Original Research Article

Renewable Energy Home Design in Bani Walid City/Libya

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Abstract

Although the applications of renewable energy in Libya were started in the last few decades, they have only gained momentum in the last few years. Considering the past gained experience, a proposed national Renewable Energy plan aims toward bringing RE into the main stream of the national energy supply system with a target contribution of 10% of the electricity demand by the year 2020. The aim of this paper is to design a house that works with some renewable energy applications in one of the Libyan cities called Bani Walid. This paper includes some important steps for designing a home such as solar home design steps, wind energy calculations, battery sizing, and cost considerations.

Keywords: Renewable energy, Wind energy, solar energy, Wind turbines, Solar panel.

INTRODUCTION

Libya is a crucial country in the Middle East and North Africa; this is because it occupies a strategic location in North Africa since it is located in place of links of Southern Europe with the rest of Africa and Eastern with Western Africa. Therefore, would play a major role in connecting the oil, gas and electricity international grid. Although the fact that Libya is considered as one of the oil-rich countries, it is important to secure alternative resources of energy especially it has only one type and limited energy resources (oil). This in turn can lead to maintain oil resources for future generations and to reduce pollution.

A Solar Energy System is sometimes referred to as an Alternative Energy System. And while that's true, wind, geothermal, and hydro systems are also alternative energy sources. We focus primarily on Solar and will therefore simply use the phrase Solar Energy System or Solar Power System. To the left are the basic components required to produce electricity from the sun. You will need one or more Solar Panels, a Charger Controller, a Power Inverter, and of course, Batteries. A brief explanation on each follows. After you get an idea of the components you'll need for your solar energy system, be sure to check out our new interactive Design Tools to calculate how many solar panels and storage batteries you will need, determine battery bank wiring, and calculate proper wire sizes.

Wind energy was utilized for water pumping in many oases since 1940. The use of this energy has not been developed extensively because the wind-mills need some maintenance from time to time. In 2004 measurements of the wind speed statistics has been conducted and showed that there is a high potentiality for wind energy in Libya. The average wind speed at a 40-meter height is between 6- 7.5 m/s.

The use of wind energy for electricity production has not been started yet in Libya, but a project was contracted for installing 25 MW as a pilot project to be erected in two years' time. A project to prepare two Atlas that provides fast access to reliable solar and wind data throughout Libya is also been contracted for. The Atlas will allow for accurate analysis of the available wind and solar resources anywhere in Libya and will be therefore very important for planning profitable wind farms and solar projects.

Home appliances and consumption

The home studied in this paper consists of two floors and tables 1 and 2 illustrate the components of each floor with the consumption of electricity for all the appliances.

Table-1: First floor appliances

	First floor	
1	Living room	Air conditioner (1000 W)+ TV (120W)+lamp lighting (2X60 W)
2	Dining+ kitchen	Refrigerator (750W)+microwave(1500W) +Blender (300W)+juicer (600W)+heater (2000W)+ lamp lighting(2X60W)+fan(100W)
3	Laundry	Washing machine (2000W)+iron(1200W) lamp lighting(1X60W)
4	Foyer	lamp lighting(1X60W)
5	Garage	lamp lighting(1X60W)
6	powder	lamp lighting(1X60W)
7	portico	lamp lighting(1X60W)

Table-2: Second floor appliances

	Second floor	
1	Master room	TV(150W)+ Air conditioner (1000 W)+ lamp lighting (2X60 W)+Satellite dish(50W) +CD player (35W)
2	Bedroom2	lamp lighting (1X60 W)+Computer PC(150W)
3	Bedroom 3	lamp lighting (1X60 W)+DVD (25W)+ stereo(25W)+ Kids TV (80W)
4	Bath	Heater (2000W)+hair dryer (1100W)
5	Hall	lamp lighting (1X60 W)
6	Tiled shower	Heater(2000W)+ lamp lighting (1X60 W)

Solar home design steps
Determine the number of solar panels you will need

Calculate your electrical load. Determine the number of watt*hours your location will use on a daily basis. For an entire home, this will take some busy work.

You need to determine
- What appliances you are going to power?
- How many Watts does each appliance consume?

- On average, how many hours do you use this appliance per day? (Don't forget to include those things that you use on a weekly or monthly basis, e.g. blender).
- Calculate your average daily watt*hour usage for your entire home. That is, multiply the watts of the appliance times the average number of hours used per day.

Appliance	number	Energy consumption (kW)	Hours/day	KW-hr/day	Cost(L.D)
Air conditioner	2	2	10	20	0.4
Refrigerator	1	0.75	24	18	0.36
Microwave	1	1.5	0.5	0.75	0.015
Fan	1	0.1	2	0.2	0.004
Washing machine	1	2	1	2	0.04
Blender	1	0.3	0.5	0.15	0.003
Iron	1	1.2	0.5	0.6	0.012
Satellite dish	1	0.05	8	0.4	0.008
CD player	1	0.035	1	0.035	0.0007
Computer	2	0.3	3	0.9	0.018
Kids TV	1	0.08	3	0.24	0.0048
Lighting lamp	16 DC	0.96	6	5.76	0.1152
Stereo	1	0.025	1	0.025	0.0005
Hair dryer	1	1.1	0.5	0.55	0.022
TV	1	0.12	8	0.96	0.0192
Juicer	1	0.6	0.5	0.3	0.006
heater	2	2	2	4	0.08
DVD	1	0.025	1	0.025	0.0005
Total AC				49.675	
Total DC				5.76	
Total AC+DC				55.435	

Determine the equivalent number of full-sun hours for your location for the month with the least amount of sunlight (December or January for Bani Walid/Libya 2018).

Table-3: The full-sun hours for home location

Month	number of full-sun hours	Month	number of full-sun hours
January	7.19	July	11.7
February	8.96	August	11.4
March	9.29	September	9.84
April	9.41	October	6.62
May	11.1	November	7.44
June	11.91	December	6.84

Divide your load calculation from step one by the number of full-sun hours from step two. This is will tell you the number of Watts of solar panels you will need to provide you enough electricity in the lowest sun-light months.

Solar Panel Watts needed: (Total Watt-hr/day)/(full sun hours/day)
Solar Panel Watts needed AC: (49675 W-H/day)/(6.84Boulder) =7262 Watts
Solar Panel Watts needed DC: (5760 W-H/day)/(6.84 Boulder) = 842 Watts

Panel's selection and specifications

In this work. The selected panels was chosen from online company website in Australia

235W HIT Panasonic Sanyo Solar Panel

$675.00 Add to cart

Suit Grid Systems or Remote Systems
1580 x 798 x 35mm
Max Power: 5.48A @ 43.0V
25 Year Warranty

Incredible 18.6% Module Efficiency!
Very High Quality - Japanese Manufacture

Fig-1: The selected panel

Compensate for system inefficiencies. Every part of a solar powered system has some inefficiency in it. The rule of thumb is if you are going to use an inverter (to produce AC) your total system inefficiency will be 30%. For systems that will be using the DC voltage directly from the battery bank, the inefficiency factor is 20%. So, to compensate for inefficiencies multiply your answer to step 3 by 1.3 (or 1.2, if there's no inverter). This answer is the number of watts of solar panels you will need to provide enough electricity for your loads.

(Solar Panels Watts Needed for AC)(1.3) = 9440W
(Solar Panels Watts needed for DC loads)(1.2) =1010
Total Solar Panel Watts Needed= 10450W

Finally, to determine how many solar panels you will need, take your answer from step 4 and divide it by the rated power output (watts) of the solar panel that you have chosen.

Total Solar Panels Needed = (Total Solar Panel Watts Needed)/(Solar Panel Rated output)
Total Solar Panels Needed = (10450)/235Watts = 45 Panels

Because
- The number of panels needed (45panels)for this house is very high and the power needed also is very large(55.435KW.hr/day)
- There are losses in the battery and the converter

So we need amount of power generated more than 55.435KW.hr/day
Watts needed for AC=49.675X1.3=64.577KW.hr/day
Watts needed for DC=5.760X1.2=6.912KW.hr/day
The total watts needed for the home=64.577+6.912=71.489KW.hr/day

Important decision

Due to the large number of solar panels required and the resulting large cost, it is possible to use wind power equipment for the desired home as shown in Figure 2.
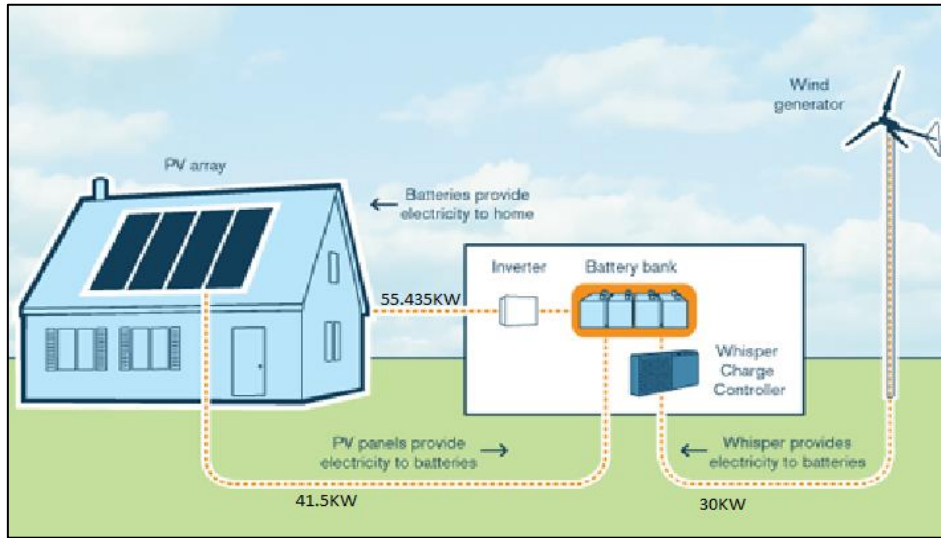

Fig-2: Using of solar and wind energy

By using 41500W.hr per day, we can find the number of panels needed:
Solar Panel Watts needed: (Total Watt- hr. /day)/(full sun hours/day)

Total Solar panels watts needed = 41500/6.84 = 6067W
Total Solar Panels Needed = 6067/235Watts =26 Panels

Wind energy in Libya

Wind energy was utilized for water pumping in many cases since 1940. The use of this energy has not been developed extensively because the wind-mills need some maintenance from time to time. In 2004 measurements of the wind speed statistics has been conducted and showed that there is a high potentiality for wind energy in Libya. The average wind speed at a 40 meter height is between 6- 7.5 m/s. Figure 3 shows the average wind speed measured in different locations of the Libyan coast area.

The use of wind energy for electricity production has not been started yet in Libya, but a project was contracted for installing 25 MW as a pilot project to be erected in two years' time. A project to prepare two Atlas that provide fast access to reliable solar and wind data throughout Libya is also been contracted for. The Atlas will allow for accurate analysis of the available wind and solar resources anywhere in Libya, and will be therefore very important for planning profitable wind farms and solar projects.

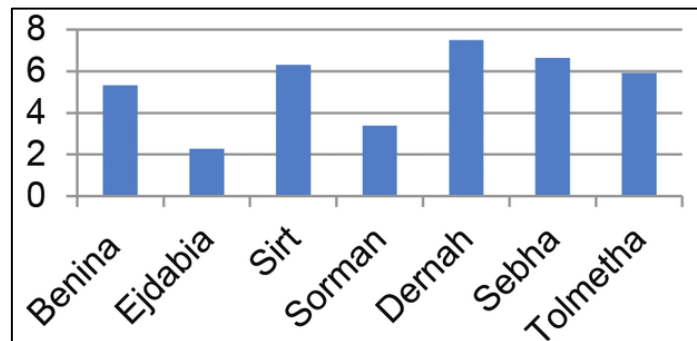Figure 3 shows the average wind speed in some Libyan cities in meter per second.

Fig-3: The average wind speed in some Libyan cities

Wind energy calculation

Wind power depends on air density, rotor diameter, and the air velocity as shown in the following figure:
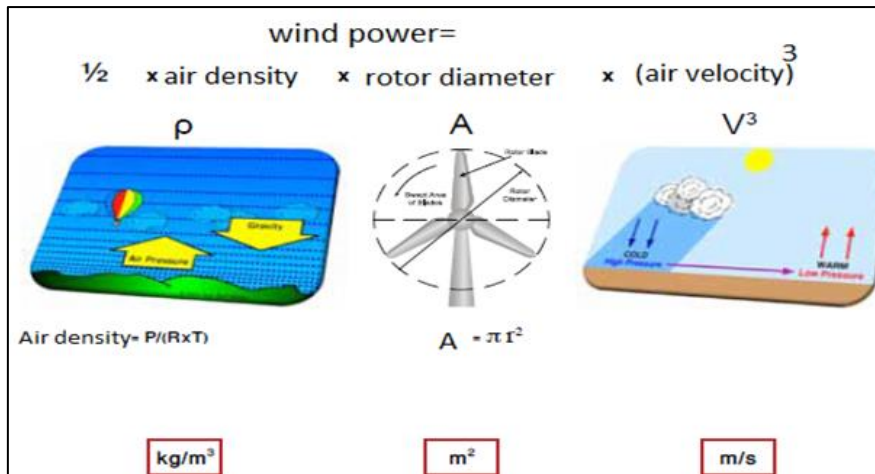
Fig-4: Wind energy calculation

Calculation of Mean monthly wind speed (m/s) for Bani Walid city: Table 4 shows the average wind speed for each month due to several years in the Libyan city of Bani Walid.

Table-4: The average wind speed in Bani Walid city

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	5.71	6.44	5.92	8.34	6.76	6.42	6.5	5.48	6.44	4.92
February	6.78	5.73	5.1	7.55	6.57	5.76	6.22	6.33	8.39	5.38
March	6.46	6.25	6.64	6.2	6.97	8.75	7.26	4.87	5.71	6.37
April	6.31	6.93	7.25	8.01	8.03	6.62	6.5	6.06	6.08	5.38
May	6.66	5.75	6.45	5,89	8.1	7.71	6.26	5.43	5.87	5.46
June	6.24	6.33	6.8	4.86	6.94	6.96	6.52	5.22	4.7	4.6
July	6.41	4.29	5.65	5.48	7.12	5.24	6.36	4.5	4.03	4.93
August	5.16	4.9	6.9	4.7	6.47	4.73	6.57	3.7	4.00	5.38
September	7.17	6.25	8.03	5.38	6.28	5.67	6.68	4.89	5.74	4.8
October	6.65	5.58	8.37	5.36	6.02	5.97	6.73	5.4	4.02	4.45
November	5.56	4.97	7.37	6.26	5.82	5.27	6.9	4.42	6.45	6.18
December	4.61	4.87	7.54	6.79	5.9	5.56	7.49	5.79	6.99	6.74

To determine the suitable rotor diameter
- ❑ From last table, Mean monthly wind speed (m/s)for Bani Walid city in ten years from 2009 to 2018 is 6.1m/s
- ❑ Air density=1.22 Kg/m^3
- ❑ Power needed=30000W.hr/day=(30000/24)=1250W

From the last equation
Rotor diameter=3.4m

Battery sizing calculation
The first thing you have to decide on is if you are going to use a 12V, 24V or 48V DC system (these are the most common selections). The advantages to using a larger DC voltage system is that the wires/cabling you will need to use can be of a smaller gauge (smaller diameter). Systems with higher DC voltages lose less energy due to resistances in wiring that those of lower DC voltage (e.g. 12V).

An advantage to 12V system is that it's a bit easier to find equipment you can power directly off of the batteries (i.e. 12V). Whereas if you were to power 12V appliances off of a 48V system, you would need to also buy a DC voltage converter.

Determine the total watt hours you will be using per day (in this project 55435W.hr).

Determine how many rainy days you might have in a row. This is the number of days that your solar panels might not be producing electricity in a row and will need to rely solely on your batteries for electricity during this time. (Typically, 3 to 7 days is used for homes and 7 to 14 for industrial purposes - like remote Telecommunications sites).

Multiply the number of watt*hours from your load calculation (Step 2) by the number of storage days (Step 3). (55435W-h)*3 =166305W.hr

Determine how deeply you want to discharge your batteries. 80% is considered the maximum amount you can discharge your lead-acid battery array, whereas 50% is an optimal amount for battery longevity. Then divide the amount calculated in Step 4 by 0.80 or 0.50 (for instance) 166305/0.80 =207881 W.hr.

Compensate your calculations for low battery temperatures. As your batteries get colder (such as in the winter months), they are capable of producing less current. Using the table below, multiply the value you calculated in Step 5 by the Multiplier Factor from table 5, according to the lowest temperature you think your batteries will experience:

Table-5: Multiplier Factor from selection

Degrees Fahrenheit	Degrees Celsius	Multiplier Factor
80°F	26.0°C	1.00
70°F	21.2°C	1.04
60°F	15.6°C	1.11
50°F	10.0°C	1.19
40°F	4.4°C	1.30
30°F	-1.1°C	1.40
20°F	-6.7°C	1.59

The lowest temperature in Bani Walid city approximately 10^0C (Multiplier Factor = 1.19).

Total watt hours you will be using per day = 202781X1.19=241309W.hr

Cost considerations

When using solar panels
The price of each panel 675$ Total price=26X675=17550$
The price of each battery 100$ Total price=80X100=8000$
Total cost =17550+8000=25550$

When using wind turbine
To get 30KW by using wind turbine with rotor diameter 3.4m.it will cost 8000$(chines company).

Finally

In this project: it is better to get all energy requirements by using 2 wind turbines with 16000$ total cost.

CONCLUSION

This study, entitled Renewable Energy Home Design in Bani Walid city/Libya, showed that solar energy can be used to supply the electricity to the home, but the cost will be partially high, where the total cost was $ 25550 .But in the case of the use wind energy in the area where the home is located, it was better to provide the home with two wind turbines with total cost of $ 16000, This means it is best to use wind turbines instead solar cells at the home site.

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