Turning Lebanese Electricity Crisis into a Great Opportunity
Is it time to invest in Solar Energy?

BLOMINVEST BANK

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Contact Information

Aline Azzi

aline.azzi@blominvestbank.com

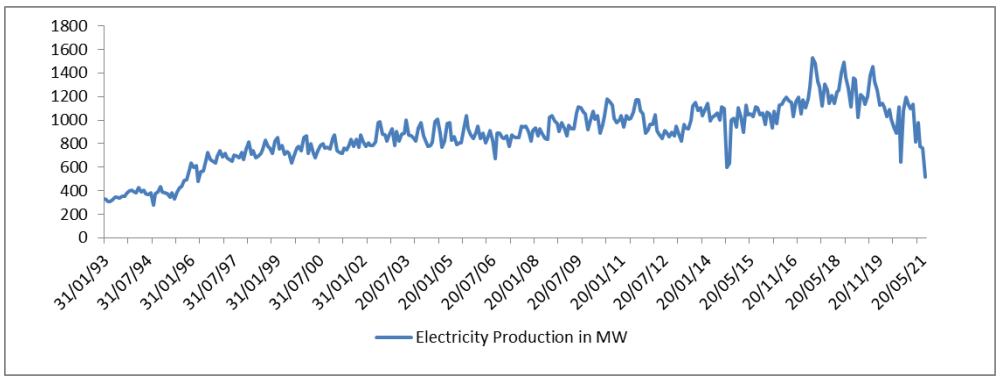
The electricity sector in Lebanon has been pulling down the economy for the last couple of decades. Fuel importation stood for nearly a quarter of the budget deficit while the national electricity demand exceeded its production capacity. And the energy sector carried substantial losses year over year that totaled more than $40 billion and grasped about 45% of the country' s public debt.

Currently, Lebanon is sinking in total darkness as it is going through political and economic crises which led to the deterioration of the Lebanese pound. Consequently, Electricité du Liban (EDL) was not able to purchase fuel to generate power. Thus, Lebanese turned to costly and polluting diesel generators, off-grid solar plus battery systems; in addition, there is a strong appeal for solar panels that makes this a viable, reliable source of energy.

So, the aim in this paper is to present an overview of the solar system, its functional mechanism, the cost and efficiency of the panels, in order to help consumers make more deliberate and thoughtful decisions by organizing relevant information and defining alternatives.

Review of Lebanon' s electricity sector

Electricity production by EDL:

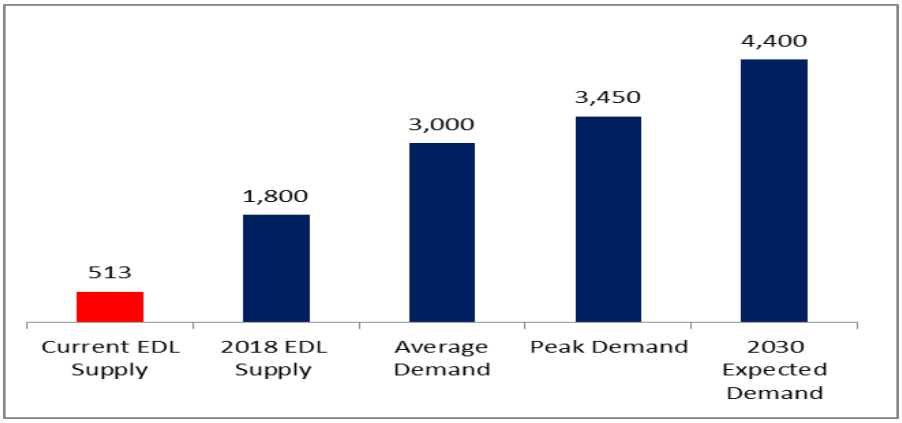


Source: Banque du Liban, BLOMINVEST

Undoubtedly, the Lebanese electricity sector underwent long-lasting power outages. The state of electricity production EDL supplied 1,800 MKH by 2018. However, by June 2021 EDL' s supply went down to only 513 MW, way less than the country' s average demand

totaling around 3,000 MW where peak demand reached about 3,450 MW. Moreover, according to a study conducted by the UNDP, electricity demand is anticipated to reach 4,400 MW by end of 2030 amid the growth of the Lebanese population, adding on the impact of Syrian refugees where they alone are responsible for 480 MW increase in electricity current demand.

Average Demand and EDL Net Supply (in MW):

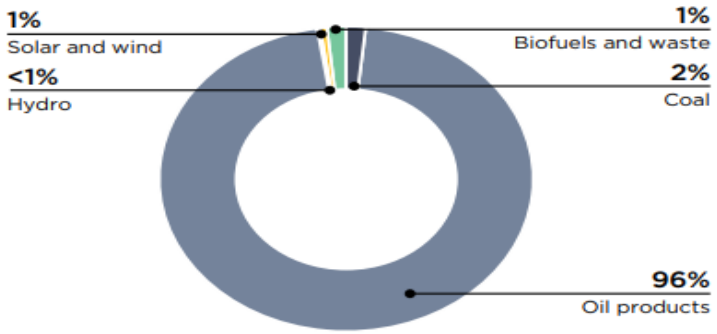


Source: UNDP, Banque Du Liban

Overall, EDL is financially unrealistic. It is enduring a high cost of production, high technical and non-technical losses tied with a fixed tariff in LBP and below cost recovery. In fact, Lebanon depends on fuel importation to fulfill its energy demand. As for its primary energy, six major components are used in the country' s energy consumption: liquid petroleum gas, gasoline, gas oil, kerosene, fuel oil and lastly bitumen. The only sources of power produced locally cover solar water heaters, hydro power plants and an insignificant solar PV contribution.

Primary energy production constituted mainly from imported oil products. In 2016, fuel imports accounted for 96% of overall energy production and imports, followed by coal 2% (IEA,2019), while solar and wind stood at 1% from primary energy supply while hydro energy supply accounted for less than 1%. It is important to note that according to the World Bank, Lebanon used to produce more than 66% of its energy from hydroelectric production in 1971, yet this number went down to 2.6% by end of year 2019.

Total primary energy supply by source (%):



Source: IEA, 2019

Talk of the town! Solar PV

Solar photovoltaics (PV) systems stand for a technology in electricity production from solar energy. This system uses cells to convert solar radiation into electricity and it consists of one or two layers of a semi conducting material, commonly the silicon.

The PV system mechanisms

The solar photovoltaic system consists of the following components: PV modules called PV panels, storage batteries (stand alone or dual mode systems), charge regulator or controller, and most importantly the inverters.

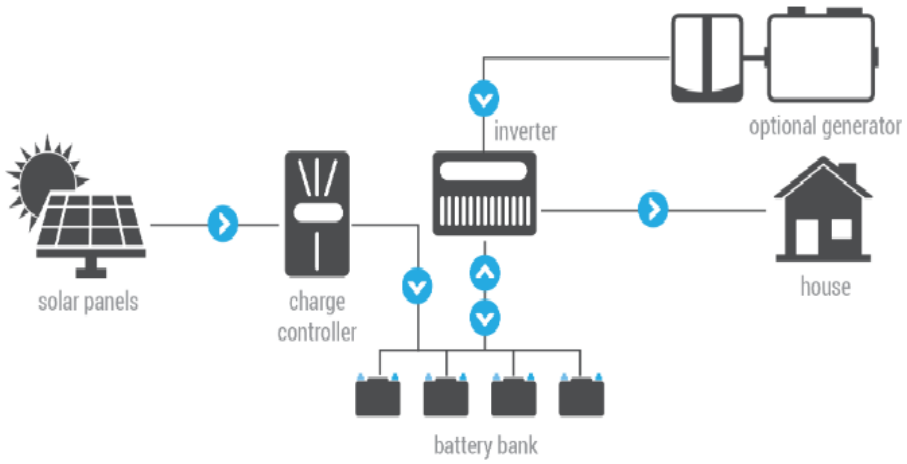
Role of the inverter

Solar PV produces Direct Current electricity (DC); however, home appliances need Alternating Current power (AC) to properly operate. Accordingly, the inverter is set to convert direct DC power to AC power.

Choice of batteries

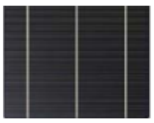
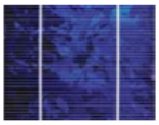
Deep cycle battery is the type recommended for solar system. These batteries are precisely designed to be discharged to low energy level and rapidly recharged for a long period. To have sufficient power to operate at night and during cloudy days, batteries should be large enough to store needed energy. So, the battery capacity should be determined by the design of the system.

Common solar PV mechanism



Choice of panels

Photovoltaic panels have 3 different major types according to their color, efficiency, and surely their price. In addition, PV systems are modular, which offers high flexibility in the design and sizing, but in most cases, the roof space determines the size of the system.

Monocyrstalline	Polycrystalline	Thin film
		
Made of single crystal silicon block	Made of polycrystal silicon block	Made of layers of very finely powdered silicon
They have the highest efficiency but also the highest cost per watt	They have lower efficiency but also lower cost per watt	They have the lowest efficiency and lowest cost per watt
They have a smooth even color, usually black	They have an uneven blue color, with fish scale effect	They have a simple black color

Source: UNDP, Solar photovoltaic electricity for your house!

Number of panels needed

The most feasible system is defined surely by designer/energy engineer. However, number of panels needed depends on the PV system size, the panel size, as well as the required output and the roof space.

Space needed

Surely the space needed depends on the type of the panels used. Mono and polycrystalline panels are more proficient than thin film type and would **require around 7-10 square meters for a 1 kWp system**. In addition to their type, installation is equally important to have efficient power. For Lebanon, the solar panels must be installed at an angle around 35 degrees from the flat surface and must be facing south in an unshaded area.

As stated by the UNDP report, any mistaken installation would lead to a 23% drop in system performance. However, giving the Lebanese weather, a typical 16 square meters PV system is enough for a 2 kWp capacity, thus could produce around 8 kWh per day which is enough to power 1 television, 1 air conditioner of 9000 BTU, 1 fridge for 4 hours, and 4 CFLs of 45 W each. In more simplified way, average power production would be **between 0.45 and 0.75 KWh daily for every square meter of PV.**

Installation mechanism

Overall, PV panels could be installed in different locations; most common and simplest is the roof. Ground installations are possible on condition that the PV are south facing and non-shaded. Today, façade PV are the most alternative used systems, normally known as BIPV "building integrated photovoltaic" systems, which are incorporated within the design of the building and can be a part of the structure replacing traditional construction materials.

When PV panels are installed on flat roofs, they are mounted on aluminum frames and usually PV panels weigh around 10 to 15 kg per square meter. However, taking the wind load into consideration is a must as it could cause extra force on the panels based on wind direction and their orientation. One another parameter to take into consideration is either the roofs are strong enough to handle the PV installation. In addition, PV tiles shall be

installed also in a very careful manner to avoid water leakage and safeguard all electrical units' inadequacy.

On grid system and benefits

On-grid systems, known as grid-tied or grid connected systems, allows the PV system to be connected directly to the national network and permits extra electricity to be exported to the national grid. This procedure requires net-metering or feed-in tariff policies so that the excess of electricity can be offset by recording bidirectional energy flow. Moreover, net metering is applicable upon an agreement with EDL and consumers could visit the EDL website for an application form.

In addition, selling electricity to EDL is usually approved under the feed-in tariff scheme. However, to date this is not possible in Lebanon. Net metering on the other hand allows a quantity exchange of electricity without transferring cash.

Lifetime of the PV system

Usually PV systems could last up to 30 years, with an average lifetime of 25 years. The estimated lifetime of the batteries is about 8 years, depending on the type, usage and maintenance of it. As for the inverter, it is expected to be replaced half-way into the PV system's lifetime.

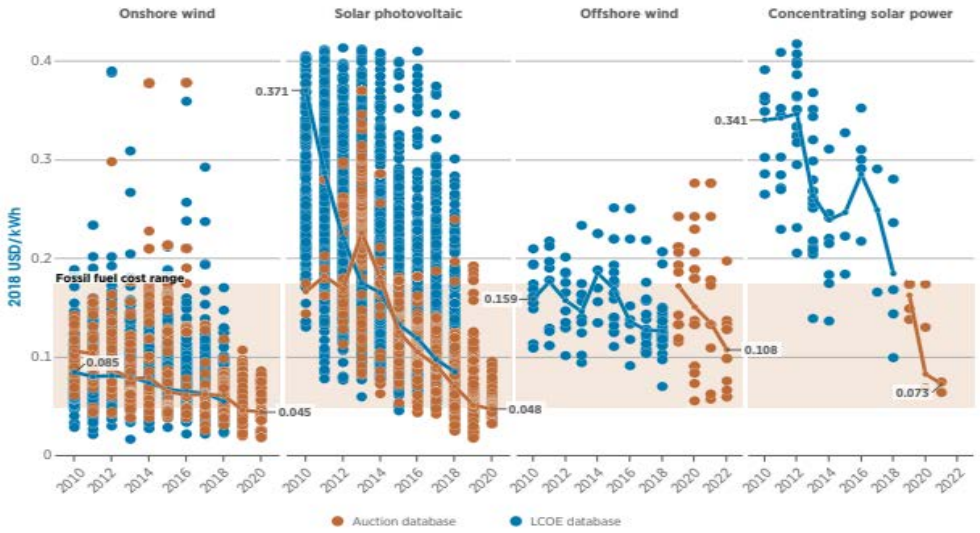
For the record, PV panels are characterized with strength and would not be damaged by heavy rain, snow loads, or minor external shock. However, lightening is a major threat to PV systems. It could damage the electronic equipment even not through direct hit, usually inverters and controllers are the most affected by lightening. Hence, protection is highly necessary following requirements that all exposed metal surfaces must be grounded regardless of the nominal system voltage.

Cost and maintenance

Wind, solar or hydroelectric productions have surpassed coal as world's largest source of energy. And, surprisingly to most, the cost of solar PV system has fallen and is expected to continue falling over the next period.

The price of the PV system varies depending on its size, type and capacity of panels, as well as the autonomy and grid requirements. According to the UNDP report, on average a complete 2 Kw peak system installed in Lebanon would cost between $10,000 and $12,000. Moreover, IRENA stated that price of solar PV modules has fallen by around 90% since the end of 2009.

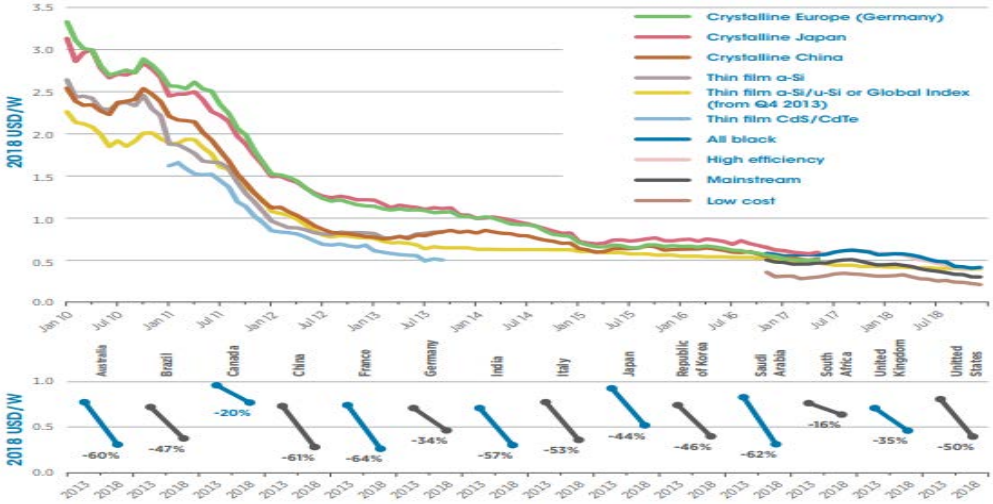
Global weighted average total installed costs and project percentile ranges for Concentrating Solar Power, solar PV, onshore and offshore wind between 2010 and 2022:



Source: Renewable energy outlook of Lebanon, June 2020

It is worth mentioning that electricity' s cost from fossil fuel ranges between 20 cents/KW and 30 cents/KW, much more than the electricity' s cost produced from solar energy, whereas cost of electricity production from solar energy is only 4.80 cents/KW. Interesting to note, this does not take into account the high environmental cost that arises from fossil fuel electricity production, which clearly points to a huge advantage in adopting solar electricity production.

Average monthly European solar PV module prices by module technology and manufacturer:



Source: IRENA, 2019 report

In reference to the above figure, the average monthly European solar PV module price in the period January 2010 to July 2018 has decreased from 3.4 USD/W by January 2010 to 0.17 USD/W by July 2018.
As shown above, prices for most distributed PV application have fallen worldwide. As for Lebanese market, the evolution of prices for distributed capacities is captured by the below figures.

For hybrid applications systems connected to the electricity grid with backup battery storage, prices have reached around 1,200 USD/kWp. However, off-grid systems encountered the largest drop in price for almost 46%, from above 5,000 USD/kWp in 2013 to around 3,000 USD/kWp in 2017. Same for on grid system with batteries connected to the grid with backup battery storage, prices also decreased by 39% since 2013 to 3,300 USD/kWp.

Both systems have relatively higher prices than on-grid and solar pumping systems due to their use of battery storage. Prices for on-grid with grid-tied systems fell by 57% to stand at 1,400 USD/kWp by 2017. All prices were based on estimations made using NEEREA data that shows costs higher than regular market prices due to financing and study costs.

However, according to the UNDP solar photovoltaics report for Lebanon, a saving of around $120-$150 per month is achievable once electricity is produced from Solar PV instead of monthly diesel generator. In addition, the expected pay-back period for solar PV system is between 5 and 8 years, depending on household consumption, location and other parameters. But overall, the solar PV is really cheaper than any conventional means of electricity generation, yet compared to the operations costs of private generators and the high prices of diesel, PV is definitely feasible today.

Moreover, solar system requires insignificant maintenance. PV must be cleaned from dust periodically with a soft towel, while batteries need to be filled with distilled water on a monthly basis. Regular checkup on the electrical equipment is useful. In addition, a semi-annual check by the installer of the system is advisable for overall performance. On average, annual maintenance could costs around $25 per kW peak.

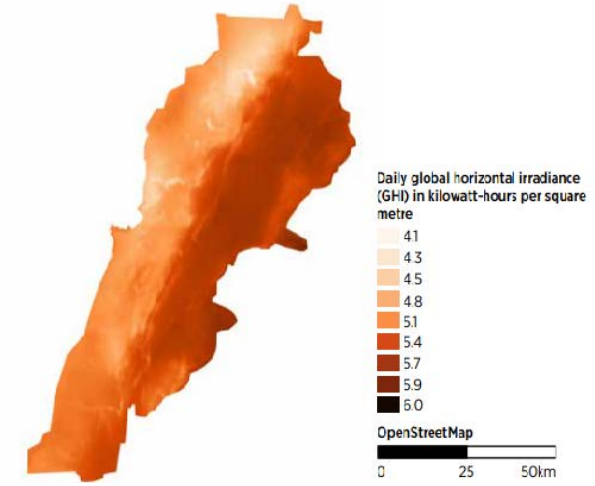
Reasons to turn into solar energy

Overall, renewable energy offers stable, clean and fully domestic system and it could play a vital role in the country' s reform plan. In addition, Lebanon benefits from around 300 days of full sun in the year with 8 to 11 hours of daily sunshine. Not to mention that with the ongoing power cuts and the all-time high cost of diesel for alternative generators, demand for solar energy is becoming the ultimate option for the Lebanese.

According to IRENA' s Global Atlas for Renewable Energy, the annual average solar irradiation in the country ranges between 1,520 kWh/m^2/year and 2,148 kWh/m^2/year with majority of areas being above the 1,900 kWh/m2/year. Based on this irradiation data and the agency' s suitability mapping approach, IRENA stated that the estimated potential for utility scale solar PV could total 182 GW. The results of its study concluded that **over 5,558**

km² of the Lebanese land is suitable for utility scale solar PV, having scored above 65%. This translates to around 182 GW of solar capacity. Noting that to secure our expected average demand totaling 4,000 MW, we only need to exploit much less land for that purpose. Moreover, estimates put the amount of investments needed to secure 4,000 MW from solar energy is around 6-7 Billion dollars, keeping in mind that optimal use of energy sources requires a hybrid system. i.e. not to rely solely on solar sources.

Solar resource potential: annual average daily GHI (kWh/m²)



Source: IRENA, global atlas for renewable energy, World Bank

Solar PV during winter

Solar PV requires daylight to function but not necessarily direct sunlight, as stated by the UNDP Solar Photovoltaic electricity report. Moreover, it needs only unhindered access to solar radiation; and means that an appropriate angle in installation facing the sun and no shading on the solar panels is enough for an efficient electricity production. Certainly, the system will accumulate more energy on a clear sunny day; however it will collect a relatively lesser extent energy on a cloudy winter day. In fact, photovoltaic cells are designed to withstand heat, cold and high winds and they are not affected by severe climate conditions. Consequently, with solar panels on top of your roof, you can produce your own electricity at no additional expenses, most importantly not exceeding the generator costs around $175 per month if privately owned.

Depending on the installed PV capacity, solar system can guarantee enough power for the entire house electrical needs. When the PV are properly installed and combined with the electrical supply from EDL and with battery storage, consumers are able to obtain 24 hours of electricity per day.

Conclusion

As Lebanon sinks deeper into economic collapse and with the long foreseen energy crisis, renewable energy provides stable ad clean power. Renewable energy would particularly

reduce the national budget as a result of drops in fuel importations; it would also secure stability in the economic and social level. However, needed actions must be taken in order to truly support the path towards clean and renewable energy sector.

Overall, it is important to note that the current 2-3 hours of electricity supply from EDL is not enough to allow consumers to fully abandon the back-up generators. The current government must take advantage from the current electricity crisis to move towards decentralized energy production and reform EDL at the technical and administrative levels. Indeed solar energy investments offer a short-term and easy solution to the ongoing crisis; however, actions, laws and needed steps must be taken for a thorough re-evaluation of the electricity entity in Lebanon.

Renewable energies cut costs and, most importantly, reduce carbon emissions and bring several socio-economic benefits, and align Lebanon with global sustainable development goals.

For your Queries:

BLOMINVEST BANK s.a.l.

Research Department

Bab Idriss, Weygand Str.

POBOX 11-1540 Riad El Soloh

Beirut 1107 2080 Lebanon

Aline Azzi

aline.azzi@blominvestbank.com

Tel" +96170627661

Research Department

Tel: +961 1 991 784

research@blominvestbank.com