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Resilient nations.

Solar **Photovoltaic**

Electricity for your House!



Solar **Photovoltaic** Electricity for your House!



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Note: The information contained within this document has been developed within a specific scope, and might be updated in the future

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INTRODUCTION TO PHOTOVOLTAICS



Jran Intermediate School - Batroun

Installing a PV system on an unshaded roof with appropriate orientation and accessible daylight would produce enough energy

Why invest in Solar Energy?

Lebanon has around 300 sunny days in a year with over 8- 9 hours of daily sunshine. While Lebanon is suffering from electricity supply shortage, solar energy presents a clean alternative that can, if properly designed, remove the need for diesel self-generation and lower the national utility electricity bill. Besides, PV is also getting government financial support, which will be discussed in the following pages.

What is PV?

Photovoltaics (PV) systems refer to a technology used to produce electricity from solar energy. PV systems use cells to convert solar radiation into electricity. The PV cell consists of one or two layers of a semi-conducting material, most commonly silicon.

How is PV different from a Solar Water Heater?

A PV system converts radiations to electricity, something a solar water heater cannot do. The solar water heater uses the thermal energy in solar radiations to heat a fluid that is then used for domestic water use.

A PV system produces electricity that can be stored in batteries, whereas a solar water heater uses an insulated hot water tank to store thermal energy generated (hot water in this case).

How much sun is good enough?

Your PV system needs daylight to work but not necessarily direct sunlight. It just needs unobstructed access to solar radiation. As long as there is no shading on the solar panels, and they are installed at the appropriate angle of incidence (to better face the sun), they would be able to produce electricity. You will collect more energy on a clear summer

day but you will also collect energy, although to a relatively lesser extent, on a cloudy winter day. In general, PV cells are not affected by severe weather conditions, and they are designed to withstand heat, cold, and high winds.

Why should I use PV to produce electricity?

The average power cut-off in Lebanon stands at approximately 6 hours per day outside administrative Beirut, and often much more to reach 9 - 12 hours in most places. An on-site generator costs around \$175 per month if privately owned, while, on the other hand, if neighborhood diesel-generator electricity is rented, the monthly subscription fee exceeds \$100 for a standard 10 - 15 Amperes.

With a PV system on your roof, you can produce your own electricity at no additional monthly expenses.

Can I use PV to power my house?

Your PV system can power your entire electrical needs, including lighting, kitchen appliances, and electronic appliances such as computers, TVs, and radios. Depending on the installed PV capacity, PV can also cater for some of the heating and cooling loads if properly designed, and, combined with the electrical supply from EDL and with battery storage, you can achieve 24 hours of electricity per day.

What other uses do PV systems have?

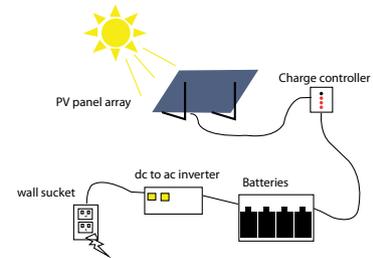
In addition to domestic on-grid and off-grid applications of PV systems, PV is used for grid-connected power plants, off-grid industrial applications, remote water pumping, and other consumer goods such as electrical appliances, watches, calculators, and toys.

What are the PV system components?

The PV system comprises the following components:

1. PV modules
(commonly called PV panels)
2. Storage batteries
(for stand-alone or dual mode systems)
3. Charge regulator or controller

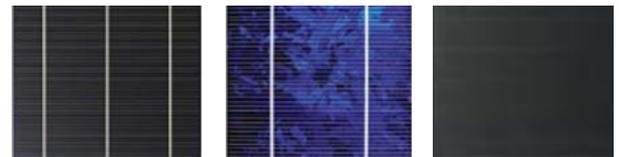
for (stand-alone or dual mode systems)
4. Inverter



Why are there different colors of PV panels?

There are different types of PV panels, they change in color, efficiency, and price. There are three major types as follows:

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



Monocrystalline

Polycrystalline

Thin Film

What are the available sizes?

PV systems are modular, which allows for a high level of flexibility in the design and sizing. In most cases, the available roof space determines the size of the system.

With a PV system, you can produce your own electricity at the same monthly cost of a private generator

What is it about the inverter?

Your solar PV system would produce DC current; however, most of your appliances would be operating on AC power supply. Thus an inverter is required to convert direct DC to AC current, and is also essential for on-grid applications to transform produced current into grid-compatible alternating current electricity and to feed back into the grid.

10 reasons to invest in a PV system

1. PV has low running cost (fuel-free)
2. PV is pollution-free
3. PV systems are safe
4. PV pays back its investment in 5-8 years
5. PV modules can be recycled
6. PV requires low maintenance
7. PV gets you electricity no matter where you live
8. PV could be aesthetically integrated into buildings (BIPV)
9. PV is considered eco-friendly and green
10. PV reduces your carbon footprint and helps combat global warming



Ibreen Municipality - Batroun

HAVING A PV ON YOUR ROOF



Hammana Community Center - Baabda

**A saving
of around
\$120 - \$150
per month is
achievable**

Can I really produce my own electricity?

If you have a roof, under the sun, on a shadow-free location, then you will be able to produce a good share of your electricity needs. On average, you would be able to produce between 0.45 and 0.75 KWh daily for every square meter of solar panels. That is equivalent to lighting one 45 W light bulb for 10 – 16 hours.

Do I need permission for that?

As long as you are not selling electricity to another consumer, then you should be fine. No planning permission is needed as long as it is installed on your premises.

Is it really cheaper than conventional means of electricity generation?

In a couple of years, it is forecasted that the cost of electricity generated from PV systems will match the cost of conventional electricity; yet, compared to the

operation costs of private generators and the high prices of diesel, PV is definitely feasible today.

How much would a PV system cost me?

The price of the system varies depending on its size, type and capacity, as well as the autonomy and grid requirements. On average, a complete 2 kW peak system installed at your premise in Lebanon would cost between \$10,000 and \$12,000.

How much will I be saving?

The savings from installing a PV system depend on the actual size and type of the system installed, as well as what the PV system is replacing. A typical 2 kWp system, if properly designed and if energy efficiency measures are carried out first at your residence, to reduce electricity demand (highly recommended action before the installation of a PV system), then the diesel generator rent will be removed, equal to at least \$100 per month, and Electricite du Liban (EDL) bills can be cut in half (very

site specific). Therefore, a saving of around \$120 - \$150 per month is achievable.

Where can I place my PV panels?

PV panels could be mounted in a range of locations, the most common and simplest of which is the roof. Ground mounted installations are possible as long as a south facing non-shaded location is guaranteed. The most common alternative being used lately is façade PV installed systems, normally known as BIPV.

What is BIPV?

Building Integrated Photovoltaic (BIPV) is an integrated system incorporated within the design of the building. It makes a part of the structure and is considered part of the whole building design and may also replace traditional construction materials.

How is it fixed to my roof?

This depends on the roof type and its orientation. For pitched roofs, a few tiles or slates could be removed and PV panels would be integrated within the inclined roof. This would be possible in the availability of south facing tilts, and if the roof inclination is almost equal to the required PV tilt angle.

In other cases, the PV panels could be installed on aluminum frames mounted on flat roofs. The frames could be either supported in the ground or by the side walls.

How would it look on my roof?

Integrated panels look the best. They may even add an aesthetic beauty to the overall design of the building. The colors vary between blue and black depending on the PV modules used.

How much weight load are we talking about?

PV panels usually weigh around 10 to 15 kg per square meter. However, when assessing the load threshold, you need to take the wind load into

consideration as it could cause extra force on the panels based on the wind direction and their orientation.

Will my roof be strong enough?

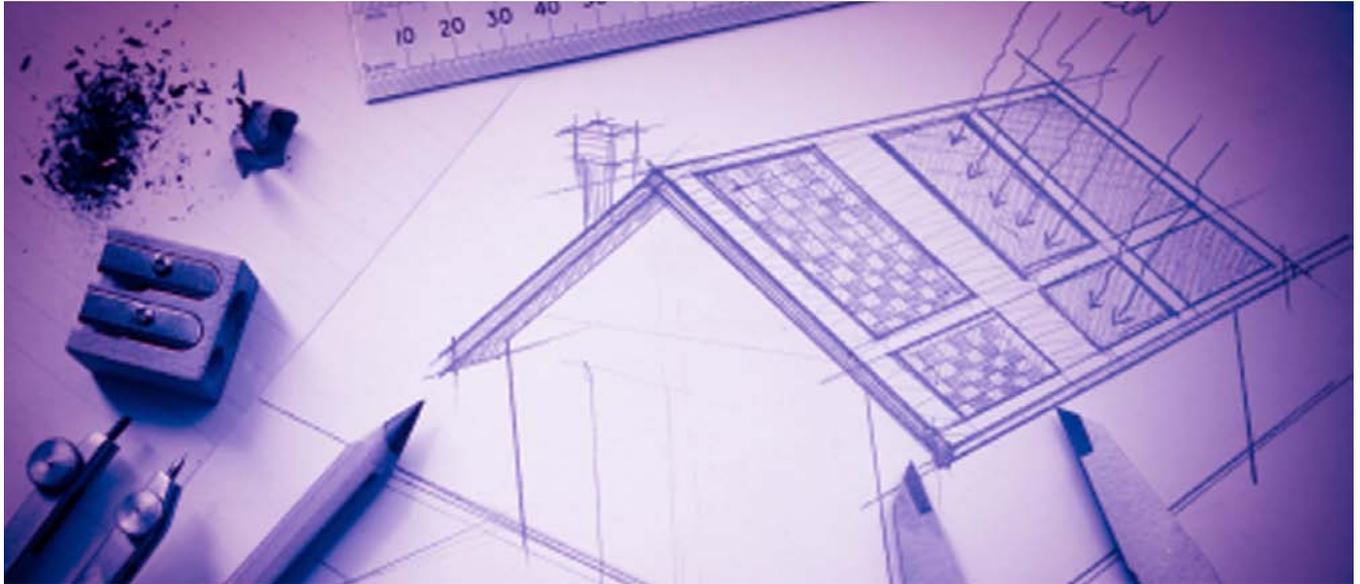
Most roofs in Lebanon are strong enough to take a solar PV installation without any reinforcement needed. In all cases, the PV installer can verify this issue if you have any doubts or think your roof is in poor condition.

What about PV tiles?

PV tiles are available and offer a pleasing and decorative look, but would entail additional costs. They shall be installed in a very careful manner to avoid water leakage and safeguard all electrical units inadequacy.

PV panels are most commonly placed on the roof for maximum daylight

BASIC DESIGN PRINCIPLES



How many panels do I need?

It depends on the PV system size required to satisfy your facility's needs, as well as the panel size, the required output, the roof space. The best thing is to contact a designer/energy engineer to help you define the most feasible system for your case.

How much space would I need?

The space occupied would depend on the type of PV modules used. Mono and polycrystalline are more efficient than thin film and would occupy around 7-10 square meters for a 1 kWp system.

How do I orient my panels to get the best out of my PV system?

To get the best out of the solar radiation, for Lebanon, the solar panels should be installed at an angle around 35 degrees from the flat surface, and should be facing south in an un-shaded area. Any shift of around 15 degrees in tilt or orientation would lead to a 23% drop in system performance.

How bad is shade?

Unlike solar water heaters, shading has significant effect on the performance of the PV system. That is because solar panels are made of a number of solar cells connected together. Even as little shading as 2.5% could reduce the electricity output of the PV significantly.

Would I need a three-phase connection?

Your domestic system would be fine with a single phase electricity supply. Residential systems usually do not install more than 10 kWp. For larger systems the issue of 3-phase should be considered.

How much electricity should I expect?

With the weather in Lebanon, a typical 16 square meters PV system would be enough for a 2 kWp capacity and would produce around 8 kWh per day, enough to power 4 CFLs of 45 W each, 1 TV, 1 air

1kWp of solar modules requires a space of 7 to 10 square meters

conditioner of 9000 BTU capacity, and 1 fridge for 4 hours.

Will I be able to stop global warming?

Taken independently, installing a PV panel will not be enough. However, it is an excellent contribution as EDL power plants emit 0.65 kg of CO₂ for each kWh produced, thus your 2 kWp system would be contributing to a daily saving of approximately 5 kg of CO₂, reaching up to 47,000 kg of carbon dioxide over the lifetime of the PV system.

How long should I expect it to live?

In principle PV modules could live up to 30 years, with an average lifetime of 25 years. The expected lifetime of batteries is about 8 years, depending on the type, usage and maintenance of the battery. A change of inverter should be expected half-way into the system's lifetime.

What batteries should I choose?

The battery type recommended for PV system is deep cycle battery. This type of batteries is specifically designed to be discharged to low energy level and rapidly recharged for a long period of time. The battery should be large enough to store sufficient energy to operate the appliances at night and during cloudy days. The battery capacity should be defined by the system designer.

Would my system still produce the same amount of energy after 25 years?

Efficiency of the solar modules drops with time. The degradation of the PV modules varies by type to reach around 80% after a period of 20 years (for crystalline PV modules). The modules shall have a performance guarantee of 20 years at 80% power output warranty. Still, 80% after 20 years is a good value!

What payback period to expect?

The expected pay-back period for a PV system is between 5 and 8 years, depending on what's being displaced, household behavior, location and other parameters.

What should I and/or the system designer really consider when designing my PV system?

When you design your PV system you should check the following:

- Capacity and load needs
- Occupancy factor and load distribution
- Hours of autonomy
- Unshaded roof space availability
- Grid requirements

**PV systems
have a
payback of
5-8 yrs**

CONNECTING TO THE GRID



Hosh El Harime Intermediate School - West Bekaa

Net metering allows small scale renewable energy to feed-in to the grid excess production

How could the grid help me?

You could benefit from the grid if you decide to install an on-grid system, which allows excess electricity to be exported to the national grid for later use. This acts as a piggy bank to save your money and reduce your electricity bill.

What is an on-grid system?

On-grid systems, also known as grid-tied or grid-connected systems, allow you to connect your solar PV system directly to the utility network. This requires additional technical restrictions and requirements and could be done through net-metering or feed-in tariff policies.

Can I sell my electricity to EDL?

Selling electricity generated through renewable energy is usually accepted under the feed-in tariff scheme, but this is not, to date, possible in Lebanon. Feed-in tariff sets different tariffs for renewable energy technologies at which the electricity utility

would buy power from homeowners. Net metering on the other hand only allows a quantity exchange of electricity without transfer of money.

What is Net Metering?

Net metering is a renewable energy incentive through which consumers with small renewable energy installations can offset the cost of power drawn from the utility. This works by installing a meter that records the bidirectional energy flow, allowing the excess power to be transmitted to the grid. The exported energy from the system is subtracted from the imported energy, and only the net output is calculated and priced.

Does this really work in Lebanon?

Net metering was launched by the Ministry of Energy and Water and adopted by EDL in 2011. It is operational and applicable upon an agreement with EDL. Please visit EDL website for an application form (www.edl.gov.lb).

Do I still need batteries for my on-grid system?

In general, grid-tied systems do not use batteries yet in Lebanon they have to. This is because we do not have to date 24h electricity supply. You still need to have battery banks to supply you with electricity during blackouts.

How would I be eligible for net metering?

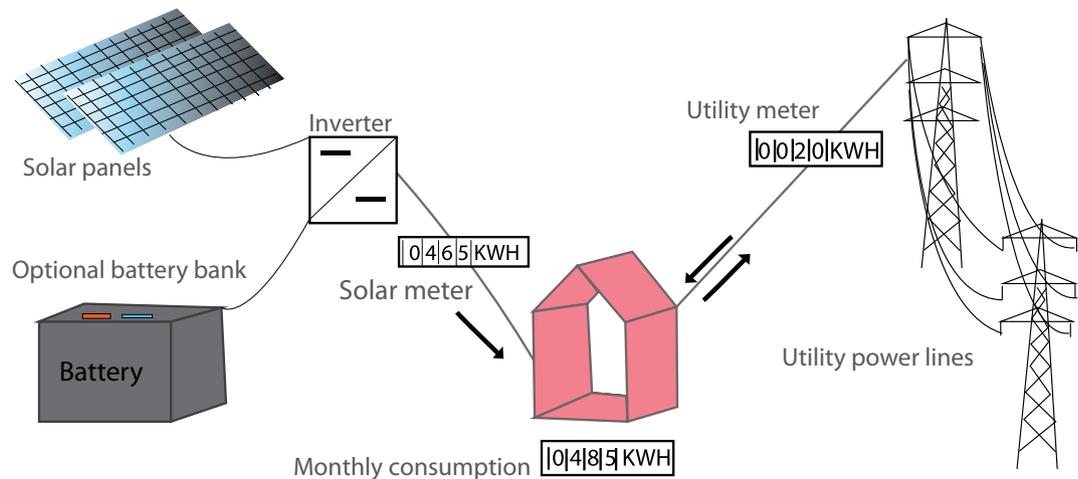
To be eligible for net metering, the technical requirements set by EDL should be met in terms of system specifications and power quality. After that, a contract is signed with EDL and a bidirectional meter is installed to start logging the electricity input and output at the house.

How does net metering work in Lebanon?

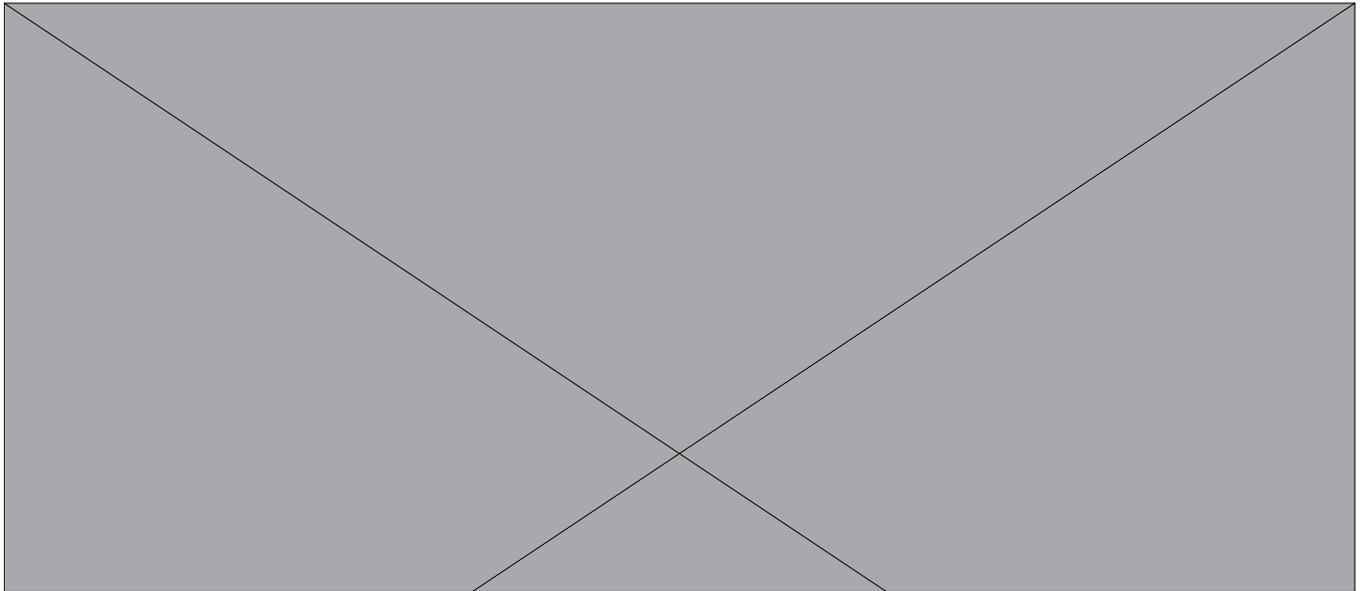
The home owner receives a bimonthly electricity bill covering only the net consumption after subtracting the exported electrical energy. The home owner pays for the difference and saves any extra electricity produced as energy credit and can be used in the following months.

What if my balance at the end of the year is negative?

At the end of each year, the account is reset to zero and the home owner will not be compensated, but this may change in the future if financial compensation is introduced.



Keeping it Safe



PV system require periodical dust cleaning while batteries need monthly distilled water filling

Should my PV system be guaranteed?

The modules usually have an overall guarantee of 20 years, of which 3 years on material and manufacturing faults and 20 years for 80% power output warranty. Inverter's guarantee is around 2- 3 years.

Do I need to maintain it?

Your solar PV system would require little or no maintenance. Solar panels should 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 remaining electrical equipment could be useful. It is advisable to request bi-annual checks by the installer of the system for overall performance monitoring. On average, annual maintenance costs are around \$25 per kW peak.

What could go wrong?

If the PV system stops producing electricity or drops its energy conversion rate dramatically before completing its 20 years, then it should be checked by the supplier for any defects.

Will it make disturbing noise?

No it won't. But the inverter can make a slight humming noise that is only audible at a very close range and only when the cabinet is open.

Is it safe to have a solar PV system?

A solar PV system doesn't create any additional safety issues. It is as safe as any conventional electrical system. There is no more risk of a fire starting than with other electrical equipment in the house.

**PV system
ought to be
protected
against lightning
hazards**

What safety regulations should I consider?

International safety regulations are set in the international standard IEC 60634-7-712. This standard outlines the major requirements for PV safety, including earthing, electrical shock protection, as well as overload, short circuit, and fire protection.

How fragile are my PV panels?

Solar PV panels are characterized with strength and ability to withstand external stress. They will not be damaged by heavy rain, snow loads, or minor external shock.

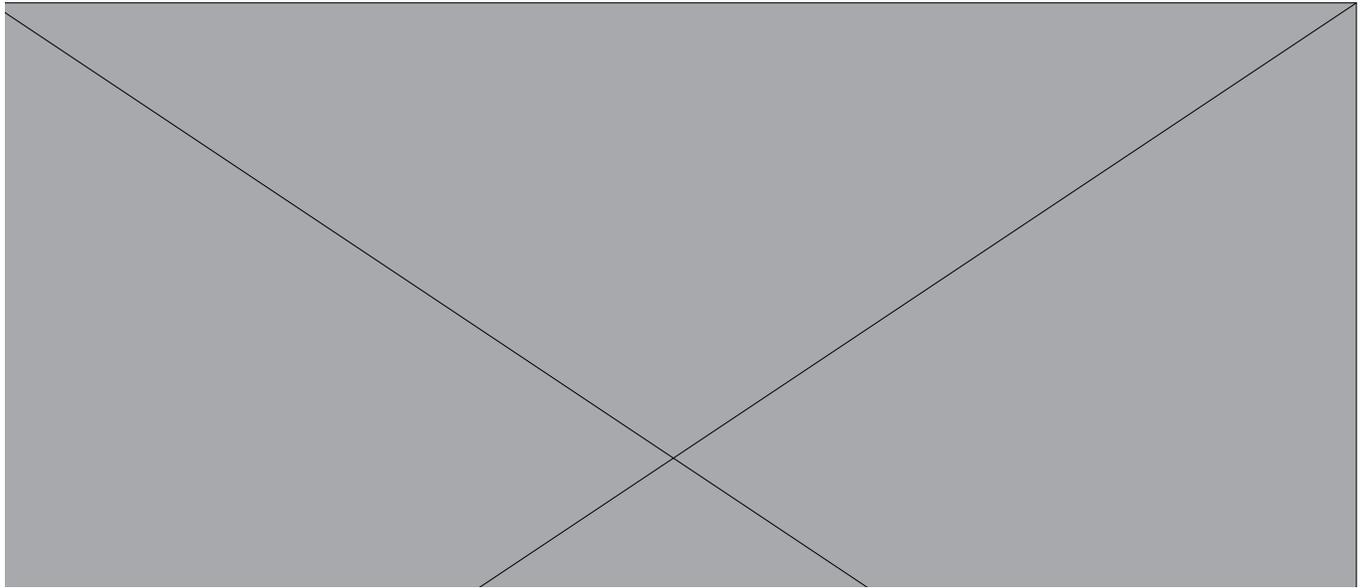
Would it handle lightning strikes?

Lightening is a major enemy to PV systems. It could damage the electronic equipment even not through direct hit; in fact it usually occurs through nearby hits and causes severe damages to the inverters and controllers. Thus, protection is highly recommended following NEC requirements that advise that all exposed metal surfaces be grounded regardless of the nominal system voltage.



JebJennin municipality - West Bekaa

Installing a PV System



The loan application will be studied by a technical team, and accordingly the loan will be granted allowing you to pay the total amount over 14 years

Do I buy a PV system now? Wouldn't it be wiser to wait until prices go down?

The PV industry has been developing for decades, and we believe it has almost reached its maturity level as prices have already decreased remarkably in the past couple of years. Definitely price reductions are further expected in the future, however given that PV systems should replace the costly diesel generator, and given that support programs and initiatives are in place, now is the right time!

What are the support initiatives in place?

In addition to net metering that helps you benefit from your extra electricity generated, you could also benefit from the NEEREA, which offers low interest loans to renewable energy and energy efficiency projects for a period up to 14 years with a grace period.

What is NEEREA?

The National Energy Efficiency and Renewable Energy Action (NEEREA) is a national platform built on the Circular 236 of the Central Bank of Lebanon (BDL), dedicated to support renewable energy and energy efficiency projects through soft loans with an interest rate of 0.6% and repayment period of 14 years.

How to benefit from NEEREA?

In order to benefit from NEEREA, you should submit a technical study performed by the contractor you hired for the design and installation of your PV system to any commercial bank, where you need to apply for a green loan. The report should include full financial and technical analysis about the system. The loan application will be studied by a technical team, and accordingly the loan will be granted allowing you to pay the total amount over 14 years, and maybe benefit from an EU subsidy based on the economic feasibility of the project.

What is the European Union (EU) subsidy?

The EU has dedicated a budget to support NEEREA projects with a grant of as much as 15% of the loan amount to be deducted from your payment at the bank. This grant is to SMEs in selected projects studied and evaluated by a technical committee assigned by the EU.

Do I need to apply for the EU subsidy?

As you apply for NEEREA, your application will be automatically transferred to the EU subsidy technical team. You do not need to apply for both.

Who can subscribe to Net Metering?

Net metering is open to any residential user who has an electricity subscription, whether belonging to EDL or other subsidiaries including EDZ, EDA, and EDJ, and regardless if they already have a PV system or they are planning on getting one that fulfils the technical requirements set by EDL.

What are the technical requirements needed?

The solar PV system should satisfy the requirements available on the EDL website: www.edl.gov.lb
The PV system should be designed by a specialist

What is the subscription procedure?

- 1.The installation of the grid-tied renewable energy should meet the technical requirements set by EDL.
- 2.The user fills in an application form for EDL (available at any EDL office and on both the EDL and the LCEC websites)
- 3.EDL net metering committee studies the technical specifications of the system.
- 4.Users with approved applications sign a one-year renewable contract with EDL agreeing on the terms and conditions.
- 5.EDL is responsible for connecting the production facility to the network and installing the meter free of charge.
- 6.The user can then begin feeding in electricity and saving money.

Where to find PV companies in Lebanon?

You can contact the Lebanese Center for Energy Conservation or log in to their website: www.lcecp.org.lb and download a list of PV dealers in the country with full contact details. Alternatively, please contact the LCEC on 01-565108 for more information.