered moderate, varying between US cents 4 to 7.98 per KWh, whereas for solar photovoltaic varies between US cent 7.88-8.40 per KWh.

For additional support investments in renewable energy, in Egypt all feed-in-tariff projects have a promise for access to the grid.

c. Net metering

In the beginning of 2013, a net metering policy was adopted in Egypt, and it is currently in the implementation process. Net metering mechanism applies to solar photovoltaic projects related to the low voltage grid. The design of the system is very complicated where the prosumers can offset only the consumed electricity in the tariff bracket that is high for each month. Customers can connect a technique that generates more electricity than their consumption, since there is no specified installation limit. This is, though, improbable due to several reasons. The fact that the electricity surplus can be only credited in the tariff bracket that is high, which motivates customers to install photovoltaic technologies that only meet a slight share of their overall need.

Egypt ERA (Egyptian Electric Utility and Consumer Protection Regulatory Agency) applied the net-metering policy in 2013 for small-scale renewable energy projects in order to inject electricity to the grid. And through the net-metering process, the excess electricity will be deducted from the balance.

CHAPTER 6

INDICATORS

A Effectiveness

The share of renewable energy in the power capacity mix that is installed, is the most familiar way to assess the whole effectiveness of a certain country's efforts to promote renewable energy. The changing size of installed generation or capacity, normally indicated as share of the power mix, is usually a very valid indicator as to how a country is committed to its national target.

In many Arab countries, a remarkable scale-up of RE installed capacity has been perceived since 2014. Including hydropower, the overall installed capacity of all renewable energy reached approximately 14 GW in 2015. Excluding hydropower, the overall installed capacity makes about 3 GW in 2015. Comparing to the year 2012, the installed capacity of renewable energy showed 150% increase where it was 1.2 GW excluding hydropower.

Renewable energy presented 6% of the Arab region's total power production capacity in 2015. Divided in the form of wind (0.9%), solar energy (0.4%) and hydropower (4.7%).

1. Lebanon

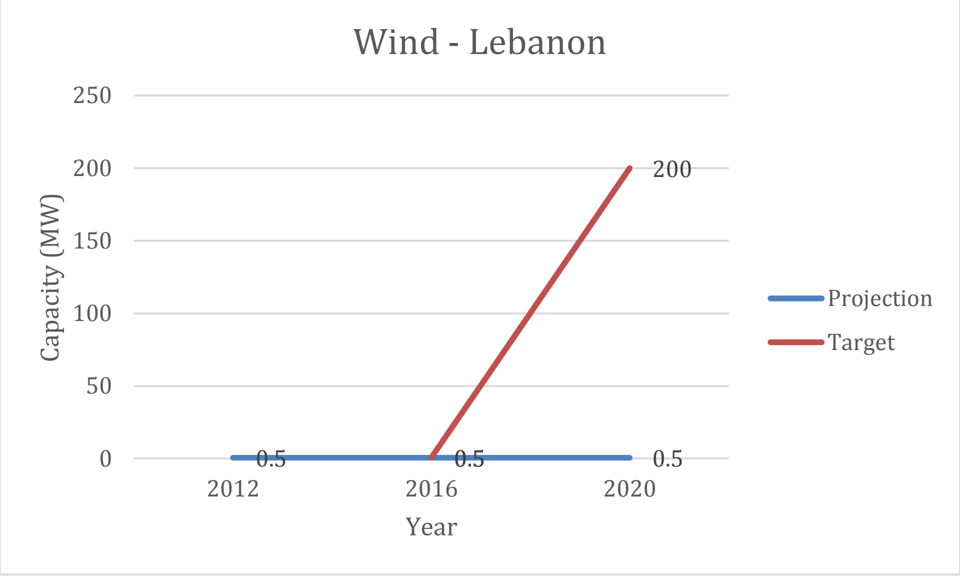

Figure 15. Wind energy projection and target - Lebanon

Wind technology in Lebanon has shown a steady output. In 2012, the installed capacity of wind recorded 0.5 MW, and it remains the same until 2016 with 0 percentage change, which means it's not feasible to reach the target of 200 MW by 2020 if we continue on the same growth rate.

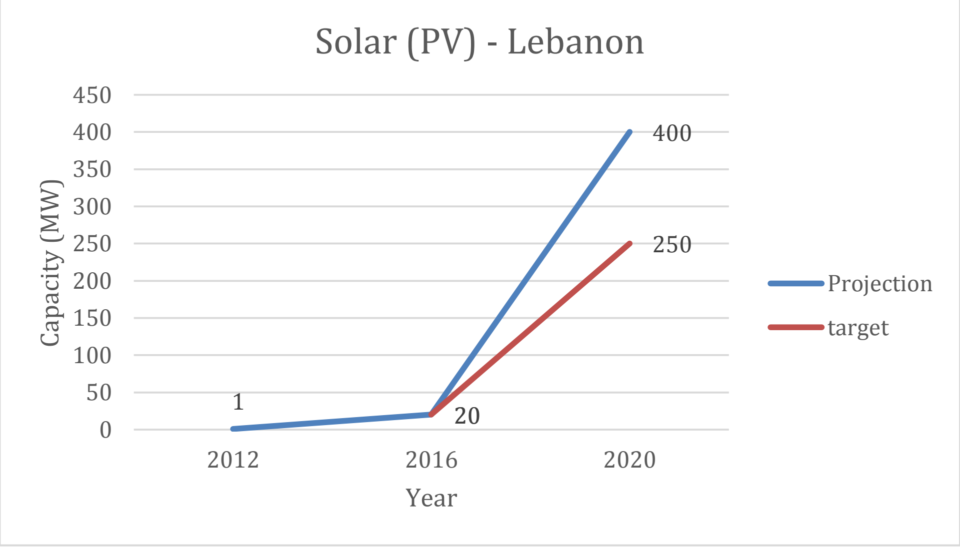

Figure 16. Solar (PV) Projection and Target - Lebanon

In Lebanon, solar photovoltaic technologies have presented a major increase in the installed capacity from 2012 until 2016 1 MW to become 20 MW, therefore there was a percentage change of 1900%, hence if the growth rate remains at this level, then it's feasible for Lebanon to reach the target of 400 MW by 2020, which is higher than the target set, which is 250 MW divided between large-scale solar photovoltaic technology (150 MW) and for solar photovoltaic distributed generation (100 MW).

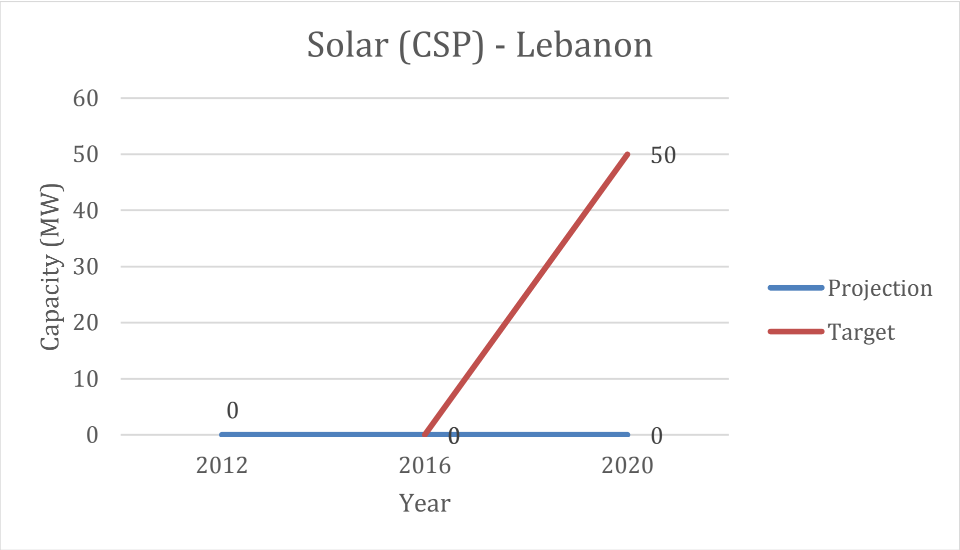

Figure 17. Solar (CSP) projection and target - Lebanon

For concentrated solar power, there was no installation throughout the years from 2012 until 2016 and the target for 2020 is 50 MW. This is not feasible, knowing that there is a target already set, but they are not considering installing concentrated solar power yet.

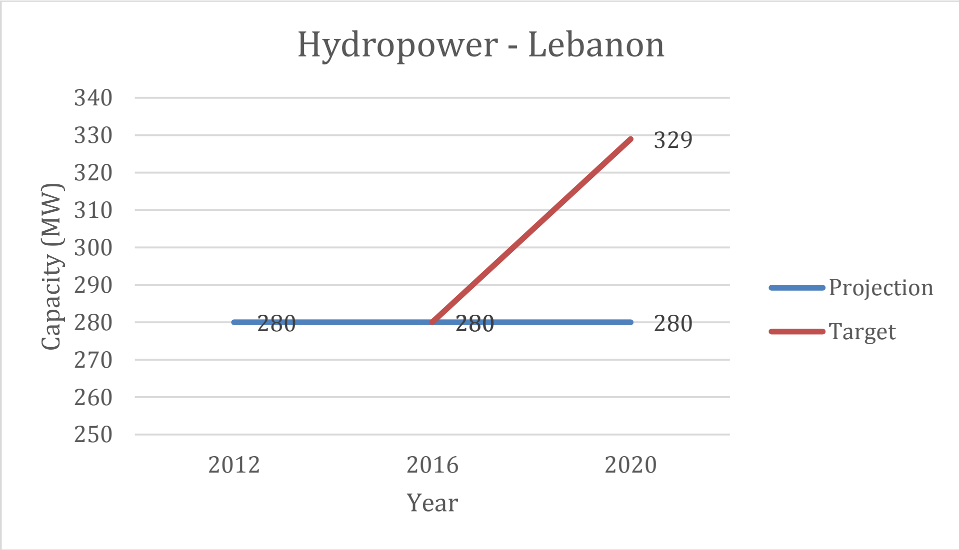

Figure 18. Hydropower projection and target - Lebanon

The installed capacity of hydropower in Lebanon remains the same in 2012 until 2016 (280 MW).

A target of 236 MW was set for the rehabilitation of existing hydropower plants to be achieved by 2020. And another target was set for the implementation of new hydropower plants of 93 MW by 2020. It is feasible because the targets set are reasonable, although the projection line is under the target line, because Lebanon have the sources and the technical know-how is available.

2. Jordan

The installed capacity of wind energy in 2012 is 1.5 MW. A huge increase has taken place in 2016; the installed capacity of wind energy became 197 MW with a percentage change of 13,033 %, thus if the growth rate remains at this level, then it is feasible for Jordan to reach the target of 1.2 GW by 2020 according to REN21 2017 report.

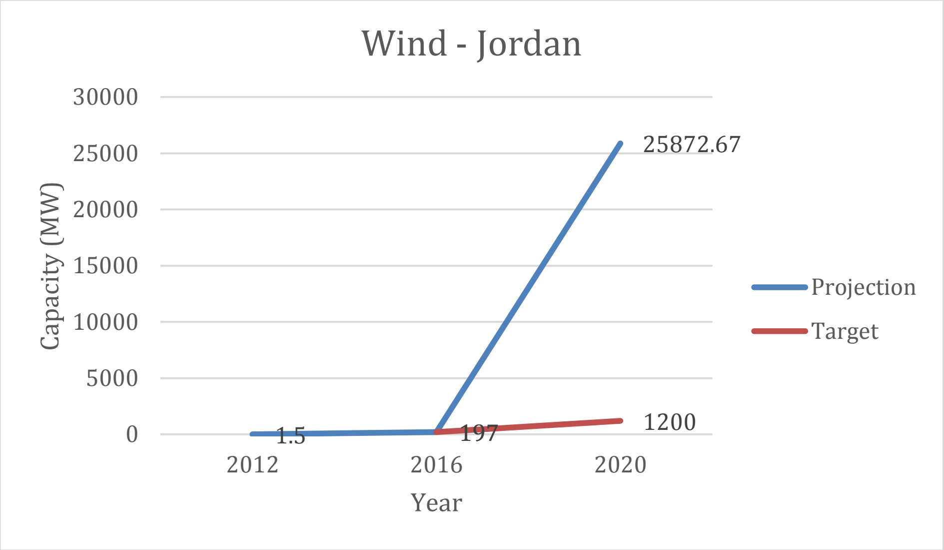

Figure 19. Wind energy projection and target – Jordan

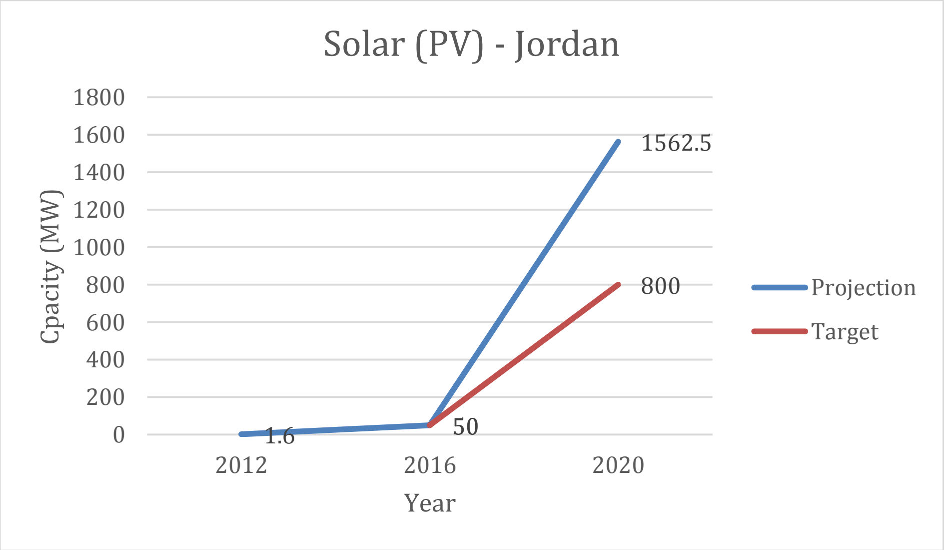

Figure 20. Solar (PV) projection and target - Jordan

Jordan had an installed a capacity of 1.6 MW of solar photovoltaic in 2012, and in 2016 a significant increase took place, 50 MW of solar photovoltaic were installed, therefore there was a percentage change of 3025%. It is feasible to reach the target set by 2020, which is 800 MW if they continue on the same growth rate.

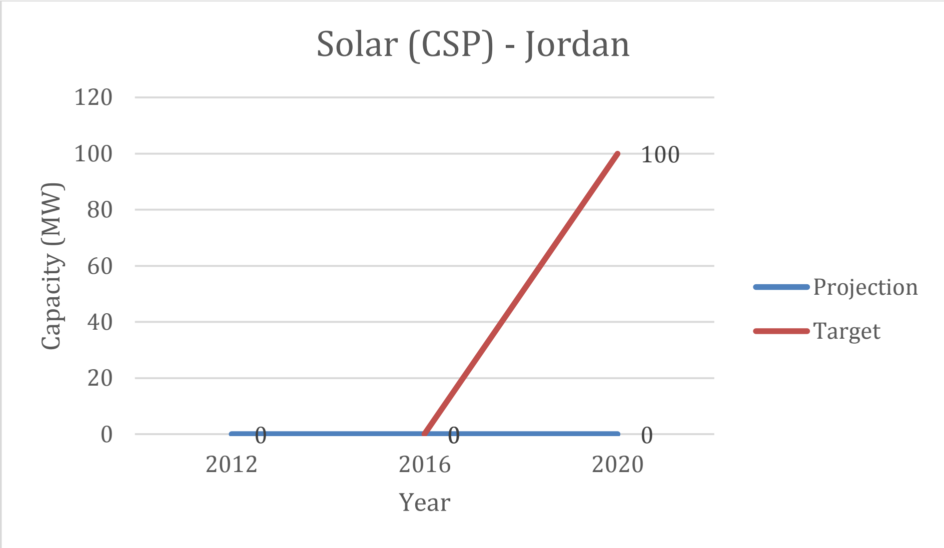

Figure 21. Solar (CSP) projection and target - Jordan

A target of 100 MW for concentrated solar power was set by Jordan to be achieved by 2020, which is not feasible knowing that Jordan doesn't installed any concentrated solar power yet.

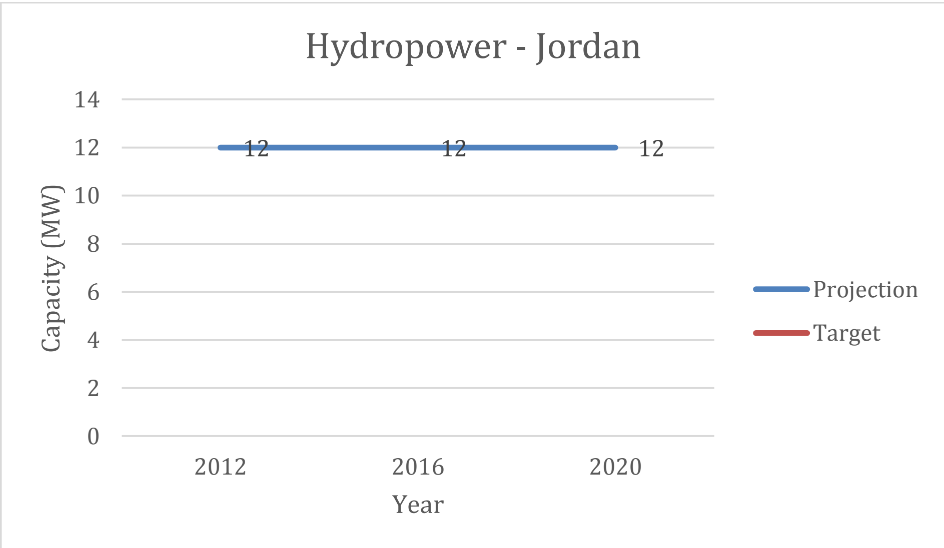

Figure 22. Hydropower projection and target - Jordan

Hydropower in Jordan has no targets, but an installed capacity of 12 MW remains the same from 2012 until 2016. This shows that Jordan doesn't want any change in hydropower technology.

3. United Arab Emirates

United Arab Emirates has neither installed capacity of wind, nor targets, and hydropower doesn't exist in United Arab Emirates.

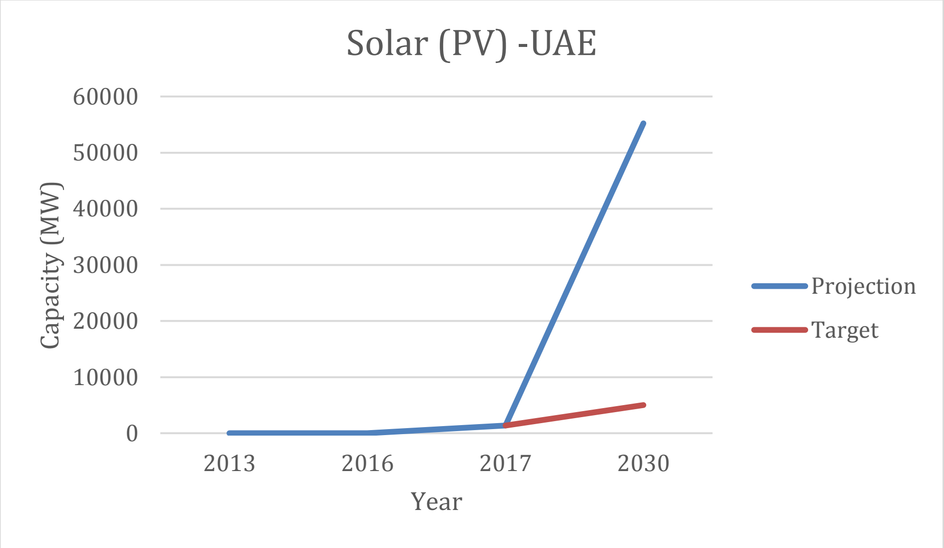

Figure 23. Solar (PV) projection and target - UAE

UAE has an installed capacity of 33 MW of PV in 2013, and it remains the same in 2016 with a capacity of 33 MW. In 2017, the capacity of solar PV has seen a huge increase to reach 1350 MW with a percentage change of 39,990.91%, so if the growth rate remains at this level, UAE will reach the target of 5000 MW by 2030.

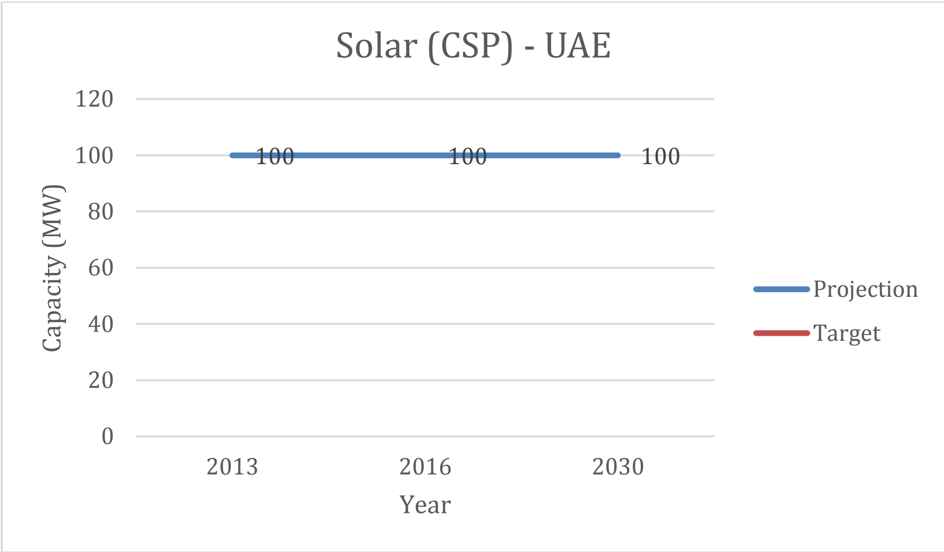

Figure 24. Solar (CSP) projection and target - UAE

Concentrated solar power in UAE has no targets, but an installed capacity of 100 MW remains the same from 2013 until 2016. This shows that UAE doesn't want any change in CSP technology.

4. Saudi Arabia

Hydropower doesn't exist in Saudi Arabia.

Table 6.1. Wind energy capacities and target - KSA

Installed capacity in 2013	0
Installed capacity in 2017	800 MW
Target by 2040	9000 MW

The preparation of a tender to be closed at the end of 2017, has installed a wind energy capacity of 800 MW, with a percentage change of 80,000%. According to AFEX 2016, a target of 9000 MW by 2040 was set by Saudi Arabia, which is feasible since they improve their capacity by 800 MW in 1 year.

Table 6.2. Solar (PV) capacities and target - KSA

Installed capacity in 2013	19 MW
Installed capacity in 2016	23.2 MW
Installed capacity in 2017	934.2 MW (23.2+920)
Target by 2040	16,000 MW

In 2013, the installed capacity of solar photovoltaic was 19 MW. In 2016, it increased to become 23.2 MW, and in 2017 an extra capacity of 920 MW was added by a preparation of a tender also to reach 943.2 MW, with a percentage change of 4864.21% between 2013 and 2017. The target set is 16000 by 2040, which is feasible since they improve their capacity by 920 MW in 1 year.

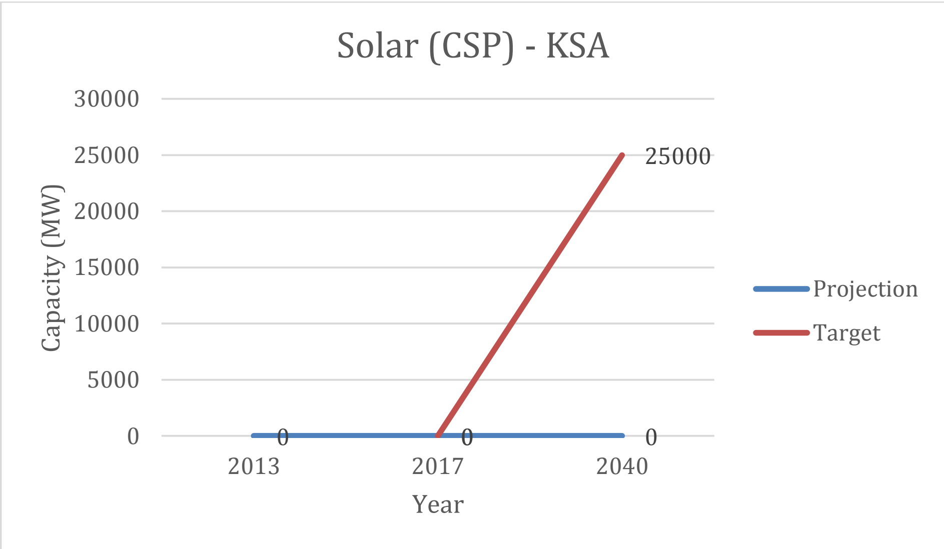

Figure 25. Solar (CSP) projection and target - KSA

A target of 25,000 MW for concentrated solar power was set by Saudi Arabia to be achieved by 2040, which is not feasible knowing that KSA doesn't installed any concentrated solar power yet.

5. Egypt

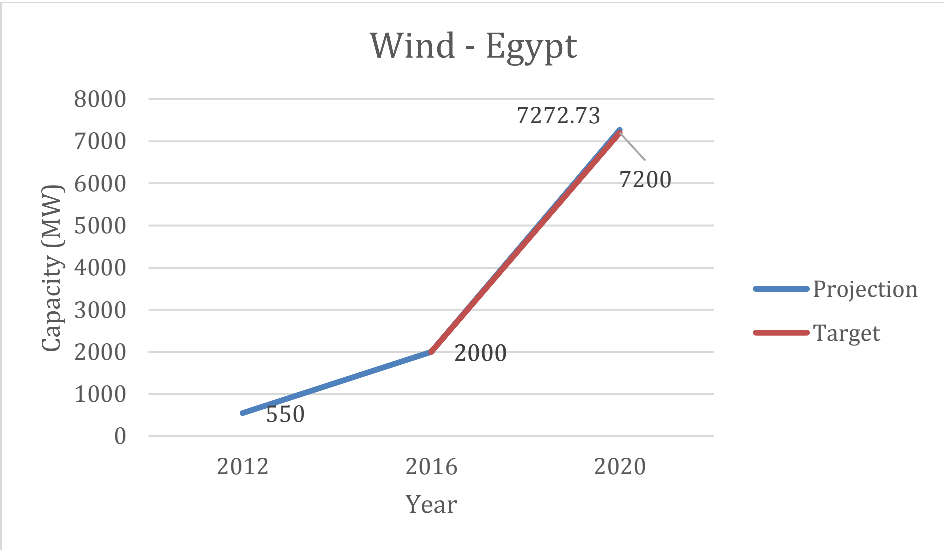

Figure 26. Wind energy projection and target - Egypt

In 2012, wind energy in Egypt had an installed capacity of 550 MW, and it increased in the year 2016 to become 2 GW, with a percentage change of 263.64%. Therefore, if they continue with the same growth rate they will reach the target of 7.2 GW set by 2020.

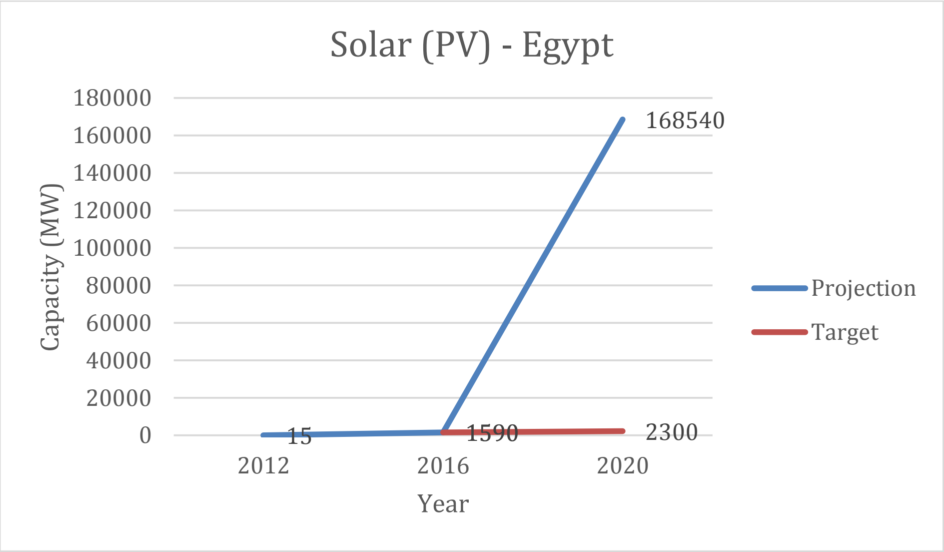

Figure 27. Solar (PV) projection and target – Egypt

Solar photovoltaic in Egypt recorded an installed capacity of 15 MW in 2012 and in 2016, 90 MW are already installed and 1500 MW are under construction, which makes a total of 1590 MW, with a percentage change of 10,500%, hence if the growth rate remains at this level, then it's feasible to reach the target of 2300 MW by 2020.

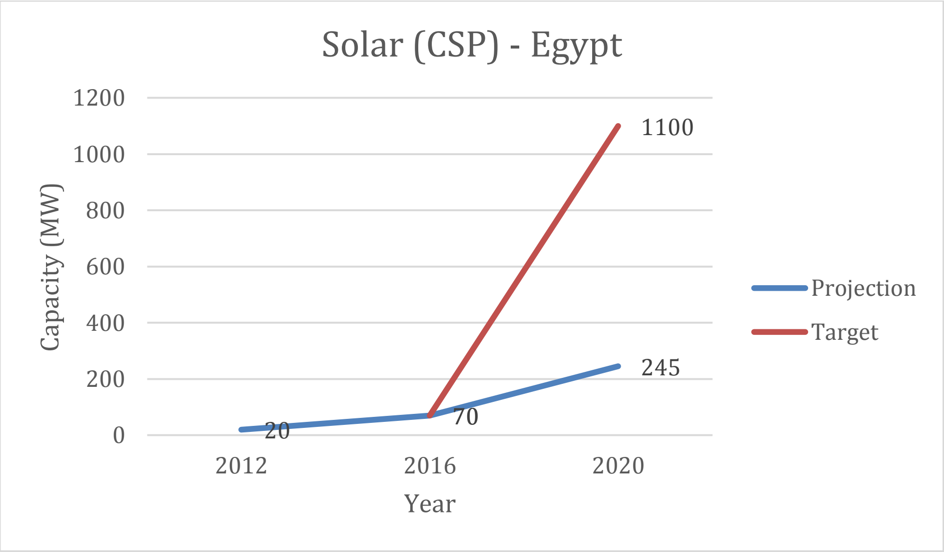

Figure 28. Solar (CSP) projection and target worst case scenario - Egypt

Concentrated solar power has an installed capacity of 20 MW in 2012. In 2016, an installed capacity of 20 MW is already existed from 2012. And a tender of 50 to 100 MW was under preparation during 2016.

The graph above shows the worst-case scenario, where the tender under preparation is considered 50 MW, which is a total capacity of 70 MW in 2016, with a percentage change of 250%. But the target of 1,100 MW by 2020 is not feasible if they continue on the same growth rate.

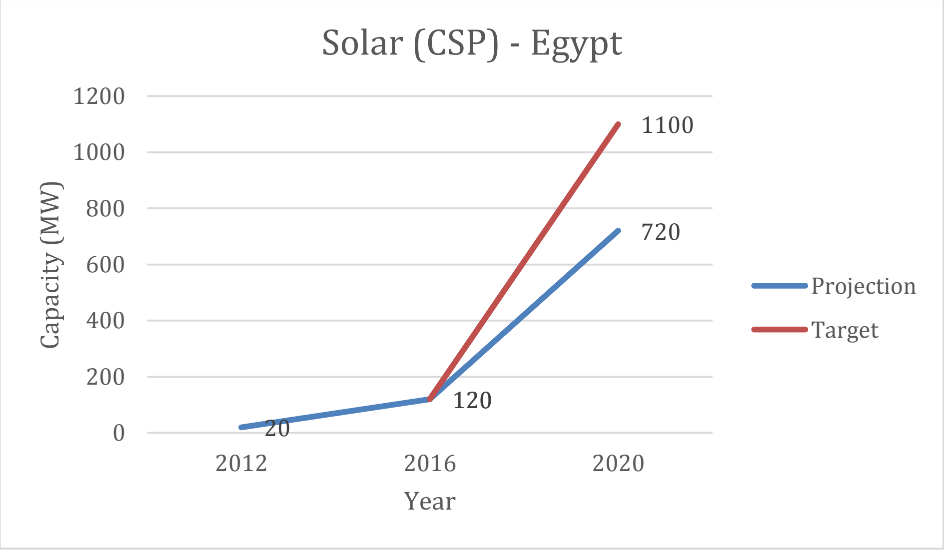

Figure 29. Solar (CSP) projection and target best case scenario - Egypt

The best-case scenario is where Egypt installs 100 MW instead of 50 MW in 2016, in this case the installed capacity will be 120 MW in 2016, therefore there was a percentage change of 500%, which is higher than the worst scenario, but it is still not feasible to get to the targets of 1,100 MW by 2020.

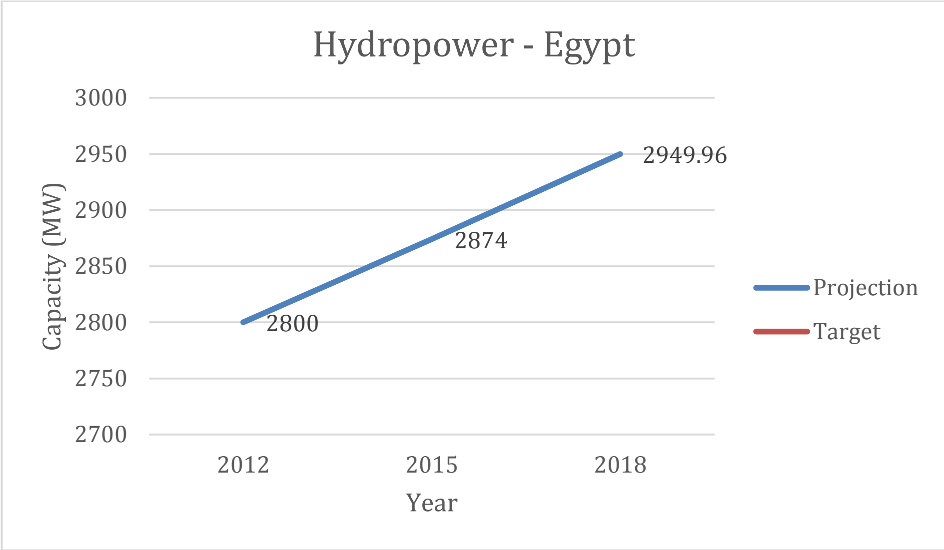

Figure 30. Hydropower projection and target - Egypt

Hydropower in Egypt has an installed capacity of 2800 MW in 2012 and it increased to 2874 MW in 2015, with a percentage change of 2.64%. However, Egypt doesn't have any target for the following years. This shows that Egypt doesn't want any change in hydropower technology.

Table 4 below summarizes the effectiveness indicator ranking for each country.

Table 6.3. Effectiveness indicator ranking

Countries	Installed capacity relative to target	Ranking
Lebanon	Solar PV is effective	5
Jordan	Wind energy is more effective then Solar PV	3
UAE	Solar PV is very effective	2
KSA	Wind energy and Solar PV are very effective	1
Egypt	Solar PV is more effective then wind energy	4

For the effectiveness indicator, Saudi Arabia is taking the first place in the ranking with high effectiveness in wind energy and solar PV; this is shown by the huge increase of their capacity within one-year relative to their targets. United Arab Emirates follows Saudi Arabia with the second place in ranking, where its solar PV is very effective with respect to its target set; where their percentage change is very high in only 1 year. Jordan took the 3rd ranking place with the effectiveness of both wind energy and solar PV; where both technologies can achieve higher than the targets set depending on future projections if they continue on the same growth rate. Solar PV is more effective than wind energy in Egypt, which makes it in the 4th ranking place, due to the wind energy, where the projections are not too high from the target set. Finally, Lebanon took the last ranking place where only its solar PV is effective.

B. Efficiency

The efficiency of a country is identified from the levelized cost of electricity at which a country signed a power purchase agreement (PPA) with a developer.

1. Lebanon

Upon a discussion with one of the bidder for the current tender in Lebanon for a wind energy project, Lebanon will sign a power purchase agreement (PPA) of US 11.3 cents/Kwh. For solar energy, there is a prediction regarding the signature agreement, which is US 8.5 cents/Kwh.

2. Jordan

ACWA power, the Saudi Arabian power engineering firm has signed a PPA for a solar plant of 61.3 MW located in eastern Jordan. Where ACWA power claims that it has the lowest photovoltaic tariff in the country until now.

The Risha project is the second solar photovoltaic plant for ACWA in Jordan. It will be developed near an existing gas turbine plant of 150 MW, which is run by a Jordanian power firm called Central Electricity Generating Company (CEGCO) where ACWA and the government are shareholders.

Once this project is complete, ACWA's file of Jordanian power projects would reach 1,665 MW, which will account for 40% of all generation of power in Jordan.

Under the power purchase agreement, ACWA will sell power to Jordan's utility National Electric Power Company (NEPCO) at a tariff of JOD 0.042/Kwh equivalent to USD 0.059/Kwh, which is the lower tariff in the country to date.

Abdel Fattah Al-Daradkeh, NEPCO's managing director, said: "This project in Risha is an important step forward in attaining Jordan's RE targets and offering in Jordan an economical and stable electricity supply.

In Jordan, the demand of electricity is increasing 7% per year, due to the mounting industrial needs and population booms in the country. In meeting this demand, renewable energy is set to play an important role. In 2016, the Ministry of Energy & Mineral Resources (MEMR) in Jordan said that it planned to launch a 3rd solar tender, but including 400-700 MW of both solar and wind.

3. United Arab Emirates

A Power Purchase Agreement has been signed by the Dubai Electricity and Water Authority (DEWA) with Abu Dubai Future Energy Company (Masdar), for the 800 MW 3rd phase of the Mohammed bin Rashid Al Maktoum Solar Park.

The Power Purchase Agreement was signed by his excellency (HE) Saeed Mohammed Al Tayer, Managing Director and Chief Executive Officer of Dubai Electricity And Water Authority, and HE Mohamed Jameel Al Ramahi, Chief Executive Officer of Masdar is also present.

Early 2016, Dubai Electricity and Water Authority declared the Masdar-led group as chosen bidder for the 3rd phase of the solar park. The group bid the lowest cost of electricity. When granted to a Masdar-led group, this auction broke the world's record with US 2.99 cents/Kwh of levelized cost of electricity.

4. Saudi Arabia

The 50 MW solar photovoltaic plant received offers at 4.9 US cents/kWh, which was considered by Taqnia in Saudi Arabia for Saudi Electric Company (SEC).
The SEC invited words of interests for the development of 2 solar PV IPPs, in Rafha and Al-Jouf north of KSA through the 9.5 GW targets of new RE capacity by 2030. The developers will be selected through a competitive process. Each site will contain the improvement of up to 50 MW of photovoltaic capacity. The independent power producers will encourage existing conventional plants in their particular locations.
Under a long-term PPA, the whole energy output will be sold to Saudi Electric Company.

5. Egypt

According to local reports, the Saudi Arabian company Alfanar's energy has signed a Power Purchase Agreement with the Egyptian Electricity Transmission Company (EETC) for the development of a solar plant in Egypt with a capacity of 50

MW.

The Power Purchase Agreement was signed when the 50 MW project reached its financial closure under the country's FiT program. In the Aswan province, the plant will be placed at the planned 1.8 GW Benban solar complex.

This USD100 million project is being supported by the Islamic Development Bank (IDB) and the European Bank for Reconstruction and Development (EBRD), and is one of the 1st utility-scale solar plants in Egypt.

Through the second phase of the feed-in-tariff, Alfanar has assigned USD200 million towards two new RE projects in Egypt with a total capacity of 100 MW.

Under the Power Purchase Agreement, Alfanar Company will sell a tariff of USD 0.084/Kwh of electricity to the Egyptian Electricity Transmission Company (EETC).

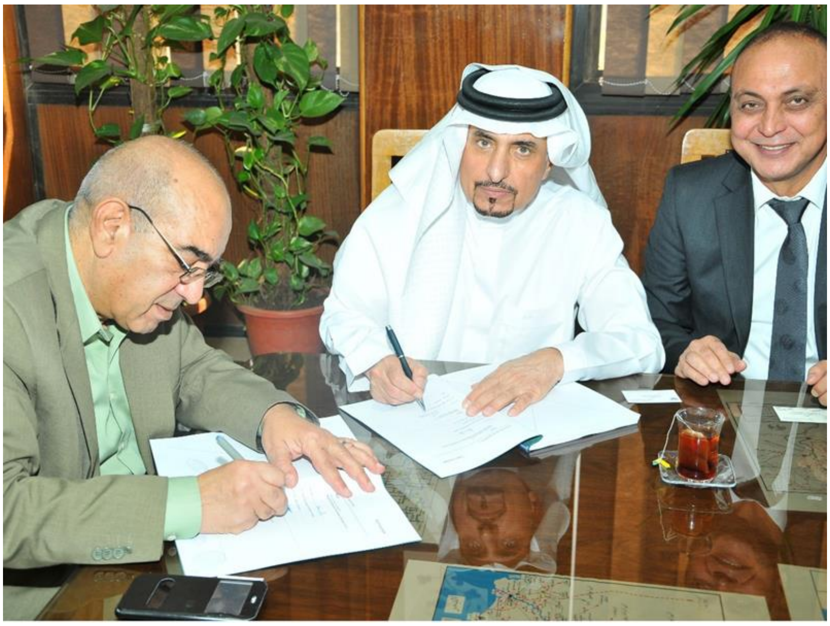

Figure 31. Alfanar PPA signing with the Egyptian Electricity Transmission Company

Table 5 below summarizes the efficiency indicator for each country.

Table 6.4. Efficiency indicator ranking

Countries	Technology	Tariff rate (LCOE) $/Kwh	Ranking
Lebanon	Wind energy ($ 0.113/Kwh)	$0.086/Kwh	5
	Solar energy ($ 0.085/Kwh)		
Jordan	Solar energy	$0.059/Kwh	3
United Arab Emirates	Solar energy	$0.0299/Kwh	1
Saudi Arabia	Solar Energy	$0.049/kwh	2
Egypt	Solar energy	$0.084/Kwh	4

For the efficiency indicator, United Arab Emirates showed in the first place with the lowest cost of $ 0.0299/Kwh for a solar energy project. Saudi Arabia came in the second place, where it recorded for a solar energy project an LCOE of $ 0.049/Kwh. After the 2nd place, Jordan came into the third ranking place with a solar energy project also for a cost of $ 0.059/Kwh. The fourth place was taken by Egypt with an LCOE of $0.084/Kwh. Lebanon came at the last place because it recorded the highest cost of $ 0.086/Kwh, combining two technologies wind and solar energy, $ 0.113/Kwh and $ 0.085/Kwh respectively.

C. Reliability

Renewable energy consumption is a share of RE in the overall final energy consumption.

This is able to measure the reliability indicator summarizing each country in a graph that shows the percentage of renewable energy consumption from 2004 until 2014 as follow.

1. Lebanon

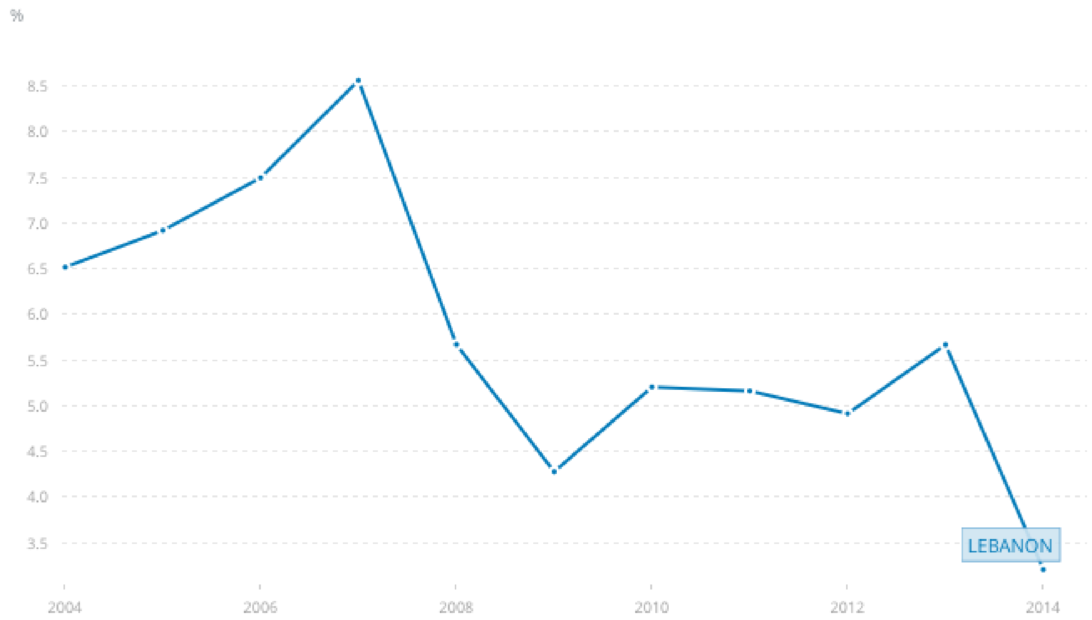

Figure 32. Lebanon – Renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

In 2004, Lebanon recorded 6.516% of renewable energy consumption. This percentage decreases to 4.277% in 2009 and this decrease continue even more to reach 3.204% in 2014.

2. Jordan

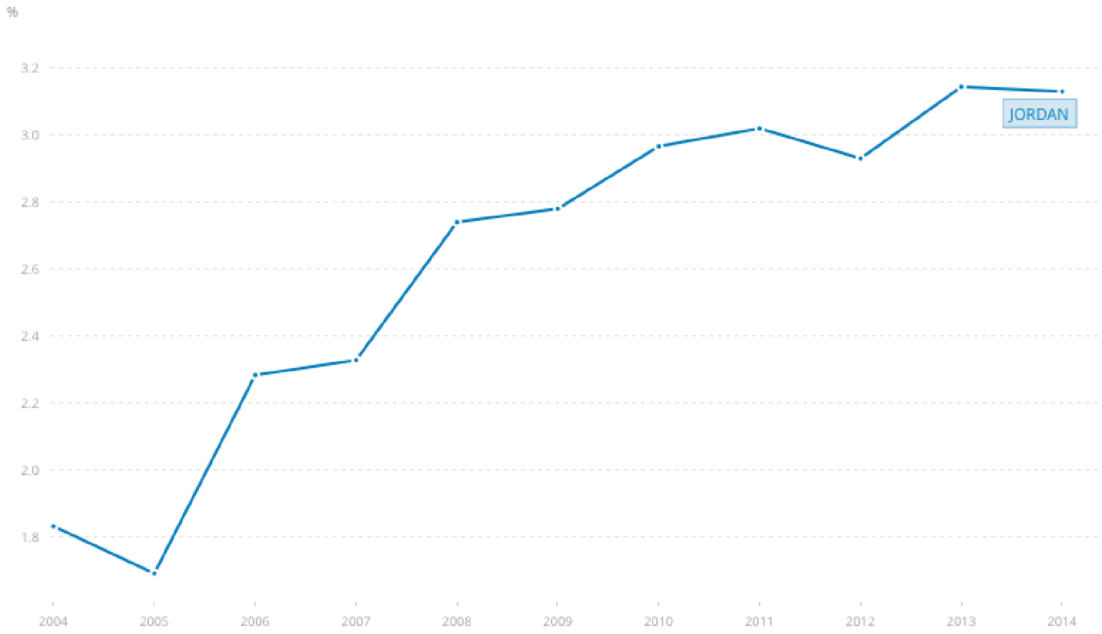

Figure 33. Jordan – Renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

In 2004, Jordan recorded 1.831% of renewable energy consumption. This percentage increases to 2.78% in 2009 and this increase continue even more to reach 3.13% in 2014.

3. United Arab Emirates

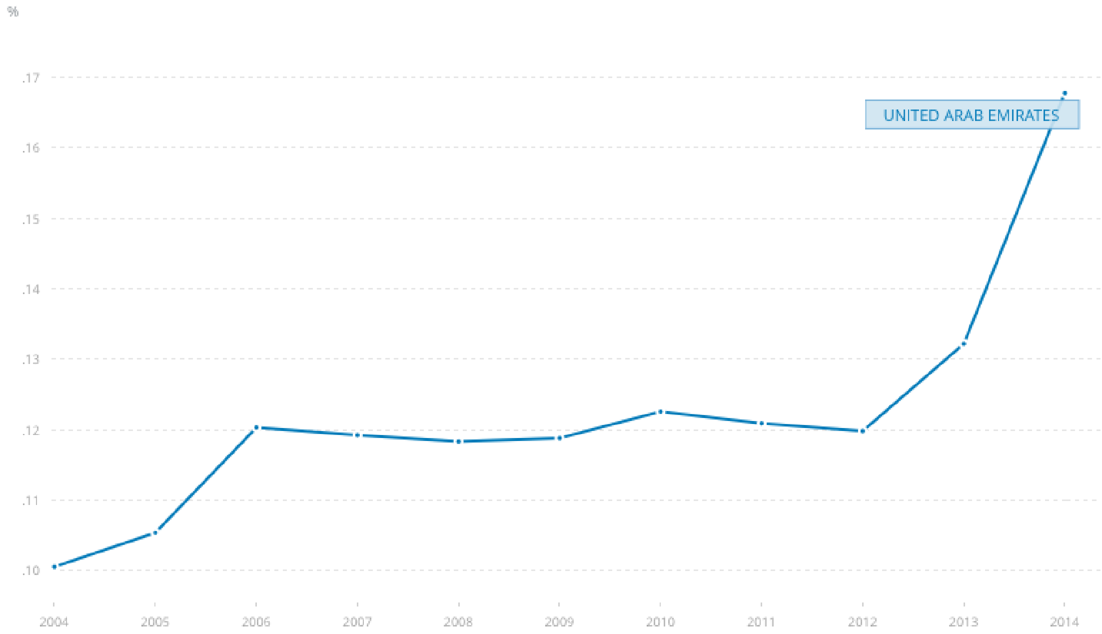

Figure 34. United Arab Emirates – Renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

In 2004, United Arab Emirates recorded 0.101% of renewable energy consumption. This percentage increases slightly to 0.119% in 2009 and this increase continue to reach 0.168% in 2014.

4. Saudi Arabia

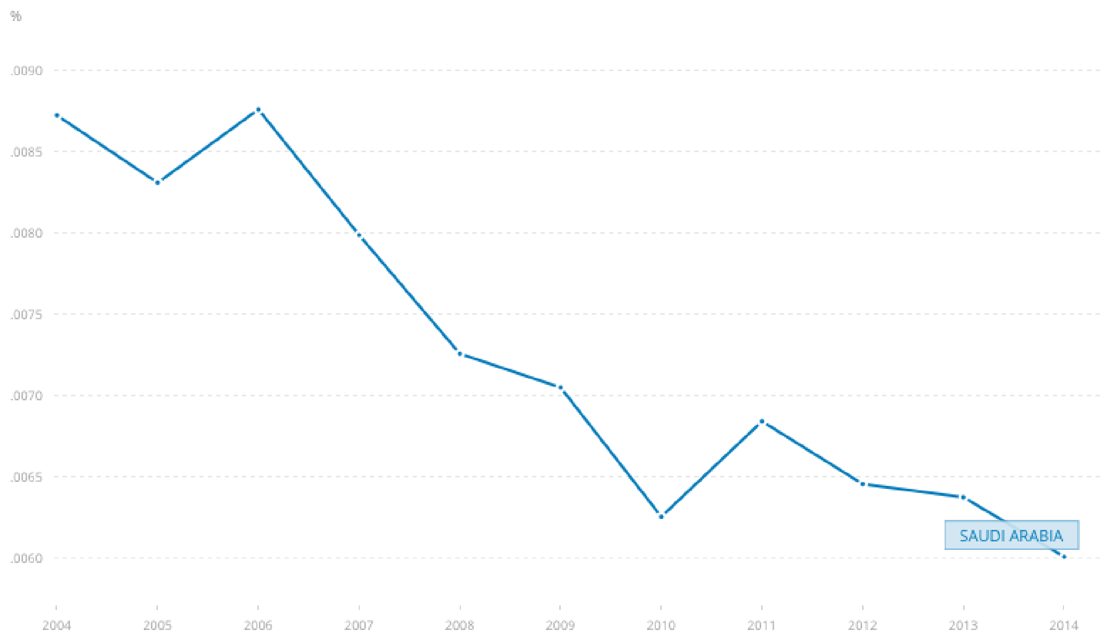

Figure 35. Saudi Arabia – Renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

In 2004, Saudi Arabia recorded 0.009% of renewable energy consumption. This percentage decreases to 0.007% in 2009 and this decrease continue even more to reach 0.006% in 2014.

5. Egypt

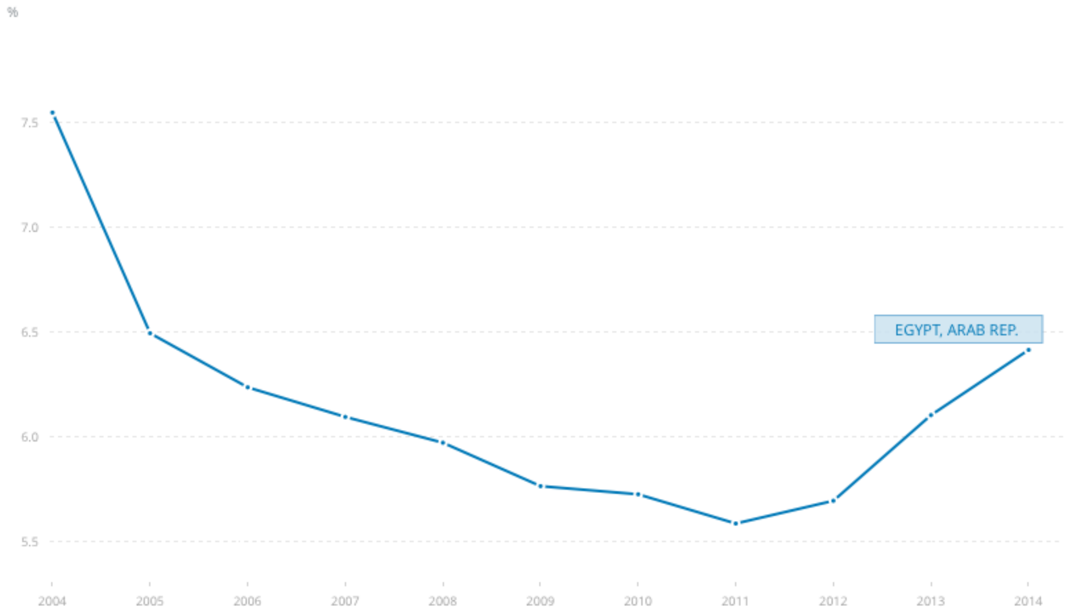

Figure 36. Egypt – Renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

In 2004, Egypt recorded 7.544% of renewable energy consumption. This percentage decreases to 5.763% in 2009 and then it increases to reach 6.413% in 2014.

Table 6 below summarizes the reliability indicator for each country.

Table 6.5. Reliability indicator ranking

Countries	Renewable energy consumption (% of total final energy consumption) in 2014	Ranking
Lebanon	3.204%	2
Jordan	3.13%	3
United Arab Emirates	0.168%	4
Saudi Arabia	0.006%	5
Egypt	6.413%	1

For the reliability indicator, Egypt took the first place with the highest percentage of renewable energy consumption in 2014, 6.413%. Lebanon came in the second place, where it recorded 3.204% of its renewable energy consumption. After the 2^{nd} place, Jordan came into the third ranking place in the renewable energy consumption with 3.13% of total final energy consumption. The fourth ranking place was taken by United Arab Emirates with 0.168% of RE consumption. Finally, Saudi Arabia took the last ranking place and recorded the lowest percentage of 0.006% of renewable energy consumption in 2014.

D. Institutional capacity

Most Arab governments have built dedicated departments or institutions within their energy ministries to encourage and supervise the deployment of renewable energy technologies.

Both implementation and organization are required for institutional setup. This lead to the understanding of institutions need: organization in order to support effectively the employment of goals set up by governments, and more importantly the procedures must fit with the goals to adequately deliver results.

Administrative and institutional barriers are main obstacles to renewable energy development. This contains lengthy, non-transparent procedures, and complicated to get permits, lack of clearness of institutional framework, and too many public authorities. To accelerate the development of renewable energy and control some of these barriers, dedicated renewable energy agencies have been established by several countries around the world.

A renewable energy agency should be a devoted body with an ability to assist in the implementation of private renewable energy projects, to design renewable energy policies, to lead the employment of demonstration and other public renewable energy projects, and streamline administrative procedures.

Successful coordination among many stakeholders is an important function of renewable energy agencies, including state institutions and private developers, to guarantee more effective use of capital, existing human, and technical resources for the achievement of renewable energy targets.

Renewable energy agencies can perform as counterparts in coordinating and negotiating donor agreements, in the countries where donor support for renewable energy development is received by governments.

Dedicated renewable energy agencies can also play an essential role in conducting resource quality valuations and feasibility studies, encouraging research and development, and in raising awareness.

Another challenge situated in the availability of fiscal and financial incentives to private renewable energy developers; in both distributed generation and utility scale projects and in the capacity to offer institutional help to streamline the administrative processes.

Placing standardized contractual documents, improving stakeholder's coordination to get required permits, facilitating land access, while properly designing incentives instruments to organize finance are among the main concern that most countries in the Arab world should pay attention to.

One of the evaluation categories of the Arab Future Energy Index 2016, is the institutional capacity, which measures the institutional capacity of the countries mentioned below to formulate and design renewable energy policies and, most significantly, offer institutional encouragement for private developers in renewable energy deployment

1. Lebanon

All activities related to promoting and supporting RE in Lebanon fall under the umbrella of the Lebanese Center for Energy Conservation (LCEC).

The Lebanese Center for Energy Conservation is founded and supported by United Nations Development Program (UNDP), which is a national organization connected with the Lebanese Ministry of Water and Energy. The institutional capacity of Lebanon is 46% according to AFEX 2016.

2. Jordan

Dedicated agency in Jordan doesn’t exist to regulate and promote renewable energy projects. Nevertheless, awareness activities and research are carried out by the National Energy Research Center. The Ministry of Energy and Mineral Resources and Electricity Regulatory Agency is responsible of the activities concerning renewable energy promotion. According to AFEX, then institutional capacity of Jordan is 69%.

3. United Arab Emirates

The United Arab Emirates has not built a national RE agency. Nonetheless, the Emirate of Abu Dhabi has built Masdar as a private company, which was structured to promote renewable energy technologies. The Emirate of Dubai also has the Supreme Council of Energy, which is the leading body tasked with coordinating and planning with concerned authorities, policy development and energy bodies to offer energy sources that are new while engaging a balanced approach for the protection of the environment. According to AFEX, then institutional capacity of United Arab Emirates is 72%.

4. Saudi Arabia

The responsibility to coordinate international and national energy policy, involving renewable energy, has been assigned by the King Abdullah City for Atomic and Renewable Energy (K.A. CARE). King Abdullah City for Atomic and Renewable Energy was founded by Royal Decree in 2010 in order to lead KSA towards a new era of energy sustainability, guiding the way in renewable and atomic energy to guarantee the best possible use of the country's abundant energy resources. According to AFEX, then institutional capacity of Saudi Arabia is 65%.

5. Egypt

Supporting and promoting renewable energy is under the responsibility of the New and Renewable Energy Authority (NREA). According to AFEX, then institutional capacity of Egypt is 69%.

The table below will summarize the institutional capacity indicator for each country.

Table 6.6. Institutional capacity indicator ranking

Countries	Institutional capacity (%)	Ranking
Lebanon	46%	5
Jordan	69%	2
United Arab Emirates	72%	1
Saudi Arabia	65%	4
Egypt	69%	3

For the institutional capacity indicator, United Arab Emirates took the first place with the highest percentage of institutional capacity, 72%. Jordan and Egypt recorded the same percentage of institutional capacity, 69% but Jordan got a higher ranking of 2 than Egypt 3. (This will be further discussed in the discussion section). The fourth ranking place was taken by Saudi Arabia with 65% of institutional capacity. Finally, Lebanon took the last ranking place and recorded the lowest percentage of 46% of institutional capacity.

CHAPTER 7

RESULTS

After studying the indicators in each country, a clear picture about the ranking of each country relative to each indicator will be set in the table below, which allows us to have a comparative matrix in order to compare each country's renewable energy deployment policies according to the indicators.

Table 7.1. Ranking of countries relative to the indicators

Indicators / Ranking	Effectiveness	Efficiency	Reliability	Institutional Capacity
1	KSA	UAE	Egypt	UAE
2	UAE	KSA	Lebanon	Jordan
3	Jordan	Jordan	Jordan	Egypt
4	Egypt	Egypt	UAE	KSA
5	Lebanon	Lebanon	KSA	Lebanon

Table 8 above describes the ranking column from 1 to 5 relative to the four indicators: effectiveness, efficiency, reliability and institutional capacity, they are described in the indicator section above in details for each country. The rankings are set as follow: ranking 1 is the highest and best ranking, whereas ranking 5 is the lowest and worst ranking.

For the effectiveness indicator, Saudi Arabia took the first ranking place, followed by United Arab Emirates with the second place, Jordan took the third place, Egypt the fourth and finally Lebanon scored the last and fifth ranking place.

Moving to the efficiency indicator, United Arab Emirates was more cost-efficient with respect to the other countries. Saudi Arabia took the second ranking place after UAE, Jordan took the third ranking place, followed by Egypt and again Lebanon took the last ranking place.

Egypt moved from the fourth ranking place in the efficiency indicator to record the first place in the reliability indicator. Lebanon took the second ranking place after recording the last places in the previous indicators, followed by Jordan with the third ranking place also. UAE and KSA took the last 2 ranking places respectively.

Finally, institutional capacity indicator showed that United Arab Emirates took the first ranking place, followed by Jordan with the second ranking place, Egypt took the third ranking place, than Saudi Arabia recorded the fourth place and Lebanon also took the last ranking place.

CHAPTER 8

DISCUSSION

This dissertation presents an assessment of the renewable energy deployment policies in each country mentioned in the previous sections.

The study in this analysis takes into consideration four indicators upon which the countries are assessed, and therefore the stated results present a balanced assessment. However, several limitations arose while analyzing the data.

To begin with, the effectiveness indicator shows that Egypt is currently controlling wind generation with a capacity of 2000 MW in 2016, while solar photovoltaic have been developed mostly in the UAE and Egypt. UAE recorded 1350 MW in 2017 and Egypt 1590 MW in 2016. Throughout the past year, Egypt regenerated itself as the controlling country in wind energy after the commissioning and the installation of a 200 MW project in Gulf al Zayt. Other wind projects in Egypt are in the pipeline currently and they will possibly make it recall its controlling position in the future. Jordan also presented an impressive growth with the assignments of 247 MW photovoltaic and wind projects in 2016. Because of the support by the United Arab Emirates and FiT small-scale program for the photovoltaic rural electrification program, Egypt reached approximately 90 MW of photovoltaic total installed capacity in 2016. With operational capacities of PV and CSP (133 MW), UAE preserves an important position in solar installations. In addition, the effectiveness indicator revealed future projections (presented in the graphs in the indicator section) on the developments during the past few years, where an image regarding future installations was built and the countries were ranked upon the projections relative to the targets set.

Moving to the efficiency indicator, the first bidding round in any country will be relatively high, this can be seen in the progressive prices in the Jordanian PV and Dubai solar park.

Jordanian PV showed a huge drop of 50% in the second tender round, which happened in 2013-2015. This drop in tariffs, since the 1st tender held in 2011-2013, reveals the dramatic decline of the cost of solar energy in Jordan. This tariff in the 2nd round was proposed by G. I. Karnomourakis S.A. SunRise PV Systems, which is a Greek company.

Similar to Jordan, UAE broke the world record in the second round in the 800 MW auction of Mohammed bin Rashid Al Maktoum Solar Park, which was awarded to a Masdar-led group at an LCOE of 2.99 US cents/kWh equivalent to $0.0299/Kwh. Before the second round, a first round of 200 MW recorded a tariff rate of 5.84 US cents/Kwh equivalent to $0.058/KWh, which was awarded to Acwa power-led group.

For this reason, both United Arab Emirates and Jordan took high-ranking places, recording a low levelized cost of electricity in the region. Due to its political stability, Saudi Arabia took the 2nd ranking place after UAE with a low cost of $0.049/Kwh. Because of its political instability last couple of years, Egypt recorded a high tariff of $0.084/Kwh. And finally Lebanon came into the last ranking place with a levelized cost of electricity of $ 0.086/Kwh with both wind and solar energy. The reason for this may be the first bidding round problem, where the bid price is high due to the lack of experience in the tender process, which resulted in a high tariff. In addition to the cost of financing and a high risk in a country like Lebanon.

Looking at the reliability indicator, the renewable energy consumption of the five countries is combined into the graph below.

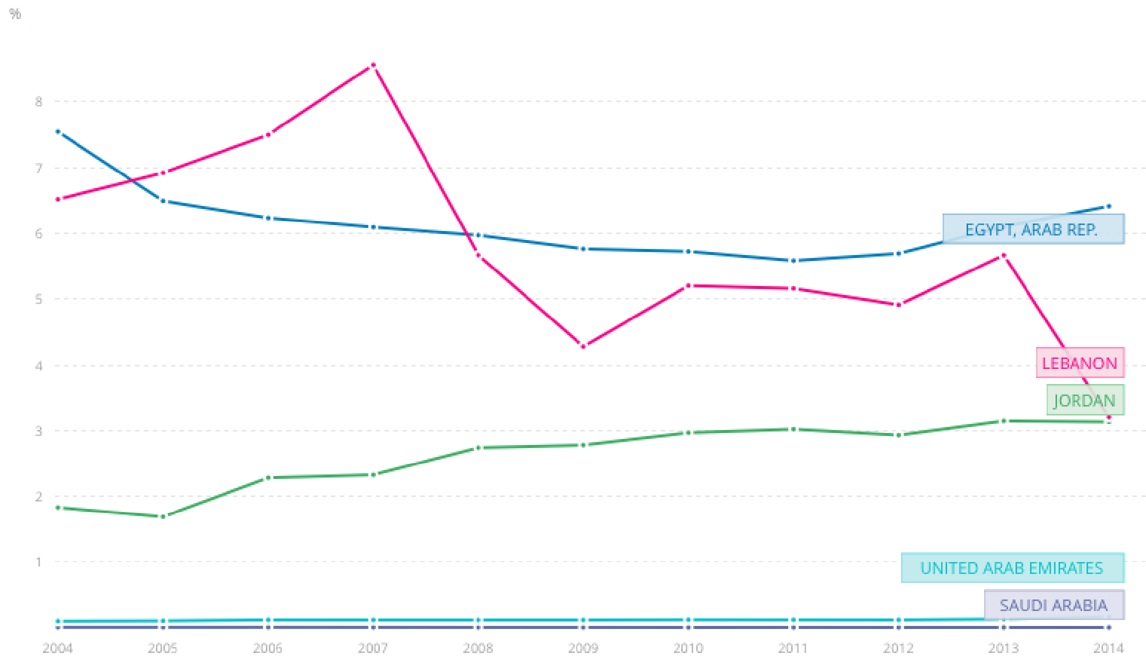

Figure 37. Lebanon, Jordan, UAE, KSA and Egypt renewable energy consumption (% of total final energy consumption) (2004-2014) (The World Bank, 2017)

This figure shows that Egypt had a percentage of 6.413% renewable energy consumption in 2014. Lebanon, recorded a renewable energy consumption of 3.204% of the total final energy consumption. Jordan had 3.13% of RE consumption. And then the United Arab Emirates and Saudi Arabia, recorded 0.168% and 0.006% respectively.

The higher the renewable energy consumption in a country the more successful is the policy implemented for renewable energy projects, and more importantly, the higher is its reliability on renewable energy.

Egypt got the first ranking place recording a renewable energy consumption of 6.413% of the total final energy consumption. In 2004, Egypt recorded a high percentage of RE consumption (7.544%). During this year, an annual report was issued by New & Renewable Energy Authority (NREA), which is responsible for increasing efforts to introduce and develop RE technologies to Egypt. This later includes the current activities and the institution's plans for the future. These activities include training programs in the field of RE technologies, energy conservation, and wind energy technologies. Moreover, new employees in NREA were receiving a training program to gain more knowledge regarding diverse sectors activities in this institution. All this effort and the inauguration of several RE projects resulted in a high percentage of RE consumption. Many fluctuations happened during a 10-years period, to reach 6.413% of RE consumption in 2014. Approximately a decrease of 1% from 2004, although the percentage is still high. For Jordan and Egypt there have been sound economic motives for the pursuit of RE, where also Jordan recorded the 3rd ranking place, which is considered high. Both countries are dependent on the importation of fossil fuels for an important part of their energy needs, and even with the decrease in prices of natural gas, oil and coal currently, it makes sound more economically for Egypt and Jordan to diversify the sources of energy in the long run. Especially that the relative cost of using RE has started to drop. In addition, Egypt has major concern considering the influence of climate change on the country. For instance, the floods that covered big parts of northern Egypt showed that Nile Delta is weak to storm floods and to any major rise in sea levels.

Lebanon took the second place in the ranking with a renewable energy consumption of 3.204% of the total final energy consumption in 2014. In the case of Lebanon where there is a shortage of electricity, and the Syrian crisis that began in 2011 only augmented this shortage. Renewable energy companies increased, especially for solar photovoltaic technologies, and many commercial institutions are now relying on solar PV to reduce the need for expensive diesel backup fuel.

United Arab Emirates and Saudi Arabia have the lowest percentage of RE consumption due to their high dependency on conventional sources of energy. RE consumption in UAE has slightly increased from 2004 until 2014, from 0.101% to 0.168% due to the implementation of several policies that encouraged the shift from conventional to unconventional sources of energy. Because of the nonexistence of renewable energy policies to improve the deployment of RE projects, Saudi Arabia has shown a decrease of RE consumption in 2014 (0.006%) of total final energy consumption.

And finally, the institutional capacity indicator is measured depending on two major aspects: Independent regulator and land access.

To have a trustworthy functioning and open power market for investors, it is essential to set transparent and independent power sector regulations. An independent regulator should guarantee a fair competition between the several stakeholders on the market and make sure that consumers are protected. The tariffs are set by the regulatory agency, as well as the issuance of licenses, enforcing legal provisions and evaluating the performance of the power sector.

One of the key elements for unlocking renewable energy investments is the access to land, and this should be simplified without involving extreme administrative problems for developers.

Abu Dhabi Regulation and Supervision Bureau (RSB), which is the regulatory agency in UAE has on its board representatives from the government, which make UAE administratively dependent on the government. However, it is known that the electricity regulatory agency in United Arab Emirates have independent power when it comes to monitoring activities and licensing. In addition, land access is already available in UAE where the authorities in Dubai have identified a massive area of 48 Km2 for the development of private large-scale projects for solar energy. Those are the reasons behind the highest institutional capacity of 72% for UAE.

Jordan and Egypt have the same percentage (69%), where both have independent regulators. The Jordanian Energy and Minerals Regulatory Commission (EMRC) is the only regulatory agency that takes decisions without government interference. It can issue licenses and set tariffs without notifying the government and getting prior approval from either the parliament or the government. And the same applies for Egypt, where an essential development occurred, in which a new law of electricity has been released in July 2015. This law separates the Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA) from the Electricity Ministry, which makes the regulatory agency independent. Concerning land access, the government of Jordan permitted an unlimited land access for foreign investors. Whereas, the law of Egypt does not allow foreign investors to have land access. This is the reason why Jordan took the second place in the ranking while Egypt got the third place.

Saudi Arabia has a low level of political independence of the Electricity and Co-Generation Regulatory Authority (ECRA) in Saudi Arabia where they operate to the government mainly as advisory bodies, which is taking the final decision. As for land access, the government of KSA doesn’t allow for land access. Saudi Arabia scored the fourth place in the ranking with 65% of institutional capacity.

Finally, Lebanon doesn’t have an electricity regulatory agency, which makes the country dependent only on the government that has corruptions, political issues and many more problems as well.

CHAPTER 9

LIMITATIONS

This section summarizes the limitations of this study. An obvious limitation in the conducted assessment is that data was collected from different countries, where each country has its own policies and targets for each renewable energy technology. Let alone the difficulty in assessing the collected information; merging these data in one table in order to rank each country considering the four indicators mentioned above was a main limitation in this analysis.

Furthermore, at least fifteen non-profit organizations were contacted either via email, or phone calls. Ministries of energy for each of the chosen countries were also contacted, however, only two organizations were responsive and supplied some information. One of them is Energy Conservation and Environment sustainability in Jordan, but unfortunately it wasn't of huge help to the content of this analysis. On the other hand, the Lebanese Center for Energy Conservation provided helpful information. Comparing between the policies was a limitation, where public competitive bidding is measured under large-scale projects, whereas net metering and feed-in-tariff were measured under small-scale projects. To start with the effectiveness indicator, one of the major limitations is that installed capacities usually happen in bulks, which means it can take up to ten years for a country to add 1 MW of wind energy for example to its existing wind energy capacity. This indicator is based on the targets, and doesn't further evaluates the value/benefits or adequacy of the targets placed. In addition to this, it is very difficult to compare between the countries under study due to their different population and their GDP. Subjectivity is another limitation encountered in the effectiveness indicator.

Moving on the reliability indicator, the latest data found for the renewable energy consumption of the five countries was in the year 2014, which doesn’t accurately reflect the current status of the countries. Therefore, more recent data could yield a different outcome/result then this study is indicating.

CHAPTER 10

CONCLUSION

Renewable energy policies are the key elements to achieve the target set by each country. To assess those policies, four indicators have been evaluated for each country chosen.

Those indicators are: effectiveness, efficiency, reliability and institutional capacity.

In this thesis, the focus was mainly on evaluating the renewable energy policies based on the indicators in order to find the best policy implemented in a certain country, for the encouragement and deployment of renewable energy projects in the Middle East region.

A comparative matrix was conducted to be able to compare the ranking of the countries with respect to the indicators under study.

An overall comparison was conducted by calculating the average ranking for each country. These results are summarized below.

United Arab Emirates is leading among the selected countries with an average ranking of 2. Followed by Jordan with an average ranking of 2.75. Egypt and Saudi Arabia got the same average ranking of 3. However, due to the political stability available in Saudi Arabia compared to Egypt, Saudi Arabia was assigned the third ranking place after Jordan, and Egypt recorded the fourth ranking place. Finally, Lebanon got an average ranking of 4.25.

This shows that United Arab Emirates and Jordan both got the highest ranking, which means the policies implemented in these countries could satisfy the targets set and encourage the deployment of renewable energy projects. The results, along with the overall ranking of the countries revealed that public competitive bidding is the best policy to be implemented.

For renewable energy projects, public competitive bidding is becoming the favorite option for the Middle East region concerning financial efficiency. A cost race between developers is running under competitive bids around the region, which reflects the competitiveness of solar PV and wind power.

This reflect the lowest price bid in the 3rd phase of Mohammed bin Rashid Al Maktoum Solar Park under a price of 2.99 USD cents/Kwh in UAE, which ranked the first place among other countries.

Furthermore, Al Mafraq solar PV project of 50 MW has shifted from a feed-in-tariff mechanism to a tender process where the tariff was set. Thus, Al Mafraq solar PV will be one of the most cost-efficient sources of electricity in Jordan and the region.

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