IEA INTERNATIONAL ENERGY AGENCY

A METHODOLOGY FOR THE ANALYSIS OF PV SELF-CONSUMPTION POLICIES

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Gaëtan Masson – IEA PVPS

Jose Ignacio Briano & Maria Jesus Baez - CREARA

Report IEA-PVPS T1-28:2016

COVER IMAGE
The Red Oak Park a neighborhood in Boulder
CO features renewable energy design
©Dennis Schroeder / NREL

WHAT IS THE IEA PVPS?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organisation for Economic Cooperation and Development (OECD). The IEA carries out a comprehensive programme of energy cooperation among its 29 members and with the participation of the European Commission. The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the collaborative research and development agreements within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems."

In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct "Tasks", that may be research projects or activity areas. This report has been prepared under Task 1, which facilitates the exchange and dissemination of information arising from the overall IEA PVPS Programme. The participating countries are Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Thailand, Turkey and the United States of America. The European Commission, Solar Power Europe (former EPIA), the Solar Electric Power Association, the Solar Energy Industries Association and the Copper Alliance are also members.

ISBN 978-3-906042-33-6

IEA PVPS TASK 1

A METHODOLOGY FOR THE ANALYSIS OF PV SELF-CONSUMPTION POLICIES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES


A residential home retrofitted with photovoltaic (PV) panels in Lakewood, CO/ NREL

1

1 INTRODUCTION TO SELF-CONSUMPTION ANALYSIS

This report aims at providing a comparative analysis of existing mechanisms supporting the self-consumption of electricity in key countries all over the world and to highlight the challenges and opportunities associated to their developments.

Mechanisms promoting self-consumption of PV electricity are based on the idea that PV electricity will be used first for local consumption and that all this electricity should not be injected into the grid. The part of the bill that can be compensated depends on several options that are used vary, depending on countries or regions, as we will see below.

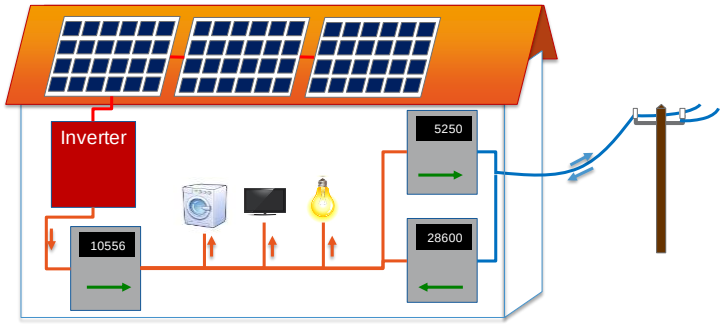
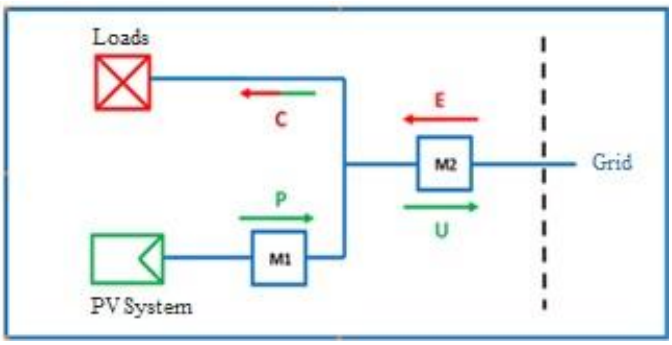


Figure 1. Example of self-consumption energy flows

We will refer to this mechanism of energy consumption in real-time (or per 15 minutes) as a "self-consumption scheme". An incentive scheme that allows compensating production and consumption during a larger timeframe (up to one year or more) is called "net-metering scheme". In case, where the compensation can be calculated on a cash-flow basis, rather than an energy basis, we will refer to it as a "net-billing scheme". Hence, some hybrid programmes exist between these two main schemes.

One of the heated debates in the market is about to identify whether compensation can apply not only to the procurement price of electricity but also to grid costs and taxes. This paper provides detailed explanation on how to classify these schemes and what their characteristics are.



The aim of this document is to define the range of existing business models that can support PV self-consumption, highlighting the difference between categories and their impacts on profitability from various perspectives.

Figure 2. Example of self-consumption metering

PROSUMERS

The neologism "prosumer" refers to an electricity consumer producing electricity to support his/her own consumption (and possibly for injection into the grid). The word is built based on the association of "producer" and "consumer" and it is used widely nowadays. In this document, the concept of "prosumer" will be used in parallel with "PV system owner" to qualify the same thing.

SELF-CONSUMPTION AND SELF-SUFFICIENCY

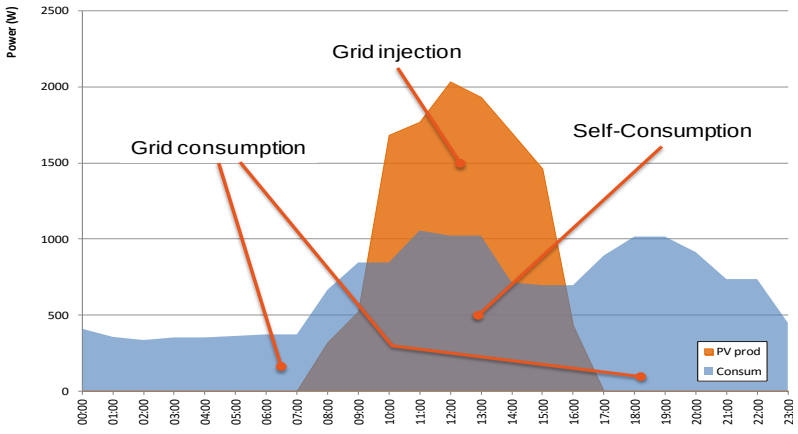


Figure 3. Comparison of production and consumption profiles

Self-consumption should not be confused with self-sufficiency. The ratio of self-consumption describes the local (or remote under some schemes) use of PV electricity while the self-sufficiency ratio describes how PV production can cover the needs of the place where it is installed. These concepts are completely different but both play important roles in the debate on the development of prosumers.

The chapter on the economy of self-consumption will go into details about current main constraints linked to the production of PV electricity for local use. Hence, in this study, the self-sufficiency ratio will not be the focus since it has little to do with this issue.

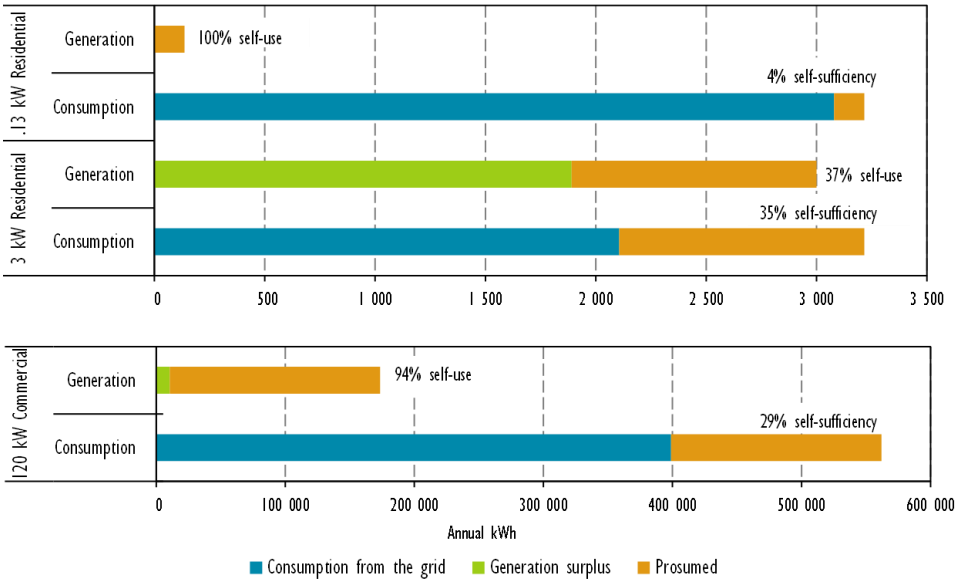


Figure 4. Self-consumption and self-sufficiency (source: IEA)


A 7.2 kW PV system on the roof offsets some of the power of the Cambria Office Building / NREL

2

2 CATEGORIES OF SELF-CONSUMPTION SCHEMES

Self-consumption can be described as the local use of PV electricity in order to reduce the buying of electricity from other producers. In practice, self-consumption ratios can vary from a few percent to a theoretical maximum of 100%, depending on the PV system size and the local load profile.

Onsite Self-Consumption	Right to self-consume	• Self-consumption is legally permitted
	Revenues for self-consumed PV electricity	• Savings on the variable price of electricity from the grid
	Charges to finance T&D costs	• Additional costs associated to self-consumption such as fees or taxes may exist
Excess PV Electricity	Value of excess electricity	• Net metering: energetic compensation (credit in kWh) • Net billing: monetary compensation (credit in monetary unit)
	Maximum timeframe for compensation	• Self-consumption: real time (e.g 15 minutes) • Net metering and net billing: time frame is typically one year although there are some exceptions (from credits that can be rolled over to the following billing cycle to quarterly compensation)

Key:
- Same between shemes
- Main differences

Table 1. Self-consumption's main characteristics

Given the diversity of policies allowing for self-consumption that are being implemented worldwide, in order to classify all self-consumption schemes, several parameters have been chosen, covering all aspects of self-consuming PV electricity. These parameters aim at categorizing all kinds of policies supporting self-consumption and to clarify the wording used in several countries, especially net-metering and net-billing schemes. The table below provides detailed information about parameters and gives a comparison of existing schemes in various countries.

PV Self-consumption	**1**	Right to self-consume
	2	Revenues from self-consumed PV
	3	Charges to finance T&D
Excess PV electricity	**4**	Revenues from excess electricity
	5	Maximum timeframe for compensation
	6	Geographical compensation
Other system characteristics	**7**	Regulatory scheme duration
	8	Third party ownership accepted
	9	Grid codes and additional taxes/fees
	10	Other enablers of self-consumption
	11	PV System Size Limitations
	12	Electricity System Limitations
	13	Additional features

Table 2. Main parameters defining a self-consumption scheme

1 - Right to self-consume

This parameters identifies whether the electricity consumer has the legal right to connect a PV system to the grid and self-consume a part of its PV-generated electricity.

2 - Revenues from self-consumed PV electricity

This parameter is based on the source of revenue from each kWh of self-consumed PV electricity. It comprises not only the savings on the electricity bill but also possible additional revenues such as a self-consumption bonus/premium or green certificates.

3 - Charges to finance grid (Distribution and Transmission) costs

This parameter indicates whether the PV system owner has to pay part of the total grid costs on the self-consumed electricity.

4 - Value of excess electricity

This parameter explains which compensation PV system owner will receive when PV electricity is injected into the grid. Examples include:

- The same value as the retail electricity price or a value based on the retail electricity price but reduced through specific fees or taxes. This is the precise definition of “net-metering” with or without additional fees or taxes. Technically, this is often described as an allowance of credits that can be used during a predefined period of time to reduce the electricity bill of the PV system owner.

- Payment through traditional support schemes such as feed-in tariff (FiT) or green certificates (GC): PV electricity gets a value defined by regulation.
- Wholesale market price through some regulated or market tariff: PV gets the price of electricity when it is injected (or an average value).
- No value (it is lost).

5 - Maximum timeframe for credit compensation

This parameter refers to schemes that allow credits for all electricity injected. Such credits can in general be used during a certain period of time during which compensation is permitted. (e.g., real-time/15 minutes, credits during: a day, a month, a year, or indefinitely).

6 - Geographical compensation

This parameter indicates whether consumption and generation can be compensated in different locations. (e.g. "Virtual net-Metering", "Meter Aggregation", and "Peer to Peer").

7 – Regulatory scheme duration

This parameter, if available, indicates the duration of the compensation scheme in term of years.

8 - Third-party ownership

This parameter indicates whether policies are permitting a third-party to own the generation asset when a self-consumption scheme is in place (e.g., through structures such as leases and PPAs).

9 - Grid codes and additional taxes/fees of self-consumption

This parameter describes which additional costs have to be borne by PV system owners

- Undifferentiated costs (e.g. self-consumption fee)
- Specific costs (e.g. balancing costs, back-up costs…)

and which specific grid codes can be asked specifically to prosumers (e.g. grid code requirements such as phase balancing, frequency-based power reduction, reactive power control, voltage dips, inverter reconnection conditions, output power control, among others).

10 - Other enablers of self-consumption

Are there other additional supports to self-consumption such as a storage bonus, demand side management, or electricity rates with TOU/tiers?

11 – System Size Limitations

This parameter states which segments are considered by the compensation scheme and if applicable which capacity limit is applied (kW - MW). For instance, self-consumption can be allowed in the range of 5 to 250 kW only.

12 – Electricity System Limitations

This parameter explains whether the regulator has foreseen a maximum penetration of PV above which the self-consumption regulation does not apply anymore. For instance: above 2% of the electricity demand or above 10% of the minimum peak load.

13 – Additional characteristics

This last parameter includes all other elements not considered above. For example, rules for aggregation of renewable energy sources would be described here in case they are required when selling PV electricity on electricity market.

The above parameters will be used in the following sections to analyse the current situation in key markets and to define the most common range of self-consumption incentives.

AN EXAMPLE - SPAIN (IEA PVPS)

- Self-consumption is allowed in Spain.
- The size of the PV plant cannot exceed the maximum power contracted.
- Two different regulations exists depending on the system size:
- Type 1: under 100 kW, self-consumption is allowed but the prosumer receives no compensation for the excess PV electricity injected into the grid.
- Type 2: Above 100 kW without limitation, self-consumption is allowed and the excess PV electricity can be sold on the wholesale market directly or through an intermediary. A specific grid tax of 0.5 EUR/MWh has to be paid together with a 7% tax on the electricity produced.
- All systems used for self-consumption above 10 kW are charged with a fee per KWh consumed. It is justified as a "grid backup toll" and is known as the so-called "Sun tax".
- At least two meters have to be installed, depending of the cases (LV or HV connection).
- Adding battery storage implies also an additional tax.
- Geographical compensation is not allowed, and self-consumption for several end customers or a community is not allowed.

			Spain	
			Below 100 kW	**Above 100 kW**
PV Self-Consumption	**1**	Right to Self-Consume	Yes	Yes
	2	Revenues from Self-Consumed PV	Savings on the electricity bill	Savings on the electricity bill
	3	Charges to Finance T&D	Yes ("solar tax")	Yes ("solar tax")
Excess PV Electricity	**4**	Revenues from excess electricity	None	Wholesale market price minus taxes
	5	Maximum timeframe for compensation	Real-time	Real-time
	6	Geographical compensation	None	None
Other system characteristics	**7**	Regulatory scheme duration	Unlimited	Unlimited
	8	Third party ownership accepted	None	Yes
	9	Grid codes and additional taxes/fees	Above 10 kW (*)	Yes (*)
	10	Other enablers of self-consumption	None	None
	11	PV system size limitation	100 kW but below or equal to capacity contracted	Below or equal to the capacity contracted
	12	Electricity system limitations	Distributor´s License	Distributor´s License
	13	Additional features	Taxes on batteries	Taxes on batteries

(*) except the Canary Islands, Baleares Islands, Ceuta and Melilla

Table 3. Spain's self-consumption schemes

This furniture factory in Gardner, Massachusetts incorporates PV panels into its design/ NREL

ANNEX

TERMINOLOGY EMPLOYED

The present document uses on the following definitions[1]:

- Feed-in tariff: an explicit monetary reward is provided for producing PV electricity; paid (usually by the electricity utility business) at a rate per kWh that may be higher or lower than the retail electricity rates being paid by the customer
- Bill savings: the difference between the value of an electricity bill without a PV system for self-consumption and with it.
- Avoided costs: costs that should be borne by consumers or utilities in the absence of self-consumption.
- Net load: the difference between electricity demand from the grid without PV self-consumption (gross load) and with it.
- Real-time compensation: compensation between PV generation and electricity consumption at the exact same time, or in some cases, by 15 minutes.
- Virtual net-Metering: a characteristic of a net-metering scheme that allows the distribution of credits across more than one meter (e.g. in multi-tenant properties).
- Meter Aggregation: a characteristic of a net-metering scheme that allows a particular self-consumer with multiple meters to elect whether to use the credits associated to the excess electricity in locations other than the generating unit.
- Peer to Peer: a characteristic of a net-metering scheme that allows a prosumer to transfer credits to other electricity consumers.

[1] Source: IEA PVPS, Solar Power Europe.

- Third-party ownership: financing arrangement that allows a self-consumer to host a PV system that is owned by a separate investor, who can take advantage for instance of available incentives, such as tax credits and depreciation deductions.
- Electricity market: market place where electricity is traded and where wholesale electricity prices are formed.
- DSO/TSO: Distribution Grid System Operator (also referred to in some countries as DNO) in charge of managing the low and often medium voltage grids. Transmission Grid System Operator (or TNO) in charge of the high voltage grid and in some rare cases a part of the medium voltage one. TSO's are responsible for organizing the balancing of demand and supply of electricity.

ACKNOWLEDGEMENT

This report is a summary of a larger report from the IEA-PVPS puiblished under the name “Review and Analysis of PV Self-Consumption Policies”. It has been written thanks to the information provided by IEA PVPS Task 1 participants. Additional information has been provided by Becquerel Institute and CREARA. This report has been prepared under the supervision of Task 1 by Gaëtan Masson and CREARA experts, in particular Jose Ignacio Briano and Maria Jesus Baez. This report has received the support from the Copper Alliance. The report authors gratefully acknowledge the editorial assistance received from a number of their Task 1 colleagues, Mary Brunisholz IEA PVPS and NET Ltd., and Ngo Thi Mai Nhan, Becquerel Institute.

ISBN 9783906042336