Technical Brief on Sustainable Energy

SOLAR PHOTOVOLTAIC SYSTEMS

SWITCH GARMENT

PROMOTION OF SUSTAINABLE ENERGY PRACTICES IN THE GARMENT SECTOR IN CAMBODIA

switchasia GRANTS PROGRAMME

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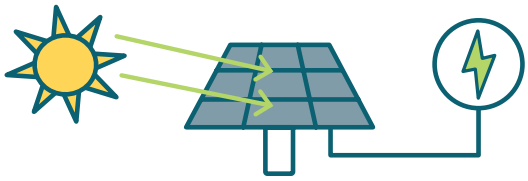
WHAT IS SOLAR PHOTOVOLTAIC?

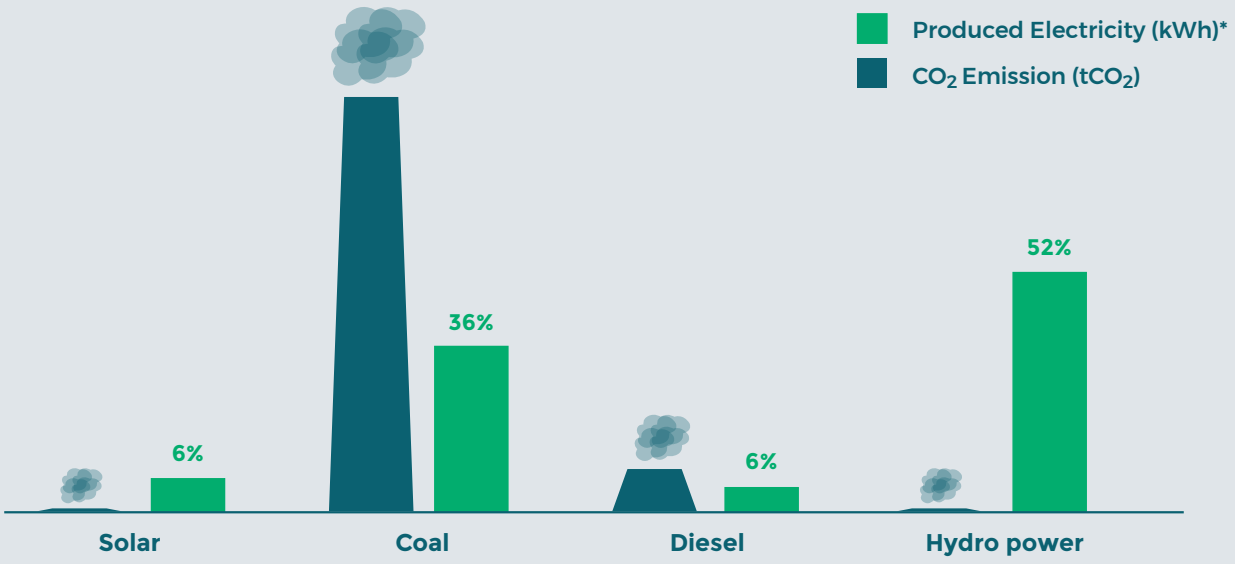
Solar Energy is a Renewable Energy, meaning it comes from a source that regenerates quickly enough to be considered as inexhaustible on human timescale. This energy coming from the solar radiation can be converted into electricity thanks to photovoltaic panel.



Cambodian Electricity Mix (Grid) 1

Electricity supplied by Cambodia's national grid is made up of a blend of different energy sources such as water (hydro), coal, diesel, solar, etc. each of which have different emissions factors i.e. tCO_2e emitted per kWh (tCO_2e/kWh) produced. In Cambodia, while hydro power, seen as clean energy, represents for 52% of the electricity produced and supplied by the national grid coal power plants, which have the highest emissions factor, make up the majority share of the remaining and is planned to increase to meet growing economic demand.

Electricity Production and CO_2 Emissions in Cambodia 2021



*Source: Annual report on Power Sector of the Kingdom of Cambodia Compiled by Electricity Authorithy of Cambodia – From Data for the year 2021

Solar does not emit CO_2 when producing electricity and even once the GHG emissions generated to make and dispose of the panels at end of life (known as embedded CO_2e) is considered, solar photovoltaic electricity still around 10 times* less CO_2/kWh than Cambodian grid electricity.

*Depending on the annual energetic mix of the grid.

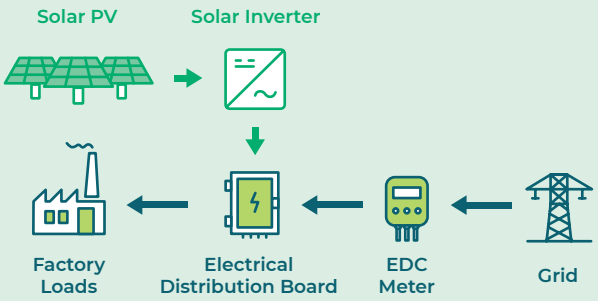
Types of Solar Photovoltaic Systems 2

1. On-Grid Solar Photovoltaic (PV)

On-Grid Solar PV is connected to national grid, therefore this solution is only possible when the national grid power is available in the neighbourhood.The factory will use the electricity produced by the solar PV system first. Then, if needed, additional electricity can be used from the grid.

Typical payback period upfront purchase in Cambodia*: 4-6 years.

- **Cheapest solution**
- **Highest savings**
- **Fastest return on investment**
- **No backup needed**



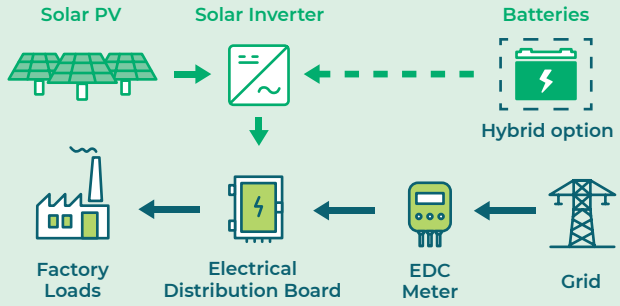
● Provided by Solar Company ● From Client

2. On-Grid Photovoltaic system with batteries

A hybrid system uses several sources of energy to generate electricity, in addition to the grid. In some hybrid systems, batteries are used to store the excess of electricity produced by the solar photovoltaic system for later use.The stored electricity can be used as a backup source of electricity.

Typical payback period upfront purchase in Cambodia*: 6-10 years.

- **Flexible backup**
- **High savings**
- **Investment can be adjusted but larger than on-grid**



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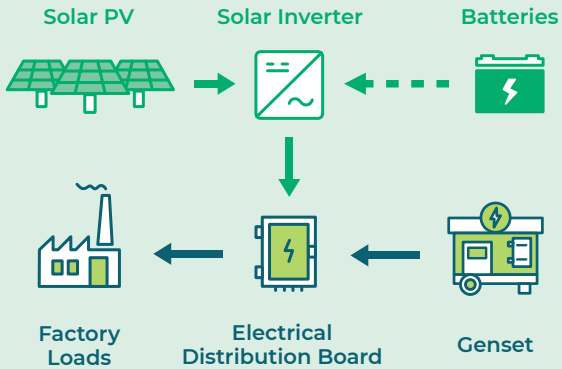
3. Off-grid Photovoltaic system with batteries

An off-grid system is not connected to the grid. It is autonomous and must provide all the energy needed. Instead of having the back up done by the grid, it is done by the batteries and/or the diesel genset. The batteries will be charged using solar energy. In case the solar panels and the batteries are not able to answer the need, the power can be supplied by the diesel genset. This option is adapted when the grid is not available but is also the most expensive as it often requires a larger PV system and batteries than when connected to the grid,

Typical range payback in Cambodia*: 10-16 years

- **Back up CO_2 consuming generator is needed**
- **Most Expensive**
- **Convenient only when off grid**



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*This information is given as a guideline only, the payback does vary significantly due to the consumption profile as well as the capacity charge implications for each project.

Main components of a Solar Photovoltaic installation 3

01. Solar panels

Transforms solar radiation into electricity.

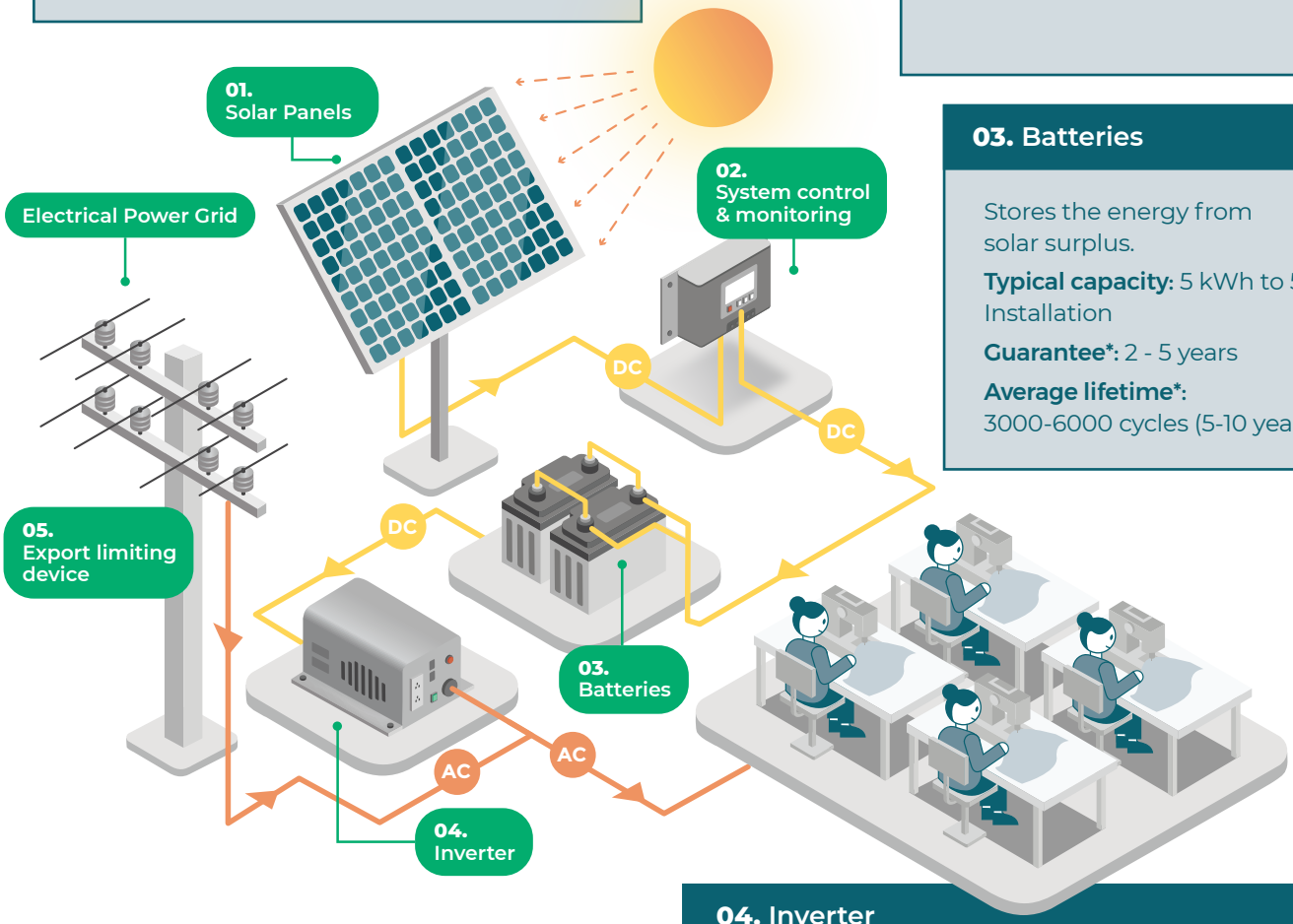
There are different types of solar panels (monocrystalline, polycrystalline, amorphous). The selection of the most suitable one will depend on the configuration of the installation, space available, cost etc.

Average lifetime*:
25 years performance guarantee

02. System control & monitoring

Monitoring solutions centrally manage the solar power installation. With automated reports and accurate positioning of faults, it is quick to identify and resolve faults, avoiding downtimes.

It allows the user to get as much energy as possible from the solar panels and regulates flow of electricity to the batteries not impacting their lifespan.



03. Batteries

Stores the energy from solar surplus.

Typical capacity: 5 kWh to 50 kWh Installation

Guarantee*: 2 - 5 years

Average lifetime*:
3000-6000 cycles (5-10 years)

04. Inverter

Converts the DC current generated by solar panels into AC current needed to power the load / equipment and appliances in the factory.

Typical inverter efficiency* : 93-98%

Installation and protection: should be installed inside, next to the electrical room or outside, next to the panel protected from bad weather.

Guarantee*: 5 years manufacturer guarantee
Average lifetime*: 10 years

05. Export limiting device

Prevents any power injection into the grid when your production is higher than your consumption (which is not allowed in Cambodia).

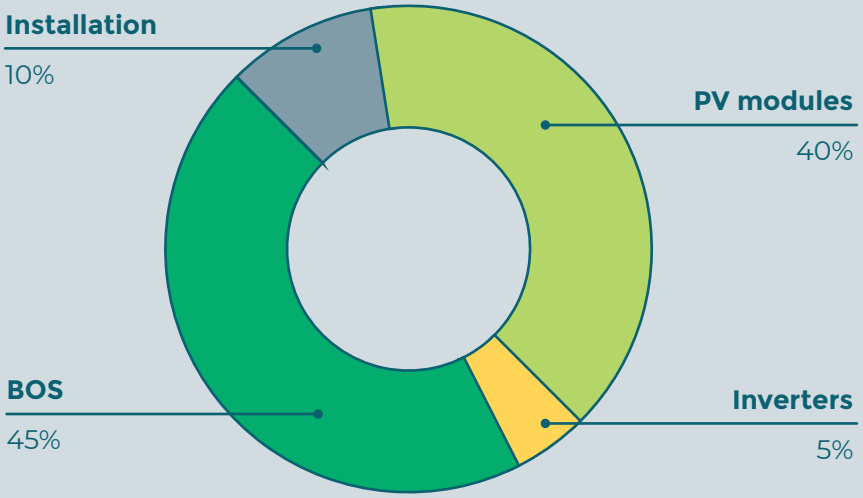
Guarantee*: 5 years manufacturer guarantee

Average lifetime*: 10 years

*This information is given as a guideline only, it depends on the manufacturer, technology and/or use of the equipment.

Cost breakdown of installation 4

Typical cost breakdown of an on-grid rooftop solar PV system.



Note: BOS includes electrical equipment (cables, breakers ...) monitoring system, shipment, tools rental and all other costs of the project.

Opportunities

Economic reasons

For the factory, installing solar photovoltaic system means that the electricity bills will decrease significantly to be more independent from the grid supply. Payback periods are usually between 4 and 6 years for on-grid solar PV systems in Cambodia, and are likely to decrease.

Environmental reasons

Solar electricity is less polluting than the electricity from the grid in Cambodia and causes lower greenhouse gas emissions.

Raise the profile of the garment factory for brands

Most major fashion brands have signed up commitments to reduce carbon emissions, such as through the SBTI initiative (science based targets.org). In addition, several have signed up to the RE100 program, committing to consume 100% renewable electricity, or have set their own Renewable Energy targets (e.g. Nike).

Long lifetime

The lifetime of a PV system is about 20-25 (including replacement of a few parts).

Barriers

Roof space available and roof strength

A civil engineering company must carry out a detailed assessment of the structure to make sure the building (roof, frame, concrete columns...) can support the weight of the PV installation or if reinforcement is needed.

Mismatch with the Consumption profile

The best load profile needs to be consistent with the solar production (i.e. 7 days a week, daytime only, with a peak towards the middle of the day). For factories with highly variable load profiles or high consumption at night, the interest of solar electricity production should be studied further.

Current PV Regulation in Cambodia

Since 2018 in Cambodia, EAC and EDC applied a regulation for all Medium Voltage and High Voltage consumers installing a PV system synchronized to the grid. Taking this regulation into account is needed when studying the feasibility of installing a PV solar System because it affect the potential savings and payback period.

Efficiency of the Solar Photovoltaic installation 5

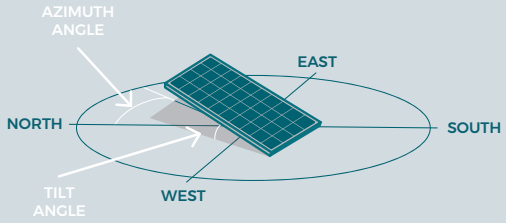
Different parameters can impact the efficiency of the solar PV installation:

Temperature

Solar panels operate best at ambient temperatures of about 25°C. When the surface temperature of a solar panel gets higher than 25°C, solar panel efficiency can decline.

Wind

Since the wind can potentially cool solar panels down, it can make them more efficient as long as the sun is still shining on them.



Orientation and angle

- The tilt angle is the angle of the PV solar panels from the horizontal plane. In Cambodia, the best tilt angles are between 10° and 15°.
- Orientation: The best efficiency is with panels oriented South. If the configuration does not allow the panels to be South, East or West are also possible with less efficiency.

Shade

Most of the time, solar panels are located on the roof to prevent the risk of having shade on the solar panel at any time of the day, optimizing efficiency.

Inverter efficiency

The inverter is what converts general Direct Current (DC) to Alternating Current (AC) electricity. Most inverter's conversion efficiency is around 97% to 99%, so the energy loss is relatively minor.

Quality of Solar Panel

The quality of the solar panel must not be forgotten when installing solar system in a facility. Products respecting some quality standard are highly recommended (ex : brands from Tier 1 list) over those that don't.

Dust and dirt

If there is a layer of dust on the solar panels, the sun radiation will not be able to effectively reach the panels, causing a reduction in efficiency until the panels are cleaned.

Operation and Maintenance 6

Operation and Maintenance of the system is often included in the agreement with Engineering Procurement Company (EPC) company. Preventive visits are generally included several times per year.

Solar Panels

Solar panels are the main part of the solar PV system. The Operation and Maintenance of solar panels are very important. Operator has to check and maintain solar PV system by:

- Checking solar panels and replacing them in case they are broken.
- Weekly or monthly clean them up before checking...

Inverter

A single failure of a solar inverter can disconnect the whole solar PV system; therefore, periodic maintenance is critical to ensure its uninterrupted operation.

- Test inverter fans for proper operation
- Check insulation of cables to prevent inverter breakdown
- Check if the cooling dust is blocked, especially air intake and air outlet.
- Check the surrounding environment temperature. Generally, it should be below 40°C.
- If after checking the steps mentioned above, the overheating problem still has not been solved, then a technical engineer should be called to help.

Energy Management Steps

A step-by-step approach for investing in a solar photovoltaic system.

01. Feasibility stage

Understanding the factory needs, Contacting Solar PV Developers and/or Engineering Procurement Companies (EPC), Preliminary Offers.

1 – Understand the factory needs:
- Why solar PV? Savings? Backup? Sustainability?
- Is it the priority? Shall other things such as energy savings be considered first?
- Need financing?

2 – Initial contact with EPCs and Developers: Discuss with different providers to know the possibilities for solutions, costs, financing.

3 – Comparing Options: Compare different offers (Quality of Equipment, Design/Production Differences, After sales support, financial options).

4 – Decision: Capex vs Financing?
Selection of EPC, Developer?

02. Contractual Stage

Due diligence, discussion of terms and conditions.

1 – Due Diligence (Can the factory guarantee payments?)**:**
- Provide Audited Financial
- Legal Check (Company Registration)

2 – Negotiate Contract Terms:
- Review contract and clarify all terms
- Negotiate Terms
- Discuss all possible scenarios (factory moves, shuts down, wants to purchase the system, price of EDC drops)
- Understand the "Conditions Precedent" and Exit Options for both sides.

3 – Sign

03. Structural Assessment

Engaging civil works company for roof assessment and reinforcement.

1 – Structural Assessment:
- A 3rd Party (Civil Engineering) does a detailed assessment of the roof.
- Duration: 3-4 Weeks
- Deliverable: Detailed report, recommendations, estimated costs.

2 – Reinforcements:
- A 3rd Party (Civil Works company) performs any necessary reinforcement.
- Duration: from 2-4 Weeks to several months.
- If reinforcements are too important, factory can break the agreement and pay for the study.

04. Project Approval (EDC)

Project submission request letter and technical specification of design and components.
- Factory to submit request letter and technical specifications of design and components. Should not be a problem for factories to get approved, if design is done according to regulation.
- Duration: 1-2 Months

05. Installation and commissioning

- Selected EPC (by client or developer) manages this stage until the delivery of an operating and commissioned solar rooftop system.
- Both the developer (if any) and EDC will perform commissioning tests.
- There are no additional permit required unless significant renovation is included in the project.

06. Operation and maintenance

Solar PV systems require some maintenance, although minimal.
- Maintenance is included if project is financed by PPA.
- If the system was purchased, after sales support is an additional yearly expense.

This technical brief has been written considering the Cambodian regulation for solar PV in 2022. This regulation could change in the future. Before implementing a Solar PV Project, it is needed to be informed on the current regulation on EDC or AEC website.

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Developed by:
Geres

With the contributions of:

Geres, the Global Green Growth Institute (GGGI) and the Textile, Apparel, Footwear & Travel goods Association in Cambodia (TAFTAC) are implementing the project "Promotion of Sustainable Energy Practices in the Garment Sector in Cambodia".

The project aims at increasing competitiveness and decreasing environmental impact towards sustainable production in the Cambodian garment industry and focuses on understanding the key barriers that inhibit the growth of the garment sector and will identify the opportunities that can help in the sustainable growth of the garment sector in Cambodia.

This will be achieved by providing hand-holding support to Garment manufacturing units in the country to identify and adopt sustainable energy practices.

This technical brief was produced with the inputs and extensive review provided by Global Green Growth Institute (GGGI) and Textile Apparel, Footwear & Travel Goods Association in Cambodia (TAFTAC).

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