FUTURE PROSPECTS OF THE RENEWABLE ENERGY SECTOR IN LIBYA

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Abstract
This study investigates the options available to the energy sector in Libyan, particularly in relation to the potential of using renewable energy as one of the main sources for the country. Libyan government has set a target for renewable energy resources sharing with current energy sources to reach 30% by the year 2030 which mainly includes wind energy, Concentrating Solar Power (CSP), Photovoltaic (PV) and Solar Water Heating (SWH). The argument here is not whether this can be completed or not within the stipulated time. But the main objective is achieving a sustainable economic growth through a clean energy system and for the energy supply to maintain meeting the growing energy demand. The aim of this paper is to illustrate the current energy supply and future demands in Libya. This paper integrates data from literature review, field visits and interviews with Libyan energy experts to paint a comprehensive picture in relation to energy demand and consumption. The findings which have emerged from the analysis of this data reflect energy challenges and opportunities in Libya. Furthermore, securing alternative resources of energy and income are becoming critically important for Libya and other countries within the Middle East and North Africa region (MENA) if they wish to maintain the same standard of living for future generations and reduce pollution, fossil fuel local consumption and carbon emission.

Keywords: MENA region, Libya, renewable energy sources, sustainability, environment.

1. INTRODUCTION

Energy plays an essential role to technological and socioeconomic development of any economy. Several studies have shown that there is a strong correlation between electricity consumption and economic growth, see for example [1] [2]. The priority for the development plans in Libya is to connect mains electricity to all regions and thus the average power consumption of each individual is deemed to be one of the fundamental factors to measure the growth level in modern societies [3]. The production of electricity is currently expensive, particularly in agricultural applications, because of the large area that the network needs to cover and the size of the investment in the infrastructure [4]. The cost of electricity in Libya in the agricultural and industrial sectors have exhausted the government public budget during the previous thirty years as indicated through the annual reports of auditors [5]][6]. The value of projects related to electricity distribution contracted or at the final stage of construction amounted to 17,144 million Libyan dinars in the field of electrical power production, transportation and distribution (1.420 Libya dinar being equivalent to 1 US

dollar) [7]. Recent studies by the same authors have shown the importance of investment in renewable energy for the future of the MENA region and Libya [8][9][10].

Oil producing countries are expected to face an increase in demand for oil and gas as part of the international economic growth. However, with the world potentially reaching peak oil, every government will be forced to encourage more efficient energy use to overcome the increasing energy cost and easing energy security concerns [11]. Libya's electricity demand is expected to grow rapidly. Libyan government is expecting that the electrical energy consumption will increase more than 250% by the end of 2020 [12][13] driven mainly by rapid economic growth [6][14]; and assuming the political situation in Libya will improve and the situation becomes more stable. Currently the dependency is on oil and natural gas, as the main source of energy for generating the country's growing demands for electricity [15][16][17]. Distribution of electrical power is difficult and expensive in Libya's vast area in which about 200 scattered villages with population ranges between 25 and 500 inhabitant and far away from the grid in most cases by more than 25 kilometres [18][19][20]. Although electricity generation between the years of 2000 and 2010 almost doubled in Libya, increasing power demand over the production capacity has recently led to electricity shortfalls; therefore the country suffers from power outages in main cities [8]. In terms of meeting growing energy demand the Libyan government has set a target for renewable energy sources sharing with fossil fuel sources to reach 30% by the year 2030 in order to achieve a sustainable economic growth through a clean energy system and for the energy supply to maintain meeting growing energy demand. Therefore investigating the options available to the energy sector in Libyan, particularly in relation to the potential of using renewable energy as one of the main sources for the country, is a task worth undertaking.

2. METHODOLOGY AND RESULTS

In order to gather evidence and information about the potential of renewable energy resources and explore the possible utilisation of renewable energy in Libya, a field visit has been done and several organisations and institutions have been contacted within the energy sector. Interviews have been conducted with key people who are responsible for policy making of these organisations and institutions. Eleven interviews are conducted with the experts, managers and academics who are working within the energy and renewable energy sectors including the Renewable Energy Authority of Libya (REAOL), Thermal Energy Conversion Department and PV Conversion Department of Centre for Energy Research and Studies of Libya (CSERS), Department of Electrical and Electronic Engineering at Benghazi University and Department of Electrical and Electronic Engineering at Tripoli University.

Based on the Planning and Studies Department of REAOL, Figure 1 presents the expected growth in the renewable energy market in Libya, assuming sustainable stability in the future situation.

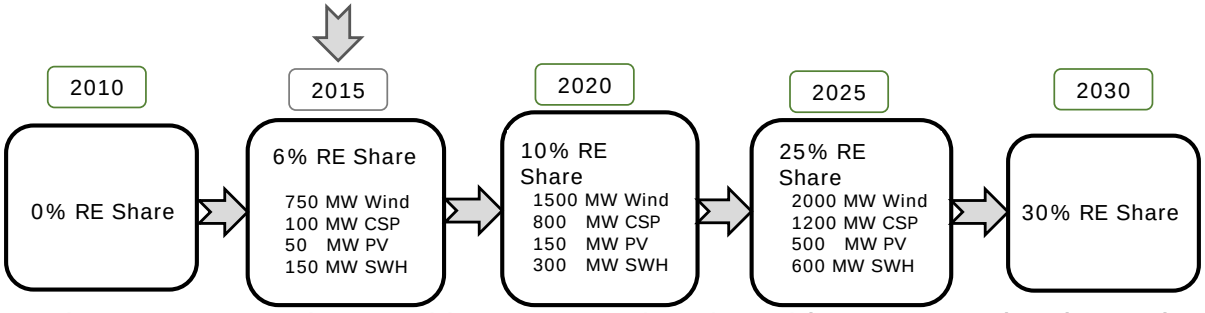

Figure 1: Expected renewable energy market share (*data source: Planning and Studies Department of REAOL*).

3. LIBYAN RENEWABLE ENERGY

3.1 Wind Energy

Table 1 presents the average wind speed in some of the main Libyan cities (based on unpublished information collected from CSERS). This indicates an average speed above 2.9 m/s, an indication of clear potential of wind energy utilisation. During an interview with a senior manager from CSERS, it has been stated that: *"…These unpublished data are used in locating viable wind energy projects for future implementations…"*

Table 1: Monthly average of wind speed (m/s) during 1985-1995.

Cities	Monthly average of wind speed (m/s) for some regions.												SUM	AVG
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
Benina	4.3	4.8	5.7	6.2	5.9	6.0	5.8	5.3	5.1	5.0	4.8	4.4	63	5.3
Ejdabia	2.2	2.8	3.9	3.6	3.6	3.4	3.5	3.0	2.7	2.3	2.0	2.0	35	2.9
Sorman	3.4	2.8	3.0	3.4	3.3	3.2	3.0	2.7	2.8	2.7	2.6	2.8	36	3.0
Zuara	4.5	4.5	5.2	5.4	5.3	5.0	4.4	4.5	4.8	4.4	4.0	4.2	56	4.7
Sirt	5.1	5.3	5.5	5.6	5.3	4.9	4.3	4.3	4.7	4.7	4.6	4.9	59	4.9
Mesrata	5.2	5.3	6.1	5.7	5.4	5.0	4.2	4.1	4.6	4.5	4.8	5.3	60	5.0

One of the main advantages of the wind in Libya is that there is a good matching between the wind patterns and the patterns of the demand of the electrical power in most places [21][3].

An interviewed senior energy policy maker has stated that: *"… Libya has important potential source for solar and wind energy. Feasibility studies have shown that the Mediterranean coastline is a good location for onshore and offshore wind farms…"*

3.2 Solar Energy

Table 2 presents the average solar power in key cities and locations in Libya provided by CSERS. It is clear that the daily average of total radiation (kwh/m^2) could reach above 6 kwh/m^2, which is a significant level of solar energy to be utilised.

Table 2: Daily average of total radiation (kwh/m^2) during 1982-1988.

Cities	Daily average of total radiation (kwh/m^2) in some Libyan regions												SUM	AVG
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC		
Tripoli	2.95	3.87	5	5.97	6.45	7.09	7.05	6.47	5.48	4	3.15	1.83	59	4.94
Gath	4	4.8	4.7	6.3	6.3	6.6	6.8	6.3	5.8	5.1	4.1	3.5	64	5.36
Jalo	3.66	4.54	5.37	6.56	6.74	7.16	7.17	6.74	5.74	4.83	3.86	3.44	66	5.48
Sabha	4.18	4.88	5.81	6.68	6.65	7.35	7.26	6.96	6.51	5.56	4.75	3.97	71	5.88
Shahat	2.3	2.72	3.93	5.45	6.05	6.73	6.72	6.14	4.67	3.59	2.69	1.97	53	4.41
Hon	3.54	4.22	5.1	6.19	6.61	7.06	7.09	6.69	5.91	4.72	3.8	3.19	64	5.34
Al-Kovra	4.43	5.38	6.04	6.86	7.24	7.43	7.25	7.19	6.45	5.67	4.7	3.99	73	6.05
Al-Quryat	3.55	4.63	5.65	6.61	6.75	7.12	7.39	7.02	5.45	4.32	3.47	3.2	65	5.43
Al-Jagbob	3.8	4.7	5.59	6.71	7.1	7.67	7.66	7.1	6.22	5.13	4	3.51	69	5.77

The renewable energy authority of Libya stated that the average hours of solar brightness is about 3200 hours per year and the average solar radiation is 6 kWh per square meter (sqm) per day.

An interviewee from General Electricity Company Of Libya (GECOL) said:
"*... Renewable energy is the hope of the world in providing clean and safe energy, to be able to bridge the gap as a result of depletion of oil and natural gas …*".

Therefore, wind and solar energy could provide a good complement to meet peak loads. And this in turn can be a good reason for encouraging investments in wind and solar energy projects in Libya.

4. RECENT AND FUTURE PROJECTS IN RENEWABLE ENERGY

The distributed generation of electricity is a new important tendency in energy systems, which should be considered as an alternative to traditional energy production. This concept is significant to prevent power failures and cost of grid maintenance. An interviewed manager from the energy policy making organisation stated that:

"… there are in total about 2.8 MWh of PV systems installed in Libyan at the moment and other technologies, such as wind, reach a capacity of about 4.4 MWh…".

Al-Fattaih wind farm project started at the end of 2010 for production power of 60 MW as a first stage of renewable energy development. The total project cost was about 184 Million Libyan Dinars. This has the intention to acquiring the scientific expertise for knowledge transfer to Libya, breaking the dependency on oil and contributing to the protection of the environment and reducing carbon emission.

In this context an interview of a senior manager at REAOL has indicated that:

"... Site selection was based on field studies which confirmed that the wind speed up to 8.5 m/s and the location is close to the public network for electricity.

The project consists of 37 turbines with a capacity of 1.65 MW/ turbine, the total capacity of the project is about 60 MW and expected annual energy output is about 235,000 MWh or 235,000,000 kWh …..".

This energy, in this case, should be sufficient to power about 25,000 homes.
In relation to the same project, another interviewee from REAOL stated that:

"…This project will achieve fossil fuels saving equivalent to 475000 Barrel of crude oil yearly. Reducing about 120 thousand tons of carbon dioxide annually…"

5. CURRENT PROJECTS IN ELECTRICAL ENERGY GENERATION

The total electricity generation by GECOL in 2012, which produced from 14 main power stations, has been approximately 33,980 GWh and it has costed about 6,003,262,899 m^3 of NG (Natural Gas), 2,388,932 m^3 of LFO (Light Fuel Oil) and 805,472 m^3 of HFO (Heavy Fuel Oil). As Libya's power demand is growing rapidly, this amount is expected to reach a level of 250% in 2020 in comparison to 2012 figures.
During the summer months of the years 2011 to 2015, Libya was hit by widespread blackouts as power plants could not keep up with demand. To prevent such outages in the future and to meet surging power consumption, Libya's state-owned GECOL has plans to spend $3.5 billion building eight new power stations. Currently this has been difficult with the government's policy as confirmed by an interviewed manager from an energy generation company who stated that:

"….Indeed, GECOL has serious financing issues due to partially low electricity prices (around 0.02 LD/ kwh) and also to the fact that only 40% of Libyans pay their energy bills..."

The stations of various kinds consume large quantities of fuel for electricity production. The quantity of the fuel which is used in steam based turbines plants to produce one MW equal to 1.962 LFO (Light Fuel Oil) type (1960 L), 0.323 HFO (Heavy Fuel Oil) type (323 L) and 44.409 NG (Natural Gas) type (44409 L).

Furthermore, during 2012 the North Benghazi station consumed the quantity of LFO = 62.079 m^3 (62079 L) aimed at producing 175.064 MWh and NG 33309.291 m^3 aimed at producing 120.724 MWh. The quantity of the fuel consumed in the production process is too large compared to plants using sunlight or wind farms so that Libya had embarked on building a farm worth of 184 million in Al-Fattaih region, which is expected to produce 60 MW and it is not using any type of fuel with reduced maintenance requirements. There are great opportunities for many areas to create wind farms in Libya. This is consistent with neighbouring countries activities in this regard such as Egypt where a new solar station to generate electricity from solar energy in the South Cairo has been built at a cost of $ 125 million and a capacity of 150 MW [22]. This is in addition to more commonly used solar energy for water heating for household and industrial use.

Another interviewee from GECOL stated:

"…The cost of developing and improving the existing plants in Libya is about 822 million LD and this will lead to an increase in electricity output by 332.2 MW. This development is expected to reduce fuel consumption and increase the life expectancy of existing stations by of 10 to 15 years on average. However, these fossil fuel stations continue to consume large quantities of fuel and produce environmental pollution. In all cases, this will still be below the expected demand.."

The same manager stated that:

"…. Currently Libya has electric production capacity of about 6,766 GW, with peak load of around 5,981 GW in 2012. Due to the age and conditions of the plants, the actual capacity is less than the designed one. Therefore, the Libyan government has to build more new plants in order to address this gap and solve this problem... "

Another interviewee from GECOL said:
"…Most of Libya's existing power stations are oil-fired; some of these have been converted to natural gas. The retirement age of many of the plants is long overdue, therefore they currently need a huge maintenance…"

It is clear from the interviews that there is some disregard from the new interim Libyan government to the renewable energy plan as stated by one of the interviewees from an energy policy making organisation:

"... Included in 2013 public budget of the state which approved by parliament, 12 LD million for the implementation of projects related to renewable energy, but it did not accomplish any projects in this regard and the outcome of implementation of the plan is 'zero' until now..."

Also reflected by one of the interviewees from one of the universities:

"... despite the inability of the existing power stations to cover the basic needs of Libyan citizens, the new Libyan government has not carried out any recent projects so far… the political problems are reflected on the normal life of citizens and disrupted most of the projects especially energy projects …"

As referred to by a senior manager in the Renewable Energy Authority:

"... It is important to report that, there is no progress in our plan till now… The renewable energy sector in need of foreign investments and consultants to implement the renewable energy future plan...."

6. CONCLUSION

Libya's electricity consumption is expected to increase significantly over the coming years. This will lead to considerable need to new power stations to cover the continuous growth in demand.
Solar and wind are the most available renewable energy sources in Libya. The renewable energy sector could provide significant power generation levels to cover some, if not all, the required increase in energy demand, if managed in the right way. There is a high level strategy to focus on renewable energy and reduce pollution and carbon emission in Libya. However, the current political situation in Libya has put most renewable energy projects and strategies on hold, perhaps until the situation becomes more stable.

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