SOLAR IRRADIATION DATA for LEBANON

The Lebanese Center for Energy Conservation (LCEC) - Interns

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1. BACKGROUND REVIEW

In Lebanon, only one publication, “CLIMATIC ZONING FOR BUILDINGS IN LEBANON”, published in 2005, includes solar irradiation data regarding the climatic zones in Lebanon of which the following methodology was followed:
In all cases, the solar data have been generated from an algorithm in DOE that builds the direct radiation and horizontal radiation data from specific information about the station including the location (latitude, longitude and altitude), the clearness number of the sky, the cloud cover and the type of cloud encountered. The values were inputted into the software to generate solar records that were in general accordance with the global horizontal solar radiation of the two stations where records were available. This allowed building weather files where the data between direct solar radiation and horizontal solar radiation are consistent. The station used used in this study were The Atlas Climatique du Liban and Post 1998 weather data records for selected stations and from private stations such as the weather station of the American University of Beirut.

Solar data was collected from different climatic zones which are divided according the "Atlas Climatique du Liban" generally divides the country into three broad climatic trends: the coastal, the mountainous and the inland. These are further subdivided into a number of sub-regions making up to a total of eight climatic regions by taking into consideration various factors.

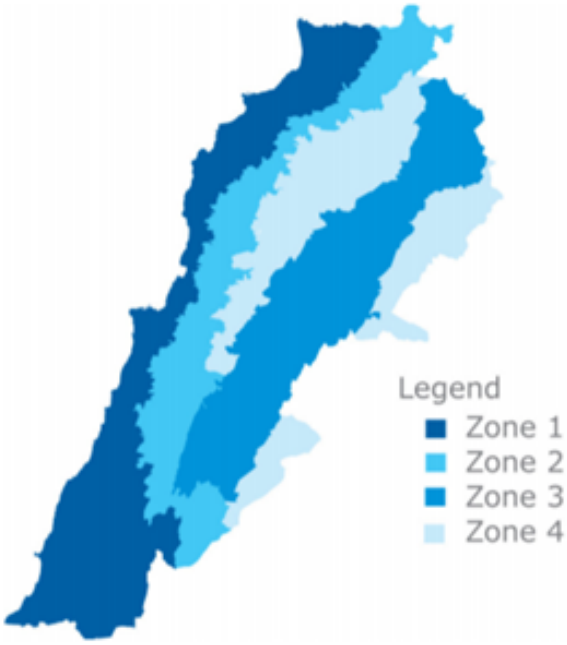

Figure 1. *Climatic Zones in Lebanon*

Table 1. *Climatic Zones' Altitudes*

ZONE 1	Coastal	0-700 m
ZONE 2	Western Mid-Mountain	700-1400 m
ZONE 3	Inland Plateau	700-1150 m
ZONE 4	High Mountain Littoral side	1400 + m
	High Mountain Inland side	1150 + m

1.1. PREVIOUS RESULTS :

Since the irradiation stations available in Lebanon can be only distributed over three climatic regions (Coastal - Beirut, Coastal - Bayssour, Inland), we chose to show the previous results of those regions. These results will be compared later on with the new results that were obtained.

Table 2. *Global Horizontal Irradiation data 2005*

MONTH	Global Horizontal Irradiation Data (2005) (Wh/m^2)		
ZONE	COASTAL - BEIRUT	COASTAL - BAYSSOUR	INLAND
JANUARY	2387.6	2503.6	2522.2
FEBRUARY	3195.8	3208.1	3282.2
MARCH	4898.1	4777.7	4861.2
APRIL	6012	6018.3	5979.5
MAY	6837	6833.2	6837.6
JUNE	7192	7209.7	7211.3
JULY	7010.4	7024	7037.5
AUGUST	6343.7	6353.2	6405.2
SEPTEMBER	5374.6	5389.1	5466.1
OCTOBER	3873.5	3896.9	3828.4
NOVEMBER	2757.2	2770.7	2765.4
DECEMBER	2273.4	2287.3	2241.2
AVERAGE	4854.6	4864.1	4877.6

2. ABSTRACT

Solar Irradiation is considered as one of the most important meteorological parameters for the operation of photovoltaic power plants, which directly impacts power production.

Due its importance in determining the performance ratio of a photovoltaic system, the solar irradiation data must be updated since it could be subjected to change over the years in accordance with climate change.

3. METHODOLOGY

The year 2019 has been chosen to proceed with due to the majority of the available data being from this year.

Data available from different sites are taken into consideration, of which they are distributed over only 3 climatic zones: Coastal, Bayssour, and Inland.
The climatic zones are split similarly to the Figure shown previously which is taken from "CLIMATIC ZONING FOR BUILDINGS IN LEBANON".
The solar irradiation calculations for the year 2019 are done by taking into consideration data from irradiation sensors and pyranometers sampled every 5 minutes.

We begin our calculation by computing first the daily irradiation for each sensor which is done by adding up the values of the data collected every 5 minutes for each day and then multiplying by (5/60). Then we proceed by calculating the average daily irradiation for each month. Therefore, to obtain the yearly result we simply calculate the average of all months.

After completing the primary result table of the solar irradiation for different sensors and different sites, a monthly transposition factor (TF) must be taken into account for the correction of the obtained results due to the different orientations, inclinations of the sensors used and in order to unify the condition of measurement.

All the tilted sensors' results are then corrected by dividing them with their corresponding transposition factor and then are averaged with the horizontal sensors of the same site in order to obtain the final results which is the Global Horizontal Irradiation.

01 Literature Review

02 Data Acquisition.

03 Data Analysis.

04 Tabulation and Documentation of the Results.

05 Interpretation of the Results and Concluding.

4. SITE OVERVIEW:

S.M.L.C PEPSICO:

- Location: Haret el Oumara,Chweifat.
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 2 horizontal sensors.

Figure 2. *S.M.L.C Pepsico. Solar PV System*

LIBANJUS :

- Location: Church Mar Antonios, Baabda.
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 1 horizontal sensor.

Figure 3. *Libanjus. Solar PV System*

FDC DISTRIBUTION CENTER :

- Location: Achrafiyeh, Beyrouth.
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 1 horizontal sensor.

Figure 4. *FDC Solar PV System*

LAS SALINAS HOTEL :

- Location: Anfeh, North.
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 1 horizontal sensor.

Figure 5. *Las Salinas Hotel Solar PV System*

4. SITE OVERVIEW:

LEBANESE ARMY FORCE ABLAH:

- Location: Ablah, Bekaa.
- Climatic zone: Inland
- Executive company name: Green Essence
- Number of solar radiation sensors: 5 sensors.

Figure 6. *Ablah Medical Center Solar PV System*

LEBANESE ARMY FORCE QOBBEH:

- Location: Qobbeh, Tripoli.
- Climatic zone: Coastal zone.
- Executive company name: Green Essence
- Number of solar radiation sensors: 5 sensors.

Figure 7. *Qobbeh Medical Center Solar PV System*

EMILE HELOU POLICE STATION :

- Location: : Saeb Salam, Beyrouth.
- Climatic zone: Coastal zone.
- Executive company name: Green Essence
- Number of solar radiation sensors: 4 sensors.

Figure 8. *El Helou Barrack Solar PV System*

MINISTRY OF ENERGY AND WATER (MEW) :

- Location: : Corniche Al Nahr, Beyrouth.
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 3 sensors.

Figure 9. *MEW Solar PV System*

4. SITE OVERVIEW:

PARISSIS STEEL ENGINEERING FACTORY:

- Location: Gharzouz, Jbeil
- Climatic zone: Coastal Bayssour
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 1 Horizontal sensor.

Figure 10. *Parissis Steel Engineering Factory Solar PV System*

ABC ACHRAFIYEH :

- Location: Achrafiyeh, Beirut
- Climatic zone: Coastal zone.
- Executive company name: Ecosys – ITG holding.
- Number of solar radiation sensors: 1 Horizontals sensor.

Figure 11. *ABC Achrafiyeh Solar PV System*

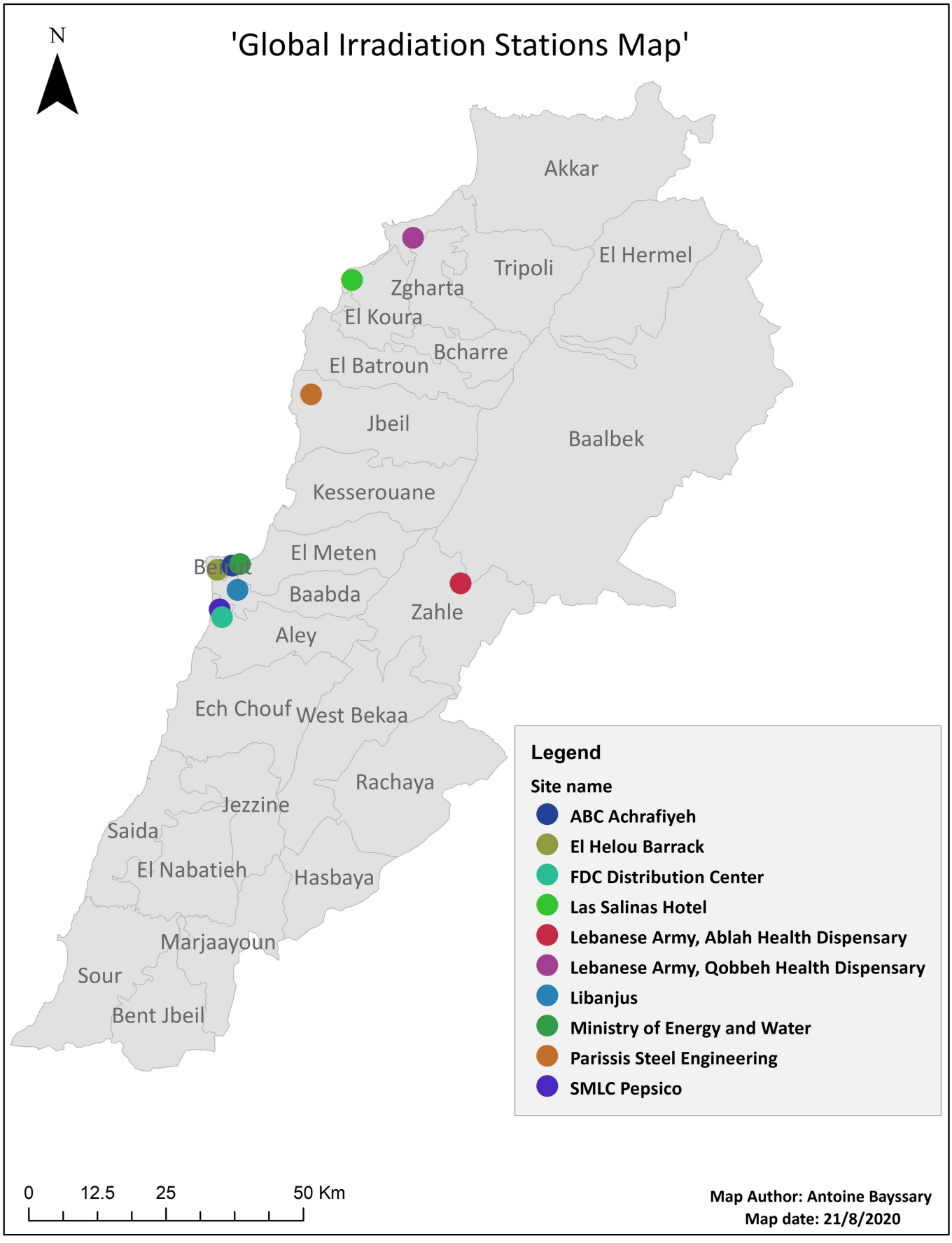

Figure 12. *Global Irradiation Stations in Lebanon*

5. RESULTS:

Table 3. *Global Horizontal Irradiation data 2019*

MONTH	Updated Global Horizontal Irradiation Data (2019-2020) (Wh/m^2)		
ZONE	COASTAL - BEIRUT	COASTAL - BAYSSOUR	INLAND
JANUARY	2388.6	2129	2658.7
FEBRUARY	2887.9	2628.3	3129.4
MARCH	4012.3	3767.6	4160.7
APRIL	5091.2	4883.7	5184.2
MAY	6311.9	6353.7	6995.6
JUNE	6193.4	6044	7328.2
JULY	6674.9	6255.7	7329.7
AUGUST	5790.9	5254.4	6579.5
SEPTEMBER	4732.8	4853.9	5532.5
OCTOBER	3571	3883.3	4083
NOVEMBER	2977.1	3175.9	3340.4
DECEMBER	2005.6	2144	2215.6
AVERAGE	4386.5	4281.1	4878.1

6. CONCLUSION:

We can notice that there is a slight decrease in the Global Horizontal Irradiation in Coastal-Beirut (9.6%) and Coastal-Bayssour (12%) in the year 2019 compared to that in the year 2005 which can be due to the fact that in the year 2005 some of the data acquired were from satellites which are not as accurate as data measured directly by sensors . Moreover, the availability of only one site in Bayssour Region might be the cause of the decrease in irradiation level since one site may include some errors if it is not being averaged with other site's data.

7. CHALLENGES

Mainly, data from the year 2019 was available in most of the sites while the other years were incomplete in other stations due to some sites being newly constructed. Therefore, only data from the year 2019 was taken into consideration.

We also faced difficulties in the data analysis and tabulation due to important missing data from some months in some sites. Hence, there are cases where we have replaced a couple of the missing months in 2019 by data of the respective months available in 2020.

In some sites, there wasn't available information regarding the exact tilt of some solar irradiation sensors and therefore were considered horizontal.

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