Technical Toolbox for Technical Measures for use in SPIN-constellations

Photovoltaic panels

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www.epcplus.org

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Content

1. General description and explanation how-to-use

EPC+ aims at standardizing technical measures in order to make them predictable for other SPIN members (including the SPIN coordinator) and thereby to reduce transaction costs.

The toolbox can serve as a guide for the providers of EPC+-services for the standardization of the measures (design parameters, calculation method, process flow) and defines quality standards for the M&V-method. Text-modules of the descriptions may also be used for the communication with the client in order to create trust into the proposed measures.

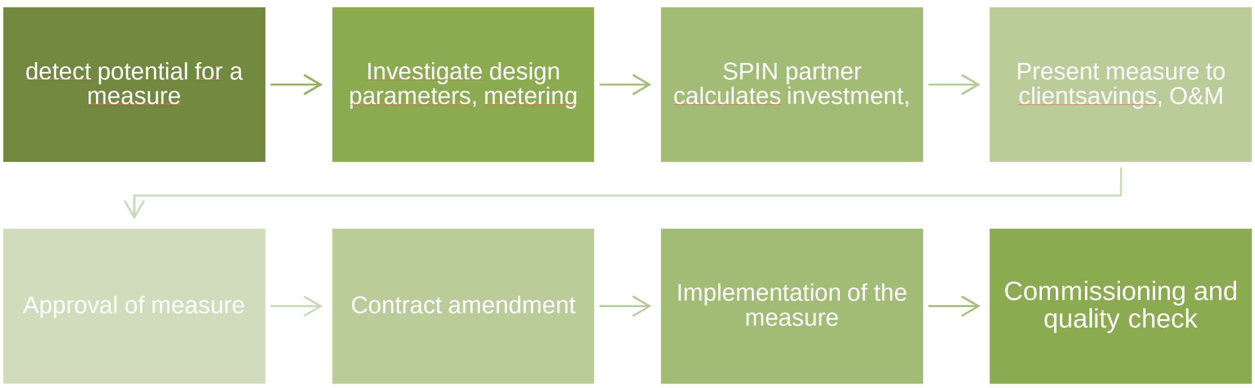
Each measure applicable for EPC+ is described on a general basis. Moreover the design parameters and the possibilities for application are defined, last but not least including a list of situations, where the specific measure is not applicable.

Calculation method

For the facilitation to introduce the measures for a SPIN the generic method of calculating effort for implementation, O&M and savings is described, ideally in form of a product-unspecific, open-source calculation tool.

Process flow

The generic process flow is identical for all measures. Therefore it is also part of the business model of EPC+, variations might be necessary for specific business cases, i.e. if measures interact with each other during their implementation or in their performance phase. See therefore also the interaction matrix of EPC measures, which serves as a quick indicator in which way measures might interact.



As a further development and because of the several players and interfaces in communication the process-flow-diagram is also visualized in the design of the ***service blueprint*** (see chapter 2.1.3)

1.1. Toolbox

All measures are being described in general and in detail. The measures are categorized in energy-efficiency and renewable energy measures.

Energy-efficiency-measures:

1. indoor lights: LED lights + control system
2. hydraulic adjustment of heating system
3. modernization of pumps
4. modernization of electrical motors
5. energy efficient ventilation and/or cooling
6. HVAC control systems, incl. integration of boilers
7. Programmers of BMS-systems of different suppliers: Siemens, Honeywell,...
8. Renovation/replacement of heating boilers

Renewable energy measures:

1. Solar DHW
2. Biomass heating systems
3. CHP
4. PV-panels
5. Wind-power
6. Heatpumps

2. PV-panels

2.1.1. Technical description

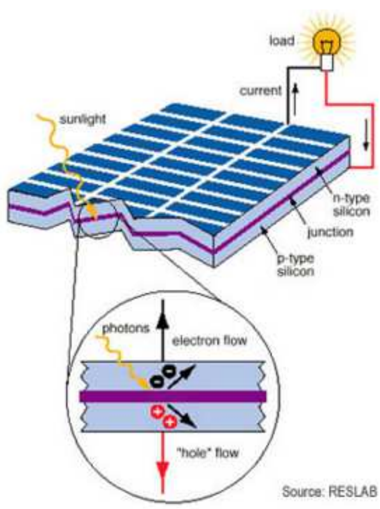
2.1.1.1. General description

Photovoltaic solar energy consists of the electricity production from solar radiation, being able to use electricity in the same place where it is generated (self-consumption) or it is injected into the grid. A typical example of use for self-consumption is at homes where the users prefer to consume their own energy (as Passive House or Nearly Zero Energy Buildings) or at small offices building. Sometimes the rate that is not consumed can be put into the grid, reducing energy costs by net balance formula or with the consequent economic retribution if any bonus exists. Finally, there is the option to sell all the electricity generated to the grid, what normally happens in medium and large installations on roofs or ground. If considering that the approach of EPC is energy consumption reduction we will consider <u>self consumption.</u>

N.B. In order for the installation of a solar photovoltaic system to be eligible as an EPC+ product**,** <u>it must be combined with an energy efficiency measure</u> as the main scope of an EPC+ product is energy saving, not energy supply. However, in order to simplify the monitoring and verification procedures, only the energy supply needs to be monitored and verified (see section 2.1.4).

- **The solar cell**

The basic element of a solar energy system is the generator, which is called the solar cell and converts photons into electricity directly from sunlight.



Thus, when solar radiation impact on the photovoltaic solar cell, an analogue voltage to the one produced at the terminals of a battery appears there. By placing metal contacts on each of the surfaces may be extracted electric power which is usable in different applications. A normal individual cell, with an area of about 75 cm^2 and enlightened enough can produce a voltage of 0.4 V and a power of 1W.

- **Materials**

Different materials of solar photovoltaic modules are used mono or polycrystalline silicon, amorphous silicon, gallium, cooper etc; recommendations to use mono-crystalline silicon because the energy efficiency of 15-17% and higher durability than other materials.

- **Components**

The main components of a PV system are:

- Photovoltaic Panel: consists of several equal silicon cells electrically connected together in series and parallel, so that the voltage and current supplied by the panel is increased to match the desired value.
- Inverter: converts the direct current generated by the panels into alternating current for discharge to the grid or consumption of household equipment that operate on alternating current. An inverter is characterized mainly by the input voltage, which must adapt to the generator and the maximum power it can provide.
- Support structure: provides subject to the panels and provides good anchorage making them resistant to the action of atmospheric elements, as well as guidance and a suitable angle for the best use of solar radiation inclination.
- Electrical system: is composed of the wiring protection elements, transformer, meter, etc.

- **Self-consumption without injection to the grid**

This approach allows consumers to produce as much electricity they use in their homes or businesses and consume directly. The main advantage of this type of consumption is saving as producing some of the consumed energy; consumer electricity bills can be significantly reduced. Also the advantage that it need not increase the contracted power, as it is own energy.

- **Self-consumption by net balance**

Allow users to manage their own electricity system through an exchange of energy with an electrical company. In this type of consumption, users can offset the energy demand of the grid with the energy fed into the grid at a different time in which the energy generated by the PV system has not been consumed. So a balance is settled in periods of production and consumption in the established billing.

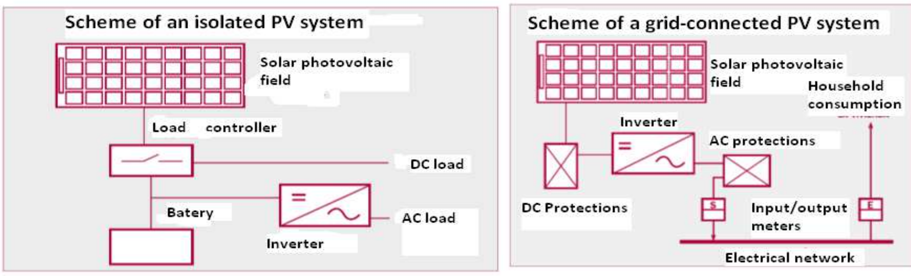


Figure 1. Solar photovoltaic installations.

- **What are the applications of solar photovoltaic panels on SMEs and how this energy benefits to these companies?**

PV systems usually cover only part of the energy consumption which can vary from 2% to 20%, but no more. This is due to the need to have sufficient surface area to install solar panels. A panel generates between 150 and 220 Wp, so a 50 kWp facility needs about 250 panels. Whereas each Wp generated by 5 collectors need 20 m^2 (considering that there are shadows and usefulness surfaces), this facility would occupy 1,000 m^2.

- **What additional non-energy benefits can be achieved?**

The first is that this energy is generated locally, so energy dependence on an external supplier is reduced. This model assumes the consumer shift from centralized to distributed energy generation where electricity is produced in many small plants located close to where it is consumed. Touring the electricity shorter distances, energy losses of the grid are avoided.

Also the improvement to control the cost of energy consumption because it would not be dependent on price fluctuations in the electricity market. However, it has to be considered that there will be variations in generation throughout the year due to the varying radiation.

2.1.1.2. Main design conditions

- **Main aspects related to the photovoltaic modules, which will affect the generation of electricity:**

- Solar potential in the area in which the SME is located: can be obtained by in situ measurements or go to the databases of radiation, if any.
- Features of the location where to install the collectors, on deck or ground: orientation and inclination possibilities of areas designed to accommodate the installation, type or land cover types of anchors.
- State of the mounting surface collectors: conservation area, potential shadows of nearby buildings or other obstacles may occur.
- Type photovoltaic technologies available in the market, its productivity against the cost of investment and performance in the town where you are installing: power installed capacity, annual production, profitability and environmental impact.

- **Variables of the monitoring system**

It requires the installation of a monitoring system that measures ratios at least of the following variables:

- Voltage and DC current at the inverter input
- Voltage, current, total power and total energy output of the inverter.
- It may be interesting to know the reactive power output of the inverter for medium to large installations, for example from 5 kWp.
- Solar radiation in the plane of the modules, measured with a cell module or equivalent technology.
- Ambient temperature in the shade.
- Temperature of the modules in case of architectural integration.

- **Architectural integration**

The architectural integration is the “insertion "of the photovoltaic system in the building, so that the system is efficient in his generation and at the same time, architecturally attractive.

2.1.1.3. Components and materials

General issues

- All installations must fulfil the requirements of protection and safety of people, and among them those provided in the regulations for low voltage (in Spain, the Low Voltage Electrotechnical Regulations or subsequent legislation).
- Ensure a sufficient degree of electrical insulation (Class I) for equipment and materials.
- All necessary safety elements will be included to protect people against direct and indirect contacts, especially in systems with operating voltages above 50 VRMS or 120 VDC. The use of equipment and electrical insulation materials of class II is recommended.
- All necessary measures to protect the installation against short circuits, overload and overvoltage will be included.
- The materials placed outdoors will be protected against environmental agents.
- Electronic equipment of the installation shall comply with EU Electrical Safety directives and Electromagnetic Compatibility (both may be certified by the manufacturer).
- For of safety and operation of equipment reasons, the indicators, labels, etc. shall be in the national language of the place where the facility is located.

Photovoltaic generators

- All photovoltaic modules must meet the IEC 61215 specifications for crystalline silicon modules, IEC 61646 for thin photovoltaic modules or IEC 62108 for concentration modules, as well as specification IEC 61730-1 and 2 about safety in PV modules. This requirement will be justified by presenting the relevant official certificate issued by an accredited laboratory.
- The module will carry clearly visible the model, name or logo of the manufacturer, the serial number and date of manufacture, enabling individual identification.
- In all cases the existing national mandatory rules for photovoltaic modules have to be complied.

Support structure

- Necessary support structures will be provided to mount the modules and all the accessories that may be required will be included. The support structure and fixing system of the modules will allow thermal expansion needed without transmitting loads that can affect the integrity of the modules, following the manufacturer's standards.
- The modules support structure has to resist, with modules installed, the wind and snow overloads.
- The design of the structure will be done for the orientation and angle specified for the PV generator, considering the ease of assembly and disassembly, and the possible need for replacements of elements.
- The stops clamping modules, and the structure itself, will not throw shadow on the modules.
- In case of integrated indoor facilities, being sometimes the roof of the building, the design of the structure and the seal between modules will fit the usual technical demands on building roofs.

Inverters

- The technical requirements of this section apply to single-phase or three-phase inverters that operate as a source of fixed voltage (value of the fixed voltage and frequency output).
- Inverters are pure sine wave. The use of sine wave inverters will be allowed when their rated power is less than 1 kVA and not cause damage to loads ensuring proper operation.
- Inverters will be connected to the output of the charge controller consumption or battery terminals. In the latter case the accumulator protection against overload and over discharge will be ensured. These protections may be incorporated in the inverter itself or be carried out with a charge controller, in which case the regulator should allow brief dips in the accumulator to ensure startup investor.
- The inverter must ensure proper operation throughout the input voltage range allowed by the system.
- Inverter regulation must ensure that the voltage and frequency output are in the following ranges , in all operating conditions:

$$V_{NOM} \pm 5\ \%, \text{ being } V_{NOM} = 220\ V_{RMS} \text{ o } 230\ V_{RMS}$$

$$f = 50\ Hz \pm 2\%$$

- The inverter will be able to deliver the rated power on a continuous basis, in the range of ambient temperature specified by the manufacturer.
- The inverter should start and operate all loads specified in the installation, especially those requiring high starting currents (TV, motors, etc.), without interfering with their proper operation or other charges.
  - Inverters will be protected against the following situations: Input voltage out of operating margin. Disconnect the battery.
  - Overloading exceeding the duration and limits.
- The no-load consumption of the inverter is connected less than or equal to 2% of the rated output power.
- Daily energy losses caused by the consumption of the inverter will be less than 5% of the daily energy consumption. It is recommended that the inverter has a system of "stand - by" to reduce these losses when the inverter is idling (no load).

- The performance of the inverter will exceed the limits specified in the table below.

Type of inverter		*Yield 20% of the nominal power*	*Yield at nominal power*
Sine wave (*)	$P_{NOM} \leq$ 500 VA	>85%	>75%
	P_{NOM} >500 VA	>90%	>85%
Non sine wave		>90%	>85%

(*) It shall be considered that inverters are sine wave if the total output voltage harmonic distortion is less than 5 % when the inverter feeds linear loads, from 20 % to 100 % of rated power.

Protections and grounding

- All installations with nominal voltages above 48 volts will have a grounding to be connected to at least the generator supporting structure and the metal frames of the modules.
- The protection system will ensure the protection of people against direct and indirect contacts. If there is a previous installation, the security conditions will not be altered.
- The facility will be protected against short circuit, overload and overvoltage.

2.1.1.4. Measure suitable for

- There is sufficient available and suitable space for the installation of the panels and equipment necessary for the operation of the PV installation.
- The cost of conventional electricity is relatively high or renewable electricity production has bonuses or incentives.
- In case of consumption, the load of industry production or use of the building is equal to or greater than 5 days / week.

2.1.1.5. Measure not suitable for

- No availability of roof to install solar panels.
- There is no facility for connection to the grid (except for self consumption non-networked).
- The cost of electricity is relatively cheap.
- The load of industry production or use of the building is less than 5 days / week.

2.1.1.6. Maintenance and guarantees

Contract maintenance (preventive and corrective) for least three years will be made. Preventive maintenance will involve at least an annual review. The maintenance contract includes the installation of the maintenance of all the elements of the installation recommended by the manufacturers. The guarantees of the main equipment and installation will be in line with current legislation. It will analyze the existing warranty extensions.

2.1.2. Calculation method

- Excel-based tool developed within the scope of the project provided in the zip-file
- The used tool of JRC http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?lang=en&map=europe

Other tools also for calculation of PV

- Polysun online calculator http://www.polysunonline.com/PsoPublic/app/home/access
- Solarius PV http://www.accasoftware.com/
- System Advisor Model https://sam.nrel.gov/

The calculation could be based on a photovoltaic power plant to be located on the deck of an industrial warehouse. The web tool used of the JRC and the Excel spreadsheet allow the consideration of options anywhere in the UE. Photovoltaic panels will be placed to self-supply the electricity needs of an SME. As input data to study SME consider the following:

Number of employees
Electricity consumption
Available area for PV
Suggested area for PV (south)
Electricity price
Annual cost of electricity

The maximum available area considered for this case is only that which is facing south.

A photovoltaic panel of polycrystalline silicon of 210 Wp is selected, which has a price of 231 € per unit.

Three possible systems can be analyzed: total sale to grid, self consumption and net balance and this tool considers self consumption.

2.1.2.1. Expected PV production

- **Energy production**

The case studied is the installation of 1,500 solar panels of 210 Wp each, having a 315 kWp photovoltaic system. With this information and other panel data (location, orientation, inclination, losses, etc.) and through the PV -GIS tool (http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?lang= en & map = Europe), the annual power generation that produces photovoltaic system installed is obtained. Once the necessary data is introduced, PV -GIS calculates the energy produced by the photovoltaic generator, which in the example is 487.8 MWh.

- **Incomes / Economic benefits**

	Dimension	Amount, formula or reference
Incomes / Economic benefit	*[€/year]*	• Self consumption -> PV -GIS calculation x purchase price of electricity by the company • 487.800 kWh/y x 0,13 €/kWh = 63.414 €/y
Energy Production	*[kWh/year]*	PV -GIS calculation=488.000

The selling price of photovoltaic electricity has been considered of 0.20 € / kWh (with bonus) and the purchase price of electricity by the company of 0.13 € / kWh (excluding VAT).

2.1.2.2. Investment costs

- Material costs
  - Solar panels: 346.500 €
  - Inverters: 95.760 €
  - Wiring and protections: 13.500 €
  - Structures: 82.000 €
- Civil works cost: 3.000 €
- Design, engineering and installation costs
  - Design, engineering and installation: 43.261 €

Total investment: 584.021 €

2.1.2.3. Running costs and maintenance

- Quality control and performance test immediately after implementation.

Mandatory output parameter:

- *Cost (€/year): 4.000 €/year*

2.1.2.4. Expected life-span of the measure and resulting replacement-costs (if any)

The estimated lifespan is 30 years, so there are no replacement costs affecting the installation.

2.1.2.5. Profitability analysis of the investment

Calculation of the payback period and net present value of the investment is done with the tool elaborated by Escan that is available http://epcplus.org/energy-service-packages/

The following parameters have been considered:

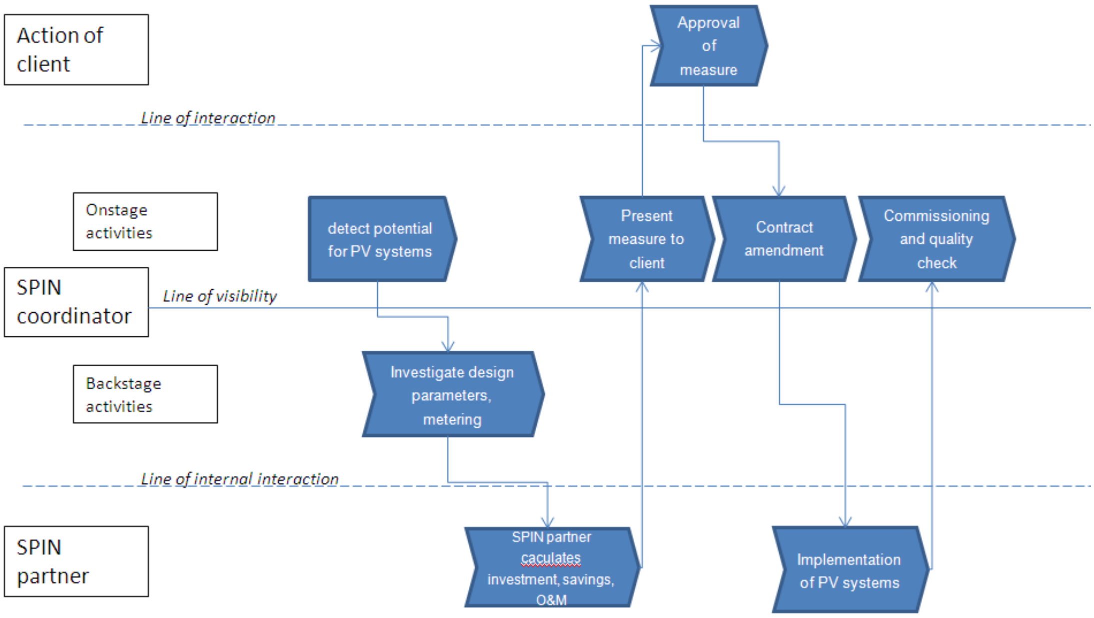
- Investment (€): 584.021 €
- Rate tax: 2%
- Savings in the first year(€/year):

	Self consumption
NPV (20 years) (€)	721.561
Payback (years)	9,2
ROI (%)	5,86

In order to elaborate a discounted cash flow analysis, amortization rate and net present value of the investment, the following tools elaborated within the context of the project can also be used:

- http://epcplus.org/energy-service-packages/

2.1.3. Process flow implementation: including quality assurance measures during and after implementation



2.1.4. Options on measurement & verification in order to evaluate the performance in relation to the given performance guarantee1

A metering plan is required for measurement & verification. The energy consumption before and after the PV systems is operating in the unit of KWh are necessary.

The data of electricity of one year before the installation is obtained with the electricity invoices; these can be monthly or bimonthly. During one year after the installation of the PV system record of the electricity data will be achieved with the meter that will be placed after the PV system. This data is the electricity produced in PV panels that is consumed by the SME.

Frequency of the measure could be every 2 years.

The performance should be according to the designed PV system and payback.

[1] Criteria: minimum effort, but still a proper qualitative proof for solid implementation and a considering performance, not installation only