EXISTING AND FUTURE PV PROSUMER CONCEPTS

D2.1

Autors:

TECHNISCHE UNIVERSITAET WIEN: Georg Lettner, Hans Auer, Andreas Fleischhacker, Daniel Schwabeneder, Bettina Dallinger & Fabian Moisl.

FUNDACION TECNALIA RESEARCH & INNOVATION: Eduardo Roman, Daniela Velte & Ana Huidobro

With the collaboration of the “PVP4Grid” consortium

Vienna, May 2018

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 764786

Index

About PVProsumers4Grid

Europe´s electricity sector is in the midst of major transformation moving from public monopolies into competitive private companies in liberalized markets. The liberalization of the market is expected to deliver more competitive and therefore more efficient and cheaper energy. Due to its cost and growth perspective, photovoltaics (PV) will be a key driver of this development throughout Europe because PV has reached a level of competitiveness that allows moving to self-consumption schemes in many European countries and eventually to peer-to-peer selling of the self-produced energy.

Such a “prosumption” role empowers consumers to participate actively in the electricity market by producing energy themselves. Technical developments such as battery systems or smart meters, and advanced business models promoting self-consumption change the technical design of the electricity systems. The success of these developments depends, however, on the regulatory and administrative framework in terms of energy policy and regulation, grid financing, taxation and legal relationships amongst the involved entities and it requires innovative solutions coupled with suitable business and management models to achieve sustainable system integration.

PV-Prosumers4Grid (PVP4Grid) is an EU-funded project coordinated by BSW-Solar, involving 11 partners from various European countries[1] and running from October 2017 until March 2020. The main objectives of PVP4Grid are to increase the market share and market value of PV by enabling consumers to become PV prosumers in a system-friendly manner, as well as a better power system integration of PV with a focus on market integration. New management and business models to combine PV, storage, flexible demand and other technologies into a commercially viable product, will be assessed, improved, implemented and evaluated.

To achieve this, detailed guidelines for Prosumers and Distributed System Operators (DSO´s), as well as policy recommendations for national and European policy makers on how to achieve the suitable regulatory framework for prosumption, will be developed. Additionally, an online tool to help prosumers to get an economic assessment of PV prosumer projects will be created, among other relevant outcomes.

Please visit www.pvp4grid.eu to learn more about the PVP4Grid project, incl. the outcomes, tools & events.

[1] See project partners and project outcomes on the website: www.pvp4grid.eu.

Executive Summary

The first chapter of this deliverable provides an introduction into different PV prosumer concepts. To start out with, some definitions of terminologies are provided in order to develop a common understanding of self-consumption (private local ["on-site"] self-consumption, collective self-consumption, virtual self-consumption), PV-Prosumer, and different PV prosumer concepts. This is very important because a widespread and generally accepted definition of a PV prosumer has not yet been established. Most definitions focus on private local self-consumption. Collective or virtual self-consumption as well as self-consumption via sector coupling is usually not addressed. PV prosumer concepts are holistic descriptions of specific use cases of PV technology. They are based on possible/feasible business models for PV prosumers and are extended with necessary technical components, connected systems and organizational structure as well as the associated legal framework.

The second chapter will elaborate on the identification of the European PV prosumer potential. First, a classification of PV implementation according to PV size classes is conducted in the target countries of this project 'PVP4GRID' (Austria, Belgium, France, Germany, Italy, Portugal, Spain and the Netherlands), also giving a first indication of the preferred customer segment of PV implementation so far. Following that, a detailed allocation of different customer groups to the different PV prosumer concepts (having been defined in chapter 1) will be conducted, and examples will be presented for the Austrian and Spanish cases in detail. Similarities and differences in terms of PV prosumer concept potentials in these two countries will be discussed, and references sill be made to the different PV policies in these two countries over the last decade.

The third chapter is devoted to the identification and analysis of the PVP4DGRID prosumer concepts in the 8 EU target countries and, additionally, in the U.S., Australia and various other EU countries, representing the majority of the EU population. For each country, we present an overview of the concepts considered for the three PVP groups (use of storage, DSM option, sector coupling, etc.).

One of the most important conclusions is that individual self-consumption is allowed and feasible in almost 100% of the countries analyzed. Conversely, collective self-consumption, regardless of scale (individual building – residential, commercial and – at larger scale – in districts / building groups), is currently not feasible in most countries. Although PVP concepts that use the public grid to sell excess PV electricity to third parties are legally allowed, such schemes are hardly ever operational in real life, due to economic, administrative and regulatory barriers. There are exceptions, like multi-apartment buildings in Austria, collective schemes in France, or "Mieterstrommodelle" that is to say, the neighbor solar supply model in Germany. Other conclusions that can be derived from the analysis, include the following

- Very frequently, PVP concepts are applied to small-scale PV plants (with a maximum of hundreds of kW, limited by the power capacity of the electricity consumer). This would mean a clear opportunity for decentralized generation.
- Battery storage is promoted in most of the countries through financial support, tax exemptions and other measures. It can be used to increase self-consumption levels and reduce the power capacity contracted by the consumers.
- Virtual models (metering, demand aggregation) are more developed outside Europe (e.g. AU, U.S.). These virtual schemes have been excluded from the definition of the PVP4Grid concepts, but they are likely to represent a great opportunity for future electricity markets in Europe.

1 Definitions and methodology

1.1 Self-consumption

Self-consumption is defined hereafter as the use of PV electricity aimed at reducing the purchase of electricity from other producers. One can distinguish between:

- **Private local (on-site) self-consumption,** where only one actor aims to consume PV electricity in one place,
- **Collective self-consumption,** where a group of actors consumes electricity from a shared PV system,
- **Virtual self-consumption,** where generation and consumption of PV happens at the same time but in differing locations.

The IEA-PVPS, published in 2016, is a compact methodology used to compare self-consumption and similar schemes with a set of parameters (IEA, 2016). This methodology is based on the idea that all schemes for prosumers that differ from simple feed-in tariff schemes contain similar elements. In this sense, all prosumption[2] schemes can be split into consumption elements associated with an excess electricity element. This classification can be used for all aspects of prosumption but is stretched to its limits when the compensation for consumption and production takes place in different locations, at least partially. For instance, charging an electric vehicle outside the production site might be possible through

---

[2] Prosumption of decentralized sources and related electricity generation can be defined as the ability for an electricity consumer to produce part or the totality of his/her electricity consumption. Prosumption is distinguished between averaged prosumption from an economic point of view (with time intervals of 15 minutes or up to one hour – depending on metering systems) and instantaneous prosumption from a technical point of view. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0767.

ad hoc regulations and grid agreements, but would also contribute partially to revenues. In such a case, we would consider that all prosumption schemes are based on physical reality: electricity injected into the grid might be remunerated as "virtual self-consumption" but will be considered as revenue for the excess electricity. The six key parameters of the IEA-PVPS classification can be described as follows:

PV self-consumption	1	Right to self-consume
	2	Revenues from self-consumed PV behind the meter
	3	Charges to finance T&D (transmission and distribution grid) impairing self-consumption savings
Excess PV electricity	4	Revenues from excess electricity
	5	Maximum timeframe for compensation
	6	Geographical compensation

1 - Right to self-consume

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

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 both the savings on the electricity bill and possible additional revenues such as a self-consumption bonus/premium or green certificates.[3]

3 - Charges to finance grid (distribution and transmission) costs

This parameter indicates whether or not 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 indicates the compensation the PV system owner will receive when PV electricity is injected into the grid. This compensation can be awarded as:

- 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

[3] On the other hand, the possibility also exists that additional charges on self-consumed PV have to be paid. This results in 'negative revenues' (i.e. cost), which have to be considered (see e.g. the Austrian case in Chapter 3, where the corresponding charge is explained for annual PV self-consumption above 25,000 kWh/yr).

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); in this case the PV electricity is given a value defined by regulation.
- Wholesale market price through some regulated or market tariff; in this case the solar power is given the price of electricity when it is fed in (or an average value).
- No value (it is lost).
- Remuneration from sales to other consumers or from distant consumption of electricity by the same customer.

5 - Maximum timeframe for credit compensation

This parameter refers to schemes that allow credits for all electricity fed in. 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, for instance, a day, a month, a year, or indefinitely). Traditional self-consumption can be considered as real-time or sometimes within 15-minute increments. Net-metering usually expands toward the complete year (sometimes less in some countries).

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”). We will consider that in this case: the distant consumption generates revenue for the excess electricity. Other parameters might be considered to clearly define the characteristics of the self-consumption scheme. These parameters have been defined in detailed in the IEA-PVPS study (IEA, 2016) and will not be explained here in detail.

1.2 PV prosumer

1.2.1 General remarks

A widespread and generally accepted definition of a prosumer has not yet been established. Most definitions have tended to focus on private local self-consumption. Collective or virtual self-consumption, as well as self-consumption via sector coupling have thus far not been addressed.

1.2.2 Existing definitions

The neologism “prosumer” refers to an electricity consumer producing electricity for his/her own consumption (and possibly for feed-in into the grid). The word is derived from a combination of “producer” and “consumer”. The Renewable Energy Directive [MDI Directive][4] gives the following definition:

“‘Renewable self-consumer’ means an active customer or a group of customers acting together as defined in Directive [MDI Directive] who consume and may store and sell renewable electricity which is generated within their premises, including a multi-apartment block, residential area, a commercial, industrial or shared services site or in the same closed distribution system, provided that, for non-household renewable self-consumers, those activities do not constitute their primary commercial or professional activity...”

The International Standard IEC 60050-617:2009/AMD2:2017, published by the International Electrotechnical Commission,[5] introduces and defines the following terms:

- ‘prosumer’: a network user who consumes and produces electrical energy
- ‘self-producer’: a party generating electric energy essentially for his/her own use, but who can also sell the excess energy.

1.3 PV Prosumer concept

PV prosumer (PVP) concepts are holistic descriptions of specific cases of the use of PV technology. They are based on possible and feasible business models for PV prosumers (with specification of the role and the effects of all parties involved, the added value provided for the prosumers as well as cost and revenue streams) and are extended with necessary technical components (e.g. metering devices, battery storage systems, etc.), connected systems (e.g. the electricity grid, electricity markets), organizational structure (e.g. billing models) as well as the associated legal framework. Table 1 summarizes all parameters necessary to describe a PVP concept.

---

3 European Commission: DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources (recast), COM(2016) 767 final, 2016/0382 (COD), Brussels, 30.11.2016

[5] IEC 60050-617:2009/AMD2:2017, Amendment 2 - International electrotechnical voca-bulary - Part 617: Organization/Market of electricity, TC 1 Terminology, Publication Date 2017-12-15, https://webstore.iec.ch/publication/27437

Table 1. Structured description of PVP concepts	
Parameter	**Description**
Key Partners and legal relations	• Which parties are involved in the PVP concept and what is their role? • Who is the operator and/or owner of the PV system? • What is the legal relation between producer (plant operator) and consumer?
Value Propositions	• What value does the PVP concept deliver to the prosumers? • What is the impact on the PV prosumer (administration, consumption behavior, spending/savings)?
Technical solution/ components	• Which components are necessary for the PVP concept (e.g. meters, ICT, storage, zero-feed-in controller, controlled asymmetric operation of the generator, etc.)?
Connected systems and impacts on those systems	• Which connected (physical/non-physical) systems are necessary for the PVP concept (e.g. the electricity grid, electricity markets)? • What is the impact on those systems?
Revenue Streams	• Which revenues arise from this PVP concept (revenues from self-consumed PV behind the meter and from excess electricity)?
Cost Structure	• Which costs arise from this PVP concept?
Organizational structure	• Which billing models are most appropriate? • What is the maximum timeframe for compensation for excess PV generation? • Which geographical boundaries are appropriate for compensation?
Regulatory and policy framework (resultant barriers for implementation)	• Which legal framework is necessary for this PVP concept? • What are the technical, market structure, regulatory, administrative, financial, grid infrastructure and public perceptions?
Long-term potential for supporting the energy transition	• What is the long-term potential of different PVP concepts to support the energy transition, including sector coupling with transport, heating and cooling- H&C?
Example implementation	• Provides an example if PVP concept is already implemented (country, utility, company, etc.)

PVP concepts can be classified according to their system boundaries; this results in the distinction of on-site, local, district, regional and trans-regional PV usage models as depicted in Figure 1. Moreover, Figure 2 presents a more disaggregated picture in terms of possible system boundaries, also addressing the possible interfaces between private and public grid. A detailed description of the different possible system boundaries is provided in Table 2.

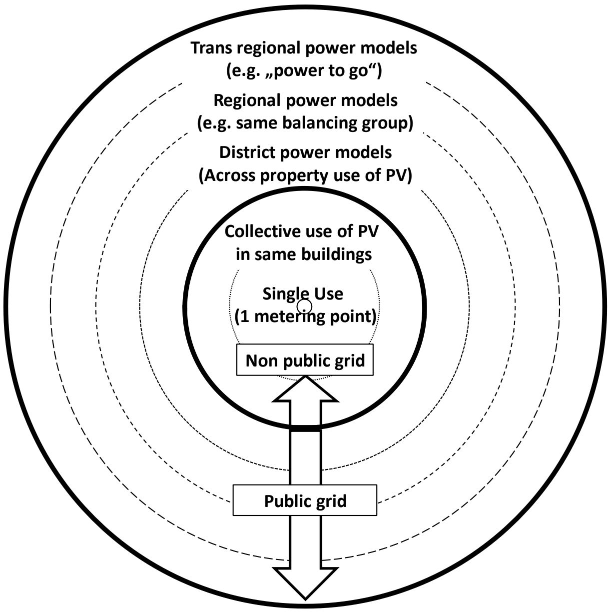


Figure 1. System boundaries of on-site, local, district, regional and trans-regional PV power usage
(Source: own elaboration)

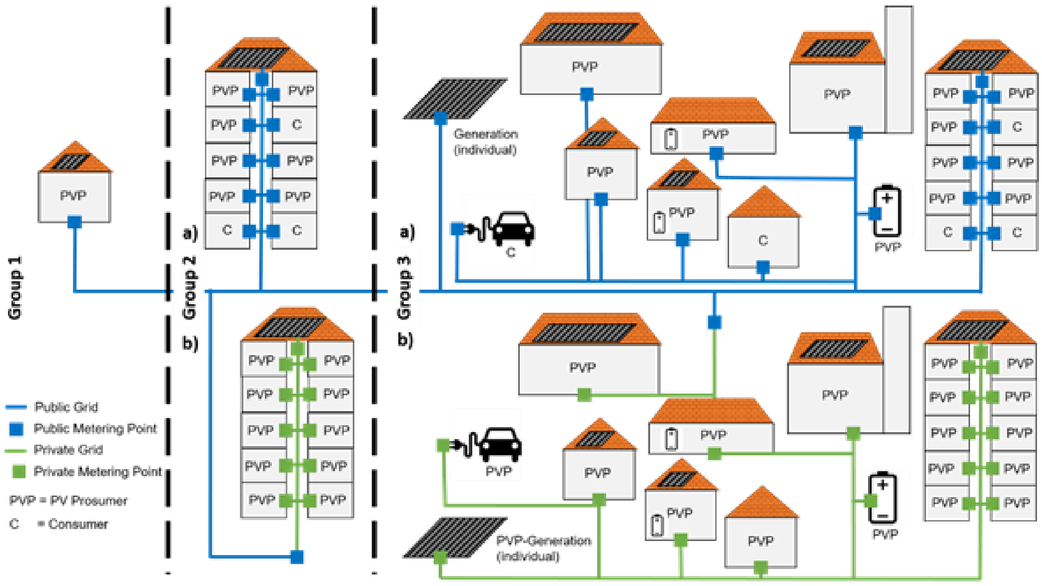


Figure 2. Classification of possible PVP concepts according to their system boundaries
(Source: own elaboration)

Table 2. Classification of PVP concepts according to their system boundaries		
Group	**Short name**	**System boundary of PV usage**
1	Single direct use (behind the meter)	One consumer directly uses the generated PV electricity on site (both cases are conceivable in this context: (i) generator legally identical to consumer, (ii) generator legally not identical to consumer). The public grid is only used for the residual electricity consumption and possible feed-in of excess electricity. PV self-consumption can be increased due to the implementation of energy storage systems, electrification of heat production (heat pumps, boilers), demand-side management, etc.
2a	Local collective use of PV in one place (e.g. in one building)	Several consumers share the generated PV electricity using the public grid (owned and/or operated by DSOs). The public grid is therefore used for the residual electricity consumption and possible feed-in of excess electricity. Each consumer can increase the share of self-consumption by certain measures (storage, demand-side management, etc.). In this case, it is not necessary for all consumers to become part of the PVP concept. Only some consumers must agree in participating in this business model. This means that each consumer has its individual connection point to the public grid.
2b	Local collective use of PV in one place (e.g. in one building)	Several consumers share the generated PV electricity without using the public grid. The public grid is only used for the collective residual electricity consumption and possible feed-in of excess electricity. Each consumer can increase the share of self-consumption by certain measures (storage, demand-side management, etc.). In this case all consumers must agree in participating in

		this business model. This means that there is only one connection and metering point to the public grid, which is common for all consumers of this place (building).
3a	District power models	Several consumers directly consume locally generated PV. The PV energy is shared using the public local grid on low voltage level (limitation is the same substation [note: this is the project-specific deliberation/definition in this project; this does not necessarily need to be a generally accepted classification]). To increase the share of self-consumption, district storage devices for example can be used in addition to the individual measures. In this case, is not necessary for all consumers to become part of the PVP concept; it is sufficient for only some consumers to agree to participate in this business model. This means that each consumer has its individual connection point to the public grid.
3b	District power models	Several consumers directly consume locally generated PV. The PV energy is shared using a private local grid at the low voltage level. To increase the share of self-consumption, district storage devices for example can be used, as well as measures from individual consumers. In this case, all consumers belonging to the private grid must agree to participate in this business model. This means that the connection and metering point at the public grid is shared by all consumers of this area. This includes the possibility of having one’s own transformer substation.

2 Identification of the European PV prosumer potential

This section is based on existing studies and general data. It can therefore be seen as meta-study and motivation for the whole project. The following questions shall be tackled:

- What is the European PV prosumer potential (specifically, in the European target countries addressed in this project) with regards to urban, rural, residential, commercial and industrial applications?
  - How many households (by percentage) are already PV prosumers, and how many can become so in the future?
  - What share of consumed energy is currently generated by PV prosumers, and what share could potentially be generated?
- To which extent can PV prosumers contribute to the national and European energy transition?
- Which grid environment (specifically urban versus rural) is capable of absorbing certain degrees of PV prosumer energy?

In the following, two of the target countries in this project, the Netherlands (NL) and Austria (AT), exemplify existing PV prosumer studies.

Examples from NL (compiled by Utrecht University):

- Wouter Schram, Ioannis Lampropoulos, Wilfried van Sark, *Photovoltaic Systems Coupled with Batteries that are Optimally Sized for Household Self-consumption: Assessment of peak shaving potential*, Applied Energy 223 (2018) 69-81. (doi:10.1016/j.apenergy.2018.04.023)
- Sander van der Stelt, Tarek AlSkaif, Wilfried van Sark, *Techno-economic Analysis of Household and Community Energy Storage systems for Residential Consumers with Smart Appliances*, Applied Energy 209 (2018) 266-276. (doi:10.1016/j.apenergy.2017.10.096)
- Geert Litjens, Bala Bhavya Kausika, Ernst Worrell, Wilfried van Sark, *Spatial Analysis of Residential Combined Photovoltaic and Battery Potential: Case Study Utrecht, the Netherlands*, Conference record of 44th IEEE PVSC, Washington D.C. (June 25-30, 2017)
- http://www.ieee-pvsc.org/ePVSC/manuscripts/MePVSC576_0621062753.pdf
- G.B.M.A. Litjens, W.G.J.H.M. van Sark, E. Worrell, *Influence of Demand Patterns on the Optimal Orientation of Photovoltaic Systems*, Solar Energy 155 (2017) 1002–1014.
- Geert Litjens, Wilfried van Sark, Ernst Worrell, *On the Influence of Electricity Demand Patterns, Battery Storage and PV System Design on PV Self-Consumption and Grid Interaction*, Proc. 43rd IEEE PV specialist conference (2016) pp. 2021-2024 (oral). (doi:10.1109/PVSC.2016.7749983)

Examples from AT (compiled by Energy Economics Group [EEG], TU-Vienna):

- Bernadette Fina , Andreas Fleischhacker, Hans Auer, and Georg Lettner, *Economic Assessment and Business Models of Rooftop Photovoltaic Systems in Multi-apartment Buildings: Case Studies for Austria and Germany*, Journal of Renewable Energy, Volume 2018, Article ID 9759680 (open source), 16 pages, https://doi.org/10.1155/2018/9759680
- Michael Wedler (B.A.U.M. Consult GmbH): *Kurze Wege für den Strom: Systemlösungen für die gemeinsame Nutzung von PV-Strom - Aktueller Diskussionsstand*. Commissioned by the Federal Ministry for Transport, Innovation and Technology. Summary of stakeholder workshop in St. Pölten, Vienna, January 2017
- Georg Brandstetter, *Gemeinschaftliche PV Erzeugungsanlagen – was steckt dahinter und welche vertraglichen Vorgaben gibt es?*, Webinar by the Federal Association Photovoltaic Austria, 30 May 2017 within the framework of the EU project PV Financing (www.pv-financing.eu)

2.1 Classification of PV in target countries

In the following Section 2.1, a classification of installed PV capacities is conducted in two steps. In the first step, installed PV capacity in 2017 is listed according to size classes ($KW_{p(eak)}$ ranges: <10 kW_p, 10-100 kW_p, 100-500 kW_p, >500 kW_p) in each of the target countries. The empirical data is collected either from national statistics, documents of the responsible ministries, or from the corresponding associations for renewable energy. In addition, it is important to note that the size classes, to a large extent, coincide with the different system boundaries of possible PVP concepts presented in Section 1.3 above, meaning that:

- Size class <10 kW_p refers to group 1 (single direct use) in terms of system boundary of PV usage. In practice this category mainly addresses private residences.
- Size class 10-100 kW_p refers to group 2 (local collective use of PV in one place, e.g. in one building). This category mainly addresses the multifamily, commercial and tertiary-building sector grouped together within a single system boundary.
- Size class 100-500 kW_p needs to be treated with caution. Depending on the customer group it can either still refer to group 2 (e.g. notably for tertiary/industrial buildings, commercial centers, hospitals, schools etc.) or to group 3 (e.g. ground-mounted PV systems up to 500 kW_p).
- Size class >500 kW_p refers to group 3 (district power models) where, in addition to smaller customers (commercial and tertiary), mainly industries and ground-mounted solar PV systems are grouped together within a single system boundary.

In the second step, total PV generation and electricity demand per sector (residential, commercial and industrial demand in percentage) and their respective target countries are listed in Table 4 for the year 2017. The knowledge of the different fractions of electricity demand per sector and their target countries, shall support the determination of the PVP potential within the different system boundaries (i.e. group 1, 2, and 3) defined in Section 1.3 above.

Table 3 Installed PV Capacities in Target Countries in 2017

Country	**AT**[6]	**BE** [7]	**FR**[8]	**DE**[9]
Total installed PV (MW) 2017	1,250	3846	8,091	43,000
Size	%[10]	%	%	%
< 10 kW	62%	62.89%	15.9% (< 9 kW)	14.2%
< 100 kW	32%	17.71% (> 10 kW et ≤ 250 kW)	18.6%	52.4%
< 500 kW	2%		13.8% (< 250 kW)	66.5%
> 500 kW	4%	19.39% (> 250 kW)	51.7% (>250 kW)	33.5%

[6] Marktstatistik Austria 2017

[7] Data provided by APERe. It is not possible to have a different split because the Belgian regulation follows these categories (≤ 10 kVA household installations, > 10 kVA et ≤ 250 kVA commercial, > 250 kVA industrial installations)

[8] Percentage are based on the third quarter 2017, source: http://www.statistiques.developpement-durable.gouv.fr, we should receive the split for all 2017 in the next weeks

[9] https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institution en/ErneuerbareEnergien/ZahlenDatenInformationen/EEG_Registerdaten/EEG_Registerdaten_node.html; BNetzA; ÜNB

[10] The % refers to installed power (shares of total installed PV (MW))

Country	**IT**[11]	**PT**[12]	**ES**[13]	**NL**[14]
Total installed PV (MW) 2017	19,283	566.4	4,864*	2,900
Size	%	%	%	%
< 10 kW_p	19.6%	Not available	2%	79.1%
10 - 100 kW_p	20.9%	Not available	27%	3.1% [90 MW]
100 - 500 kW_p	37.8%	Not available	43%	10.9% [317 MW]
> 500 kW_p	21.7%	Not available	28%	6.9% [200 MW]

Table 4 Electricity Demand and PV-Generation in Target Countries

AT[15]	2015	2016	2017
Total annual electricity demand (GWh)	61,060	61,850	Not yet available
Share of residential sector (%)	29%	29%	Not yet available
Share of commercial/tertiary sector (%)	22%	23%	Not yet available
Share of industrial sector (%)	41%	42%	Not yet available
Total annual PV generation (GWh)	937 (1.5%)	1,096 (1.8%)	Not yet available

[11] 'Rapporto Statistico 2016 – Solare Fotovoltaico', GSE (www.gse.it)
[12] Portugal IEA-PVPS Country Report 2017
[13] Ministry of Energy, Tourism and Digital Agenda, PRETOR, 2018; * The total installed PV capacity in Spain has been 4,729 MW by the end of year 2017. Please note, that in the years 2018-2019 another 3,900 MW will be installed that was awarded in a recent tender.
[14] SDE+ subsidy support overview end 2017: https://www.rvo.nl/sites/default/files/2018/02/SDE-projecten%20in%20beheer%20januari%202018.xlsx [NOTE, the amount of land based PV parks is expected to increase considerably in 2018, based on subsidies granted. Nationaal Solar Trend report, 2018
[15] Statistik Austria 2017

BE	2015	2016	2017
Total annual electricity demand (GWh)	83,140*	84,187***	81,200*** (11 months)
Share of residential sector (%)	22.7%*	22.6%[16]	Not yet available
Share of commercial/tertiary sector (%)	26.6%*	26.2%	Not yet available
Share of industrial sector (%)	45.6%*	45.6%	Not yet available
Total annual PV generation (GWh)	3,049**** (3.7%)	3, 047**** (3.6%)	3,200****

FR	2015[17]	2016	2017
Total annual electricity demand (GWh)	476,000**	483,087***	481,694***
Share of residential sector (%)	35%	36%	Not yet available
Share of commercial/tertiary sector (%)	49%	47%	Not yet available
Share of industrial sector (%)	16%	17%	Not yet available
Total annual PV generation (GWh)	7,400** (1.6%)	8,300** (1.7%)	9,043***(1.9%)

*Final ‘ observed ‘ electricity consumption by sector in Belgium in 2015 - FEBEG 2016 - MISSING 5,5 % (transport, agriculture, energy transformation)

** SOURCE: IEA PVPS 2015 - 2016 REPORT

*** ENTSO -E – National electrical consumption

**** APERe 2017 website: http://www.apere.org/fr/observatoire-photovoltaique

[16] FEBEG report

[17] SOURCE: « épartition par segments de la consommation (hors Corse) sur les réseaux – Bilans électriques nationaux 2015- 2016 -RTE. In the commercial sector are included: Enterprises, Professionals and SMEs/SMI

DE[18,19]	2015	2016	2017
Total annual electricity demand (GWh)	524,700	527,400	531,600
Share of residential sector (%)	25.1%	24.4%	24.2%
Share of commercial/tertiary sector (%)	26.7%	27.9%	28.0%
Share of industrial sector (%)	46.0%	45.3%	45.4%
Total annual PV generation (GWh)	38,726 (7.4%)	38,095 (7.2%)	39,800 (7.5%)

IT[20]	2015	2016	2017
Total annual electricity demand (GWh)	292,074	314,300	Not yet available
Share of residential sector (%)*	23%	22%	Not yet available
Share of commercial/tertiary sector (%)*	33%	35%	Not yet available
Share of industrial sector (%)*	44%**	43%**	Not yet available
Total annual PV generation (GWh)	22,942 (7.9%)	22,104 (7.0%)	Not yet available

PT	2015[21]	2016	2017[22]
Total annual electricity demand (GWh)	46,853	47,327	47,973
Share of residential sector (%)	25.5%	27.7%	Not yet available
Share of commercial/tertiary sector (%)	26.4%	26.6%	Not yet available

[18] Please note: The gross electricity generation is much higher in Germany because of the large proportion of electricity exports; see https://ag-energiebilanzen.de/index.php?article_id= 29&fileName=20171221_brd_stromerzeugung1990-2017.pdf

[19] Source PV DE generation : http://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/ energie-daten-gesamt-xls.xls; https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/ aktuelle-fakten-zur-photovoltaik-in-deutschland.pdf

[20] Source: 'Bilanci Energia Elettrica', TERNA (http://www.terna.it/it-it/sistemaelettrico/ statistiche eprevisioni/bilancienergiaelettrica/ bilancinazionali.aspx)
* Including 2 % contribution of the agricultural sector
** Source: 'Rapporto Statistico 2016 – Solare Fotovoltaico', GSE (www.gse.it)

[21] PORDATA (www.pordata.pt)

[22] Portugal IEA-PVPS Country Report 2017

Share of industrial sector (%)	48.1%	45.7%	Not yet available
Total annual PV generation (GWh)	790 (1.7%)	826 (1.8%)	970 (2.0%)

ES[23]	2015	2016	2017
Total annual electricity demand (GWh)	230,263	232,154	234,503
Share of residential sector (%)	27.8%	27.8%	27.4%
Share of commercial/tertiary sector (%)	18.3%	18.3%	18.2%
Share of industrial sector (%)	53.8%	53.9%	54.4%
Total annual PV generation (GWh)	8,243 (3.6%)	7,978 (3.4%)	8,359 (3.6%)

NL[24]	2015	2016	2017
Total annual electricity demand (GWh)	118,373	119,595	Not yet available
Share of residential sector (%)	21.9%	21.4%	Not yet available
Share of commercial/tertiary sector (%)	32.6%	32.5%	Not yet available
Share of industrial sector (%)	45.4%	46.1%	Not yet available
Total annual PV generation (GWh)	1,450 (1.2%)	1,900 (1.5%)	2,572 (2.2%)

23 CNMC: Spanish Energy Regulator
24 CBS, Statistics Netherlands, https://opendata.cbs.nl/statline/#/CBS/nl/

2.2 PV prosumer potential

Based on the share of PV generation and electricity demand presented in Section 2.1 above, the following chapter presents a qualitative analysis for two target countries, Austria and Spain, and in the different sectors, while also providing an indication of the PVP potential within the different system boundaries (i.e. groups 1, 2, and 3) as defined in Section 1.3 earlier in this document. In detail, the long-term PVP potential is estimated – depending on system boundary (group) metrics – also using electricity demand per sector as an indicator for potential assessments, with further investigation presented in Table 5 and Figure 3 below.

2.2.1 Consumer sector

In the following Table 5 and Figure 3, starting from total annual electricity demand, the allocation of the different customer groups to the different PVP concepts is conducted in the two target countries Austria and Spain, using information in Table 3 and 4 in terms of preferable PV system size and electricity demand in the different sectors per country:

- The Austrian case is illustrated in Table 5a and Figure 3a (using additional information in terms of structural data from *Statistik Austria* and Oberhuber/Denk [2014]).
- The Spanish case is illustrated correspondingly in Table 5b and Figure 3b (using inputs delivered from partner TECNALIA).

When comparing Figure 3a (Austria, AT) and Figure 3b (Spain, ES) it can be clearly seen that in the residential sector in the segment of the single/double family housing in Austria, the group 1 PVP concept potential is significantly higher than in Spain. The most plausible reason for this difference is that in Austria, for small PV systems, no feed-in tariff (FiT) has been foreseen (an investment subsidy only; see Section 3 of this document for details); as a result, residential customers have from the beginning already considered PV self-consumption as their preferable solution. In this context, the maximum size of the PV system is limited to an installed capacity of a few kW_p to operate the PV system most economically. On the contrary, if a FiT is granted (like in Spain) for smaller PV systems as well, then smaller customers would have no incentive to consider the physics of their own load. Moreover, it is favorable to feed the produced PV electricity into the grid. As a consequence, small residential customers might also not be entirely aware of the potential and benefits of PV self-consumption.

In the segment of multi-family housing/housing blocks, the PV systems are on average already bigger; as a result, the PVP potentials in both countries, Austria and Spain, converge when allocating the PV system to the concepts of group 2 and group 3.

In the small commercial sector, the same fundamental differences exist between the two countries as is the case in the residential sector in the segment of the single/double family housing. Again, the absence of FiT for small PV systems seems to trigger the PV self-consumption concept even more than in the Spanish case, where predominantly larger PV systems have been installed in the commercial/tertiary sector as a consequence of FiT support. In addition, it can be observed that in the commercial/tertiary sector there exist significantly fewer large businesses in Spain than in Austria. This also limits the group 3 potential in Spain significantly, in contrast to the Austrian case in this segment (see Figures 3a and 3b).

Table 5a (AT): Allocation of different Customer Groups to different PVP Concepts in Austria

Austria (AT) / Values in GWh	Year 2016*	Comment
Total Annual Electricity Demand (GWh)	61850	-
Share of demand in residential sector (29%)	17937	-
Single-/Double-Family Housing (40%)	7175	-
...whereas 62% Group 1 (<10 kW)	4448	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 38% Group 3	2726	Self consumption up to 100% even w/o battery storage
Multi-Family Housing / Housing Blocks (60%)	10762	-
...whereas 32% Group 2 (10-100 kW)	3444	Self consumption of 60-100% (w/o versus w/ battery storage)
...whereas remaining 68% Group 3	7318	Self consumption up to 100% even w/o battery storage
Share of demand in commercial/tertiary sector (23%)	14226	-
Small (retail) business & offices (30%)	4268	-
...whereas 62% Group 1 (<10 kW)	2646	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 38% Group 3	1622	Self consumption up to 100% even w/o battery storage
Medium (retail) business & offices (30%)	4268	-
...whereas 32% Group 2 (10-100 kW)	1366	Self consumption of 60-100% (w/o versus w/ battery storage)
...whereas remaining 68% Group 3	2902	Self consumption up to 100% even w/o battery storage
Large (retail) business & offices (40%)	5690	-
...whereas 6% Group 1 (<10 kW)	341	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 94% Group 3	5349	Self consumption up to 100% even w/o battery storage
Share of demand in industrial sector (42%)	25977	-
...whereas 6% Group 1 (<10 kW)	1559	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 94% Group 3	24418	Self consumption up to 100% even w/o battery storage

* The methodology is demonstrated based on 2016 electricty demand values. For a target year in the future, e.g. 2050, the corresponding linear stretching factor (in case of electricity demand increase) needs to used for each of the categories.

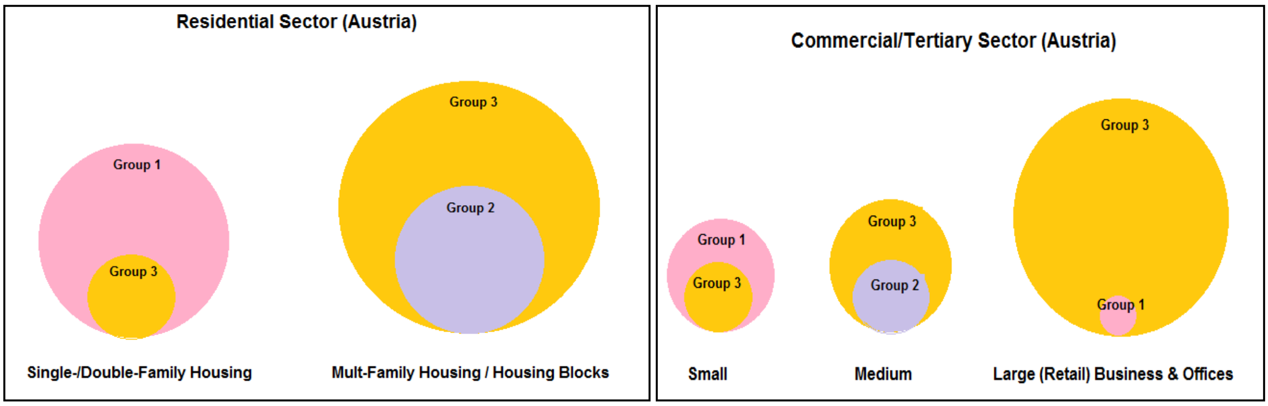


Figure 3a. Graphical illustration of Customer Group Allocation (Residential and Commercial/Tertiary Sector) to different PVP Concepts for the Austrian Case

Table 5b (ES): Allocation of different Customer Groups to different PVP Concepts in Spain		
Spain (ES) / Values in GWh	**Year 2017***	**Comment**
Total Annual Electricity Demand (GWh)	234503	-
Share of demand in residential sector (27,4%)	64254	-
Single-/Double-Family Housing (33,5%)	21525	-
...whereas 2% Group 1 (<10 kW)	431	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 98% Group 3	21095	Self consumption up to 100% even w/o battery storage
Multi-Family Housing / Housing Blocks (66,5%)	42729	-
...whereas 27% Group 2 (10-100 kW)	11537	Self consumption of 60-100% (w/o versus w/ battery storage)
...whereas remaining 63% Group 3	31192	Self consumption up to 100% even w/o battery storage
Share of demand in commercial/tertiary sector (18,2%)	42680	-
Small (retail) business & offices (87%)	37131	-
...whereas 2% Group 1 (<10 kW)	743	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 98% Group 3	36389	Self consumption up to 100% even w/o battery storage
Medium (retail) business & offices (11%)	4695	-
...whereas 27% Group 2 (10-100 kW)	1268	Self consumption of 60-100% (w/o versus w/ battery storage)
...whereas remaining 63% Group 3	3427	Self consumption up to 100% even w/o battery storage
Large (retail) business & offices (2%)	854	-
...whereas 2% Group 1 (<10 kW)	17	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 98% Group 3	837	Self consumption up to 100% even w/o battery storage
Share of demand in industrial sector (54,4%)	127570	-
...whereas 2% Group 1 (<10 kW)	2551	Self consumption of 25-70% (w/o versus w/ battery storage)
...whereas remaining 98% Group 3	125018	Self consumption up to 100% even w/o battery storage

* The methodology is demonstrated based on 2017 electricty demand values. For a target year in the future, e.g. 2050, the corresponding linear stretching factor (in case of electricity demand increase) needs to used for each of the categories.

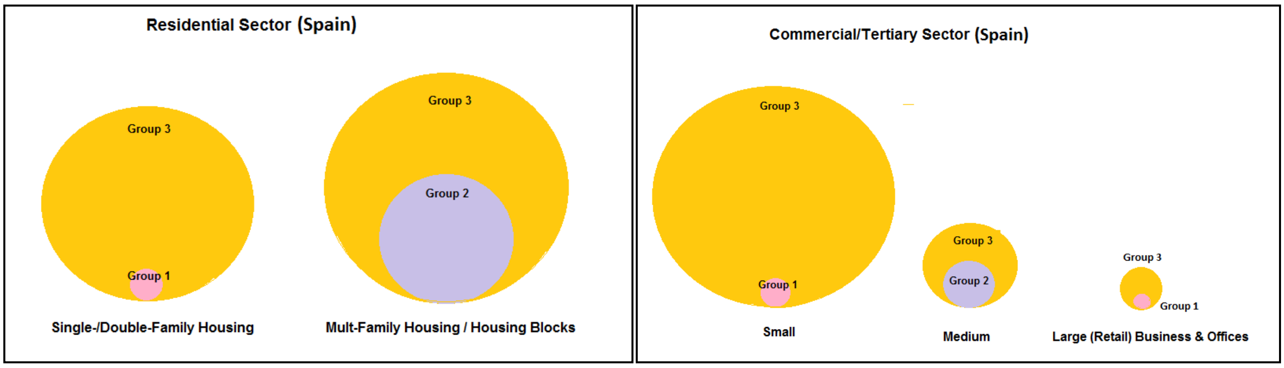


Figure 3b. Graphical illustration of Customer Group Allocation (Residential and Commercial/Tertiary Sector) to different PVP Concepts for the Spanish Case

2.2.2 Grid areas

Group1 (single direct use) and group 2 (local collective use of PV in one place, e.g. in one building) PVP concepts usually are connected at the low voltage (LV) level. For these concepts there is no need to consider incorporation of different voltage levels via substations. Within group 3 concepts, for category 3b also higher voltage levels than the LV level can occur. This means that within the private grid there also exists the possibility of implementing substations to enable the connection of the different customer groups (residential, commercial, tertiary, industries and also ground mounted solar PV systems) on the most fitting voltage level.

2.2.3 Renewable targets

The renewable electricity targets in Europe (currently, 2030 is envisaged as target year with dedicated quantitative numbers per renewable technology and country) are important to further accelerate PV integration within several system boundaries. The corresponding targeted PV installations are presented in Table 6 below. At present, at European level there is policy discussion to revise the currently binding renewable targets up from 27% (in total) to 35% (in total). In the event of an agreement to reach 35%, the corresponding national PV targets are expected to also be scaled upwards.

Table 6 PV Installations in 2017 and PV Targets in 2030 in Target Countries

Country	**AT**	**BE**	**FR**	**DE**
Total installed PV (MW) 2017	1,250	3,846[25]	8,091[26]	43,000
Total installed PV (MW) 2030*	3,500	5,740	24,100	58,200
Stretching Factor: 2030/2017	2,80	1,49	3,01	1,36

Country	**IT**	**PT**	**ES**	**NL**
Total installed PV (MW) 2017	19,283	566.4[27]	4,864[28]	2,900
Total installed PV (MW) 2030*	48,900	720	37,000	8,000
Stretching Factor: 2030/2017	2,54	1,51	7,60	2,75

[25] Source: https://www.pv-magazine.com/2018/02/06/belgian-solar-market-grew-by-50-in-2017/
[26] Source: SDES
[27] https://www.pv-magazine.com/2018/01/04/pv-covered-1-6-of-portugals-power-production-in-2017
[28] https://www.pv-magazine.com/2018/02/06/the-rebirth-of-spains-solar-sector-135-mw-of-new-pv-systems-installed-in-2017/
Spain's PV industry has seen very limited development since 2012, when a moratorium on incentives for new renewable energy installations was implemented. However, the country's installed PV power is set to grow more substantially over the next few years, after the Spanish government allocated around 3.9 GW of PV capacity in an auction held in late July 2017

*Source: Fraunhofer IWES (2015)

Finally, in order to be able to assess the already implemented PVP concepts for a future target year (e.g. 2030), somebody can combine the information in Table 3 (share of size categories of PV systems per country) and Table 6 (stretching factors), also taking into account the allocation of the different PV size categories (<10 kWp, 10-100 kWp, 100-500kWp, >500 kWp) to the PVP concepts (group 1, group 2 and group 3) and the annual full load hours of PV generation per country as well as electricity demand predicted for the target year. This enables a rough estimate of the share of the different PVP concepts already implemented per country for any future target year of interest. To illustrate this, in Table 7 below the quantitative numbers are derived and allocated to the different groups 1, 2, and 3 for the Austrian case by the year 2030.

Table 7 Customer Group Allocation (Residential and Commercial/Tertiary Sector) to the different PVP Concepts for the Austria case in year 2030

Austria: Allocation of PV Generation to the different Groups 1,2,3 in 2030		
Total Annual Electricity Demand in 2016	61,850	GWh, Table 4
Average Electricity Demand Increase per Year	1,50%	Table 4 (Increase from 2015 to 2016)
Total Annual Electricity Demand in 2030 (GWh)	76076	GWh
Total installed PV in 2030	3500	MW, Table 6
...whereas PV Size < 10 kW in 2030	2170	MW, Share from Table 3
...whereas PV Size < 100 kW in 2030	1120	MW, Share from Table 3
...whereas PV Size < 500 kW in 2030	70	MW,Share from Table 3
...whereas PV Size > 500 kW in 2030	140	MW, Share from Table 3
Average Annual Full Load Hours of PV in Austria (h)	1000	Source: Biermayr et al (2017)*
Total PV Generation in 2030 (GWh)	3500	GWh
...whereas from PV Size < 10 kW in 2030	2170	GWh
...whereas from PV Size < 100 kW in 2030	1120	GWh
...whereas from PV Size < 500 kW in 2030	70	GWh
...whereas from PV Size > 500 kW in 2030	140	GWh

Allocation of 2030 PV Generation in Austria to the different Groups 1,2,3 in the Residentail and Commercial/Tertiary Sector corresponding to long-term Potentials given in Table 5a/Figure 3a...		
Residential Sector (29%)	**1015**	**GWh**
Single/Double Family Housing (40%)	406	GWh
Group 1 (62%)	252	GWh
Group 3 (38%)	154	GWh
Multi-Family Housing / Housing Blocks (60%)	609	GWh
Group 2 (32%)	195	GWh
Group 3 (68%)	414	GWh
Commercal/tertiary Sector (23%)	**805**	**GWh**
Small (retail) business & offices (30%)	242	GWh
Group 1 (62%)	150	GWh
Group 3 (38%)	92	GWh
Medium (retail) business & offices (30%)	242	GWh
Group 2 (32%)	150	GWh
Group 3 (68%)	92	GWh
Large (retail) business & offices (40%)	321	GWh
Group 1 (6%)	19	GWh
Group 3 (94%)	302	GWh

*Biermayr et al (2017): Innovative Energietechnologien in Österreich: Marktentwicklung 2016

3 Identification and analysis of existing PVP Concepts

In this section, existing PVP concepts, as defined for the purpose of PVPV4GRID in this document, are listed and described with sufficient detail for the eight target countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Portugal and Spain), most relevant international markets (U.S. and Australia, both divided into multiple regulations, one for each state in the country), and a set of EU countries (e.g. Greece, the UK, Cyprus, Hungary, etc.). For the eight EU target countries under review, this chapter presents an overview of the legal situation affecting PV prosumption. A more detailed analysis of these countries will be presented in the deliverable D2.4 report on PVP4GRID concepts. This publication has to be considered as the main reference document for the aforementioned EU countries.

Broadly speaking, recent, present and near future regulation has been analyzed for each country with regards the prosumer concepts, based on the methodology defined in Section 1; on this basis, the PVP concepts are grouped with regard to their system boundaries. Table 8 provides an overview of all concepts under consideration.

Table 8. Overview of considered PVP concepts

Group 1	**Single direct use**	• Private local self-consumption • E-mobility as DSM option • Load management applications • Sector coupling
Group 2	**Local collective use of PV**	• Shared use of PV in larger buildings and facilities.
Group 3	**District power models**	• Providing local grid services through active PV management • Shared use of PV in industrial parks, University facilities, etc.

The initial source of information for the proposed assessment has its origin, in many cases, in the national associations and country representatives in PVP4GRID projects, whose information has been compiled with data extracted from previous EU-funded projects, such as PV-FINANCING (especially for

Spain, Italy, Austria, France and Germany), and other documents, e.g. Study on “Residential Prosumers in the European Energy Union” - GfK Belgium Consortium, May 2017, which gathers the drivers, regulatory aspects and economic performance in the area of small-scale self-generation for residential consumers over the life cycle of investment in EU countries.

The information is presented first for the eight target countries, then for a selection of other EU countries and, finally, for the U.S. and Australia. In all cases, effort has been made to unify the nature and extension of the information. However, this has not always been possible, since some countries offer a very good overview of the PVP concepts, while for others only few paragraphs have been obtained. ,Examples of the application of selected PVP concepts are displayed for some countries, but not for all. Finally, for the Australia and U.S. cases, the information gathered is more complete, as these countries will not be included in the D2.4 report.

The following table is a summary of the current situation for each selected country and shows which of the PVP concepts are available or feasible, and if there are examples that provide insights into the implementation phase.

Table 9. Overview of PVP concepts allowed in each country

Legend: NM = Net-Metering NB = Net Billing SC = Self-consumption FiT = Feed-in-Tariff PPA =Power Purchase Agreement

Country	Group 1	Group 2	Group 3	Comments
Austria	YES SC + market price or SC+FiT or SC	YES 2a) including multi-apartment, office, and commercial buildings	YES, legally possible although economically not feasible	Storage is promoted with financial support in CAPEX
Belgium	YES, 2 options: - Pure SC - NM	NOT allowed yet, except for some exceptions at reginal level	NOT allowed yet, except for some exceptions at reginal level	Example for industrial park near Mery (demonstrative)
France	YES SC + fixed FiT+financial support	YES, designed as a virtual private network embedded in the public network	Limitation to the same low voltage station, but allowed	Example of shared SC: Gironde Habitat/Les Souffleurs in a multidwelling
German y	YES Very common SC+FIT	YES, Mieterstrommodelle” (neighbour solar supply model) PPA also possible	Allowed, however, hardly found due to condition of “consumer identity”	

Country	Group 1	Group 2	Group 3	Comments
Italy	YES SC+PPA or NM (or NB, as it exchanges money, not energy (*Scambio sul posto*)	NOT feasible	NOT feasible	Battery storage costs can be included for tax reduction purposes The last reform of the residential electricity bill, flatten the energy costs, making SC less convenient
Netherlands	YES Net-metering (“saldering")	YES, developed for apartments buildings	YES, Postal Code Rose Policy	Analysis of optimal PV orientations and tilt for maximized SC (UU). Subsidy support scheme SDE+
Portugal	YES SC+ % of MIBEL	YES, allowed, although strong barriers for its implementation	YES, allowed, although strong barriers for its implementation	Subsidies to investment for building renovation POSEUR
Spain	YES SC1: no remuneration for excess SC2 + Market price No NM	NOT feasible. Collective self-consumption is not regulated yet	NOT feasible. Collective self-consumption is not regulated yet	Sun tax in force: charge for the electricity self-consumed. Storage is allowed
Bulgaria	Only FiT available NM not allowed	Not feasible	Not feasible	
Croatia	YES SC and NM	N/A	N/A	
Cyprus	YES, partially. NM without SC for households and non-domestic consumers. SC with no injection (autonomous)	N/A	N/A	Storage is allowed Subsidies for NM under 3kW to avoid electrical poverty
Czech Republic	SC with NM, price to be agreed. Limited < 10 kW	N/A	N/A	Investment support programme until 2021
Denmark	SC with NM (no economic transaction) SC with NB also	N/A	N/A	NM based on hourly basis

Country	Group 1	Group 2	Group 3	Comments
	possible			
Finland	YES SC and NM allowed, conditions to be agreed	N/A	N/A	Lack of access priority for electricity produced from RES
Greece	YES SC with annual NM FiT with annual NM (NB)	N/A, although virtual net metering regulated	N/A, although virtual net metering regulated	Surplus of electricity not netted in 1 year is lost
Hungary	YES SC with NB (monthly, 6-monthly, yearky9	N/A	N/A	Other incentive programs: FiT, Green premium, subsidies program
Poland	YES SC with annual NM. 1 kWh fed = 0,7 or 0,8 kWh netted	N/A	N/A	Prosumers are exempted from VAT (now amended it in parliament)
Turkey	YES SC with NM	N/A	YES OIZs, Industrial parks, Universities	PPAs not allowed for unlicensed projects
UK	YES SC + tariff rates	N/A	Not available information	VAT reductions for PV
Australia	YES. 8 different regulations (8 states) SC+NM	No regulatory framework. This segment is still on an experiment level.	No regulatory framework. This segment is still on an experiment level	Storage very common Good examples included future concepts, e.g. Virtual metering
USA	Calif.: YES, multiple NM schemes available Ariz: YES, NB. Fees for SC. Utah: NM, FiT Nev: YES, SC + storage; NB	Calif: Yes, NM aggregation, including virtual metering Utah: YES. Aggregation of meters	Calif: Yes, including virtual metering, e.g. Community Choice Aggregation Colorado: solar-powered smart district, Utah: community shared solar projects	In all the states, virtual metering, storage, aggregation is available at city / district level.

N/A: for the purpose of this study, N/A means that regulation referring to this specific PV concept has not been identified by the project team, but does not necessarily imply that this concept is not implemented in some way in the country in question.

It is worth mentioning that according to EU law, PVP concepts intending to use the public grid (group 1, groups 2a and 3a) to sell excess PV electricity to third parties are legally allowed to do so since the liberalization of the EU electricity market, as any kWh (energy) fed into the grid through any electricity meter can be allocated to any other customer's bill. However, due to economic, administrative and/or regulative barriers, such schemes hardly ever become operational in real life.

3.1 EU target countries

3.1.1 AUSTRIA

Individual self-consumption (group 1)

Individual self-consumption in Austria is allowed. Electricity not self-consumed (excess electricity) is injected into the grid and the PV system owner is remunerated either by a feed-in-tariff (FiT) or equal to the market price (represented by a power purchase agreement PPA).

In general, in Austria two financial instruments that support PV installations are implemented: (1) investment grants and (2) fixed FiTs. There are different thresholds in terms of installed PV capacities (5 kWp, 30 kWp, 50 kWp, 100 kWp, 200 kWp, 500 kWp) , according to which these two different support instruments are granted, either exclusively or in a combined support model of both instruments:

- Small PV systems up to 5 KWp, the typical installations in residential buildings, receive investment grants only. This amounts to 275 euros/kWp for PV systems on a building ("rooftop") and also small "free-standing" PV systems (considering a ceiling up to a maximum of 35% of the PV system investment cost). For building-integrated PV systems (BIPV) an amount of 375 euros/kWp is provided for (also with a ceiling of up to 35% of PV system investment cost).
- For "PV community facilities" the same investment subsidies are granted as shown above for PV systems up to 5 kWp, with the two following restrictions: (i) a maximum of 5 kWp per person (i.e. an individual shareholder of the community facility) can be applied, and (ii) the maximum capacity of the PV community plants cannot exceed 30 kWp.
- For dedicated PV systems in the agricultural/forestry sector, the same investment subsidies are also granted as shown above for PV systems up to 5 kWp, with the restriction that these PV systems need to be in a capacity range between 5-50 kWp.
- Those PV systems between 5-200 kWp installed on a building ("rooftop") or integrated into a building (ground-mounted PV systems are explicitly excluded here) receive a FiT of 7.91 cents per kWh in 2018. As in the past, an annual adjustment of this FiT is foreseen, resulting in 7.67

cent per kWh in 2019.[29] In addition to the FiT tariff in the range of 5-200 kWp for PV systems on buildings or building-integrated, another 30% of the PV system investment cost is remunerated. However, a ceiling of the per kWp amount to 250 euros/kWp (for capacities in the range of 5-100 kWp) and 200 euros/kWp has to be considered.

- For larger PV plants between 200-500 kWp an investment subsidy of 200 euros/kWp is granted, but limited to maximum 30% of the total PV system investment cost.

Collective self-consumption (local collective use of PV) – Group 2

After years of discussions among different stakeholder groups, the PV support in Austria was subject to a recent amendment of energy legislation in Austria in 2017. In the context of this reform, the financial support presented above has been implemented, while also allowing further innovations and incentives in terms of PV-self consumption,[30] and also explicitly addressing multi-apartment buildings, as well as financial support for energy storage technologies in combination with PV systems:

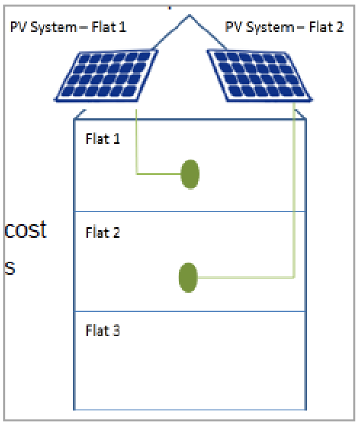
- The amendment of the Austrian energy law (*Elektrizitätswirtschafts- und organisationsgesetz)* in 2017 provided the legal basis to implement the common use of PV systems among tenants/owners of individual apartments in multi-apartment buildings. Currently, different sharing models are being developed for the various types of apartment units (so-called static [individual PV self-consumption] versus dynamic [collective PV self-consumption] and allocation of PV production to the different load profiles). This is a process led by the Austrian regulatory office; it requires implementation of feasible models for accounting and clearing by the distribution grid operators even prior to the final full roll-out of smart meters and without any consideration of the circumstances of the physics of the electricity distribution system inside a multi-apartment building, and also bypassing any legal barriers preventing the direct sale to multiple consumers unless a "third-party grid operator" acquires a special grid operating license within the building.[31]

[29] In the past, PV plants with a capacity of 5-200 kWp were subsidized with a FiT of 11.5 cents/kWh (2015). In general, the FiT is adjusted annually and is valid for 13 years. For comparison reasons, the retail electricity tariff in Austria is between 10-15 cents for companies and 20-24 cents for households, including surcharges and taxes.

[30] PV self-consumption above 25,000 kWh per year is still subject to a fee *(Elektrizitätsabgabe)* of 1.5 cents/kWh. This has not changed since 2017.

[31] One of the problems of Austrian legislation in the past has been that for direct sales to individual apartments inside a multi-apartment building, a "third-party grid operator" is requested to acquire a special grid operating license within the building. This has not been the case so far and, therefore, collective use of PV systems in multi-apartment buildings was not an issue until 2017 (i.e. unless the principles according to the amended energy law in 2017 went into force). There were some niche applications that were limited to commercial shopping malls, commercial large office buildings and industrial parks that were compatible with the previous energy law *(Elektrizitätswirtschafts- und organisationsgesetz 2010)*.

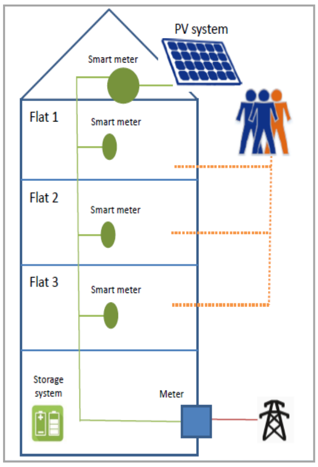
- In Austria, the installation of PV systems has been – and still is – most common in the residential sector for small PV sizes up to 5 KWp or even slightly larger. In the near future, different kinds of sharing models in multi-apartment buildings – as described above – will hopefully become reality.[32] Not only in terms of economics, but also in terms of optimal integration into the electricity system, it is important to maximize PV self-consumption. A complementary technology significantly increasing the share of PV self-consumption is energy storage. Since 2017, financial support of energy storage has been implemented in Austria as follows: an investment subsidy is granted for energy storage capacities in the range between 0.5-10 kWh per kWp installed PV capacity, with an amount of 500 euros/kWh of usable energy storage capacity. In general, there is no upper limit in terms of energy storage capacity. Instead, the limit is the link of the energy storage capacity range and the PV system size.



In summary, with regards to multi-apartment buildings in Austria, the following concepts have, on the one hand, been eligible in the past until 2017, and, on the other hand, have been applicable since the amendment of the energy law in 2017.

Until 2017, three different modes of operation of PV systems existed for this kind of multi-user buildings:

1. Full feed-in without any PV self-consumption;
2. Exclusive use of PV electricity via the existing electricity grid for general services in commercial and office buildings, shopping malls (e.g. lighting in common spaces, elevators) with excess PV electricity being fed into the grid;
3. PV electricity for the supply of individual tenants requiring the installation of an individual grid (not exactly group 2b, as it is not shared self-consumption. See figure on the right. Source: Shared generation facility model in Austria. PV Financing, Intersolar Europe 2017).



[32] In the case of commercial large office buildings, as a result of an amendment of the building regulations in 2013, Viennese building owners are confronted with some specific regulations: new office buildings are obliged to install a PV system with a capacity of 1,000 kWh per 100m^2 gross floor area. However, it must be noted that this regulation is not consistent with the regulation for PV usage according to the energy law amendment in 2017, as it is not possible for multiple tenants of the same office building to consume and/or share the PV electricity produced.

- Since 2017, a new regulation of collective PV self-consumption has been in place for any kind of building, including multi-apartment buildings. The main aspects are as follows:

1. Tenants willing to use PV electricity have to purchase a certain share of the PV system and establish a local operator association.
2. The PV system is connected to the building's main power supply line.
3. Smart meters will be required - as soon as possible - to ensure the exact billing of electricity consumption from each apartment (individual meters).
4. Excess PV electricity is fed into the grid.
5. Tenants can share their amount among each other (shared self-consumption).
6. It would be legally possible, although economically not feasible, for group 3 to use the public grid to sell excess PV electricity to third parties.
7. The grid operator is responsible for metering each unit's electricity consumption and balancing the electricity costs per metering point.
8. No grid fees are to be charged.

Source of graphics: PV Financing project, INTERSOLAR 2017, June. Shared generation facility model in Austria.

Public buildings and financing

For PV installations on public buildings, it is important to first clarify the ownership of the building. Schools are usually owned by the municipality, which therefore also pays for the electricity consumed. In this case the business model is quite simple, as the municipality itself can implement the installation of the PV system. In the case of higher schools or universities, the building is usually owned and rented out by a real estate company, whose consent becomes necessary when planning a PV system. These PV systems can be financed by the municipality or an external investor (typically an energy supply company).

However, the most common financing model by far in this case is crowdfunding, which allows for direct local participation and investment - i.e. a small PV system funded by multiple private investors. Through the possibility of direct involvement in regional projects, the local population is not only offered an investment opportunity, but also the chance to contribute to a greener municipality. For municipalities, the construction of a PV system on a public school or university through crowdfunding can represent an important first step to establishing a direct relationship between energy production and consumption, thus raising awareness.

<u>Motivation - Value proposition</u>

For individual households (in single family houses as well as multi-apartment buildings) there are several reasons to invest in a PV system. These include: (i) independence, (ii) self-consumption, (iii) hedging against rising electricity prices (avoidance of kWh-related taxes and surcharges of purchased electricity from the grid), (iv) reduced electricity costs as well as (iv) a “green” lifestyle.

For the remaining cases, the main segment drivers are reduced electricity costs and marketing reasons and, as exemplified by the city of Vienna, the regulations for the office buildings.

The main driver for public educational facilities to invest in a PV system is typically to raise awareness among students and the local population about green energy.

3.1.2 BELGIUM

In Belgium, only PVP concept - **group 1: individual self-consumption** – is fully possible, with two different alternatives:

- Pure self-consumption, i.e. getting retail price for the energy fed in and not self-consumed. For industrial and commercial installations, price is agreed through PPAs with energy suppliers.
- Net-metering (max 10 kWp and 5 kWp, depending on region), with 1-year period for compensation.

Groups 2 and 3*: local collective use in one place, e.g. the same building* and district power models are not allowed yet, except for some exceptions at regional level (*Wallonia, CWaPE allows district self-consumption in a few industrial districts for research purposes).*

<u>Group 1: individual self-consumption</u>

The main billing models in the country are:

1. net-metering for household installations
2. self-consumption for industrial installations

The installations eligible for the net-metering in the region are the systems below 10 kWp in Flanders and Wallonia and below 5 kWp in the Brussels region. Under the net-metering scheme, prosumers feed the excess electricity into the grid when they have an oversupply, and for every unit of electricity injected they can consume one unit of electricity from the grid, paying only the net difference. The time during which the excess electricity can be consumed is called “netting precision” and can vary from one hour to one year, according to the varying regulations. Thus, the maximum timeframe for compensation is one year.

Industrial installations, by contrast, are allowed to self-consume, and the excess electricity that they produced is remunerated through a PPA with utility suppliers. Moreover, depending on when the PV plant is installed, some PV plants are allowed to receive additional green certificates based on the percentage of electricity self-consumed.

In terms of economic advantages, prosumers can benefit from savings on the electricity bill and on the sale of the excess PV electricity produced and not consumed. As explained above, in the case of net-metering, prosumers are eligible for compensation for production and consumption over a one-year timeframe, paying only the net difference.

Regarding industrial and commercial installations,, self-consumption allows them to benefit from consuming the electricity self-generated rather than buying it from the market. Moreover, they can benefit from selling the excess electricity to energy suppliers through long-term power purchase agreements (PPAs).

Not everything is positive, however. The two billing models in Belgium do have costs for the prosumer. Taking into account that the electricity bill entails electricity tariffs that are covered to pay fixed costs as well as variable costs such as the exploitation of the grid, the self-consumption model means that part of these costs such as the grid fee are not paid by prosumers. Particularly in the case of net-metering, prosumers are exploiting the grid, since they are feeding in electricity directly into it. To “solve” this situation, Flanders currently levies a grid tax called “the prosumer tariff”, to be paid to the DSO to repay some of the additional costs incurred in feeding the electricity into the grid in the net-metering schemes that allows full compensation of the PV consumption. This tax varies between €87.14/kW and €121.46/kW[33] per year and is charged for all existing and new PV systems smaller than 10 kW (the ones who benefit from the net-metering). Prosumers can avoid this tariff if they ask to install a new meter that separately tallies what goes out and what goes in. In this case, they wouldn’t benefit from the net metering anymore, and would have to sell their excess electricity to a retailer.[34] In Wallonia, the same kind of tariff is supposed to enter into force in 2020.

Parties involved in the PVP concept

Since competencies for renewable energy are developed at regional level, regulations and laws change according to the three Belgian regions. The three regulators are CWaPE (Walloon Commission pour l’Energie), Brugel (Brussels Regulator for Electricity and Gas Markets) and VREG (Flemish Regulation

---

[33] Source: https://www.vlaanderen.be/nl/bouwen-wonen-en-energie/elektriciteit-aardgas-en-verwarming/prosumententarief-voor-eigenaars-van-zonnepanelen-windmolens-en-wkk-installaties-kleine-installaties)

[34] Source: APERe 2015 IEA-PVPS REPORT

Entity for the Electricity and Gas Markets). There are three main parties involved in the PVP business model:

1. the owner of the building
2. the user of the building (electricity consumer)
3. the owner of the PV installation

The relationship between the plant operator and the owner of the PV system is not clear, and revolves around the definition of "energy producers," which is a central stakeholder category within Belgian law. This definition changes according to region. In **Wallonia,** this figure is legally defined as the legal person who:

1. carries the project risk,
2. owns the electricity (which implies that he can sell It to an energy supplier),
3. supports the investment necessary for the PV system,
4. has a right to use and enjoy the installation,
5. bears the maintenance and operation costs.

In the **Flemish** region, energy producer is defined as:
"... the owner of the production installation or the natural or legal person who is indicated by the owner as the person entitled to this."

The relationship between the power plant operator and consumer changes according to this definition. If the power plant operator and the energy consumer are the same entity, meaning that the risk on the PV plant is carried by the consumer himself, who is also the owner of the PV plant, then he is the owner of the energy that he produces; thus the consumer is in fact a prosumer, and operates in the self-consumption framework.

On the other hand, if the power plant operator is a different entity from the consumer, and he is the one who carries the risk associated with the installations, he is the owner of the energy produced. For this reason, if the power plant operators sell the electricity to the end customer, he is considered by law to be an energy supplier, must consequently apply for a license, and must return a quota of green certificates to the regulator.

A direct consequence of this law is that collective self-consumption in not incentivized, since selling electricity produced to a different entity is seen as utility retailing, which is subjected to licenses and bureaucratic processes. However, in Wallonia, the regional regulator for Energy, CWaPE, allows district self-consumption in a few industrial districts for research purposes.

Technical and administrative aspects

The kind of meter required in PV plants changes according to each regional regulation. In Wallonia, all the PV plants are required to install a simple meter. For household installation a smart meter is not required, but PV plants that are above 10 kWp need to also install a GPRS monitoring device in order to receive the green certificates. In some cases, depending on the year of installation, a different amount of green certificates could also be issued for the percentage of energy self-consumed.

In Brussels, installations have a time of use price meter that charges different prices for the electricity according to the time of the day.

In Flanders, there is a production meter or green electricity meter, which is a meter that the DSO installs and is mandatory for installations >10 kWp. Moreover, small prosumers who want to avoid the payment of the grid fee can install a two-index meter that that separately counts what is fed in and what is taken out of the grid.

While the high and extra-high voltage grids in Belgium are managed by a single Transmission System Operator (TSO), in this case the company Elia, the regional regulators are responsible for all questions relating to distributing and transmitting electricity locally in networks with a nominal voltage below 70 kV. The companies in charge of carrying this out are the local Transmission System Operator (LTSO) in Wallonia, the regional Transmission System (RTS) in the Brussels area and the *plaatselijk vervoernet* in Flanders. The low voltage grid is also implemented at the regional level. The main Distribution System Operators are ORES, Tecteo (Resa), Régie de Wavre, AIESH and AIEG in Wallonia, Sibelga in the *Brussels* capital region and Eandis and Infrax in Flanders.

Another important aspect for self-consumption is the electricity market, which in Belgium is common at the national level and is called *“Belpex.”*

Other measures to increase self-consumption

At the household level the presence of storage systems and DSM is not incentivized due to the net-metering system. As it concerns bigger systems and installations, storage facilities don’t have a strong presence on the market due to their still high prices which do not yet make them competitive. Currently the integration of PV prosumption with electric vehicles is still a long ways off, but it will in all probability be possible in the future, since according to FEBIAC Belgium had 5,194 electric vehicles in 2016, while in 2017 another 2,713 EV were registered.

More promising is the integration of heat pumps with direct water heaters. In 2017, only counting the Flemish region, the number of heat pumps reached 22,000 units, which amounts to a doubling in four years.[35]

There is currently no regulation aimed at the convergence of PV prosumer concepts with either transport or heating and cooling in buildings.

Groups 2 and 3: Collective self-consumptions

The entire regulatory framework for self-consumption requires legal approval. While net-metering has been set up for small installations, it is currently being revised. At the same time, for larger installations, the framework must still be adapted. Currently, collective self-consumption is not implemented in Belgium, there is no regulative framework and its application is strongly discouraged by the definition of energy supplier provided by law. In fact, in the district power model, the power plant operator is a different entity from the consumer, and sells the electricity to the end customer. This means that he is considered by law to be an energy supplier, and thus he is subject to licenses and bureaucratic processes. In summary, collective self-consumption in Belgium has not yet been fully implemented due to the lack of a regulatory framework. In recent months, thanks to the introduction of the concept of collective self-consumption in the Energy Code in France (May 2017), things are slowly starting to change and policymakers, particularly in Flanders, are showing a willingness to introduce future regulations.

Nowadays, the shared use of PV in larger buildings and facilities such as multi-family houses is not allowed. For instance, in the case of a block of flats with a single PV installation on top, there is a single owner of the installation, who he is considered the legal entity representing the buildings. The energy can be used by this legal entity only to cover the common expenses of the building.

In case the co-owners want to install a PV installation to cover their own consumption, they need ask for the agreement of the owner's association to use part of the common roof, and install a personal solar PV installation in order to produce their own energy, which could be used to cover their own consumption needs.

Despite the lack of regulation, several examples can be found in Belgium. In Wallonia, the regional regulator for Energy, CWaPE, allows district self-consumption in a few industrial districts for research

[35] http://www.energyville.be/en/nieuwsbericht/number-heat-pumps-flanders-doubles-4-years-time

purposes. In Belgium there is currently an active project for the implementation of the micro-grid realized by the University of Liège, but only for research purposes[36].

3.1.3 FRANCE

The most important regulation in France, effective since 9 May 2017, is the *"Arrêté du 9 mai 2017 fixant les conditions d'achat de l'électricité produite par les installations implantées sur bâtiment utilisant l'énergie solaire photovoltaïque, d'une puissance crête installée inférieure ou égale à 100 kilowatts telles que visées au 3o de l'article D. 314-15 du code de l'énergie et situées en métropole continentale NOR: DEVR1712972A".*

This decree establishes the conditions for the purchase of energy produced by PV systems in buildings, and only plants installed on buildings whose installed capacity does not exceed 100 kW are eligible (art.1, Décret d 28 mai 2016). For PV installations >100 kWp, public tenders are carried out.

In France the FiT without the possibility of self-consuming was the rule for both PV systems in buildings until 2017. However, the new law issued in May has introduced the possibility to opt for self-consumption. Under this law, PV installations can choose between two different models. The first model implies a FiT without the possibility of self-consumption, while the second model involves self-consumption with an investment grant and a fixed FiT for excess electricity fed into the grid. Since the first option does not provide an incentive for self-consumption, the analysis in PVP4GRID will be focused on the second possibility.

An **investment grant depends on the installed capacity and is set according to the quarter in which the request of connection is sent to the regulator.** Every quarter, degression coefficients will be applied to the investment grant, based on the number of completed network connection requests that are made during the last two quarters. The French regulatory authority will publish the new coefficients 3 weeks after the end of each quarter (art. 14 Arrêté du 9 mai 2017 soleil). The new rates are published at the following address: www.cre.fr/operateurs/producteurs/obligations-d-achat.

In addition, plant operators can receive fixed remuneration for surplus electricity in the case of individual self-consumption. The level of this compensation depends on the system size and is intended to reflect the degree to which this electricity helped achieve the national energy targets. The fixed tariff for the purchase of the excess electricity is constant, and thus not linked to a degression index. Eligibility for the tariff is limited by time. The duration of payment varies according to the source of energy. For PV electricity, it is established at 20 years.

---

[36] http://blog.cet-power.com/2017/10/20/merygrid-microgrid-industrial/

Group 1: self-consumption: local use

The most important parameters to be considered, arising from current regulation, can be summarized as follows:

- Individual and collective self-consumption are allowed according to the French energy code, following the adoption of a series of legal and regulatory provisions in 2016 and 2017. To date, however, PV systems on buildings and rooftops cannot compete with the retail price of electricity.
- Most new PV installations now incorporate individual self-consumption, given the fall of the modules' cost, the increasing electricity prices and the gradual decrease of FiT.
  One case in point is the number of campaigns launched by EDF. EDF ENR, subsidiary of the EDF Group, has launched a collective self-consumption product that targets joint-ownership associations, housing and vertical housing stakeholders wishing to produce their own electricity. The service, named "*Notre Soleil & Nous,*" comes one year after EDF introduced its "*Mon Soleil & Moi*" self-consumption model for residential customers.
- Collective self-consumption is a nascent concept. Few projects have been launched to date: Gironde Habitat/Les Souffleurs, in a multi-dwelling perspective, Smartmagne Village (not operational yet). But there are many expressions of interest. Projects owners are awaiting specifications (micro-grid tariff -"TURPE"- for instance, to be explained later) in order to refine their business plans.
- As a primarily French special feature, collective self-consumption is designed as a virtual private network embedded in the public network. In this context, the role of the DSO (Enedis, operating 95% of the network) is key.
- The energy code provides for the possibility to introduce PV storage systems under certain conditions. But for the moment, these provisions are not yet economically viable (notably because of the TURPE rules).

When PV in buildings is considered, the previous statements are slightly modified in the following sense:

- Given that retail electricity price is lower than FiT for systems in buildings, such projects adopt a model based on FiT instead of self-consumption.37 Thus, public support is still necessary if economic viability is intended.
- France has a FiT program for small PV systems, which pays for the excess electricity fed into the grid (currently 10 cents/kWh). Compensation is significantly higher for BIPV than for BAPV, in

[37] The electricity price for household installations is around 17.11 cents/kWh, including all taxes and levies. According to the table reported in the link below, from 30 Sept. 2018, BIPV installations will receive a tariff of 18.22 cents/kWh and 0 cents/kWh of building integration bonus. It is therefore possible that FiT and self-consumption will soon be at the same level. http://www.photovoltaique.info/Aujourd-hui-arrete-du-9-mai-2017

order to extend and boost the BIPV implementation. Although grid parity has already been achieved for BAPV systems in locations with good radiation values (e.g. Marseille), BIPV FiTs are still above the grid electricity price.

- The steady increase in the price of grid electricity might facilitate the path to change.

Group 2: collective Self-consumption

A simplified and general definition of shared self-consumption is when one or more PV installations provide energy to several consumers located in the same place or in different locations. There are plenty of cases of application, which will improve and widen the business models for PV installations in buildings:

- Residential / tertiary building: energy produced on top of the roof is shared by occupants (group 2).
- Nearby buildings: energy produced in one building is distributed to several places (group 3).
- ower supply for VE and other applications: eco-neighbors, etc.

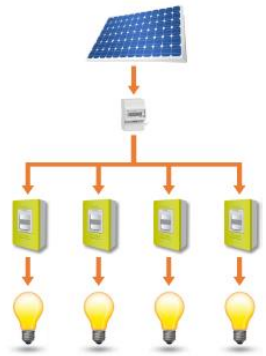


Figure 4 Representation of collective self-consumption. Source: Sunchain, 2017

Some of the main features of collective self-consumption are summarized below:

- Consumers and producers have to be part of a same legal entity. The form of this entity has to be decided on a case by case basis: Association, company, cooperative….
- The PV installation operated by one producer cannot exceed 100 kW.

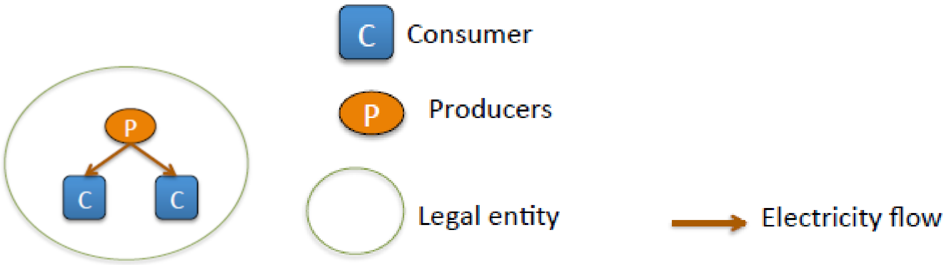


Figure 5 Collective self-consumption at a glance. Source: PV Financing EU project. Julien Courtel. 2017

In a typical contract, the energy producer (EP), the Distribution System Operator (DSO), the consumers (C), the producers (P) are involved.

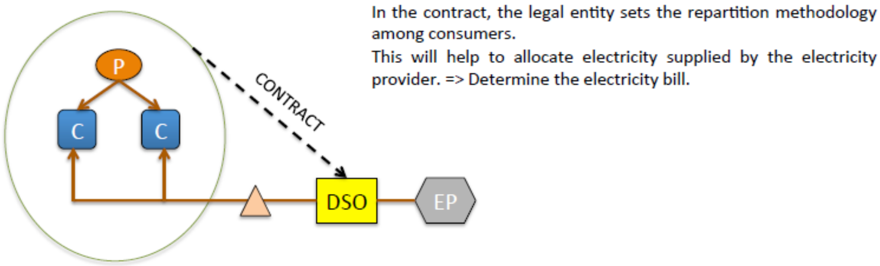


Figure 6: Stakeholders involved in a collective self-consumption contract. Source: PV Financing EU project. Julien Courtel. 2017

Other key aspects are:

- The grid operator is obliged to install smart-meters.
- Storage is determined for a consumer (C) when electricity is stored and for a producer (P) when it is supplied.

Input is still missing in order to have a complete collective self-consumption regulation:

- The TURPE = the price that has to be paid by consumers for the services of the grid operator. A “micro-TURPE” will be published and adapted to self-consumption projects. The financial viability of collective self-consumption projects will depend on this micro-TURPE.
- This micro-TURPE amount will be the key for the quantity of collective self-consumption projects that will be achieved. The technical documentation describes the connection to the grid (deadlines, information needed, and so on).
- A contract template between the legal entity and the grid operator is needed.
- The limitation of the scope to the same low voltage station will become a barrier in the medium-term.

3.1.4 GERMANY

In Germany, PVP concepts are all of them accepted.

Single direct use: classic self-consumption ("Eigenversorgung") – group 1

The concept of classic "self-consumption" is widespread and accepted by consumers in Germany. The regulatory agency "Bundesnetzagentur" tends to criticize self-consumption because it is not subject to grid charges. From a legal standpoint, self-consumption is only allowed when the plant operator and the consumer are the same entity (*Personenidentität*). The operator doesn't have to be the owner of the facility, but has to bear the economic risks of the plant operation. In this concept the electricity purchaser has the option to buy the PV system or rent it.[38]

In the self-consumption model, the user is obliged to have an electricity contract with a utility to secure the electricity supply. The excess of electricity produced (or not consumed electricity) is typically fed into the grid according to the corresponding FiT (EEG).

Up to March 2012 the self-consumption of PV electricity was even supported with a bonus for installations up to 500 kW. Until August 2014 (no caps concerning the size of installation), all PV installations were generally exempted from paying the EEG-surcharge (though without further incentives).

In 2014 the legislation introduced a surcharge for self-consumed electricity produced by PV plants above 10 kW.[39] They are subject to a payment of 40% of the current EEG levy (surcharge). The 40% surcharge currently corresponds to 2.7168 cent/kWh (as of 2018), the KWh price for households is approximately 29.42 cent/KWh (as of 2018 including all taxes). This is one major barrier for the profitability of self-consumption projects.

According to German legislation, the following principles must be met in order to be considered a self-consumer:

- Same person as electricity producer (person / legal entity who is running the installation) = electricity consumer (consumer identity)[40]

---

[38] In Germany the model of renting the system is called "Pacht", which differs from the "Leasing" model in the contract conditions regarding the transfer of risks for the operation to the lessee in order to qualify for self-consumption. The "Pacht" self-consumption model applies to tenants or buildings owners.

[39] Since 2017 self-consumers pay 40% of the EEG surcharge. Systems up to 10 kWp and with an annual generation of less than 10 MWh are exempt from this charge.

[40] In the case of legal entities as well, the principle of "Personenidentität" (same person) applies. This means, for example, that a company cannot deliver electricity to a subsidiary or affiliated company.

- Plant is located in immediate proximity to consumer (the public grid is not needed for the delivery of electricity).
- Public grid is not used (this is the main reason why self-consumption in Germany is not possible outside the EEG, as the rules for being “off-grid” are strict and require that no connection exists to the grid at any point whatsoever). However, excess electricity or electricity that is not needed is typically fed into the public grid to receive FiT.

In particular the interpretation of “consumer identity” is very strict and poses a major obstacle for the development of self-consumption projects.

Policy framework barriers for implementation

- Surcharge on self-consumed electricity for installations above 10 kW
- Equality of time must be proven for each ¼-h time period. This requires appropriate meters, evaluation and reporting. Also, there is the duty to report the amount of self-consumption to the Federal Network Agency (Bundesnetzagentur) every year by the end of February. In both cases there is the danger of having to retroactively pay the full EEG-levy.
- The optimization of the consumption profile, which is currently differentiated according to sectors and their electricity consumption (e.g. households between 20% and 40% and large buildings around 70% and 90%), is one of the keys to making self-consumption profitable. This factor has particular influence on the household sector. The increase of profitability in this sector can be achieved through technical improvements and the appropriate sizing of the PV system. For instance, storage can increase the self-consumption rate, but is in general not economical at the moment.

Local collective use of PV in one place (tenants OR owners of apartment in multi-family dwellings) – group 2

The collective use of PV in one place is allowed in Germany. Currently the most profitable option is the so-called “Mieterstrommodell”, or tenant power model, which is a scheme governing the use of the electricity produced by a PV system when the plant operator and the consumer(s) do not coincide but are connected directly. The plant operator may just sell PV electricity or also other electricity to the consumer(s). The latter may have just one supply contract with the plant operator, or two contracts, one with the PV plant operator and one with a company meeting the residual electricity demand. Public utilities, green energy suppliers, energy and housing cooperatives, homeowners’ associations, building management companies and commercial building developers can be plant operators.

The PV electricity framed by the “Mieterstrommodell” (*neighbor solar supply model*) is subject to payment of the full EEG levy. However, in summer 2017 the German legislature decided to incentivize these models. The scheme aims at supporting, for example, landlords willing to install solar panels on the roof of the building that they rent out (within the limit of 500 MW/year). Electricity from solar panels installed on apartment buildings and sold to tenants is eligible for support.

The support is paid out as a premium (*Mieterstrompremium*), which is calculated as the difference between the reference value ("*anzulegender Wert*") applicable when the installation enters into operation and 8.5 cents/kWh ("deduction value"). The specific premium is only granted for the electricity produced by the PV installation and consumed by the tenants. Excess electricity produced by the PV installation but not consumed by the tenants and consequently fed into the grid remains eligible for support for electricity fed into the grid (ordinary feed-in tariff).

In order to receive support, the plant operator can sell the electricity to either: a) tenants of the building or b) owners of apartments in the building. Both models qualify for support through the “Mieterstrom-Gesetz”, or Tenant Electricity Law.

It is also possible to collectively use a PV system in one place without using “Mieterstrom” with a regular power purchase agreement – PPA (*Liefervertrag*). In the PPA the purchaser has two contract options: the first option offers 100% of electricity supply, which includes the PV electricity produced from the system and electricity from the grid when needed. This tariff is regularly cheaper than the grid tariff.

The second contract option offers the supply of electricity produced from the PV system. Here the tenant must have a contract with a utility for the supply from the public grid. The electricity bill would be a mix of both. PPA’s are subject to the whole EEG surcharge, thus making profitability difficult.

Policy framework barriers for implementation

- The scheme favors only producers of electricity from solar installations with installed capacity of no more than 100 kW.
- Metering for these installations can be quite complicated and burdensome.
- Germany has further explained that a landlord (or any third party delivering electricity) will need to comply with several administrative requirements. One requirement, which makes this type of project more cumbersome, is that the supplied solar electricity always needs to be 10% cheaper than the basic tariff of the basic provider. This condition might be difficult to meet, depending on the local grid tariffs, which are part of the basic tariff. Grid charges differ by region, so that the

region is a decisive factor in the economic viability of the “Mieterstrom” model, since the price spread between local grid tariffs can be comparatively high.

- The full EEG-levy still needs to be paid by the consumer of *Mieterstrom,* or tenant electricity.

District power models – group 3

This concept is allowed in Germany. However, due to the condition of “consumer identity” described above, this model can hardly be found in Germany. If a group of individuals or a company delivers electricity to individuals, this is not considered to be self-consumption, which makes the PV electricity less competitive. Germany does not have an energy regulation on private district grids.

3.1.5 ITALY

According to Italian law, a self-producer is generally defined as the “physical or legal person producing electricity mainly for their own use”. Shared or collective self-consumption in Italy is not allowed at the moment, and only individual direct use of electricity produced (individual self-consumption) is possible. However, legislation is now slowly opening to grid services offered by PV operators. At the moment it is just a test phase, so it cannot include any collective PVP concepts within these groups. It is likely that during the project development, the situation will change, so that an update of this document could include such models.

As will be explained below, although it is interesting, this simple model cannot be seen as a key model for the energy transition since it applies to single-users only. A significant PV contribution will only be possible if and when the legislative frameworks also open the doors to the exchange of PV electricity among multiple users.

Individual direct use: group 1

In Italy, the 79/79 Decree recognizes that each citizen and enterprise can produce energy to meet part of their needs (self-consumption, savings), and can also sell the excess energy (revenues). The energy produced can be sold to the national grid of ENEL (and paid by the Electricity Service Operator GSE), or to another end user, as established by a resolution of the Energy Authority, through a PPA.

The system has been in place since 2008, and it is a mechanism of simplified purchase and resale arrangement (*ritiro dedicato*), whereby PV producers (PV plant operators) sell the electricity to the GSE at a guaranteed price instead of selling it through bilateral contracts with the national Energy distributor (ENEL), or directly on the IPEX market (Italian Power Exchange).

In Italy, producers of renewable energy at small capacity can also decide to use the **net-metering** system (*scambio sul posto*) if the plant's capacity is in the range of 20 kW o 500 kW. The plant operator pays the supplier for the electricity consumed, while the GSE gives credit for the electricity fed into the grid. The PV plant owner will receive compensation equal to the difference between the value of electricity exported to the grid (e.g. for PV installations, the energy fed in during daytime), and the value of the electricity consumed in a different period, on a yearly basis. If the balance is positive, it can compensate possible negative balances in the years that will follow. Since 2015 this system requires operators to pay an annual fee for the cost of management, verification and control.

With regard to different roles and relationships, the plant operator is usually a PV service provider company, while the PV owner could be either the electricity consumer or a service provider company that then sells the PV electricity to the final user through a PPA. In the residential sector, the PV plant is almost always owned by the building user, while for larger plants in the industrial and commercial sector, PPAs are also in place, even though it is not a very common solution yet. For instance, if the PV plant is owned by an external company, a PPA contract between the two parties (producer and consumer) is signed, which details the duration of the contract (usually between 8 and 15 years), who owns the plants after this period and many other provisions. A detailed example of such a contract (in Italian) is available here: www.pv-financing.eu/wp-content/uploads/2017/07/D4.3-IT_PPA-agreement-definitivo.pdf.

In November 2015, Italy started a new procedure for the construction of small PV installations: the "Simplified Procedure for the Construction, Connection and Start-up of Small PV Systems on the Roofs of Buildings" (including houses, small businesses, small warehouses and apartment buildings). The process only requires the compilation and submission of a single application form for both the construction and operation of generation plants using renewable energy sources. The capacity threshold for the application of the Single Authorization procedure for PV plants is 20 kW.

The revenue analysis for single self-consumption considers the savings from self-consumption and remuneration for excess electricity fed into the grid. The last reform of the residential electricity bill, unfortunately, has made self-consumption less convenient than before by flattening the energy costs. It is worth mentioning that small residential PV systems (up to 20 kWp) can benefit from a tax reduction of 50% of the investment to be recovered over a 10-year period. Furthermore, battery storage can also be included in the eligible costs for the tax reduction, as part of the PV plant and up to a maximum investment of EUR 96,000.. Moreover, building automation measures, which can also contribute to increase the self-consumption rates, can benefit from a 65% tax reduction over 10 years. These fiscal measures are valid until the end of 2018, even though they are usually renewed every year. Finally, the purchase of a PV plant can trigger the reduced VAT rate of 10 %, which applies to enterprises, professionals and private persons.

A deeper analysis of the motivation for self-consumption establishes that the main value for the consumer lies in the electricity savings linked to the self-consumed PV electricity, which amounts to about 0.2 euro/kWh in the residential sector. As already explained, Italy also has a remuneration system in place for excess electricity (the ‘Scambio sul posto’ scheme); this, however, can give to the user between 0.08 and 0.1 euro/kWh, much less than the savings that can be obtained through the self-consumption.

Given the economic difference between self-consumed and excess electricity, it is crucial for the PV prosumer to increase the self-consumption share as much as possible. This is usually not a problem for commercial and industrial applications, but it is a key issue in the residential sector, which, at least for the moment, is the most relevant market for PV in Italy. For a typical residential load profile and a normal PV production curve, the share of self-consumption that can be obtained is around 30–40%. Of course, this share can be substantially increased through DMS measures, storage in batteries and changes in consumption behavior. Moreover, electric heating through heat pumps or electric boilers could be another way to increase self-consumption. An example from a 3 kWp residential system installed in central Italy in 2015 shows how the user, after PV plant installation, was able to increase the self-consumption rate from about 30% to 54%, thanks to a change in consumption behavior only.

No specific legal framework is needed for this simple self-consumption in Italy, apart from the existing one. The main barrier for a wider implementation is the cost of the equipment (storage, above all), which can increase the self-consumption share. From this point of view, it is interesting to note the initiative by the Lombardy Region to support the purchase of storage systems through a 50% incentive on the investment, which can be also combined with the tax reduction mechanism. However, this is not a continuously available support scheme and is only available for very short time periods.

3.1.6 THE NETHERLANDS

Individual self-consumption- group 1

Individual self-consumption or single direct use is allowed in the Netherlands, and has in fact been standard practice for a long time. This leads to a net annual electricity consumption for a household with a PV system that is lower than the same household without a PV system. This principle is known as net-metering (or in Dutch “saldering"): the price for buying retail electricity (~0.23 euro/kWh) is the same as the benefit received from the utility when feeding electricity back into the grid. With present market prices of 1-1.5 euro/Wp for a 3-5 kWp PV system, the economic payback time is 5-7 years.

As this is sometimes seen as a hidden subsidy, a revision of the net-metering system is in progress. Although the former Minister of Economic Affairs in 2017 promised that this system would remain in force until 2023, in 2018 the new Minister stated that he will replace the system with a new one in 2020 – although he emphasized that the present business case of PV system owners will not be negatively impacted. Net-metering will be replaced by a form of feed-in tariff system, the details of which will be worked out in 2018-2019.

Net-metering is allowed for so-called small users, i.e. for PV systems up to 15 kWp in size with a grid connection that is limited to 80 A in three phases and where the electricity has to be supplied and fed into the same point. Before 2014 the maximum amount of excess PV generation was 5000 kWh. However, this rule was lifted in 2014. If the amount of generated PV electricity is higher than the annual consumption, the owner of the system receives a much smaller fee from the utility company, amounting to about 0.05-0.07 euros/kWh. As a result, homeowners now typically invest in PV systems that would generate the annual electricity demand. In the Netherlands, installing a PV system in one's home does not require a building permit, which simplifies the installation procedure.

With typical PV system size in the Netherlands of about 3-4 kWp, and typical household demand of 3500 kWh annually, self-consumption is estimated to be about 30% on annual basis. This varies and has been modeled by research institutions (e.g. University of Utrecht).

Collective self-consumption (local collective use of PV and district power) – group 2 and group 3

In apartment buildings in which apartments are owned by individuals, four solutions for self-consumption are shown in Figure 7. First, PV energy can be used for collective services in the building such as elevators and lighting; in general, this solution is not considered collective self-consumption, as the consumer is only one entity, namely an association of apartment owners (VvE: Vereniging van Eigenaren). Note that all owners benefit from a reduced electricity bill as they are (mandatory) members of the association of owners. In the second solution, individual apartment owners actually own part of the full PV installation on the roof, which is directly connected to the apartment. Strictly speaking, this is not shared self-consumption, since the extra energy produced by the owner's part of the PV system cannot be used by other owners (which thus would actually fit within group 1). Third is a combination of both options in which a distributor is needed. The fourth option is the special case of the so-called Postal Code Rose policy, in which anyone living in one postal code is able to invest in a PV system in and directly around the postal code area they live in.[41]. The benefit is an exemption from the energy tax on the energy bill.[42]

An innovative solution was developed by and named after Hermann Scheer: a power distributor 'Herman' that connects the PV system on the apartment building roof to individual households sequentially in such a way that the apartments can profit from net-metering (see Figure 8).

Finally, several housing organizations are experimenting with how tenants can optimally profit from adding PV systems on apartment buildings. This would be possible using the 'Herman' distributor, or by setting up energy service companies. Ownership of the system can lie with the housing organization, and depending on the connection to the apartment, the cost of the system can be included as rent increase. The tenant's housing costs are then lower due to PV generation. Also, housing organizations could allow tenants to collectively or individually invest in a system on the roof for an annual fee (which can also be zero).

A very recent change in the Electricity Act, in effect as per 24 March 2018, allows consumers to have contracts with multiple utilities regarding electricity only, with the intention to facilitate new market models that would speed up the energy transition. Note that with every contract per connection, there should be a separate electricity meter. It would thus be possible to have a separate contract for household consumption, another one to sell one's PV energy, and yet another one for charging one's EV. For single households, this may be complex, but it may allow for viable business models for apartment buildings.

---

[41] Note that a postal code area typically comprises of 25-50 addresses only; in the Netherlands there are about 440,000 different postal codes.

[42] see also: B.B. Kausika, O.Dolla, W.G.J.H.M.van Sark, *Assessment of policy based residential solar PV potential using GIS-based multicriteria decision analysis: A case study of Apeldoorn, the Netherlands,* Energy Procedia 134 (2017) 110-120

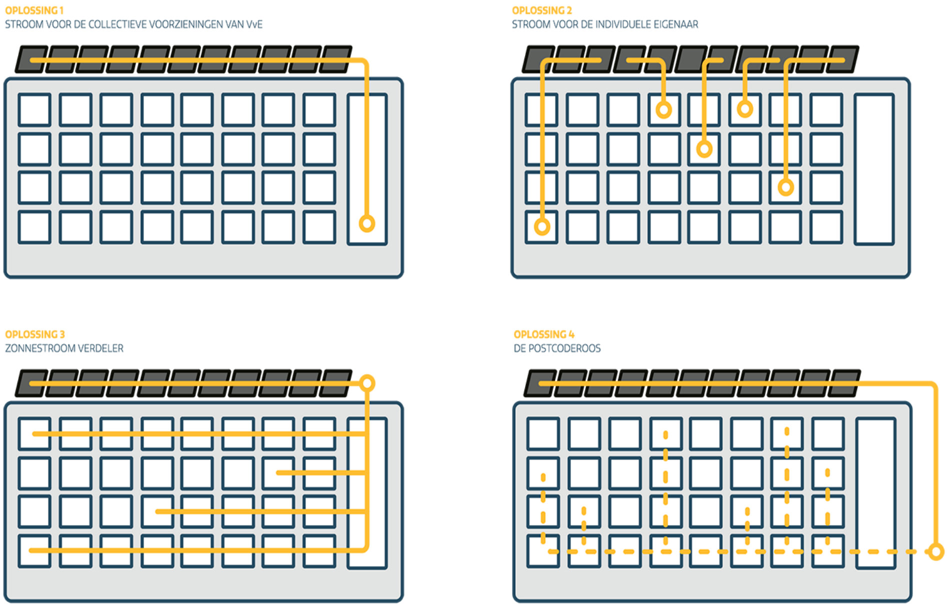


Figure 7. Modes of self-consumption for an apartment building: 1 PV for collective services, 2 PV for individual apartments, 3 PV for both collective services and apartments using a distributor, 4 PV to the grid, but apartment owners profit from the Postal Code Policy (zero energy tax) (https://devvezonnecoach.nl/oplossingen/)

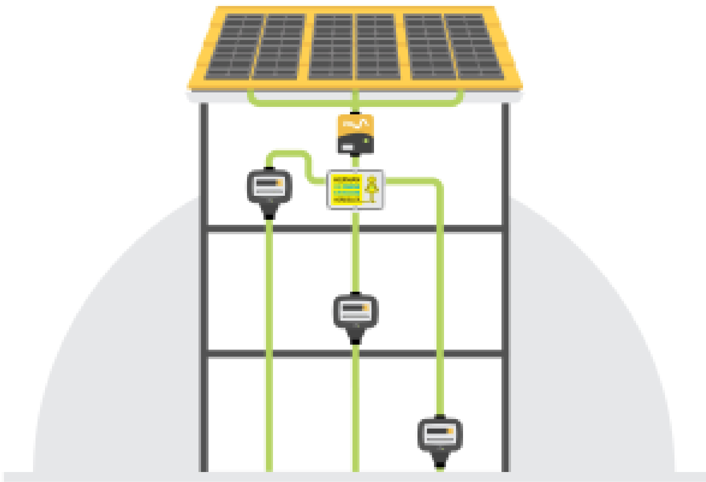


Figure 8. “Herman” the power distributor (named after Hermann Scheer, http://lens-energie.nl/herman-de-zonnestroomverdeler/)

Subsidy support scheme SDE+

For investment in PV systems larger than 15 kWp, a fee per generated kWh can be applied for within the framework of the SDE+ (Subsidy for Renewable Energy) scheme; these installations should not be connected with the 3x80 A limitation. Two categories exist: a) PV capacity between 15 and 1000 kWp, b) PV capacity larger than 1000 kWp. This is based on the assumption that larger investment costs of larger PV systems will be lower per Wp than smaller ones. Usually, applications for support are organized in phases per year, whereby the fee depends on the phase. Usually, the later the phase in the year, the higher is the fee. In spring 2018, the following three phases apply: phase 1: 0.09 euro/kWh (before 19 March 2018); phase 2: 0.09 euro/kWh (before 19 March 2018); phase 3: 0.112 euro/kWh (before 19 March 2018).

These fees are to be corrected depending on how electricity is used, i.e. delivered to the grid or not (self-consumed). For grid delivery, the correction is 0.038 euro/kWh, and for not delivering to the grid it is 0.063 euro/kWh.

3.1.7 PORTUGAL

In Portugal, self-consumers are defined, with regard to renewable energy, as the persons who produce energy through renewable sources for self-consumption.

Individual self-consumption – group 1

Individual self-consumption in Portugal is allowed and ruled by Decree Law 153/2014. Self-consumption units in Portugal are called UPAC (*Unidade de Produção em Auto Consumo*).

The grid-connected capacity of a UPAC system is limited to the consumption capacity defined by a consumer contract. The capacity of the PV generator can be up to twice the grid-connected capacity.

Electricity that is not self-consumed (excess production) is fed into the grid. Prosumers in Portugal are remunerated for this electricity that is fed into the grid on the basis of a contract with the DSO, according to the energy provided in kWh, for which the system owner receives 90% of the Iberian Market price (MIBEL). Systems up to 1.5 kW do not receive remuneration for the excess electricity fed into the grid. For a PV system to operate profitably, it is necessary to maximize the share of self-consumption. The injected electricity is sold to the Electricity Provider (CUR – *Comercializador de Ultimo Recurso*). For Prosumers the reasons to invest in a PV system include independence, hedging against rising electricity prices, reduced electricity costs, as well as a “green” lifestyle.

No feed-in-tariff system is applied.

Subsidies to investment in systems can be obtained through a Portuguese structural fund called POSEUR if the system is integrated into a fundamental renovation of the building.

Installing a PV system at one's home does not require a building permit. The production or operating license required for power plants is replaced for micro-plants and small production plants by an exploitation certificate which involves some costs. In order to obtain this certificate, installations have to register in a centralized national register, or registration system. This implies that a consumer can only commission an authorized installer after registration is done and paid for (registration by a certified technician). After installation, the device still has to be inspected in order to receive an exploitation certificate and cover the costs. Once the exploitation certificate is obtained, the owner can conclude the purchase contracts, which include the purchase contract for the excess electricity to be exported to the grid.

Collective self-consumption (local collective use of PV) - group 2a and 3a

The Decree Law 153/2014 allows for the selling the excess energy to a third party. This requires the same license as a regular producer of electricity. This is a very strong barrier, which in practice prevents the success of this business model in Portugal.

Collective self- consumption with a private grid - group 2b and 3b

The Decree Law 153/2014 allows for the establishment of different business models (art. 28 of DL153/2014). Here again is the same license as the regular producer of electricity is required to have. It is also a very strong barrier, which in practice prevents the success of this business model in Portugal.

3.1.8 SPAIN

Local use of self-consumption – group 1

The current legislation in Spain, Royal Decree 900/2015, dated 9 October 2015, regulates the administrative, technical and economic aspects of the production and supply of electricity for self-consumption. It should be noted that the Royal Decree affects all supply points connected to the electricity distribution network. Off-grid PV systems i.e. installations that do not have any grid connection point and have no possibility of physical connection with the public grid, are therefore exempt. The law establishes two types of self-consumption, with different conditions:

Self-consumption 1 (only for self-consumption, no remuneration for feed-in)

The owner of the PV system must be the same as the owner of the supply point, i.e. the consumer. It is not necessary to register the generation facility as an electricity production facility. In the past, it was necessary to register it in the self-consumption register (*Registro Administrativo de autoconsumo*, Law 24/2013, dated Dec. 26 2013, of the Electricity Sector). After the Constitutional Court ruling of May 2017, there is no longer any obligation to register the system, and now the individual regions in Spain are responsible for their own regulations (not done yet). Contracted power can be up to a maximum of 100 kW and the generation facility's capacity cannot exceed the supply point's contracted power. Two energy meters are required: one for net energy generation (mandatory) and the other one independent from the first one, at the border point. A third meter for consumption is optional. The consumer does not receive any remuneration for the excess electricity fed into the grid, thus making this type of self-consumption less attractive in terms of economic benefits. Electrical storage is allowed.

Self-consumption 2 (self-consuming and selling)

It is feasible that there is a separate consumer and producer for the same installation (different legal persons), i.e. the owner of the PV system may differ from the owner of the supply point. It is necessary to register the PV generation system as an electricity production facility in the electricity production facilities register (*Registro Administrativo de instalaciones de producción de energía eléctrica,* Royal Decree 413/2014, June 6).

The generation facility's capacity shall not exceed the supply point's contracted power, but there is no limit for it as in self-consumption 1. The consumer may receive compensation for the excess electricity fed into the grid, based on market price. It is mandatory to install one bidirectional meter to register net generation and one meter for total energy consumption, with the option of a bidirectional meter at the border point. Consumers who decide to self-consume under the new Royal Decree of 2015 will have to continue paying the electricity access tariffs of consumption like any other consumer. Additionally, they will have to cover the charges associated with the costs of the electrical system for the electricity they self-consume. For now, these charges are transitory and divided into two types (the law indicates that this might change in the future when a charge calculation methodology will be implemented):

- Fixed charges, based on capacity (installed PV power)
- Variable charges, based on self-consumed kWh

Fixed charges: PV systems with no meter measuring the customer's total consumption (not legally required), and no battery systems are exempt from paying fixed charges. On the other hand, the fixed charges are applied if the installation has electrical storage and this storage is used to reduce the contracted power with the energy provider, or if peak consumption surpasses the contracted capacity. This measure tries to limit the effect of the storage systems for increasing self-consumption ratios. There are some exceptions that should be mentioned regarding the payment of variable charges for self-consumption:

<u>Variable charges:</u>

- Consumers whose contracted power is less than or equal to 10 kW are exempted from paying the variable charges for self-consumption.
- Co-generation production facilities are exempted from any charges until December 31, 2019.
- Balearic Islands have reductions in the variable charges for self-consumption, while the Canary Islands, Ceuta and Melilla's electrical systems have total exemptions from these payments.

The charge for the self-consumed electricity has been termed "Sun Tax" and implies an extra cost for consumers with PV self-consumption. The larger the ratio of self-consumption, the higher the amount of money to be paid as "Sun Tax" concept. This measure, of course, is detrimental to the development of PV self-consumption in Spain.

RD 900 entered into force in October 2015. Although grid-connected self-consumption in Spain represented around 35 MW of new installed capacity in 2016, this figure is far below its maximum potential due to legislative uncertainties. In 2017, the PV sector recovered, thanks to the huge cost reduction of PV systems and good radiation conditions in most of the Spanish regions, despite the unfavorable regulation that includes not only charges but administrative barriers. In the future, the self-consumption market is expected to increase exponentially in Spain, and the only limiting aspects will be the legal and administrative barriers that are still present in the regulation.

<u>Collective self-consumption - groups 2 and 3</u>

On the other hand, collective self-consumption is not regulated in Spain. It was prohibited according to the RD 900/2015. However, in May 2017 the Constitutional Court annulled article 4.3: "An energy generator cannot be connected to private grid owned by several consumers under any circumstances." The decision for developing a regulation for collective self-consumption now falls under the jurisdiction of the regional governments, but as of March 2018, none of the regions has developed rules for governing the shared self-consumption. Nevertheless, not all issues fall under regional competence in the case of self-consumption. There are several issues that the Ministry of Energy must regulate, such as the technical schemes allowed for collective self-consumption and how to regulate the legal persons to pay the network access and system charges in such schemes. So far, the Ministry has not shown any willingness to develop this regulation. Thus, groups 2a, 2b, 3a and 3b are not yet feasible in Spain.

3.2 Other EU countries

3.2.1 BULGARIA

In Bulgaria, the electricity fed into the grid can be sold at preferential prices (guaranteed price through a FiT) applied to energy produced from renewable sources. New rooftop or facade PV installations with a maximum installed capacity of 30 KW are eligible for the FiT scheme:

- up to 5 kWp: about 13.06 c€/kWh with 1,261 hours on average per year
- 5-30 kWp: about 10.94 c€/ kWh with 1,261 hours on average per year

The promotion of renewable energy involves several measures including the mentioned FiT system, with a guaranteed payoff of the generated electricity, with long term contracts of about 20 years for solar PV. These long term contracts are not applied to small installations of less than 30 kW who declare that their production will be for self-consumption.

These small RES installations (up to 30kW) in buildings can benefit from simplified procedures and lower fees if they are already connected to the grid. In addition, they are exempt from the need to prepare an assessment of the available renewable resources on site.

The Energy and Water Regulatory Commission (EWRC) regulates the electricity selling price at the wholesale market and the FiT at which the RES producers sell electricity to suppliers. Distribution grid operators are statutorily obligated to conclude purchase agreements with the operators of renewable energy plants (obligation to conclude a contract). In pursuance of the agreement concluded, the plant operator is contractually entitled to payment for his electricity.

The tariffs are revised and set by the regulatory authority for energy every year on 30 June. Tariff digression is not regulated by law and the tariff rates can be drastically reduced every year. In pursuance of the amendment, the FiT may not be changed during the entire term of a subsidy agreement. The FiT applicable is the one in force on the date on which the plant was put into operation.

Although a FIT scheme for PV projects up to 30 kW on roofs and facades in urban areas is theoretically in place, as explained, the value of the FIT, is very close to the value of the energy for final buyers and it does not stimulate the installation of new PV capacities at all. On the top of this, the free market of electricity in Bulgaria is not well developed and new installations cannot benefit from the chance to participate in the free market and to avoid the restrictions of the regulated market on which they are currently operating.

Furthermore, the BSA (Bulgarian Solar Association), said that net metering for residential and commercial PV and auctions for large-scale renewable energy projects are two options that the Bulgarian government is not considering.

3.2.2 CROATIA

Croatia recognises 3 types of prosumers generating electricity from RES:

(1) prosumers not connected to the grid;

(2) those connected to the grid but without technical capacity to consume and feed the electricity from and into the grid;

(3) those connected to the grid and with technical capacity to draw and feed the electricity from and into the grid.

Those not connected to the grid cannot benefit from the specific tariff for the electricity that they feed into the grid, based on a special metering system for calculating the net electricity fed into the grid and the electricity consumed from the grid.

Residential installations are considered as prosumers in Croatia, thus they can feed and sell the electricity into the grid. Croatia applies specific tariffs to prosumers for the electricity injected into the grid, which are lower than the retail price of the electricity. Prosumers with capacity to feed-in their surplus electricity need to sign a contract by which the prosumer is entitled to be compensated for the electricity fed into the grid. The electricity suppliers are obliged to accept the surplus electricity generated by the priority electricity producers that are registered as such, have a connection to the grid and a meter for netting the electricity consumed and fed.

In Croatia, producers of electricity from RES are encouraged by the RES law (ARES) to generate electricity from RES through financial incentives such as premium tariffs (sustav poticanja tržišnom premijom) and guaranteed prices (sustav poticanja zajamčenom otkupnom cijenom) applicable only to production facilities with installed capacities of 30 kW or less. These incentives are mutually exclusive. Financing for these incentives comes partially from the funds collected as part of the fee for incentivising the production of electricity generated from RES. The fee is set at 0.035 kn/kWh.

To benefit from premium tariffs, prosumers must acquire the status of priority electricity producer provided that they are in a Registry, have a connection to the grid, have a meter enabling calculation of net electricity fed into de grid and meet all the requirements set out in the construction permit. Therefore, producers of electricity that are not connected to the grid are not eligible for premium tariffs. This premium tariff is set in the contract between the electricity producer/prosumer and the Croatian Energy

Market Operator (HROTE), which is concluded following a public tender that is published once a year. The premium tariff may be granted to numerous electricity producers. The supplier is required to calculate, once a month, the bill for the prosumer by deducting electricity fed into the grid from the electricity consumed from the grid. The priority electricity producer with generation capacity of up to 30kW has the right to the guaranteed purchase price provided a contract is concluded with HERA after being selected as best bidder in a public tender (Article 34 of the ARES).

3.2.3 CYPRUS[43]

Electricity from RES is promoted in Cyprus through subsidy combined with a net metering scheme. Furthermore, there is a transitional FiT scheme in place, thus, individual self-consumption is allowed (Group 1).

Grid development is a matter of central planning (Transmission Grid Development Plan 2017-2026 by the Cypriot TSO) and access of electricity from RES to the grid will be granted according to the principle of non-discrimination; with regards to the use of the grid, RES will be given priority.

There is number of policies aiming at promoting the development, installation and use of RES installations as well as specific RES H&C obligations. Net metering and self-consumption schemes were launched in 2013 and are supported to be extended until Cyprus will reach RES national targets for 2020.

The Ministry of Energy, Commerce, Industry and Tourism launched a Plan [44]for promoting PV installations entitled "Solar Energy for All". The Plan introduced a net-metering system in Cyprus:

Category A: PV systems with generating capacity up to 5 kW connected to the grid using the **Net-Metering** method for all consumers. Total Available Power: 20 MW

- Subcategory A1: for residential systems, which are used as permanent residences by vulnerable consumers (subsidy paid EUR 900/kW). Total Available Power: 1,2 MW.
- Subcategory A2: for residential systems, which are used as permanent residences by non-vulnerable consumers (without subsidy). Total Available Power: 8,8 MW.
- Subcategory A3: Systems for non-household consumers (without subsidy). Total Available Power: 10 MW. 2 MW additional are reserved for agricultural companies and fisheries and 1 MW to public educational institutions such as public schools and kindergartens.

[43] Cyprus Energy Angency, Dec 2015 newsletter; Cyprus PV market, Anthi Charalambous, Head of Energy & Environment Division, Cyprus Federation of Employers & Industrialists, December 2016

[44] For more information and application forms, interested parties may contact the www.cie.org.cy websites, www.cera.org.cy, www.mcit.gov.cy, www.eac.com.cy and local district offices of the Ministry of Energy, Trade, Industry and Tourism, the EAC and the Cyprus Energy Regulatory Authority

Category B: PV systems for **<u>self-production</u>** with capacity from 10 kW up to 2.000 kW each for commercial and industrial units. PV systems under this category are available for consumers with commercial or industrial electricity tariff (commercial and industrial buildings, public buildings, army buildings, schools, etc.) in order to produce electricity for their own use (self-production).

There is also an **<u>autonomous self-consumption</u>** (not connected to the grid), with maximum power 20 kW.

In the case of net-metering, the electricity offsetting (netting) can be carried out once per billing period (every two months or each month) for each calendar year by Electricity Authority of Cyprus (EAC) or by any other electricity supplier to which the consumer has contracted. Any surplus can be transferred in the next two months or next month while any deficits will be invoiced. The final account (measurement of February- March) of the calendar year will be the final settlement. Electricity surplus cannot be carried over from one calendar year to the next. In addition, electricity produced by PV installations for self-consumption purposes (industrial/ commercial units) shall not be fed into the grid, which means “0” injection.

<u>Procedure: For households and non-domestic consumers</u>

A Net-metering contract is signed between EAC-DSO and the applicant, who also pays a €250 fee (administrative costs). The contract has a duration of fifteen (15) and ten (10) years for households and non-domestic consumers respectively. EAC- DSO is responsible for controlling the PV plant within 25 days.

<u>Procedure: For industrial/ commercial units (autonomous electricity production)</u>

The DSO is responsible for controlling the connection of the PV plant to the distribution grid within thirty (30) days. Plant operators under storage category are eligible for installing storage facilities. For that reason, interested applicants should submit with their application all necessary information provided by the manufacturer i.e. the safety regulations as well as the contribution that the installation of storage facilities has in the whole system.

<u>Feed- In Tariff</u>: “Support Scheme for RES electricity production by plants that will be finally integrated in the competitive electricity market” introduces a transitional scheme, where RES plants can connect to the grid and receive an “RES price”. However, these RES plants will enter the competitive electricity market 12 months after the initiation of its operation This FiT applies to legal persons and private entities and is called “<u>transitional FiT</u>”.

Subsidy (As additional supporting measure): "Solar Energy for All" scheme aims at supporting the purchase and installation of PV until 3kW for vulnerable social groups that will operate under a net-metering scheme. The grant amounts to € 900 per kW (max. € 2,700 per installation). Addressed to all natural persons belonging to vulnerable social groups. In addition, recipients of the family allowance for single parents, with a family income less than €39,000 are also eligible. The obligated party is the state, represented by a committee of the Ministry of Energy, Commerce, Industry and Tourism (Administrative Committee of the Special Fund for RES and Energy Efficiency) as well as the EAC.

3.2.4 CZECH REPUBLIC

In the Czech Republic, self-consumption of electricity from PV is possible. Renewable energy is supported through either a guaranteed FiT or a green bonus paid on top of the market price. Plant operators are free to choose either option and swap it once every year. However, in August 2013, the Czech Parliament amended Act No. 165/2012 (Act No. 310/2013 Coll.), which de facto abolished the FiT scheme and green bonus and so from January 2014, the support for new RES plants generating electricity has been stopped.

The definition of prosumers is based on whether the surplus of energy generated by the micro source of up to 10kW is fully consumed or partially fed and sold back to the grid. The ability for prosumers to feed electricity into the grid was introduced in 2016, when it was recognised (by tax law) that the income from feeding the surplus of electricity from installations without license is not considered to be a business income. In terms of energy law, it is still not possible to feed the surplus to the grid, because there is no such definition of a "prosumer". Micro PV arrays up to 10 kW without a licence are considered a "customer" and as a customer, they cannot not arrange an agreement to sell the surplus. Moreover, prosumers should have zero reserved capacity, which is another condition (DSO) preventing prosumers from feeding the surplus to the grid.

The surplus of energy generated by the micro/small sources without a licence can be fed to the only if there is a contract on an annual discount regulating the contributions to the grid. If those contractual provisions exist, small PV sources of electricity up to 10kW may feed the surplus electricity to the grid. If the electricity fed to the grid could be sold, the price, which is not regulated must be negotiated with the distribution company. However, in practice, this is rarely used.

The residential prosumers must notify the authorities of a new PV installation. The majority have an energy tax applied on the basis of the energy consumed (energy tax is applied only on electricity purchased from the grid, self-consumption from PV is free from any taxes and fees from 2016)

There are close to none application fees for prosumers in terms of acquiring an authorization to operate a PV array, and when potential prosumers are submitting a request for a permit inside the framework of the "*Nova Zelena Usporam*" investment support program, they even receive a financial support for about 50% of the whole cost. This programme was launched by the Ministry of Environment; it is administered by the public environmental fund of the Czech Republic and will run until 2021. It aims to support the energy-saving reconstruction of houses and apartment buildings, the replacement of unsuitable sources of heating and the promotion of renewable energy.

Similarly, consumers in the Czech Republic generating energy from sources connected to the grid are obliged to pay a one-off payment in order to connect to the distribution system. According to Czech law, the DSO has a right to request payment in relation to the cost of connection, depending on the amount of requested reserved capacity. Prosumers generating energy from micro sources do not need to pay to access the grid, given that as one of the conditions for this type of installation is zero reserved capacity on the grid, thus zero (or, at least, negligible) input into the low voltage distribution system.

Since mid. 2017, the Czech Ministry of Industry and Trade is providing subsidies for the installation of a PV system combined with storage under the incentive program *storgaPodnikání a inovace pro konkurenceschopnost* (OPPIK). For solar-plus-storage, there is no limit on PV output, but for each kW of PV installed small businesses must install a 5 kW battery.

In terms of grid use, operators of renewable energy plants are not entitled to priority connection to the grid. The use and the expansion of the grid are subject to general legislation on energy. The grid operator is obliged to enter into connection agreements (only in case of prosumers). Plant operators are entitled against the grid operator to non-discriminatory use of the grid for the transmission or distribution of electricity from renewable sources.

3.2.5 DENMARK

In Denmark, electricity from renewable sources is mainly promoted through (1) a premium tariff and (2) net-metering.

- **Premium tariff.** The generation of electricity from renewable sources is promoted through a premium tariff system based on bonus payments. The operators of renewable energy plants usually receive a variable bonus, which is paid on top of the market price. The sum of the market price and the bonus shall not exceed a statutory maximum per kWh, which depends on the source of energy used and the date of connection of a given plant.

The Danish grid operator (Energinet.dk) may grant support for electricity produced in PV-installation. For projects where the decision on commitment for tariff was met on 01.01.2017 or later the total aid per project may not exceed an amount equivalent to 15 M€. Following installations are eligible for the support:

- Installations with an installed capacity of max. 6 kW per household and connected to self-consumption installation
- Common PV installations established on the roofs of buildings or integrated into buildings that are not built with the purpose of mounting solar cells:
- Common PV installations, which are not connected to self-consumption installation:

- **Net–Metering.** The metering system does not enable any remuneration to the residential prosumer, but provides for a compensation scheme between the excess of electricity generated and fed into the grid and the electricity purchased in other periods where the needs for electricity might be greater. Prosumers in Denmark, are able to sell electricity back to the national grid provided they have requested (and obtained) the net settlement to Energinet.dk. This leads to a compensation mechanism whereby the value of the energy fed back into the national grid is deducted from the cost of electricity taken from the grid by the prosumer. The excess energy not settled may also be sold and the price will be determined by agreement with a supplier based on the market price, which is dependent upon the time of sale and the current demand on the national grid. PV Plants must be connected to a collective grid and be listed in a key data register. Plant operators must apply to Energinet.dk for net-metering. The net-metering is calculated on **an hourly basis.** Energinet.dk determines whether the conditions for net-metering are met and which type of net-metering will apply.

  Eligible under following conditions:

  - For solar energy installations > 50 kW the plant has to be connected to a private supply system or the plant has to be located at the place of consumption.
  - For solar energy installations up to 50 kW the plant has to be connected to a private supply system.

  Electricity producers using all or part of the electricity produced for their own needs are totally or partly exempt from paying Public Service Obligation (PSO) on this electricity. The PSO is a charge levied to support renewable energy. It depends on each consumer's individual level of consumption. The surcharge for the support of renewable energy is part of the PSO tariff. The surcharges are determined by Energinet.dk four times a year. Which surcharge a plant owner is exempt from depends on the installed capacity of his plant.

- Solar energy installations up to 50 kW are exempt from the whole PSO tariff:
- Solar energy installations > 50 kW are exempt from the surcharge for the support of renewable energy

The owners of eligible PV plants are entitled to total or partial exemption from PSO (tariff).

For tenants who are not the owners of eligible plants, may be entitled to total or partial exemption from the PSO tariff for own consumption of electricity produced in a plant that uses only renewable energy sources if:

- the plant is 100% owned by the owner of the property,
- the owner of the property has made the plant available to the tenant for net metering and
- the tenant pays the electricity consumption directly to the grid company on an hourly basis.

3.2.6 FINLAND

Finnish solar energy policy[45]: The Finnish Government doesn't have solar energy targets or specific policies and solar PV is excluded from the current FiT system. The future supporting scheme will be based on auctioning, in which the solar PV seems not competitive with wind power at current prices[46].

In Finland the self-consumption of PV electricity and net-metering scheme are allowed. Solar electricity self-consumers are exempted from grid fees and electricity taxes up to 100 kVA system size or 800 MWh yearly production. Consumers that purchase some electricity from the grid can offset part of their power bill by feeding self-generated electricity back to the grid. Pricing and billing arrangements are freely determined by the distributors, so long as they comply with general principles of the Electricity Market Act. If installed capacity is less than 100kVA, the prosumer does not need to purchase a separate metering device.

Other supporting schemes are available, e.g. Investment grants available for municipalities and companies: 25% for PV and 20% for solar heat collectors (Housing sector and state properties are excluded) or the fact that single houses can get household tax deduction from solar system installation work (approx. 5-10% from the whole investment price) – doesn't apply to house co-operatives

Other interesting aspects of the energy policy in Finland is the lack of access priority for electricity produced from renewable energy sources, following the principle of non-discrimination.

---

[45] Source: FinSolar - Creating solar energy market growth in Finland, M.Sc.(Eng.) Karoliina Auvinen Aalto University

[46] Another reference comes from VTT: There is discussion on the necessity of residents in apartment buildings need to have their own meters and that the PV production cannot be balanced over the consumption of the housing cooperative as a whole for legislative/taxation reasons. There is some discussion on pilots of energy collectives related R&D in media. So, R&D support might be the best guess for PV support specifically for energy collectives.

3.2.7 GREECE

In Greece, self-consumption is allowed, and self-producer is defined by the Law 4001/2011 as a producer who generates power, mainly for their own use, and feeds any surplus into the transmission or distribution system. The law 3468/2006 enables energy compensation through the balance of the power generated from a self-producer's installation with the energy consumed in a different installation of the same self-producer if it is located in the same or adjacent spaces. The net metering scheme allows to net the electricity produced in small plants by self-producers with the energy consumed. Netting is however relevant only to the so-called "competitive" part of the bill, i.e. the energy part. With regard to grid costs and other imposed taxes, in most cases, the auto-producer pays the relevant taxes for the actual use of the grid they make (they are only exempted of most taxes for the part of energy they self-consume directly at their premises).

Recently, the Greek Ministry of the Environment and Energy has published a new Law on Energy Communities (Law 4513/2018). The new Law allows citizens, Local Authorities, as well as private and public law entities to participate, in the production, distribution and supply of energy. According to the explanatory memorandum to the Law, the latter introduces the institutional framework for the establishment and operation of energy communities in Greece. Moreover, the Law aims to promote the social and solidarity-based economy and innovation in the energy sector, to deal with energy poverty, to develop energy sustainability, to produce, store, distribute and supply energy, to enhance energy self-sufficiency and security in island municipalities, and to improve energy end-use efficiency at local and regional level.

Furthermore, one second Law which concerns the virtual Net Metering for PV systems allows Local Authorities to aggregate their consumption from different buildings and to offset the aggregated consumption with their PV production.

So 2 schemes related with PVP4GRID project are in force in Greece:

Net metering. The amendment of Law No.3468/2006 introduces net metering for all RES for autonomous producers, while "virtual net metering" is applicable to PV and small wind power plants only in certain cases. Furthermore, a similar PV (virtual) net metering scheme was introduced in 2017. PV plants connected to the grid are eligible.

- For the interconnected system: PV plants <20kW or 50% of the agreed capacity consumption (PV Capacity ≤0.5 x Sum of the agreed power consumption (kVA). For non-profit legal person this could reach up to 100%.

- For non-interconnected islands connected to low voltage distribution network: PV plants <10kW or 50% of the agreed capacity consumption (PV Capacity ≤0.5 x Sum of the agreed power consumption (kVA). For non-profit legal person this could reach up to 100%.
- Island of Crete PV plants: <20kW or 50% of the agreed capacity consumption (PV Capacity ≤0.5 x Sum of the agreed power consumption (kVA). For non-profit legal person this could reach up to 100%.

Max. capacity limits for each PV plant are defined:

- Interconnected system: 500kWp (this limit has been decided to increase to 1 MWp in H2-2018)
- Non-interconnected islands: 20kWp (50kWp for non-profit legal person)
- Island of Crete: 100kWp (300kWp for non-profit legal person).

Net metering process follows a 3-years cycle. Each time the electricity retailer issues an electricity bill, the electricity fed into grid and the electricity consumed has to be measured. If the difference is positive, meaning that more electricity is produced and fed into the grid than consumed, this surplus is credited to the next electricity bill. However, any surpluses after the end of the year will not be disbursed by the electricity retailer to the self-producing electricity consumer and will be annulled. If the difference is negative, i.e. more electricity was consumed than produced, and then the plant/ installation operator is obliged to pay the difference.

The **new PV (virtual) net metering (not considered in our PVP4GRID project),** scheme follows an identical process. It also follows a 3-year cycle, while there is a liquidation procedure, when the PV plant operator switches to another electricity retailer. It should be noted that the new PV (virtual) net metering scheme foresees how the surplus of electricity is introduced as an accounting record in the "Special Account for RES and CHP".

The new scheme allows farmers and specific legal entities that undertake work of public value (e.g. schools, universities, hospitals, city and regional councils, etc.) to install solar PV systems far from the point(s) of electricity consumption.

An example is the 10 kW PV system installed recently at the rooftop of a school in the Northern city of Thessaloniki. Power generated via this installation will be fed in the distribution grid. However, the amount of electricity injected into the grid will be claimed by a hostel for women and children who are victims of violence, managed by Thessaloniki's city council and located far from the school. The 10 kW PV installation in Thessaloniki was funded by Greenpeace Greece.

Feed-in tariff II (rooftop PV): The scheme supports electricity generation by roof-mounted PV installations of up to 10 kWp on the mainland and rooftop off-grid installations of up to 5 kWp, through a guaranteed feed-in tariff, currently 95€/MWh. The national energy supplier measures the electricity exported to the grid and sends electricity bills to the plant operators. If the FiT for the electricity produced exceeds plant operator's electricity charges, the national supplier shall pay the difference. If the tariff exceeds the installation operator's electricity bill, he will receive the exceeding amount. The scheme applies to private individuals, small enterprises and public entities, and it can be considered as a kind of *net billing* scheme. The feed-in-tariff is reduced by 5% every six months. Tariff is paid for 25 years from the moment of connection.

3.2.8 HUNGARY

The support system for electricity from RES has been modified in mid-2016 and has been partially replaced by the new Renewable Energy Support Scheme (METÁR) which came into force 1 January 2017. Depending on the size of electricity installation, different supporting mechanism applies. Electricity from RES is supported by a FiT for installations with a capacity of 50 kW-500 kW. For installations with a capacity of 0.5-1 MW, the market (‘green’) premium applies. Plants with a capacity >1 MW and generally all wind power plants are obliged to participate in a tendering procedure in order to receive the green premium. Household-sized power plants up to 50 kW can benefit from net metering. In general, subsidy programmes also promote the use of renewable energy sources in the electricity and heating sector. In 2017 those subsidy programmes are foremost realised within the framework of the Environment and Energy Efficiency Operational Programme (EEEOP) and the Economic Development and Innovation Programme (EDIOP) which offer non-repayable grants and favourable loans, inter alia in combination with the FiT

Next, a revision of schemes useful for PVP4GRID is presented.

- **Net Metering.** Household-sized power installations with a max. capacity of 50 kVA, connected to a low-voltage system, are eligible for net metering in case that the power plant connects to the low-voltage grid The electricity surplus injected to the grid is remunerated by the electricity supplier with the retail electricity price. Connection to the public grid is only possible with an operational approval. If the approval is given, the local electricity traders or the universal supplier (egyetemes szolgáltató) is obliged to feed the electricity into the grid. However, in most cases, the residential prosumers must notify the authorities, although household power plants do not need to pay a fee for connecting to the electricity grid.

  The payment of fix basic grid distribution charges and distribution capacity charges are due. Three situations can be distinguished:

1. The electricity consumption exceeds the electricity generation: the grid user pays for the balance of electricity consumption and electricity generation.
2. The electricity consumption equals the electricity generation: the grid user does not have to pay for any electricity consumed, but the fix basic grid distribution charges and the distribution capacity charges are due.
3. The electricity consumption is below the electricity generation: the grid user has to pay the fix basic grid distribution charges and the distribution capacity charges; the electricity trader pays the retail price for the excess electricity fed in-to the grid.

Procedure:

- The plant operator of household-sized power plants and the grid operator agree on the billing period, which can be <u>monthly, half-yearly or yearly</u>
- The plant operator is informed about the balance of electricity fed into the grid and the electricity consumption. The plant operator will be remunerated for the electricity surplus by the electricity trader or universal supplier with the retail electricity price.

Electricity traders and universal suppliers (egyetemes szolgáltató) are obliged to remunerate the plant operator with the retail electricity price for the electricity surplus fed into the grid.

- **Feed-in tariff.** In general, the FiT system remains unchanged for installations between 50 kW-500 kW which are not subject to tendering procedures. The transmission system operator (TSO) MAVIR Ltd. is legally obliged to purchase electricity from renewable sources, to sell it at the electricity stock market HUPX and pay a guaranteed price to plant operators. Furthermore, the TSO is financially responsible for grid balancing.
- **Green Premium I.** The Green Premium is granted for renewable electricity producing plants between 0.5 MW-1 MW. Those plants are not subject to tendering procedures. The tariff is set out by a Government Decree which is determined through a market reference price and an ‘administrative premium’. Albeit receiving the Green Premium (I+II), plant operators are still obliged to sell the generated electricity on the electricity stock market HUPX. Furthermore, plant operators are financially responsible for grid balancing.
- **Green Premium II (Tender).** Plants with a capacity higher than 1 MW and generally all wind power plants are subject to obligatory tendering procedures. Basically, demonstration projects are excluded from the obligation to tender.

- **Subsidy Programmes.** Support for renewable energy may be provided through operational programmes under the main scheme of 'Széchenyi Plan 2020`, mainly EEEOP (Environment and Energy Efficiency Operative Programme), EDIOP (Economic Development Investment Operational Programme), TOP (Territorial and Settlement Operational Programme), CCHOP (Competitive Central Hungary Operational Programme) and RDOP (Rural Development Operational Programme). In certain cases, FiT can be combined with the favourable loans or investment grants within the subsidy programmes.

3.2.9 POLAND

Poland, uses specifically the term "prosumer" in their legal and regulatory framework. The definition of prosumers in Poland, as adopted in 2016, under the amendment to the RES law, covers the final recipients of electric energy on the basis of a comprehensive agreement, who produce electric energy only from RES in a micro-installation in order to use it for their own purposes and are not associated with their business activity. So 2 important features for the definition: <u>micro-generation and not related to business activity</u>. A micro-installation is a RES installation with a total installed capacity of not more than 40kW connected to the grid of rated voltage of less than 110 kV.

The net-metering support system, for prosumers was adopted by the parliament in July 2016. In accordance with the system, electric energy placed in the grid by prosumers is annually compared with energy taken from the grid in a proportion of 1 to 0.7 for the systems above 10kW, and in a proportion of 1 to 0.8 for systems below 10kW. This means that for 1kW produced and not consumed by a micro installation above 10kW, the prosumer would get 0.7 kW from the grid. It addresses to Individual persons, public institutions, enterprises. The prosumer signs a complex agreement with the energy seller. The seller calculates the difference between the produced and consumed energy. The Competent authority is Energy Regulatory Office (URE). The costs of the subsidy scheme are borne by the final consumers of electricity and the costs of the distribution mechanism are transferred to the consumers through the price of electricity.

Installations with total installed capacity lower than 40 kW or free-standing PV modules are exempt from the building permit. In those cases, the prosumer only needs to notify public authorities about the installation. However, the setting up of micro installations needs to be carried out by qualified and certified experts who are subject to inspection, and can control whether the installation requires authorisation and complies with the standards for energy production. Although an energy permit or payment prior to the start of operations however is not needed, in most cases, the residential prosumers must notify the authorities.

There are no connection fees for the prosumer applying for the opening of a micro-installation. The costs are covered by the grid or network operator. Network costs are determined by the connection agreement between the investor of a micro-installation and the grid operator.

According to the RES Law in Poland, the surplus of electric energy fed by the prosumer to the grid as compared to the energy taken by the prosumer from the grid shall not be considered as an income in the meaning of the income tax law for legal persons. This means that the energy surplus generated by the prosumers is not subject to income tax.

The RES Law sets out specific tax provisions applicable to prosumers who are exempt from the VAT and income tax. The Law establishes that the activity carried out by a prosumer shall not be considered to be an economic activity nor as a provision of services or selling in the meaning of the VAT Law and, therefore, prosumers are exempted from the VAT[47].

Furthermore, electricity from renewable sources is supported through a tax relief as well as loan and subsidy schemes from the National Fund for Environmental Protection and Water Management. Regional funds are also available to support RE sources.

3.2.10 TURKEY

Turkish Electricity Market Law, (Law No 6446, March 2013) and the License Regulation updates (November 2013) state the requirement of a license to be obtained from the Energy Market Regulatory Authority in order to generate electricity in the Turkish Electricity Market.

The projects with installed capacities under 1 MW do not require a license (called unlicensed) to connect to the grid. The power consumer, operator and investor cannot be different entities in this kind of projects. All unlicensed PV projects must be approved by the Turkish Electricity Distribution Company (TEDAS). For grid connection, projects under 1 MW apply to the local DSOs and pay grid usage fees to the DSO for electricity fed into or received from the grid once they can connect.

The privilege of unlicensed projects aims to enhance electricity generation for meeting own energy demands (self-consumption) therefore to be eligible for the under 1 MW regulation, companies need to show a consumption point. In theory a system can be a maximum of 30 times the power demand of the consumer. Therefore, in theory demand of 33kW would allow you to install a 1MWp installation. However, the regulation does not specify any minimums regarding the consumption point.

[47] However the Polish government has proposed an amendment with VAT, it is in the Parliament and it is difficult to forecast what will the outcome be.

The most important driver in the industry is the FiT placed by the government. The support scheme for PV plants has the highest tariff at 0.133 USD per kWh injected to the grid, guaranteed for 10 years. Any plant to benefit from the active FiT needs to connect to the grid before the end of 2020 by law. No segment differentiation is defined yet by law, meaning regardless of the size of the capacity all PV installations connected to the grid receive the same FiT. On the other hand, reduced energy prices make PV use for self-consumption less profitable. Relatively the electricity price in Turkey is not high and for industrial and agricultural facilities it is even lower. Apart from the FiT, several other support mechanisms are in practice for enhancing renewable energy investment nationwide. Turkish Transmission Company, TEIAS and the distribution companies give priority to the connection of renewable energy power plants. The distribution companies are also enforced to procure renewable power in up to 20% of its consumption in their supply to ineligible customers. RES power plants pay only 1% of the regular licensing fee and are exempt from the annual license fee for the first 8 years in operation. They are also bound to pay only 15% of the system usage fees for the first 5 years. The same reduction of 85% applies on fees related to transportation and transmission infrastructure investments as well.

Bilateral agreements are not subject to the consent of Energy Market Regulatory Authority (EMRA) under the current system. Therefore, licensed companies can enter into PPAs between themselves or with third parties. These agreements do not put a limit to the pricing, sales condition and/or agreement periods therefore the convenience of the agreements is very much supportable.

Examples of application segments in Turkey, valid for PVP4GRID are: 1) Residential Single Family; 2) Commercial Office Building and Factory; and 3) Industrial Parks and Universities. 2 business models are actively used: **Net-metering and Self-consumption**. The description of the Net-metering model is presented under Residential Single Family Segment. Self-consumption model is described under Commercial Office Building and Factory and under Industrial Parks and Universities.

Residential Single Family

The business model for self-consumption of Turkey in the residential segment for Single Family is Net metering. Currently for this segment no other business model is possible. The main barriers on investing in residential PV systems are listed below:

- Cash-flow difficulties due to huge amount of initial/advance investment payments,
- Lack of widen authorized sales and maintenance service availability, meaning EPCs are mainly focusing on 1 MW un-licenced market rather than micro market referring the range of 11kW to 50 kW.
- Un-matured micro green finance/loan products

- Legally rooftop of an apartment is a joint property (community property). To use some rooftops of a neighbourhood to build PV systems for an investor is nearly not possible since all flat owners should give permissions and should facilitate from the system. The application procedure for this option is not clear either.

The main driver for families to build a rooftop PV system is to make savings from electricity bill costs while creating additional income through selling the generated electricity during daylight. Residential PV based electric generation system is feeding the grid during the day. And at night families get the electricity from the grid. The difference between consumed and produced electricity is calculated and residential electricity generation is purchased based on FiT.

Because the initial investment costs are still high, families mainly prefer to use a bank loan for rooftop systems. Although very few in number, there are banks having green/eco loan options with considerably lower interest rates and longer tenor periods like 5 years. Self-funding is also used by middle or upper class families. Surplus electricity can only be purchased by electricity Distribution Company which is the grid operator and the electricity provider.

Commercial-Office Building and Factory

PV Systems are not likely common in commercial segment. Besides the high operational costs and limited loan options provided by banks, not accepting the project itself as collateral is one of the main financial barrier for this segment. Investors or project owners have to provide extra collateral which is not easy in most cases.

The motivation for PV systems to be installed in commercial / office building is similar to that in the residential sector. Additionally, in Turkey PPA business model where generally the investor, operator and power consumer are completely different parties is not legally allowed yet for unlicensed projects under 1MW. Here the agreement is done with DSO and purchase price is the FiT. Debt loan is used with 15-20% equity share. EPC companies are building up the system and provide O&M services. For commercial segment Regional Development Agencies are also an option to receive a grant.

Industrial Parks and Universities (Group 3)

The projects over 1MW are obliged to attend a tender to get a licence. OIZ (Organized Industrial Zones) are legally recognised as free-electricity producers with the Renewable Energy Law. Under this law with the regulation called Support Mechanism for Renewable Energy (SMRE), the Organized Industrial Zones and Universities that generate their own electricity are exempted for the obligation to follow the licenced procedure for over 1 MW investments. If the institutions decide to sell their electricity to third parties, they have to apply for the licence. The “less than 1 MW” producers can sell the electricity (net-metering) only as a service fee. The existing legislation does not allow them to invoice the electricity itself.

OIZs can build up PV solar capacity with more than 1 MW without license legislation duties (i.e. un-licensed) and should consume all electricity for their member companies. If in case the generated energy exceeds the need of the OIZ and if OIZ decides to feed the grid, in this condition OIZ should apply for license process to be energy seller. This procedure is also challenging and expensive.

All OIZs of Turkey enjoy very low electricity prices which results in the unprofitability of solar investments most of the time. For such situations OIZs try to utilize its own power through the companies within the OIZ and generate income for the whole zone rather than buying electricity from the grid. OIZs are generating their own electricity to sell it to their members with 6-8 USD cent/kWh. The return period of this kind of investment increases to 12-15 years rather than 7-10 years. Since they have produced their own energy or supplied electricity from the grid with lower prices due to bulk purchasing power, such a new expensive investment is not so attractive at the beginning.

The education segment environment and business model is exactly the same with industrial parks. Both universities and organized zones are exempted from the licensing procedures and they are allowed to act like Distribution Companies. Up to this date no any university or organized industrial zone has such an application. All PV systems installed in universities or industrial parks are for self-consumption only. For this reason, education segment business model can be considered as same with industrial segment

Case: Gebze Guzeller Organized Industrial Park, located in Kocaeli province which is the neighbour province of Istanbul. The OIZ is placed in Marmara Region which is the most concentrated and most active industrial region in Turkey. The ground-mounted solar plant with 500kW capacity built for self-consumption. The predicted annual generation is 640.000 kWh and the annual performance is expected to be 1271 kWh/kWp.

For source of funding loan can be taken by banks, grants can be received by Regional Development Agencies and/or equity share can be also used.

3.2.11 UNITED KINGDOM

In UK self-consumption and injection of PV electricity in the grid are permitted. Under the **FiT** scheme, accredited producers whose plants have a capacity of less than 5 MW can sell their electricity at fixed tariff rates established by the Gas and Electricity Market Authority (Ofgem). PV installations are eligible. The FiT scheme was introduced in 2010, offering a fixed payment for 20 to 25 years to households generating electricity from microgeneration installations[48] for every unit of energy they generate and feed into the grid. The tariffs depend on the technology and whether the household is an individual or a community. The FIT rates change in line with inflation in accordance with the Retail Price Index (RPI).

The UK FiT has two components that have influence in the consumption habits: (1) a 'generation rate', which is a payment for each kWh generated by the PV (regardless of whether it is exported or used within the home), and (2) an 'export rate', which is a payment for each kWh exported to the grid. Since its inception in April 2010, the UK government has progressively lowered the generation rate to reflect PV's falling capital costs (although the export rate has risen very slightly). There are several elements of the FIT degression mechanism in the UK:

- **'Default degression'.** The frequency of degression differentiates depending on technologies. Source: http://www.fitariffs.co.uk/
- **'Contingent degression'. '**Contingent degression' allows the degression rates to be adjusted depending on the actual levels of deployment under the FITs.

Furthermore, the decline of the generation FiT rate has made maximizing self-consumption even more important—as the FiT historically played a significant role in determining solar investment payback, electricity bill savings (achieved through self-consumption) make up an increasing proportion of the overall returns to solar investment.

As FiT decrease and self-consumption plays a more important role in the economics of PV, potential PV adopters face greater uncertainty about the expected return on their investment, as this depends not only on estimating PV generation but also self-consumption.

In order to be eligible for the highest generation tariff rates, solar PV installation(s) or its/their extension(s) with a total installed capacity up to 250 kW need to to demonstrate that the building to which the solar PV is attached to has achieved an Energy Performance Certificate (EPC) rating of Level D or above. Installations which do not meet this requirement are eligible for a lower (L) tariff rate. To receive higher generation rate, non-domestic solar PV community energy and school installations with declared net capacity up to 250kW have to demonstrate minimum energy efficiency level G and above.

In regards to smaller PV systems rated up to 3.68kW (16A) per phase at a single premise, the prosumer does not need to contact the Distributor Network Operator (DNO) prior to commissioning. The installer

[48] In the UK, microgeneration includes the generation of electricity of up to 50kW, so for PV instalations of less than 50 kW, in order to be accredited, will take part in the Microgeneration Certification Scheme (MCS), an independent scheme that certifies microgeneration products of less than 50 kW and installers in accordance with consistent standards. The Energy Tax Act establishes that the energy tax does not apply to installations with generation capacity below 50 kW or to a legal person who owns an installation with generation capacity of less than 50kW that has not been fed into the grid.

will need to carry out two key tasks on the prosumer's behalf in order to ensure connection to the grid: the generator must inform the DNO about the installation or any work to be undertaken and then submit an Installation Commissioning Confirmation Form within 28 days of commissioning the installation. For bigger systems above 4kW, the installer will need to get permission from the DNO in order to connect to the grid.

Network costs are variable in UK. There are on-going charges which cover the cost of reinforcement and O&M costs (system charges). These costs are not uniform; they depend on the location and vary depending upon capacity available on the network. These charges have been levied by DNOs since 2005.

The UK applies a VAT reduction on energy saving items. The good and services tax is reduced from 17.5% to 5% for certain goods and services including microgeneration systems. In addition, residential prosumers are exempt from income tax on revenue from electricity sale.

Finally, regarding network aspects, RES Electricity is connected to the grid under the principle of non-discrimination, RES-E plant operators are granted the right to access the grid and grid operators are obliged to expand the grid if this is necessary to accept all generated RES-E from a plant.

3.3 International models

3.3.1 AUSTRALIA

Australia is divided into 8 states, leading to 8 different legal frameworks for the analysis of PVP concepts. Next, information on the local use, collective use of self-consumption is depicted, considering the particularities of the different states. The amount of consulted references is very wide, so the complete set is listed in Annex III. For the Australia case, very interesting examples have been found. They might not be directly linked to our PVP concepts, but they have been anyhow considered as best practices and examples for the future evolution of PVP concepts in Europe. One notorious example is the 50,000 home solar and battery systems across South Australia, which is the world's largest Virtual Power Plant planned so far. A summary of examples for Australia are also included in Annex III.

Local use of self-consumption – Group 1

PV support in Australia is **decentralised**, i.e. there is no national scheme but only state-run (Solar Choice, 2017). This means that there are 8 states, and consequently 8 different PV support schemes: Victoria, South Australia, ACT & Canberra, Tasmania, Northern Territory, Western Australia, Queensland, New South Wales. With regard to the development of PV support schemes, there was a common pattern for the Australian 8 states. At the beginning, generous FiT on 'gross metering' were provided to consumers (Solar Bonus Scheme; State of Queensland, 2018a), yet most of them ended by around 2011 - 2012. Currently, the dominant doctrine for PV support is a FiT on ‘net metering’ scheme, which is focused principally on self- consumption, where the excess electricity is fed-into the grid, receiving a remuneration that is far below the electricity price (Synergy, 2017).

In general, PV support in Australia is very **deregulated**. This means that there are basically two distinct parties concerning PV (i.e. the “qualifying customer” and the licensee) and in most cases, the distribution network operator and the regulator play only a marginal role. Taking the example of the state of Victoria, the parties are the following (Electricity Industry Act 2000):

"Qualifying customer" (consumer), of a relevant licensee or small retail licensee, means a person who:

- purchases electricity from that relevant licensee or small retail licensee;
- and engages in the generation of electricity

And "relevant licensee" (electricity supplier) means a person that:

- holds a licence to sell electricity; and
- sells electricity to more than 5000 customers;

"Small retail licensee" (electricity supplier) means a person that:

- holds a licence to sell electricity; and sells electricity to 5000 or less customers (e.g. multi-family houses, commercial buildings, business parks)

Net metering in Australia only refers to the fact that the solar energy exported to the grid (as a portion of the solar energy produced by the system) is measured by the meter, while FiT refers to the rate that a solar system owner is paid for the solar energy they export to the grid – whether that rate is subsidised or (in most cases now) not subsidised.

Under the previous scheme, all of the customer’s solar energy was sell into the grid receiving a generous rate for the sell (gross FiT) and the new scheme is more deemed for self-consumption exporting only the excess- to the grid, as rates are much lower than previously (net FiT) (Solar choice, 2017). The purchase price for the excess of electricity depends on each count, and even on the period of the day.

Table 10. Overview of the current situation on PV support in all Australian states		
State	**Support Scheme**	**Legal Source**
Victoria	"Transitional Feed-in Tariff" (TFIT)	Electricity Industry Act 2000 [Vic]
South Australia	retailer feed-in tariff	Electricity Act 1996 [SA]
ACT & Canberra	Retailer market offers (non-premium FiTs)	-
Tasmania	Regulated FiT Rate	Office of Tasmanian Economic Regulator, 2017; Electricity Supply Industry Act 1995
Northern Territory	retailer feed-in tariff	-
Western Australia	Renewable Energy Buyback Scheme (REBS)	Electricity Industry Act 2004 [WA]
Queensland	retailer feed-in tariff/ regional feed-in tariff	Queensland Government, 2018a; 2018b; Queensland Competition Authority, 2017
New South Wales	retailer feed-in tariff(benchmark)	Independent Pricing and Regulatory Tribunal- IPART, 2017.

The impact of self-consumption in economics of Australia network is very limited, due to the fact that PV schemes for individuals are mostly designed for self-consumption, while the electricity purchase rate for excess electricity is offered at a diminished price. In some cases, this can be regarded as a disincentive.

In the self-consumption-net metering scheme, there are basically two technical components. The first one is the installation of net meters. There are different types of meters being implemented, depending on where households are located. It is possible to choose between a simple accumulation meter, a simple interval meter, or a digital smart meter (Solar Choice, 2017). Apart from that, energy storage is also gaining in importance.

For example, in South Australia, if a PV plant owner receives AUS 44c per kWh as distributor FiT, the previous more generous FiT scheme, the support will cease if an energy storage device (e.g. battery storage) or another grid-connected renewable generator is installed. This is because it is not possible to distinguish between the electricity fed into the grid from the solar PV system and a storage device or generator (South Australia Government, 2018).

In ACT & Canberra, under the “Next Generation Energy Storage Grants”, $ 3 million has been awarded in the latest grant round (Round 3) in 2018. The installers operating under the program are able to offer support for battery storage. More specifically, this scheme provides subsidised battery storage systems to Canberra’s homes. Up to 5,000 battery storage systems are expected to be installed and the level of subsidy depends on the size of the battery. In average, residential customers receive AUS $4,000 in support (ACT Smart, 2018).

Australia’s Electricity Network Transformation Roadmap (CSIRO) has also identified the drivers for boosting battery storage in Australia (CSIRO, 2017). By early 2020’s, the major driver is expected to be the advantage of allowing rooftop solar owners to reduce the amount of solar output that has to be exported because demand on site is too low when the energy is available. As explained above state subsidised export prices for rooftop solar have come to an end. The prices received for exports without those subsidies are well below the value of that electricity if the owner were able to use it on site. Storage is viewed as a viable investment, if there is a ‘cost gap’ that is lower than the value of exploiting this ‘gap’ in solar export and grid import prices. This is expected to occur in the next years with the fall of battery prices (CSIRO, 2017).

Between the mid-2020s and 2050s, the driver for battery storage installation under the Roadmap is expected to change. Batteries will be doing more than shifting rooftop solar output, as more customers will receive a service that includes a demand based tariff. In addition, they will be used to avoid network critical peak days (5 days per year) and daily peak pricing periods (CSIRO, 2017).

Furthermore due to the emergence of energy storage facilities, there is an upwards trend towards “behind the meter” applications (Langham, 2016).

Collective self-consumption - Groups 2 and 3

There seems to be no regulatory framework concerning the local collective use via public grid. This segment is still on an experiment level. However, it should be noted that according to Australia’s Electricity Network Transformation Roadmap (CSIRO, 2017), installed solar PV capacity is expected to increase by more than 400% (20GW) by 2026 as well as 32GWh of battery storage on the network. Until 2050, the amount of solar PV capacity would increase almost three-fold to 72GW with a corresponding increase in battery storage to 87GWh.

As for the private use of the grid, current regulations make the transition from conventional grid supply arrangements to standalone power systems or micro-grids very difficult to enact. This is merely applied to isolated and regional cases and not for urban centres. It is expected that up to 10% of customers are likely to leave the grid by 2050, increasing average bills to other customers by AUS $132 per year.

Nevertheless, there will be also an opposite trend, as 1 million customers will stay on-grid and export their excess electricity to the grid, resulting in cost reductions of around AUS $ 1 billion (CSIRO, 2017).

At district power level, the situation is similar regarding the regulation, so there seems to be no framework concerning the realisation of public / private grids in the district power model. It is worth mentioning that in 2017, Western Power submitted a rule change request to the Australian Energy Market Commission which sought to remove certain barriers to distributors deploying alternative technologies and methods of providing distribution services, such as transitioning customers to off-grid supply. The Commission had finally not ended in a final rule on alternatives to grid-supplied network services, as this could create radical changes in the definitions distribution system (Australian Energy Market Commission, 2017).

3.3.2 USA

The analysis in the case of US is similar to the one for Australia. There is a federal regulation, common for all the states which is presented in Annex IV, and then state-based regulation. So federal framework + 5 states have been analysed, the most interesting from the PVP4GRID perspective: California, Utah, Colorado, Arizona and Nevada. Consequently, information on the local use, collective use of self-consumption is developed, considering the particularities of the different states. As in the case of Australia, for the clarity of the report, 2 additional annexes have been proposed: Annex V for the US references and Annex VI for the selected examples.

Local use of self-consumption – Group 1

3.3.2.1 California

The California Public Utilities Commission (CPUC), which competences are derived from the California State Constitution (Article XII, Section 3), regulates investor-owned electric and natural gas utilities operating in California. Through its oversight over utilities, the CPUC has played a key role in making California a national and international leader on a number of energy-related initiatives designed to benefit consumers, the environment, and the economy.

Self-Generation Incentive Programme (SGIP) is one of the longest-running and most successful incentive programmes that originally aimed to reduce peak-load energy consumption as a reaction to the energy crisis of 2001. However, it changed dramatically and it no longer supports solar PV technologies, which were supported by the new California Solar Initiative (CSI) programme (2006).

Net Energy Metering (NEM)

Incentives in the form of Net Energy Metering (NEM) is '*a special billing arrangement that provides financial credit to customers with solar PV systems for the full retail value of the electricity their system generates'*. Prosumers who generate energy ('customer-generators') in the amount exceeding their electricity needs receive financial credit for any surplus energy fed back to their utility. According to Pacific Power (2017), as one of the distribution system operators (DSO) in California, NEM is available to '*a residential, small commercial, commercial, industrial, or agricultural customer that owns and operates a renewable electricity generation facility […] with capacity of not more than one megawatt that is located on the customer's owned, leased, or rented premises, is interconnected and operates in parallel with the Utility's transmission and distribution facilities, and is intended primarily to offset part or all of the consumer's own electrical requirements*'. The NEM is available within the entire territory served in California by the respective utility.

The system 'allows to offset electricity consumption at one time with excess generation at another time. Consumption and generation of electricity are valued at the same rate, meaning that electricity generated by prosumer and electricity consumed that is provided by the utility is valued and billed at the same rate (1:1 ratio per kW of electricity) (CalCom Solar, 2018). Therefore, a prosumer can offset his own electrical needs partially or even fully. Prosumers are billed at the end of a 12-month period following the date of the utility's final interconnection of an eligible residential or small commercial customer-generator (Pacific Power 2017, p. 1). Still, the utility shall permit the customer to pay monthly for net energy delivered/consumed, too.

According to the California Public Utilities Commission (PCUC, 2018), NEM represents an important element of the policy framework that support direct customer investment in grid-tied distributed renewable energy generation. Prosumers who utilise NEM are still eligible for any other rebate, incentive, or credit provided by an electric utility (PCUC, 2018). According to the data of the PCUC (2018), 'more than 90% of all megawatts (MW) of customer-sited solar capacity interconnected to the grid in the three large investor-owned (IOU) territories (PG&E, SCE, and SDG&E) in California are on NEM tariffs'. The NEM programme is based on the Commission's Decision (D.) 16-01-044 from January 28, 2016.

Transition from NEM 1 to NEM 2

The cap of 2,409 MW for the original NEM (NEM1 or NEM 1.0 or Former NEM) programme has been already reached and therefore, new prosumers who would like to participate at the NEM programme have to take service under the new NEM2 (also referred to as NEM 2.0). Prosumers still receive retail bill credits per kWh for their solar electricity that are equal to the value of kWh of utility electricity. The deadline to move from NEM1 to NEM2 was set for the 1 July 2017 by the Commission. Please see the table[49] extracted from the official website of CPUC (2018) to see the main differences between former NEM (NEM1) programme and current one (NEM2):

	Former NEM	Current NEM
Interconnection fee	None	$75-$145
Non-bypassable charges	Yes, based on "netted out" quantity of energy consumed over the course of a year	Yes, based on "netted out" quantity of energy consumed in each metered interval (metered interval is 1 hr for residential customers and 15 min for nonresidential customers)
Time-of-use rate	Not required	Required
Installation size limit	1 MW	No limit; can only be sized up to customer's annual load
IOU program cap	5% of IOU's aggregate peak demand	No cap

Under the new NEM2 programme the maximum size of generator is no longer limited to 1 MW, and prosumer's generator is limited only by his own annual load.

The utility determines whether a prosumer is either a net energy consumer or a net energy generator as Net Energy Metering technology measures the difference between consumed and generated electricity by prosumer's own PV system. If a prosumer is considered to be net energy generator over the respective billing period, 'the net kilowatts generated are valued at the same price per kilowatt as the utility would charge for the baseline quantity of electricity during that billing period, and if the number of kWh generated exceeds the baseline quantity, the excess shall be valued at the same price per kWh as the Utility would charge for electricity over the baseline quantity during that billing period' (Pacific Power, 2017, p. 1). On the other hand, if a prosumer is considered to be a net energy consumer, his net monthly consumption of electricity is calculated according to the terms of contract or tariff to which the same customer would be assigned to if the consumer did not use an eligible RES.

Interconnection fees, Time-of-Use (ToU) rate and general expenses for devices

NEM2 requires using Time-of-Use (ToU) rate and a prosumer has to pay an interconnection fee. Yet, the new programme has banned many fixed charges for residential customers, including demand charges, grid access charges, installed capacity fees, and standby fees (charges), except for generators larger than 1 MW which are obliged to pay to apply, and to bear all interconnection costs.

[49] **Source:** California Public Utilities Commission. *Key differences between the two tariffs*. Available at: http://www.cpuc.ca.gov/General.aspx?id=3800.

The amount of interconnection fees differs from utility to utility. If a residential prosumer or small commercial system owner connects to grid a self-generating facility under the NEM2 programme with capacity under 1 MW, he is obliged to pay fees depending on the utility he is connected to. For example, PG&E prosumers must pay one-time fee of 145 USD for most residential systems, and SDG&E customers must pay charge of 132 USD. They must use the aforementioned ToU rate, and there are no fees for solar production that is immediately used. Additionally, they are obliged to pay approx. 2-3¢ for each kW consumed from the grid (the so-called Non-bypassable charges; NBCs), which are built into electric utility even if that electricity comes as an offset to extra solar production. Prosumers must cover all the expenses related to the usage of Net Metering System, e.g. '*all equipment necessary to meet applicable safety, power quality, and interconnection requirements'* established by the respective Acts (Pacific Power, 2017, p. 4).

It can be noted that utilities have developed guides, which are updated on an annual basis, so that prosumers can predict total costs of their systems (incl. standard interconnection fees and obligatory equipment prices). Please find them in the column on the right side.

Customer-generators taking service under tariffs employing Time-of-Use (ToU) that generate electricity (net kWh produced) should be valued for the same price as the utility would charge it, i.e. retail kWh sales during the same period. Time-of-Use (ToU) pricing schemes reflect the market balance between electricity supply and demand. In this case, ToU meters are capable of recording electricity flows throughout the day are used. As a result, utilities can charge different electricity rates at different times of the day, week respectively. On the basis of this scheme, prosumers are motivated to generate electricity in peak hours when supply is low and demand is high. As Eissler et al. (2017) add, new policies will likely aim in a similar direction and PV system with storage capabilities for load shifting could become the most profitable investments under these new policies.

Excluding smart ones (ToU) mentioned above, there are in general two types of electric meters that are used to measure electricity flows of a prosumer to/from the public electricity grid. These, known as single bidirectional meters. Yet, even though they are capable to measure electricity flows (however sometimes they cannot be installed due to billing purposes), they are incapable to record time of its usage. This category of meters may consist of the installations of two electric meters (Dual Metering); one to measure electricity going from the grid to the respective prosumer, and the other one to measure energy supply that stems from the prosumer's electricity generation to the grid. An additional meter to monitor the flow of electricity in each direction may be installed with the consent of the customer-generator. Moreover, if the existing prosumer's meter is not capable of monitoring the flow of electricity in two directions, he is responsible to cover all the expenses involved in purchasing and installing a meter that is able to measure electricity flow in both directions (Pacific Power, 2017).

Prosumers are obliged to install on customer’s side of the meter a safety disconnect switch, which should be accessible to the utility personnel so that PV system may be fully disconnected from the utility’s electric service in case it would jeopardise a safety operation conditions. According to Pacific Power (2018), there are these 6 typical steps which should be followed by any future prosumer (Net Metering Application Process Flow). These steps normally last 70 business days; 30 days are dedicated to application and approval, 30 days to installation and inspection, and the last 10 days to net meter installation, according to Pacific Power (2018).

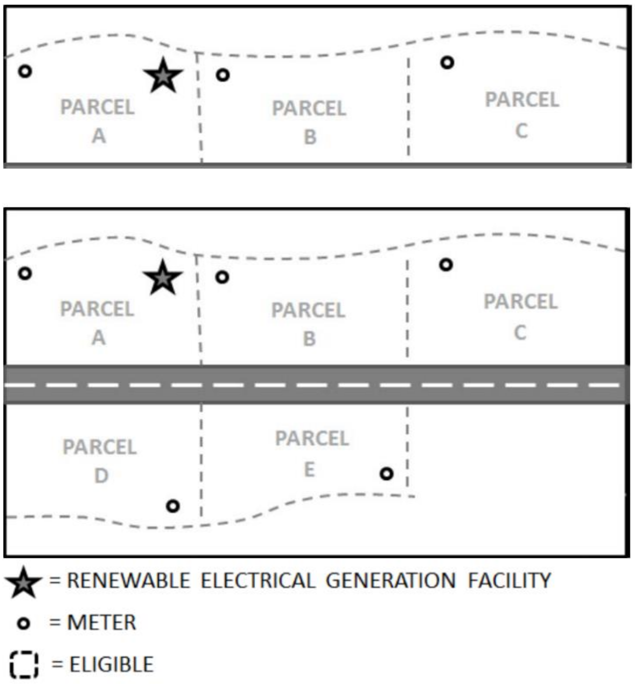
Sub-programs of NEM 2

The NEM2 programme comprises the following Net Energy Metering sub-programmes:

1. Standard NEM (NEMS; up to 30 kW),
2. All other NEM not covered by NEMS (NEMEXP),
3. Virtual NEM (VNEM),
4. NEM Aggregation (NEMA),
5. Multifamily Affordable Solar Housing Virtual NEM (NEMVMASH) and
6. NET for multiple generating facilities subject to different tariffs (NEMMT) (PGE, 2018).

The Net Energy Metering Aggregation or Aggregated Net Metering (ANM) (NEMA; also called Meter Aggregation or SB 594) is a smart meter technology that aggregates or combines electrical loads from multiple meters tied to a single, centralised renewable energy generator (e.g. solar panel system). According to Pacific Power (2017, p. 2), a special system of billing applies to NEMA. The eligibility criteria meet renewable electrical facilities, or a combination of those facilities, up to and including 1 MW of installed capacity. ‘*All accounts included in an Aggregation Arrangement are ineligible to receive net surplus compensation*’.

According to the Pacific Power (2017, p. 8), ‘*an eligible customer-generator with multiple meters (‘Aggregated Accounts’) may elect to aggregate the electrical load of the meters located on the property where the renewable energy generation facility (‘Generating Account’) is located and on all property adjacent or contiguous to the property on which the renewable energy generating facility is located, provided that all properties are solely owned, leased, or rented by the eligible customer-generator that elects to aggregate its electric load.*’ The parcels that are divided by a street, highway, or public thoroughfare, which are solely owned, leased or rented by one single prosumer are defined as contiguous. Please see the illustration[50] below.



Under this system, the electric meter of customer monitors the amount of electricity consumed by himself and also how much excess electricity is fed back into the electricity utility grid. Thus, in addition to monthly customer transmission, distribution, and meter service charges, customers are obliged to pay solely for the net electricity consumption exceeding his own PV system generation.

PV systems are connected to the public grid, and prosumers can either sell the generated electricity or consume it. If the generated electricity is fed into the grid, their electricity bill is reduced by running the electric meter backwards crediting the customer account at full retail rates, even to the electricity consumption equilibrium (zero-out of the prosumer's electricity bills). Moreover, if the prosumers generate more electricity than they consume in the respective twelve-month period following the date of the utility's final interconnection, they can receive a payment for this energy surplus (so-called Net Energy Metering Net Surplus Compensation Rate or NSC Rate; NCSR) under special utility tariffs.

---

[50] **Source:** Pacific Power. *Schedule No. NEM-35, Net Metering Service*. p. 9. Available at: https://www.pacificpower.net/content/dam/pacific_power/doc/About_Us/Rates_Regulation/California/Approved_Tariffs/Rate_Schedules/Net_Metering_Service.pdf

A prosumer can choose to receive the compensation either in a form of check or to apply for the compensation toward his future electricity charges, bills receptively for his energy surplus exported to the grid during the last 12 months (i.e. Renewable Energy Credits; REC).

This decision can be taken once every 12 months. However, in case of the first one, the compensation must be equal or higher than USD 25, otherwise a prosumer will receive just a credit to his bill. The second option is based on credit compensation in the future billing period of a prosumer. The NSC rate is in both cases determined by using a simple rolling average of the day-ahead "default load aggregation point" electricity prices from 7 a.m. to 5 p.m. corresponding to the customer's 12-month relevant period', therefore, on a 12-month rolling average of the market for energy (Pacific Power, 2011, p. 1). The decisive month for setting the NCSR Energy price for a prosumer (i.e. Net Surplus Generator) is a month when the relevant period (normally12 months) ended. These prices slightly differ depending on the respective utility and they reach approximately 0.29 USD per kWh (as of February 2018).

If the electricity needs of prosumers are not fully satisfied by their PV generation, additional power needs are covered by the utility from the electricity grid. As the State of California, California Energy Commission and California Public Utilities Commission (2018) note, 'switching between solar system's power and the utility grid power is instantaneous-customers never notice any interruption in the flow of power'.

If the electricity needs of consumer are governed by the NEM Agreement, an electricity meter of respective prosumer is read on a monthly basis informing customer about the net amount of electricity consumed or fed into the grid during that billing period. The Interconnection Agreement for Net Metering Service in California (up to 1000 kW) can be found on the following link: https://www.pacificpower.net/content/dam/pacific_power/doc/Efficiency_Environment/Net_Metering_Customer_Generation/CANetMeteringAgreement.pdf. Residential and small commercial customers can choose between monthly or annual period of billing to utility for their net electricity consumption.

Eligible criteria for NEM fulfil the retail customers of an electric utility in California who generate electricity using solar on their premises with a generating system's peak capacity output equal 1,000 kW or lower. Customers who are willing to participate on the NEM system are obliged to apply at the utility in order to receive its approval of system's connection to the utility. The ones who already operate its own PV systems should contact their respective electricity utility with a request for NEM so that their installations can join the scheme. All the state or utility-sponsored incentive programmes require to interconnect the installation to the utility.

Another example besides the aforementioned (NEM), is the Expanded Net Energy Metering (NEMEXP), which is intended for larger residential and commercial generators with installed capacity (generator size) that ranges from 30 kW to 1 MW.

Prosumers in California can also use the so-called Non-Export Interconnection that is available to all types of technologies (incl. PV) and sizes. According to PG&E (2018), in order to be eligible to apply an applicant has to fulfil one of the following criteria:

1. installation of reverse-power protection device,
2. installation of under-power protection device,
3. certification of non-islanding generating facility equipment as well as design of the interconnection has to ensure that the incidental power exports will be limited,
4. the gross nameplate rating of the generating facility will not exceed 50 percent of the minimum electrical load of the host customer's facility over the previous 12 months,
5. the generating facility completely offsets the facility load by being both (a) optimally sized to meet its peak demand with load following functionality on the generator controls, and (b) ensuring conditional (inadvertent) export of electric power from the generation facility to the distribution provider's distribution or transmission system, occurring no more frequently than twice in any 24-hour period. Also, the exports are greater than two seconds, but no more than 60 seconds. If this option is selected, option 1 or 2, above, will also be required.

Please note that the Non-export kind of Interconnection includes also interconnection study fees for applicants. Standby charges do not apply for PV generating systems under 1 MW.

The California Solar Initiative (CSI) offered cash back rebates for installing solar on homes or businesses until December 31, 2016 when the programme was closed. Among eligible customers belonged households, businesses, farms, schools, and government and non-profit originations that earned cash rebates for every installed watt of solar energy. The rebates for all the customers of PG&E, SDG&E and SCE have been exhausted.

California Solar Incentive Programme (CSI) was created by the California Public Utility Commission in 2011. The programme incentivised the initial cost of installing a photovoltaic system in California and in total 3.5 MW of PV systems were installed in California.

<u>Energy Storage Devices</u>

The CPUC has required the state’s three large investor-owned utilities to create 1.3 gigawatts of energy storage by 2024. However, energy storage facilities are in general not eligible for the NEM programme due to the fact that the energy stored may not be from RES, except they are pair with the Net Energy

Metering Multiple Tariff (NEMMT). NEMMT is a NEM program for a customer who operates a NEM-eligible generator in conjunction with a non-export or NEM fuel cell generator. This program allows a customer to interconnect these technologies with PG&E's electric grid at one service point, using one account, and still qualify for the special rate options that would be available if each technology were interconnected and billed separately.

In addition, California is encouraging prosumption by making advanced energy storage systems eligible for its **Self-Generation Incentive Program** rebates. In an even more innovative step, San Diego Gas & Electric, an investor-owned utility in southern California, is proposing a new rate structure that would reward the installation of behind-the-meter batteries. If owners of the batteries permit the utilities to draw on stored energy during pre-arranged peak periods, they will receive a lower, preferential rate for electricity.

3.3.2.2 Arizona

The Arizona Corporation Commission (AZCC) ensures safe, reliable, and affordable utility services in the state. The AZCC established the Renewable Energy Standard and Tariff (REST; or Renewable Portfolio Standard, RPS) in August, 2017. This measure identified short and long-term goals of the states, and it requires from regulated electric utilities to generate at least 15% from RES by 2025.

According to the legislature of Arizona (Senate Bill 1465), **Distributed Energy Generation System** '*means a device or system that is used to generate or store electricity that has a capacity, singly or in connection with other similar devices or systems, greater than one kilowatt that is primarily for on-site consumption, and this system does not include an electric generator that is intended for occasional use'*.

According to the NREL (2018), '*Arizona has a net-metering programme with no size limit but is specific to the customer's load. Arizona solar customers are eligible for an up-front incentive through the state's solar and wind tax credit. Large systems are eligible for additional production-based incentives. Several Arizona utilities also offer rebate programs that midscale solar projects are eligible for*.'

The **Net Metering (NM)** programme had been available to investor-owned utilities and electric cooperatives that generated electricity from RES (incl. PV) in Arizona since 2009. However, in December 2016, the AZCC decided to end NM programme in the state and to move to a new tariff system that significantly lowers export rates that the utilities pay to PV customers for excess energy. According to the conditions of new "**Net Billing**" programme, new customer-generators are credited at an avoided cost rate for energy exported to the grid. Although the ACC did not state any exact limit on system-size capacity, the eligible systems must be sized to not exceed 125% of the customer's total connection load. The new Net Billing programme does not apply to customers who were connected to the utilities before the decisive date, and these customers are eligible for further support that stems from the former Net Metering rules for a period of 20 years.

According to the **Arizona Law, individual homeowners' private property rights** to solar access are protected by dissolving any local covenant, restriction, or condition attached to a property deed that effectively prohibits the installation or use of solar energy. This applies to residential sector.

In February 2017, the ACC approved the Rate Plan of Tucson Electric Power (TEP) that as the first utility in the state introduced new pricing scheme and monthly fees for solar customers. New residential PV customers are charged by 2.05 USD per month and new small commercial customers 0.35 USD per month so that the installation costs of the second electric meter could be covered, according to the TEP. This is being applied just to the new customers who have not applied before the utilities' rate conclusion date. According to it, benefiting Residential Net Metering customers may remain on the tariff for 20 years from their initial connection date, they cannot increase the size of the solar generation system, and customers will be subjected to all rates and changes applicable to Residential Rate Tariff. On the other hand, this tariff can be transferred to a new owner of the property. Both directions of electricity flow should be registered by the meter. When the changes take effect on or before March 1, residential and small commercial customers will be able to choose new Time-of-Use (ToU), Peak Demand and Demand TOU plans as alternatives to a Basic plan. The TEP applies monthly billing period in case of NM for residential customers. Customers will need to have interval meter data available (minimum data collection of every half hour), and monthly administrative charge for data cost is set to 3.38 USD. It is estimated that the changes will add approx. 8.50 USD to the average customer's monthly bill. Additionally, a fixed monthly discount of at least 15 USD for low-income customers was also implemented. As Woofenden (2017) states, 'the simple policy of one-to-one credit of net metering is replaced with a scheme that includes no banking of energy credits, and a steadily-dropping compensation for any energy that homeowners send back to the grid'.

As mentioned before, Arizona provides **Residential Solar Energy Credit (Tax Credit)** for solar energy devices that are designed to provide heating, cooling, produce electrical power (incl. solar photovoltaic systems – collectors, batteries, inverters, solar system related wiring) and for other purposes.

Since 2006, there are Property Tax Exemptions that allow businesses and homeowners to exclude the added value of a RES (solar) system from the valuation of their property for taxation purposes. This measure represents a fiscal incentive for entities that own system intended for the production of solar energy for on-site consumption.

In Arizona, there is no state Interconnection Policy for distributed generation. Therefore, state's utilities, including SRP, Tucson Electric Power (TEP), and APS have developed their own interconnection agreements and procedures for distributed generation. For example, if a household is interested in the installation of PV system, TEP provides an electricity consumption report for 8 USD to identify its annual power usage.

The PV array size must be at least 1.2 kW for grid-tied systems.

According to the DSIRE (2017), owners of solar PV systems are required to obtain a Building Permit before their systems may be installed. Building permits are processed on the local level and awarded by counties and municipalities.

According to the Community Solar Hub (2018), there are four sold-out Community Solar Programmes at disposal to residential and commercial customers based in Arizona:

1. Bright Arizona Community Solar Programme (Nogales, 1,700,000 W);
2. SRP Community Solar Programme (Tempe, 20,000,000 W);
3. Bright Tucson Community Solar Programme (Tucson, 22,300,000 W) and
4. Sunwatts Sun Farm Programme (Marana, 22,700 W).

The prosumers of the largest electric utility in Arizona, Arizona Public Service Electric Company (APS), pay a fixed demand charge of 0.70 USD per kW and month

3.3.2.3 Utah

Interconnection and Net Metering Agreement states that any excess electricity generated from the solar PV system, not used by the building or residence, is placed onto the utility's electricity grid. This agreement is required to be in place before a PV system is turned on. The agreement is provided by utilities service providers.

The largest provider of electricity in Utah, Rocky Mountain Power (RMP), has recently changed its Net Metering (NM) programme, and only the applicants who submitted their application (NOT installed their solar systems) before November 15, 2017 are allowed to be grandfathered. This policy is based on the settlement agreement approved by the Public Service Commission of Utah on 29 September, 2017. As a result, the NM customers are eligible to benefit from the former NM programme until 2035.

Net metering was available for residential systems with a capacity up to 25 kW and non-residential systems with a capacity up to 2 MW, whether owned by the utility customer or a third party. These entities have the same 1:1 kWh credit for the energy they overproduce (excess kWh credits are applied to the customer's next bill at retail rate). From 15 November, 2017 (Cap Date) on, the so-called transition programme has been launched for customers with new generation systems. Prosumers are still credited if they produce more energy than they have used although the ratio 1:1 is not applicable anymore. According to GoSolar (2017), the remuneration for excess electricity has been only slightly reduced (to approx. 90%). Exported Customer-Generated Energy Credit Rates (incl. PV) for Residential Customers (anyone that receives electric service under Electric Service Schedules 1, 2 and 3) is set to 9.2¢ per kWh. According to RMP (2017), energy charges for electricity consumption, net of Exported Customer Generated Energy within each 15-minute interval, if any, shall be computed in accordance with a Customer’s applicable standard service tariff. However, there are still many municipalities that provide NM programme in Utah, e.g. customers of the City of St. George Services Department (SGESD). For instance, Murray City Power is currently in the process of revising its Pilot Net Metering programme (promoting installations up to 10 kW).

According to the Utah’s Rule R746-312-15 on Agg**regation of Meters for Net Metering Interconnection**, a public utility is obliged, upon request from an interconnection customer, to aggregate for billing purposes a meter to which the net metering facility is physically attached (the designated meter) with one or more meters (the additional meter). Meter aggregation is allowed for meters located on a customer’s adjacent properties, and also the following conditions have to be met: the additional meter is used to measure only electricity used for the interconnection customer's requirements; the designated meter and the additional meter are subject to the same rate schedule; and the designated meter and the additional meter are served by the same primary feeder (Rule R746-312-15). If in a monthly billing period the net metering facility supplies more electricity to the public utility than the energy usage recorded by the interconnection customer's designated meter, the utility will apply credits to the next monthly bill for the excess kilowatt-hours first to the designated meter, then to additional meters that are on the same rate schedule as the designated meter.

Municipal Utilities in Utah provide Net Metering (NM) programme, FiT; also known as buy-all, sell-all arrangement and Solar Export Credit for PV systems.

Grid Interconnection

The state’s interconnection rules are based on the Federal Energy Regulatory Commission’s (FERC) interconnection standards for small generators. According to the DSIRE (2016), Utah's rules for interconnection include provisions for three levels of interconnection for systems up to 20 MW, based on system complexity. Please see the summary of interconnection timelines of the largest and the only rate regulated public utility providing electricity service in Utah, Rocky Mountain Power (RMP), for systems under 25 kW below.

RMP has over 800,000 customers in Utah and serves about three fourths of the geographic area of the state and a larger percentage of the state's population (Utah Department of Commerce, 2018).

According to the Utah Department of Commerce (2018), Municipal Utilities are considered part of the local government entity and are not regulated by the Public Service Commission. Typically, rates are set by the municipal utility and approved by the city council.

Tax Credits, Tax Exemptions

According to the OED, residential energy PV systems are eligible to apply for Renewable Energy Systems Tax Credit (RESTC). This kind of tax credit expires in 2025 in Utah, and no tax credits for residential PV systems will be available. Please note that Tax Credit is not the same as Rebate. Rebate is money paid by the local utility company to help you purchase an energy efficient technology or a renewable energy system (incl. PV), and it is applied as an immediate benefit when installing PV system.

State credit of eligible applicant can be claimed via “Renewable Residential Energy Systems Credit, Code 21”. Tax Credit is non-refundable (claimed only against State of Utah) and it is used for the purpose of solar PV system purchase and installation, and to receive the form of cash as a Tax Credit is excluded. The Tax Credit used for commercial purposes is refundable. Solar PV system must be installed on a commercial unit, i.e. the one where the owner conducts business.

The City of St. George Services Department (SGESD) still provides NM programme, however, since 2014, application fee, bi-directional meter fee, and monthly solar reliability fee have been implemented. An application must be approved by the SGESD before a building permit will be issued. Installation of eligible PV system (up to the maximum of 250 kW) cannot begin until a building permit is issued.

Utah exempts the purchase or lease of equipment used to generate electricity from alternative resources (incl. solar) from the state sales tax, i.e. **Alternative Energy Sales Tax Exemption**. Eligible purchases or leases must be made for or by an alternative energy production facility on or after July 1, 2004, and before June 30, 2027. All leases must be made for at least seven years. The minimum capacity of electricity producing facility is set to 2 MW (or an expansion of the existing facility by at least 1 MW), therefore, this financial incentive does not apply to residential installations. The programme is administered by the Utah State Tax Commission.

There is no Property Tax Exemption for PV installations in Utah.

3.3.2.4 Nevada

The rights of RES customers who are residents of Nevada include: right to generate, consume and export renewable energy and reduce his or her use of electricity that is obtained from the grid, use technology to store energy at residence, he or she has to be allowed to connect RES systems (incl. battery storage) to grid, with the electricity meter on the customer's side that is provided by an electric utility. Customer should be connected to the grid in a timely manner, in accordance with utility's requirements, after providing written notice to the electric utility providing service in the service territory and installing a nomenclature plate on the electrical meter panel indicating a system that generates renewable energy or stores energy. The system must meet all applicable state and local safety and electrical code requirements. Among rights of Nevada's residents belong also right to obtain fair credit for energy exported to the grid (AB 405).

Since the beginning of the programme on 1 January 2003, owners of RES can earn Portfolio Energy Credits (PEC), which they can sell to utilities so that they can achieve the Nevada's RPS. Normally, one PEC is equal to one kWh of electricity generated. However, according to DSIRE (2016), each kWh generated by a PV system installed on the premises of a retail customer on or before December 31, 2015 will be credited with 2.4 PECs. This multiplier ended for new solar systems installed after that date (1 PEC = 1 kWh), but will continue for existing net metered solar PV systems. Customer-maintained distributed renewable energy systems receive a 0.05 adder for each kWh generated. The programme is administered by the Public Utility Commission (PUCN). Please note that owners of PV systems installed under the rebates provided by the Nevada Renewable Energy Incentive Programme are not eligible to participate.

Nevada Renewable Energy Incentive Programme (or Renewable Generations Rebate Programme) is a financial utility incentive programme that is based on the Nevada Legislature creating the Solar Energy Systems Incentive Programme, which requires public utilities to develop and administer programmes that offer rebates to customers who install grid-connected solar energy system on their property. The maximum system size of renewable energy sources is limited to 500 kW. However, incentive amounts differ depending on the size of system and sector.

In order to participate in the programme, users must be customers of the public utility Nevada Energy. Comparison of both aforementioned solar energy incentives can be found on the following link: http://www.solup.com/rebate-vs-pecs/.

Net Metering programme was changed on 22 December 2015 by the order of PUCN, which tripled the fixed charges that solar customers should have paid in the next years. Moreover, it dramatically reduced the credit that solar customers received for net excess generation by three-quarters (GreentechMedia, 2016). However, the most controversial step was to apply this changes also retroactively meaning that nearly 18,000 existing solar customers were affected.

In mid-2017, the Assembly voted to approve a Senate version of the bill (AB 405) regarding the rate structure applicable for RES up to 25 kW (typical size for rooftop solar systems installed at homes or by small businesses), and Net Metering programme (note: it is sometimes not considered to be metering due to the fact that it does not provide full retail rate compensation, Net-billing instead) not was restored in Nevada. It implements desired requests related to Net Metering, however, it applies just at a discounted compensation rate. This allows reimbursing excess electricity generated by solar at 95% of the retail electricity rate (Tier 1). According to the Legislature, the retail rate will be gradually decreasing based on the amount of electricity produced and signed up to the NM programme. If the limit of 80 MW of installed and signed up electricity for the programme will be reached, the Second Tier will decrease net metering rate to 88% of the retail rate. Subsequently, when the Second Tier limit of another 80 MW is reached, this rate will decrease again to 81% (Tier 3). The Last Tier (Tier 4) will apply 75% of the retail rate for customers who applied or signed up when Tier 3 is exhausted. This value will be fixed for all future customers. Please note that all these rates will apply to the respective installations for a period of 20 years, and the billing period for net metering must be a monthly period. Customers may carry forward excess electricity to subsequent billing periods indefinitely. Finally, according to the PUCN (2018), net metering customers will remain in the same customer class as non-net metering customers and cannot be charged any fee or charge that is different than that charged to non-net metering customers. Net metering customers will pay the same basic service charge and other fees as non-net metering customers. As of 12 March 2018, the installed capacity of Tier 1 is 12.535 MW (out of 80 MW). NV Energy customers can choose from Standard Rate Schedule or Time-of-Use (TOU) Schedule, which includes different rates depending on the time of day. More detailed information regarding Net Metering has not been found yet due to not inaccessible website of NV Energy (https://www.nvenergy.com/renewablesenvironment/solar/netmetering.cfm).

Tax Exemptions

Renewable Energy Systems (incl. PV) are exempted from Property Tax for all years following the system installation. The exemption is equal to 100% for the value of qualifying system, without any maximum limitation, and it is available for any property owner. This fiscal initiative is administered by the Nevada Department of Taxation.

Community solar programmes

According to the Nevada Legislature, there are no state-wide community solar policies or programmes. However, this information can be provided on an individual basis by local utilities and service providers. In June 2017, Nevada Governor vetoed bills on community solar programme (AB 392), which would have established a state-wide community solar programme with associated utility credits, as well as the increase of RPS to 40% by 2030 (AB 206).

References

- European Commission: DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources (recast), COM(2016) 767 final, 2016/0382 (COD), Brussels, 30.11.2016
- Fraunhofer IWES (2015): *The European Power System in 2030: Flexibility Challenges and Integration Benefits. An Analysis with a Focus on the Pentalateral Energy Forum Region.* Analysis on behalf of Agora Energiewende. 067/02-A-2015/EN, Rev. 1.01, Publication: June 2015
- IEC 60050-617:2009/AMD2:2017, Amendment 2 - International electrotechnical vocabulary - Part 617: Organization/Market of electricity, TC 1 Terminology, Publication Date 2017-12-15, https://webstore.iec.ch/publication/27437
- IEA (International Energy Agency): A Methodology for the Analysis of PV Self-Consumption Policies, Photovoltaic Power Systems Programme, Editors: Gaetan Masson (IEA PVPS), Jose Ignacio Briano & Maria Jesus Baez (CREARA), Report IEA-PVPS T1-28, 2016.
- Oberhuber Andreas, Daniel Denk: Zahlen, Daten, Fakten zu Wohnungspolitik und Wohnungswirtschaft in Österreich, Endbericht, Forschungsgesellschaft für Wohnen, Bauen und Planen, Im Auftrag des BMWFJ, Wien, April 2014.
- Study on “Residential Prosumers in the European Energy Union”. JUST/2015/CONS/FW/C006/0127, Framework Contract EAHC/2013/CP/04, Prepared by: GfK Belgium consortium, 2 May 2017.

Annex I Implementation examples – research studies in Netherlands

For a set of households and commercial buildings of which demand patterns were known, optimal PV orientations and tilt were derived for maximized self-consumption, see Figure A.1. The influence of the residential and commercial demand patterns is shown in the distribution. The left part of the violin plot provides the distribution of results obtained from residential systems. Results of commercial systems are shown at the right part of the violin. Note that PV system sizes, indicated on the horizontal-axis, are not equally dispersed. Demand data were normalized to an annual (2016) energy demand of 1 MWh. Mean values of the distributions are indicated by dotted lines. A relative PV system size of 1 kWp for each MWh annual energy demand is commonly installed in the Netherlands, since this will approximately fulfil the annual demand. PV systems sizes smaller than 1 kWp per MWh annual energy demand are installed when there are space (or monetary) limitations, and as a consequence the self-consumption is higher, while clearly self-sufficiency is lower. PV systems >1 kWp per MWh annual demand are normally not installed, but included in this analysis for a better understanding of the effect of demand patterns on PV orientation. The larger the ratio PV size and demand, the lower the self-consumption will be, and the higher the self-sufficiency will be.

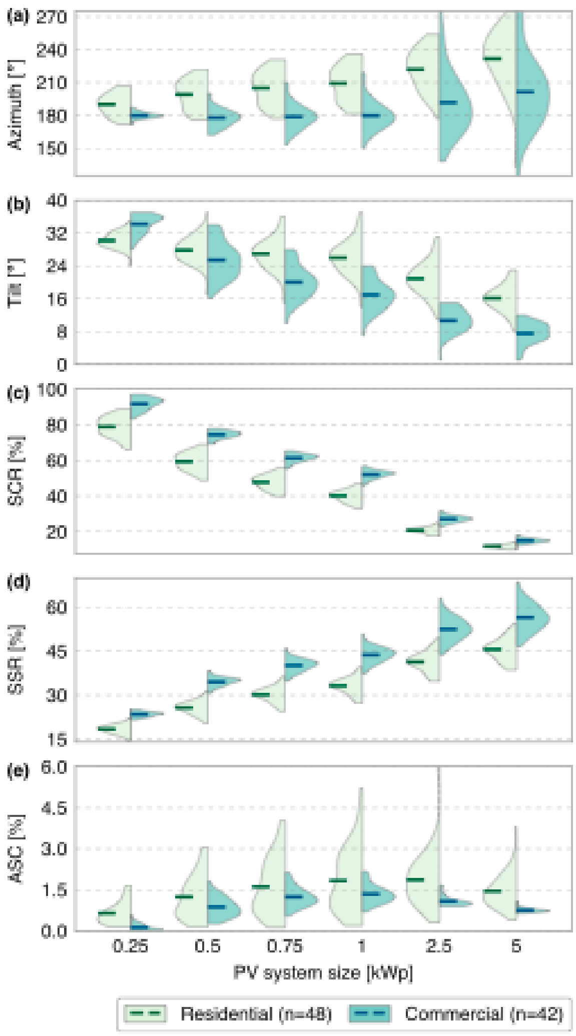


Figure A.1. Optimal orientation for annually maximized self-consumed energy (a, b), corresponding self-consumption rates (c), self-sufficiency rates (4), and added self-consumption (e) shown using violin plots. Distributions of residential systems (left part of violin plot) and commercial systems (right part) are shown for six PV system sizes. Note that data were normalized to 1 MWh annual demand (G.B.M.A. Litjens, W.G.J.H.M. van Sark, E. Worrell, Influence of demand patterns on the optimal orientation of photovoltaic systems, Solar Energy 155 (2017) 1002–1014.)

Currently, a few pilot experiments are running that are focused on increasing self-consumption in a smart-grid environment, such as “Your Energy Moment”, a pilot by one of the Dutch Distribution System Operators (ENEXIS), see E.A.M. Klaassen, C.B.A. Kobus, J. Frunt, J.G. Slootweg, *Responsiveness of residential electricity demand to dynamic tariffs: Experiences from a large field test in the Netherlands*, Applied Energy 183 (2016) 1065-1074. As smart grids host a large number of diverse energy technologies and ICT, many concepts can be investigated such as network reliability regarding energy and power flows, energy-efficiency, local sustainable energy production and consumption, demand side management by self-consumption, solar and demand forecasting techniques and mutual trading of energy with neighbors, and controlled charging of EV by renewable energy sources and patterns of use. An overview of current pilots is shown in Figure A.2. The research in the CESEPS project will perform a comparative validation of smart grid technologies and concepts in more than four existing demonstration projects in the Netherlands under the umbrella of the *Smart Energy Collective* of DNV GL, such as *PowerMatching City*, *Your Energy Moment*, and pilots in the cities of Heerhugowaard, Lochem and others.

Figure A.2. Map of the Netherlands with various locations of smart grid pilots which are evaluated in the CESEPS project (Angèle Reinders, Moreno de Respinis, Jorien van Loon, Anton Stekelenburg, Frits Bliek, Wouter Schram, Wilfried van Sark, Tara Esterl, Stefan Uebermasser, Felix LehFuss, Esin Gultekin, Barbara van Mierlo, Elena Markočič, Brigitte Hassewend, Carla Robledo, Ioulia Papaioannou, Ad van Wijk, Mike Lagler, Ernst Schmautzer, Thömas Hohn, Lothar Fickert, Co-Evolution of Smart Energy Product and Services: a Novel Approach towards Smart Grids, Proceedings of the Asian Conference on Energy, Power and Transportation Electrification (ACEPT), 2016, pp. 1-6).

Annex II References used for Australia

- **ACT Government, 2018**. Next Generation Energy Storage Grants. Available at: http://www.environment.act.gov.au/energy/cleaner-energy/next-generation-renewables
- **ACT Smart, 2018.** Household Battery Storage. Available at: https://www.actsmart.act.gov.au/what-can-i-do/homes/discounted-battery-storage
- **Arena, 2015**. Investigating local network charges and local electricity trading. Available at: https://arena.gov.au/projects/investigating-local-network-charges-and-local-electricity-trading/
- **ARENA, 2017a**. An Introduction To Arena's Remote And Regional Projects Insights From The Portfolio Of Projects Funded Under The Regional Australia's Renewables (Rar) Program. Available at: https://www.oecd.org/dev/inclusivesocietiesanddevelopment/Session-4-an-Introduction-to-Arena-Projects.pdf
- **ARENA, 2017b.** Here comes the sun. Available at: https://arena.gov.au/assets/2017/11/here-comes-the-sun-moreland-energy-foundation.pdf
- **AusTrade, 2017**. Microgrids, Smart Grids And Energy Storage Solutions. Available at: https://www.google.gr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj0qMTypPPZAhVnGZoKHdu2Ag8QFghCMAA&url=https%3A%2F%2Fwww.austrade.gov.au%2FArticleDocuments%2F2814%2FMicrogrids%2520Smart%2520Grids%2520and%2520Energy%2520Storage%2520Solutions.pdf.aspx&usg=AOvVaw1tazAWB5f9okmUVlVavry8
- **Australian Energy Market Commission, 2017**. Final Rule Determination National Electricity Amendment (Alternatives To Grid-Supplied Network Services) Rule 2017. Available at: https://www.aemc.gov.au/sites/default/files/content/9669d72d-070e-4aaf-9848-b30fd5ce29c3/ERC0215-Western-Power-final-determination-to-publish.pdf
- **Canstar Blue 2017**. Solar Installation Costs Explained. Available at: https://www.canstarblue.com.au/energy/alternative/solar-power/solar-installation-cost/
- **CSIRO, 2017**. Electricity Network Transformation Roadmap: Final Report. Available at: http://www.energynetworks.com.au/sites/default/files/entr_final_report_april_2017.pdf
- **Electricity Act 1996** (SA). Last amended on 12.10.2017. At: https://www.legislation.sa.gov.au/LZ/C/A/ELECTRICITY%20ACT%201996/CURRENT/1996.96.AUTH.PDF
- **Electricity Industry Act 2000 [Vic]** amended on 14.02.2017. Available at: http://www6.austlii.edu.au/cgi-bin/viewdb/au/legis/vic/consol_act/eia2000261/
- **Electricity Industry Act 2004 [WA]** amended on 14 June 2017. vailable at: https://www.slp.wa.gov.au/pco/prod/filestore.nsf/FileURL/mrdoc_32111.pdf/$FILE/Electricity%20Industry%20(Licence%20Conditions)%20Regulations%202005%20-%20%5B01-b0-00%5D.pdf?OpenElement
- **Energy Australia, 2017**. Other fees and charges. vailable at: https://www.energyaustralia.com.au/home/help-and-support/faqs/other-fees-and-charges
- **Ergon Energy, 2017.** Meter Services Charges. Available at: https://www.ergon.com.au/retail/residential/tariffs-and-prices/what-is-the-metering-services-charge
- **Essential Services Commission, 2018.** Minimum electricity feed-in tariffs to apply from 1 July 2018 Final decision. Available at: https://www.esc.vic.gov.au/wp-content/uploads/2018/02/minimum-electricity-feed-in-tariffs-to-apply-from-1-July-2018-final-decision-20180227.html#pf9
- **Frontier Economics, 2018**. South Australia's Virtual Power Plant-Frontier Economics Assessment. Available at: http://www.frontier-economics.com.au/documents/2018/02/south-australian-virtual-power-plant-summary-note.pdf
- **Government of South Australia, 2018**. Solar Photovoltaic Systems. Available at: https://www.sa.gov.au/topics/energy-and-environment/energy-efficient-home-design/solar-photovoltaic-systems
- **Government of Victoria, 2018.** Microgrids. Available at: https://www.energy.vic.gov.au/microgrids
- **Horizon Power, 2014.** Onslow distributed energy resource micro-grid. Available at: https://horizonpower.com.au/media/2763/onslow-fact-sheet.pdf
- **IPART, 2017.** Solar feed-in tariffs Benchmark range 2017-18. Available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/pricing-reviews-energy-services-publications-review-of-solar-feed-in-tariffs-201718/solar-feed-in-tariffs-201718-final-report-june-2017.pdf

- **Langham Ed, 2016**. Local Network Credits & Local Electricity Trading: Opportunities For Councils. Available at: http://reroc.com.au/system/files/Ed%20Langham_Local%20Electricity%20Trading-%20Virtual%20Net%20Metering.pdf
- **Office of Tasmanian Economic Regulator, 2017.** Feed-In Tariffs. At: http://www.economicregulator.tas.gov.au/electricity/pricing/feed-in-tariffs
- **Our Energy Plan, 2018.** World's largest 'Virtual Power Plant' to lower energy bills by 30%. Available at: http://ourenergyplan.sa.gov.au/virtual-power-plant
- **Power and Water, 2017**. Solar Energy Transformation Program (SETuP). Available at: https://www.powerwater.com.au/sustainability_and_environment/setup
- **Queensland Government, 2018a**. Market feed-in tariffs in South East Queensland. Available at: https://www.qld.gov.au/housing/buying-owning-home/market-feed-in-tariffs-seq
- **Queensland Government, 2018b**. Feed-in tariffs for regional Queensland. Available at: Feed-in tariffs for regional Queensland. https://www.qld.gov.au/housing/buying-owning-home/feed-in-tariff-regional-queensland.
- **Queensland Copmpetition Authority, 2017**. 2018-19 Regional Feed-in Tariff. Available at: http://www.qca.org.au/Electricity/Regional-consumers/Solar-Feed-in-Tariffs-(1)/In-Progress/2018-19-Regional-Feed-in-Tariff
- **Reneweconomy, 2015.** Byron shire to be first in Australia to pilot virtual net metering. Available at: http://reneweconomy.com.au/byron-shire-to-be-first-in-australia-to-pilot-virtual-net-metering-74516/
- **RENEWeconomy, 2018.** Carnegie to build W.A.'s largest micro-grid at Kalbarri. Available at: http://reneweconomy.com.au/carnegie-to-build-w-a-s-largest-micro-grid-at-kalbarri-95650/
- **Rutovitz Jay, 2016a**. Trials Results: Virtual Net Metering & Local Network Credits. Available at: https://www.uts.edu.au/sites/default/files/All_Energy_presentation_2016_10_04.pdf
- **Rutovitz Jay, 2016b**. Virtual Trial of Local Electricity Trading and Local Network Credits: A Community Solar Farm. Available at: https://www.uts.edu.au/sites/default/files/LNCLET_Trial_Case_study_MSH.pdf
- **Singleton Argus, 2015**. Singleton Solar Farm leading the way. vailable at: https://www.singletonargus.com.au/story/3350855/singleton-solar-farm-leading-the-way/
- **Solar Choice, 2017**. Information On Australian Solar Feed-In Tariffs. Available at: https://www.energymatters.com.au/rebates-incentives/feedintariff/
- **State of Queensland, 2018a.** Solar Bonus Scheme 44c feed-in tariff. Available at: https://www.qld.gov.au/housing/buying-owning-home/solar-bonus-scheme-44c
- **Synergy, 2017**. Renewable Energy Buyback Scheme Net Feed-in Tariff price schedule SWIS customersonly-1July 2017 https://www.synergy.net.au/-/media/Files/PDF-Library/REBS_Pricing_Schedule.pdf?la=en&hash=F17D284A297E4097400F1E8FA44BB106C7B98824
- **Western Power, 2017.** Solar, batteries & electric vehicles. Available at; https://westernpower.com.au/connections/solar-batteries-electric-vehicles/

Annex III Examples and best practices in Australia

Example 1

A very promising and pioneering project that might paves the way for community electricity trading is the Singleton PV farm which provides 12% of the annual electricity consumption to the University of Technology Sydney's Chau Chak Wing Building for the next two years. More specifically, about half of the 407 kW solar farm's energy credits will be attributed to the University in what is called a Virtual Net Metering (VPN) arrangement (Singleton Argus, 2015). Despite the fact that this concerns a commercial PV plant, this can be the first step for boosting decentralized electricity.

Example 2

South Australia's (SA) '**Virtual Power Plan**t' Project is an ambitious project that aims at creating the world's largest virtual plant in the world (Our Energy Plan, 2018). The project aspires to equip 50,000 home solar and battery systems across South Australia, thus creating the world's largest Virtual Power Plant. During the trial period 1,100 households are given a 5kW solar panel system and 13.5kWh Tesla Powerwall 2 battery, while such systems are expected to be installed in 24,000 households. The 50,000 household threshold is expected to be reached within four years (Our Energy Plan, 2018).

Frontier Economics has conducted a preliminary assessment and concluded that customers should expect a reduction in electricity tariffs of about 30% once all reasonable costs and benefits are taken into account. This means an electricity price around AUS $ 27c/kWh, as current retail price is at AUS $ 40c/kWh (Frontier Economics, 2018).

More specifically, the following energy saving costs are mentioned (Frontier Economics, 2018):

Reduction of wholesale price in SA for all customers by about AUS $ 3/MWh with each additional 50 MW of installed capacity;

Improvement of the reliability of the system, as likelihood of the Value of Lost Load event will be reduced (AUS $14,200/MWh Market Price Cap will not be reached);

Improvement of the electricity market security and stability, due to the fact that during the trial, the Tesla 100 MW battery resulted in about a 75% reduction in the costs being paid for by customers for frequency control services.

Example 3

It is estimated that from 2021, networks will connect new customers in remote areas (typically 1 km or more from the existing grid) with standalone power systems where it is demonstrated to be a lower cost than grid extension (CSIRO, 2017).

Example 4

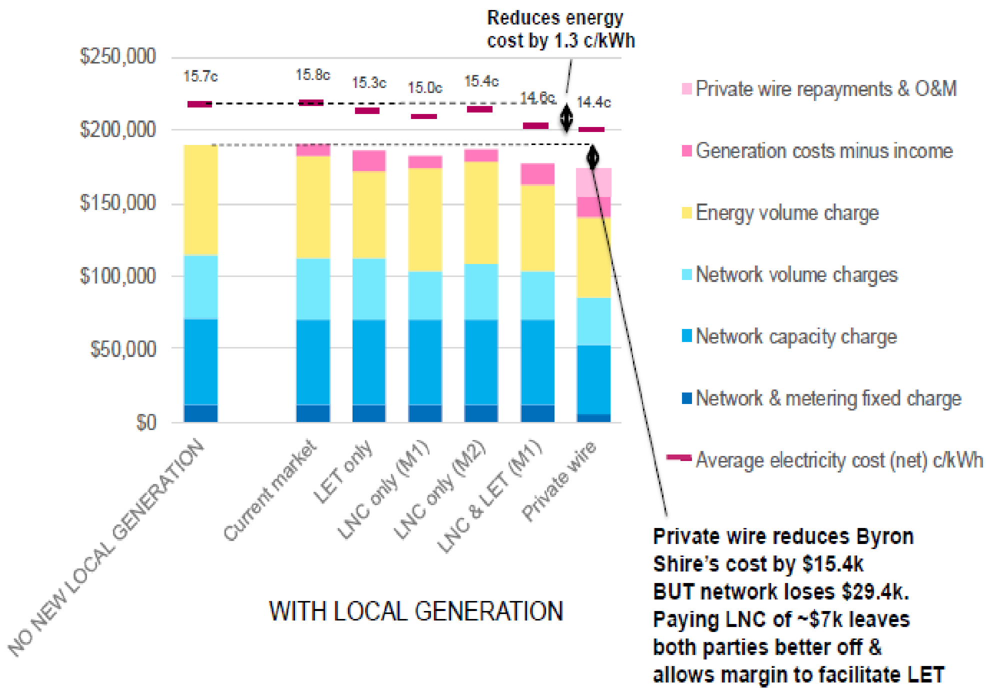
Australian Renewable Energy Agency launched in 2015 the programme “Investigating Local Network Charges and Local Electricity Trading” (Arena, 2015). The programme investigates the potential of local electricity trading, carrying out five trial sites (3 of them PV plants) (Langham, 2016). According to that project, “behind the meter with or without storage” are available technologies that can be implemented. The first stage of local electricity trading (single entity) can include two buildings, where they can exchange electricity in peer-to-peer modus (Langham, 2016).

More specifically, the project looks into two concepts (Rutovitz, 2016a):

Local Network Credits (LNC): export credits for energy generated & consumed ‘locally’ and consequently recognise the value in reducing future network costs;

Local Electricity Trading (LET), also known as Virtual Net Metering: netting off generation from one site to another site on a time-of-use basis, so that Site 1 can ‘sell’ or assign generation to nearby Site 2.

One of the trials took place in **Byron Shire** (located in New South Wales), where Cavanbah Sports Centre installed a 150kW solar plant that supplied electricity to West Byron Sewage Treatment Plant (Langham, 2016). The table below shows the results of the Byron Trial (Langham, 2016). Here different scenarios were investigated. It is possible to see that in contrast to the reference scenario (no new local generation) electricity cost decreases slightly with both concepts (LET and LNC). Interestingly, there is a scenario where the construction of a private grid is also foreseen. According to the table, this can be seen as the best investment option but it is not the best solution for the network (Langham, 2016).



The **second trial in Moira and Swan Hill** implemented a more complicated approach, as a 100kW-200kW power plant (One-to-many Solar garden or Community Solar Farm) that energy output is virtually 'split' and transferred to many individual sites. As with all Local Electricity Trading sales, the physical electricity may not reach the buyer's site, but is reconciled against their usage for billing purposes (Rutovitz, 2016b). Several scenarios were tested and it was found that the investment will vary according to the potential investor's current energy use profile and tariff, and the size of their investment. The figure below presents a clear overview of the energy cost outcomes, while the table presents the cumulative results for each type of investors (Rutovitz, 2016b).

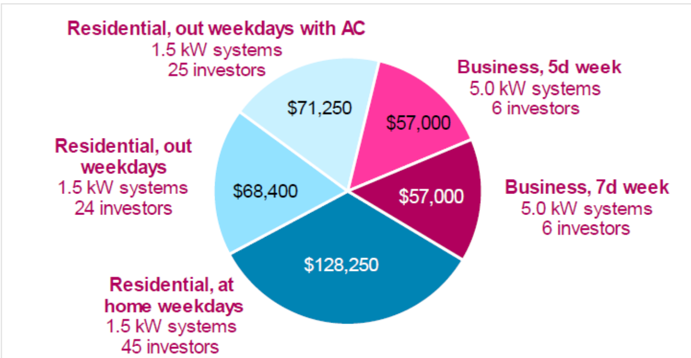
	RESIDENTIAL				BUSINESS	
	At home weekdays	At home weekdays	Out weekdays	Out weekdays with AC	5 day week	7 day week
	3kW	1.5kW	1.5kW	1.5kW	5kW	5kW
Investment	$5,700	$2,850	$2,850	$2,850	$9,500	$9,500
Solar % of consumption	36%	27%	29%	16%	32%	18%
Generation used on site	49%	74%	67%	58%	86%	99%
Annual energy cost pre investment	$2,054	$2,054	$1,757	$2,565	$6,535	$12,612
Annual energy cost with LET	$1,649	$1,811	$1,526	$2,350	$5,428	$11,399
IRR with LET	4.3%	6.5%	5.9%	5.0%	10.8%	12.3%

The overall results of the trial are presented below along with a figure that shows the investment allocation between different investment profiles (Rutovitz, 2016b). All in all, annual energy bills in aggregate could improve by approximately AUS $35,000/year in the LET only case, and by approximately AUS $42,000 for the combined LET and LNC case. Realizing AUS $380,000 capital investment, this has 10 to 11 years payback for investors overall (Rutovitz, 2016b).

Overall project results – residential and business investors

	Before investing	Local Electricity Trading (LET)	LET & Local Network Credit
Annual energy cost ($)	$313,619	$277,837	$271,668
Simple payback (years)	n/a	11 yrs	10 yrs
Investment rate of return (IRR)	n/a	5% to 12.3%	7.5% to 14.2%
Lifetime benefit ($)	n/a	$756,547	$886,992

Residential and business investors – mix of investor profiles



Example 5

Apart from the Byron example (example 4) that includes a scenario with the construction of a private grid, there seems to be an increasing interest in creating private grid, known as micro grids in Australian areas.

For example, ARENA (2017b) has published a report investigating the potential of PV solar micro-grids. A representative group of five households in Northcote Victoria were selected. Based on this selection, the potential of two options (the realisation of an integrated micro-grid against individual solar/battery deployment) under three criteria/ parameters (more solar power, less cost and electricity demand stabilisation) was assessed (ARENA, 2017b). The outcomes were compared against four scenarios. The report concludes that battery storage can contribute to a steadier electricity sharing network which may assist in balancing the network. It is argued that one the one hand, microgrids may introduce significant infrastructure costs as well as associated operations and maintenance costs. They may also incur administrative costs to manage customers, provide billing and coordinate maintenance. On the other hand, the cost of extending or maintaining the grid may be avoided by establishing a microgrid. Two examples are highlighted. For residential developments (no infrastructure available), investments in distributed energy resources and control systems can be cost effective as they minimise the reliance on the broader grid, thus lowering connection costs for the developer and operating costs for residents. For some regional or remote communities, microgrids can be an alternative to maintaining an expensive network connection (ARENA, 2017).

Another example is Horizon Power, in Western Australia. The company Horizon Power uses a combination of diesel or gas and renewable energy sources (wind, solar and hydro). Several sites incorporate a large proportion of renewable energy into their systems. High renewable energy penetration systems include Kununurra (99%), Denham (45%), Marble Bar and Nullagine (both 34%). The total load is 275MW, with a total renewable energy generation of 48MW and a hosting capacity of 88MW.

Another project of Horizon Power is the one in Onslow (Western Australia). More specifically, Horizon's Onslow system aspires to constitute the largest energy microgrid (so-called Distributed Energy Resources -DER- micro-grid) (Horizon Power, 2014). The project foresees the construction of a 'backbone' infrastructure i.e. a new transmission line, zone substation, distribution network extension and a gas-fired modular power station and is expected to be fully operational by 2020 (Horizon Power, 2014). It should be noted that the remote microgrid market is expected to increase to over AUS $20 billion annually by 2024 (AusTrade, 2017).

A further project in West Australia, realised by Carnegie Clean Energy and Lend Lease, aims at constructing 4.5MW/2MWh battery storage that will work with local wind and solar generation to boost reliability in the Kalbarri town, thus, improving the distribution line connection which is affected by severe weather conditions (RENEWeconomy, 2018).

In the isolated Northern territory, the NT SETuP Project aims at installing 10MWp of PV with battery storage between 0.8 MW- 1.6 MWh. Thirty communities (sub-projects) will have solar PV installed which will operate in parallel with existing diesel supply (ARENA, 2017a). In addition, 1 MW solar facility will be centrally built and is expected to meet 50% of the community's annual electricity needs (Power and Water, 2017).

In 2018, Victoria issued a call for application concerning development and implementation of state wide demonstration projects, using microgrid models, with contribution of up to $10 million in grant funding over four years (Government of Victoria, 2018).

Annex IV – US Federal Level supporting schemes

Renewable portfolio standards (RPS) are likely to increase prosumption because they encourage utilities to purchase customer-generated renewable energy to meet the standards. Several states have special carve-outs in their renewable portfolio standards requiring that a certain percentage of the overall target be sourced from distributed generation. Some states like California have adopted even more targeted programs. California has issued a series of legislative and regulatory mandates that promise to increase prosumption in the state. On the distributed generation side, California has required its three largest investor-owned utilities to craft plans identifying distributed resource potential and explaining how the utilities will incorporate distributed resources in their territories. New homes in California must also be prosumption-ready: the state's Long Term Energy Efficiency Strategic Plan calls for all new residential construction to generate as much energy as it consumes by 2020.

Residential Energy Conservation Subsidies (Personal and Corporate) provided to customers by public utilities are non-taxable. This exclusion does not apply to electricity-generating systems registered as "qualifying facilities" under the Public Utility Regulatory Policies Act of 1978 (PURPA). If a taxpayer claims federal tax credits or deductions for the energy conservation property, the investment basis for the purpose of claiming the deduction or tax credit must be reduced by the value of the energy conservation subsidy (i.e. a taxpayer may not claim a tax credit for an expense that the taxpayer ultimately did not pay).

Renewable Energy Solar Tax Credit. A taxpayer may claim a credit of 30% of qualified expenditures for a system that serves a dwelling unit located in the United States that is owned and used as a residence by the taxpayer. Expenditures with respect to the equipment are treated as made when the installation is completed. If the installation is at a new home, the "placed in service" date is the date of occupancy by the homeowner. Expenditures include labour costs for on-site preparation, assembly or original system installation, and for piping or wiring to interconnect a system to the home. If the federal tax credit exceeds tax liability, the excess amount may be carried forward to the succeeding taxable year. Photovoltaic system must provide electricity for the residence, and must meet applicable fire and electrical code requirement. Please see the maximum allowable credit, equipment requirements and other details for solar-electric property below.

- 30% for systems placed in service by 12/31/2019
- 26% for systems placed in service after 12/31/2019 and before 01/01/2021
- 22% for systems placed in service after 12/31/2020 and before 01/01/2022
- There is no maximum credit for systems placed in service after 2008.

- Systems must be placed in service on or after January 1, 2006, and on or before December 31, 2021. The incentive expires after 2021.
- The home served by the system does not have to be the taxpayer's principal residence.

According to the **Form 5695 on Residential Energy Credits**, qualified solar electric property costs are costs for property that uses solar energy to generate electricity for use in your home located in the United States. No costs relating to a solar panel or other property installed as a roof (or portion thereof) will fail to qualify solely because the property constitutes a structural component of the structure on which it is installed. Regarding the **federal level of the US**, the **Investment Tax Credit (ITC)**, originally established by the Energy Policy Act of 2005 (P.L. 109-58), allows the homeowners (Section 25D) to apply for credit to their personal income taxes, at least by the end of 2021. According to the Solar Energy Industries Association (SEIA), the credit is used when homeowners buy solar systems directly having them installed on their homes as well.

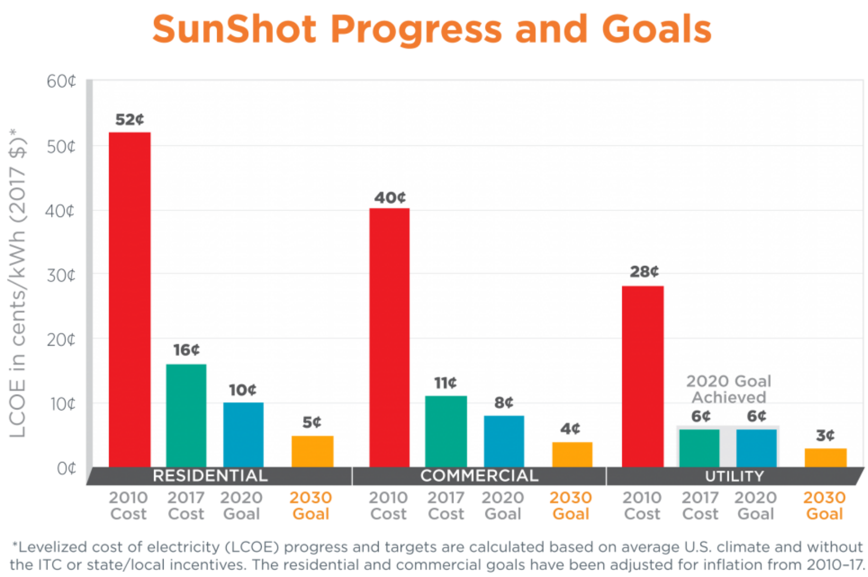
The Public Utilities Policies Act of 1978 (PURPA) created an obligation for electric utilities to offer to purchase power from, and interconnect with, qualifying generation projects. PURPA is implemented through a set of rules established by the Federal Energy Regulatory Commission (FERC). Qualifying Facilities (QFs) must meet certain criteria as specified in the FERC rules. Each state is regulated by a public service or utility commission that has certain responsibilities for the implementation of PURPA as provided in the FERC rules. PURPA established the framework for states of the U.S. to implement numerous regulatory and ratemaking standards that the aforementioned authorities were obliged to adopt. As Wellinghoff and Weissman (2015, p. 318) further state, PURPA was amended by the Energy Policy Act of 2005 that introduced the obligation of net metering policies and interconnection rules' adoption by regulated commissions and non-regulated electric utilities. Although the methodology set by the state must be in accordance with the parameters set by FERC rules, states have broad discretion to set avoided cost rates (i.e. incremental cost to electric utility of electric energy or capacity or both which, but for the purchase from the qualifying facility/facilities (QFs), such utility would generate itself or purchase from another source). According to Wellinghoff and Weissman (2015, p. 317), the Federal Law introduces the following rights of qualified cogeneration and small renewable sources' operators:

1. right to interconnect with its host utility by paying a non-discriminatory interconnection fee approved either by the state commission or non-regulated utility;
2. right to purchase certain services from utilities;
3. right to sell energy and/or capacity to its host utility;
4. relief from certain state and federal regulatory burdens.

Additionally, the FECR has *de facto* established on the federal level the right to use on-site generation for own purposes, therefore, a legal right to self-generate. Finally, self-generation is allowed in the following modes: on-site self-supply (‘behind-the-meter’), remote self-supply (from the same company), or third-party supply.

The SunShot Initiative (2020) was an initiative launched by the U.S. Department of Energy in February 2011. Its goal was to enable solar electricity costs to be competitive with conventionally generated electricity by 2020 (without subsidies), and to reduce the total costs of solar energy by 75% by the end of the decade. The SunShot Vision Study describing solar potential was published by the Department of Energy a year later. In 2016, eight reports that examined the lessons learned since the beginning of the Initiative were published. These reports tackle with issues of solar financing, environmental and public health benefits, and challenges that solar development faced. Three years earlier than expected, on 12 September 2017, the official targets of the initiative were met, i.e. utility-scale solar cost target of 0.06 USD per kWh. The goal of the next SunShot Solar Initiative (residential and commercial one) is to meet the target of 0.03 USD per kWh by 2030. The programme is led by the U.S. Department of Energy Solar Energy Technologies Office (SETO). Please see the graph below describing SunShot Progress and Goals.

Solar Easements are typical provisions enforceable by law that are implemented in many states of U.S. According to the Utah Code (Title 57, Chapter 13), Solar Easement means a right, whether or not stated in the form of restriction, easement, covenant, or conditions in any deed, will, or other instrument executed by or on behalf of any owner of land or solar skyspace for the purpose of ensuring adequate exposure of a solar energy system as defined herein. Solar skyspace is defined as the space between a solar energy collector and the sun which must remain unobstructed such that on any given clear day of the year, not more than 10% of the collectable insolation shall be blocked. The easements are instruments that ensure unobstructed access to sun, and they should protect solar installations from shadow during their whole lifetime. The easements shall be created in writing and shall be filed, duly recorded and indexed in the office of the recorder of the county in which the easement is granted.



-

Source: Solar Energy Technologies Office. 2018. *SunShot Progress and Goals*. Available on: https://www.energy.gov/eere/solar/sunshot-2030.

To get the general overview of PV potential it is reasonable to use **Solar Calculator** that estimates potential of roof-mounted PV installation (based on property type, average monthly electricity bill, roof size and actual offers in the area).

Example of application of ITC. According to the up-to-date data, U.S. residential customers pay 2.71 – 3.57 USD/Wp of installed PV solar. Taking into account the U.S. average of system size at 6 kW, solar costs after federal tax credit vary between 11,380 – 14,990 USD. This represents a 6.5% fall in comparison with the previous year average. The calculation does not include different incentive schemes that are applied by states, local governments and utilities.

Solar Panel Pricing for 6 kW solar PV systems (after 30% Federal Tax Credit) in the U.S. states

California $11,928 – $15,204

Arizona $10,332 – $12,096

North Carolina $10,500 – $14,196

The average U.S. household's payback period for PV solar systems is 7 years.

References

- Jacobs, S. (2016): The Energy Prosumer. Please find more details on: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2662924. Please find more details on the following link: https://www.irs.gov/publications/p525
- Instructions for Form 5695 on Residential Energy Credits (2017). Available at: https://www.irs.gov/pub/irs-pdf/i5695.pdf.
- Wellinghoff and Weissman. 2015. *The Right to Self-Generate as a Grid-Connected Customer*. Available at: http://felj.org/sites/default/files/docs/elj362/23-305-326-Wellinghoff_FINAL%20%5B11.10%5D.pdf
- Please find more information on the ITC on the following links: http://programs.dsireusa.org/system/program/detail/1235; https://www.seia.org/sites/default/files/ITC%20101%20Fact%20Sheet%20Feb17.pdf
- Please find the SunShot Vision Study (2012) on the following link: https://www.energy.gov/eere/solar/sunshot-vision-study.
- Please find the Reports and Key Findings of the On the Path to SunShot series on the following link: https://www.energy.gov/eere/solar/path-sunshot.
- Please find more information on Solar Easements according to Utah Code on the following link: https://le.utah.gov/xcode/Title57/Chapter13/57-13-S1.html.
- Please find general information (Right to Self-Generate as a Grid-Connected Customer) on Solar Easements in the U.S. on the following link: https://www.caionline.org/Advocacy/StateAdvocacy/PriorityIssues/SolarRestrictions/Pages/default.aspx
- Please find the Solar Calculator developed by the EnergySage on the following link: https://www.energysage.com/solar/calculator/.
- Please find more information on the **CPUC** on the official website: http://www.cpuc.ca.gov/energy/.
- Please find more information on **RPS** in Ca on the following links: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350, http://www.energy.ca.gov/portfolio/ and Jacobs, S. (2016): https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2662924
- Please find more information about the **SGIP** on the following links: http://www.cpuc.ca.gov/General.aspx?id=11430 and https://energy.gov/savings/self-generation-incentive-program

Annex V – References used for USA

- Commission's Decision: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K181/158181678.pdf.
- NEM 2.0 in California:
  - https://news.energysage.com/net-metering-2-0-in-california-everything-you-need-to-know/.
  - https://www.sce.com/wps/portal/home/residential/generating-your-own-power/Grid-Interconnections/!ut/p/b1/hc_RCoIwFAbgZ-kB8pxtYXY5seZEklqU7Sas1hJSyyRfP43uovrvfvgOnB80pKDL7JHbrMmrMrv0Xbu7SAaciBGViR9T5K4fcpKoieeSDmw7gF_C8d_9BvSLEE_wUCqUYkYClNGaqBgDVHP2AZZj2oNpnPiEokffYCJwGkZJB1YLhpItcK44Z4juG_x4MgJtL9W-G7zxQbejm9jafhov98yzoGtzMrWpnXN1byBt29axtTFlYw7nwhzzzDlUBVyLFHM51DM7GDwBVUj2Hg!!/dl4/d5/L2dBISEvZ0FBIS9nQSEh/
  - https://www.sdge.com/business/electric-rule-21-resources
- NEM Agreement of Pacific Power for its prosumers based in California: https://www.pacificpower.net/content/dam/pacific_power/doc/Efficiency_Environment/Net_Metering_Customer_Generation/CANetMeteringAgreement.pdf.
- NEMA: https://www.pacificpower.net/content/dam/pacific_power/doc/About_Us/Rates_Regulation/California/Approved_Tariffs/Rate_Schedules/Net_Metering_Service.pdf.
- NEMA Rules applied by PG&E: https://www.pge.com/en_US/business/solar-and-vehicles/net-energy-metering/net-energy-metering-overview/nem-aggregation/nem-aggregation.page.
- Interconnection Fees of the Utilities operating in California: https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/interconnections-renewables.page
- Jacobs, S. (2016): The Energy Prosumer. More details on: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2662924
- Resolutions E-4610 and E-4665 of the CPUC: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K158/77158265.PDF

  http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M098/K386/98386302.PDF.
- The rate structure was set by the Commission Decision (D).11-06-016, http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/FINAL_DECISION/137431.htm).
- up-to-date NSCR data of the three main utilities operating in California (PG&E, SCE, SDG&E):
  - https://www.pge.com/includes/docs/pdfs/shared/solar/AB920_RateTable.pdf
  - https://www.sce.com/wps/portal/home/regulatory/tariff-books/rates-pricing-choices/net-surplus-compensation/!ut/p/b1/vVJNU8IwFPwtHjiGpJ-0xwx1auugIjC2vTBpSNtoSUoaQP31BoaDBxG5mFM-Nvve7j5YwAwWgux4TTSXgrSHc-Ev0yTCVuzaSTxKI4SfolG0ePYt994ygNwA0JmF0aX_L7CABRW60w3Me8qWVArNhF4yMUCn_QApVm9boqX6GCBNFK8qUEr51psXolkPOsUpFzWgjeSUmWvBNOi3qmu3PaBy3THRHyUdqnWUr2BuW9YKlYENKPEq4Pp2BULiU-A5vuuwILQcl8D0D_JtNRlPakNLdAO4qCTMvrcIsx9bhNnZFg0nf91sCmyMORjwrmH2D84ckzBqwxjd3qWPKInnUwclzhQ9zDB2EPJPgF_CNn7VrSyPg5NjUTqBMUaxiimmho3sjZL9fj-spaxbNjTlYW7mZ3TW4bELZ1dGdoHQv5qwWy_WgeO1daDDBBSl1-0-5_jm5gsr3y6L/dl4/d5/L2dBISEvZ0FBIS9nQSEh/
  - https://www.sdge.com/clean-energy/excess-generation-credit/annual-compensation-excess-generation.
- NEMMT (PG&E):
  - https://www.pge.com/en_US/business/solar-and-vehicles/net-energy-metering/net-energy-metering-overview/nem-multiple-tariff/nem-multiple-tariff.page
  - https://energy.gov/savings/self-generation-incentive-program

- NEMEXP: https://www.pge.com/en_US/business/solar-and-vehicles/net-energy-metering/net-energy-metering-overview/expanded-nem/expanded-nem.page.
- Non-Export Interconnection policy of PG&E:
    - https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/larger-self-generation-programs/non-export/non-export.page
    - http://www.cpuc.ca.gov/General.aspx?id=6058.
- SGIP
    - http://www.cpuc.ca.gov/General.aspx?id=11430
    - http://www.cpuc.ca.gov/General.aspx?id=5935
- CSI: http://www.cpuc.ca.gov/General.aspx?id=6043
- REST in Arizona: http://www.azcc.gov/divisions/utilities/electric/res.pdf
- Senate Bill 1465: https://www.tep.com/wp-content/uploads/2016/04/sb1465_laws_0090.pdf
- Former NM programme in Arizona:
    - https://energypolicy.asu.edu/wp-content/uploads/2014/01/Policies-to-Know-Arizona-Net-Metering-Rules-Brief-Sheet_Updated.pdf
    - https://pv-magazine-usa.com/2016/12/20/arizonas-changes-to-net-metering-could-derail-the-states-rooftop-solar-market/
    - https://pv-magazine-usa.com/2017/07/28/arizona-sun-rises-judge-endorses-aps-solar-industry-settlement/
- eligibility, availability, aggregate capacity limit, export compensation rate under Net Billing programme in Arizona: http://programs.dsireusa.org/system/program/detail/3093.
- Solar Rights: https://www.azleg.gov/viewdocument/?docName=http://www.azleg.gov/ars/33/00439.htm
- Residential Solar Net Metering and Rates applied:
    - https://www.trico.coop/documents/Schedule-NM-2018-Updated-Avoided-Cost-Final.pdf
    - https://www.utilitydive.com/news/arizona-regulators-approve-new-rates-solar-fees-for-tucson-electric-power/435926/.
- Residential Solar Energy Credit (updated in July 2017): https://www.azdor.gov/Portals/0/Brochure/543.pdf
- Individual and Corporate Income Tax Credit: https://www.azdor.gov/Portals/0/RefundCredits/RenewableEnergyforSelfProduction.pdf
- Residential Solar Tax Exemption (SB 1229; Solar and Wind Equipment Sales Tax Exemption:
    - https://www.azleg.gov/legtext/50leg/2r/bills/sb1229p.pdf
    - https://www.energy.gov/savings/solar-and-wind-equipment-sales-tax-exemption
- Property Tax Exemption: http://programs.dsireusa.org/system/program/detail/1683
- Form of Interconnection Agreement used by TEP and APS:
    - https://www.tep.com/wp-content/uploads/2017/09/interconnectionsept_2017.pdf
    - https://www.aps.com/en/globalservices/installers/Pages/resources-for-green-energy-installers.aspx.
- Final Rules of FECR: https://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp
- Electric Service Requirements for Small Distributed Generation Sources (2017) that have to be followed by the installers in the TEP service territory: https://www.tep.com/wp-content/uploads/2017/11/SR-702.pdf
- HB 2615: https://www.azleg.gov/legtext/48leg/2r/bills/hb2615s.pdf
- A.R.S. § 11-323
    - https://www.azleg.gov/ars/9/00468.htm
    - https://www.azleg.gov/ars/11/00323.htm
- http://energy.utah.gov/solar/
- NM applied by RMP: https://www.rockymountainpower.net/content/dam/rocky_mountain_power/doc/About_Us/Rates_and_Regulation/Utah/Approved_Tariffs/Rate_Schedules/Net_Metering_Service.pdf

- Electric Service Schedule No. 136 of RMP: https://www.rockymountainpower.net/content/dam/rocky_mountain_power/doc/About_Us/Rates_and_Regulation/Utah/Approved_Tariffs/Rate_Schedules/Transition_Program_for_Customer_Generators.pdf
- Murray City Power: http://www.murray.utah.gov/77/Net-Metering-Program
- Utah Net Metering Changes: https://gosolargroup.com/blog/utah-net-metering-changes/thrive-without-net-metering/
- Meter Aggregation: https://rules.utah.gov/publicat/code/r746/r746-312.htm#T15
- Electric Rate Schedules of Commercial Installations (**Bontiful City**): https://www.bountifulutah.gov/file/e7320f11-3ab8-44e8-b389-4128cac4314e
- FiT also applies in **Lehi City**: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/69238/Solar_Feed-in_Tarrif_Policy_3.pdf
- **Incentives** used by **Municipal Utilities** in Utah: http://www.solarsimplified.org/connecting-to-the-grid/solarpolicies
- Utah Rule R746-312 on Electrical Interconnection: https://rules.utah.gov/publicat/code/r746/r746-312.htm#T4
- **Solar PV Tax Credit** in Utah: http://energy.utah.gov/wp-content/uploads/Solar-PV-System_FAQ-1.pdf
- SGESD's NM programme (incl. Interconnection Agreement form:
  - https://www.sgcity.org/pdf/utilities/energydepartment/netmeteringdocuments/netmeteringprogram.pdf
  - https://www.sgcity.org/pdf/utilities/energydepartment/netmeteringdocuments/netmeteringagreement2018.pdf
- Consumer Protection (regarding Lease Agreements, Purchase Agreements, and Power Purchase Agreements, AB 405): http://puc.nv.gov/Renewable_Energy/Consumer_Protections_REBR/.
- NSR 704.001: https://www.leg.state.nv.us/Nrs/NRS-704.html#NRS704Sec001
- Regulated Utilities by PUCN in Utah: http://puc.nv.gov/Consumers/Be_Informed/PUCN_Regulated_Utilities/
- Solar System Incentive Programme here: https://www.leg.state.nv.us/Nrs/NRS-701B.html#NRS701BSec010
- **Assembly Bill No. 405**: https://www.leg.state.nv.us/Session/79th2017/Bills/AB/AB405_EN.pdf.
- NM in Nevada: http://puc.nv.gov/Renewable_Energy/Net_Metering/
- Net Metering Rates for Northern and Southern Nevada
  - https://www.nvenergy.com/brochures_arch/rate_schedules/np_netmetering_rates.pdf
  - https://www.nvenergy.com/brochures_arch/rate_schedules/spp_netmetering_rates.pdf.
- Property Tax Exemption
  - https://www.leg.state.nv.us/nac/NAC-361.html#NAC361Sec052
  - https://www.leg.state.nv.us/NRS/NRS-701A.html#NRS701ASec200.
- Latest developments of Community Solar in Nevada: https://www.pv-tech.org/news/nevada-governor-vetoes-bills-says-higher-rps-and-community-solar-would-be-p
- VNEM: http://www.cpuc.ca.gov/General.aspx?id=5408
- The MASH programme is -currently closed: http://www.cpuc.ca.gov/General.aspx?id=3752
- Forms:
  - https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/larger-self-generation-programs/res-bct/res-bct.page
  - https://www.pge.com/tariffs/tm2/pdf/ELEC_FORMS_79-1112.pdf.
- CCA - Clean Power Exchange (CPX): https://cleanpowerexchange.org/california-community-choice/ http://www.leginfo.ca.gov/pub/01-02/bill/asm/ab_0101-0150/ab_117_bill_20020924_chaptered.html
- Lo, Chris (2018): Smart cities: building a solar-powered smart district in Denver. https://www.power-technology.com/features/smart-cities-building-solar-powered-smart-district-denver/

Annex VI - Examples and best practices in USA (not necessarily PVP concepts within PVP4GRID)

Example 1 - Virtual Net Energy Metering in California

Local Collective Use

According to the State of California, California Energy Commission & CPUC (2018), there are other major support scheme options for solar customers besides the aforementioned Net Energy Metering (NEM) Programme for single users (see section 3.3.2.1 for more details). These are a kind of collective use via public grid. Most of them make use of the “virtual” concept and thus, they cannot be considered as one of the selected PVP concepts. Next, Virtual Net Energy Metering (VNEM) example is detailed.

The **Virtual Net Energy Metering (VNEM)**, *‘which allows the electricity produced by a single solar installation to be credited toward multiple tenant accounts in a multifamily building without requiring the solar system to be physically connected to each tenant's meter’*, and the programme was piloted under the CSI Multifamily Affordable Houses Programme (MASH). However, based on the pilot programme, VNEM was expanded to the general multi-tenant market by Decision (D.)11-07-031 of the CPUC. According to the definition of the CPUC (2018), VNEM is *‘a tariff arrangement that enables a multi-meter property owner to allocate, the property's solar system's energy credits to tenants’*. Therefore, VNEM is a solution for multi-tenant building that overcame issues that were related to equitable distribution of the generation from a PV system. The detailed information on how the VNEM works is provided by the CPUC (2018): *‘Virtual Net Metering (VNM) allows multifamily participants to install a single solar system to cover the electricity load of both common and tenant areas connected at the same service delivery point. The electricity does not flow directly to any tenant meter, but feeds directly back onto the grid. The participating utility then allocates the kilowatt hours from the energy produced by the PV system to both the building owner's and tenants' individual utility accounts, based on a pre-arranged allocation agreement. The intent of VNM is to help multifamily residents receive direct benefits of the building's solar system, rather than all of the benefits going to the building owner.’*

Example 2 - Renewable Energy Self-Generation–Bill Credit Transfer, California

Renewable Energy Self-Generation – Bill Credit Transfer (RES-BCT) is based on the principle that allows solar customers to transfer their excess credits to another electricity account. The programme was established by the legislature effective since 2009. RES-BCT was established by AB 2466 and codified in Section 2830 of the Public Utilities Code. In detail, the programme is limited by 5 MW of generator size (since 1 January, 2012), and it enables eligible entities to share generation credits. Among eligible ones belong cities, counties, special districts, school districts, universities, political subdivisions or other local public agencies. These entities can share their generation credits from a system located on one government-owned property per location (Generating Account) with billing accounts (Benefiting Account(s)) at other government-owned properties, which can be based on one or more locations within the same geographic boundary. As mentioned in the previous sentence, in this scheme two kinds of accounts are used; generating and benefiting accounts, which must be on a Time-of-Use (TOU) schedule, and can be located on different places within the same city or county.

An eligible renewable generator must be installed either by itself or by third party on a property that is owned or under the control of Local Government in its geographic boundary. Subsequently, utility installs a generator account meter that enables to individually measure electricity used and fed into its grid. The information on electricity exports are crucial for calculation of the generation credits. Finally, the Local Government defines up to 50 Benefiting Accounts that it owns, operates or controls per Arrangement, and it sets percentage ratio of generation credits among these accounts.

According to one of the major utilities operating in California, PG&E (2018), an applicant must follow instructions of the utility and send an interconnection application together with Electric Rule 21 Application, Single-line diagram, Authorization to Receive Customer Information or Act on a Customer's Behalf - Form 79-1095 and Variance request. Additionally, the respective utility requires three further documents to interconnect prosumers generating facility, i.e. Interconnection Agreement for Non-Export Generating Facilities - Form 79-973, RES-BCT Application - Form 79-1112 and Signed-Off Building Permit.

The costs include also 30 USD as a monthly billing administrative charge as well as 500 USD as a one-time billing setup recover charge per Generating Account.

Example 3 Community Choice Aggregation (CCA) - California

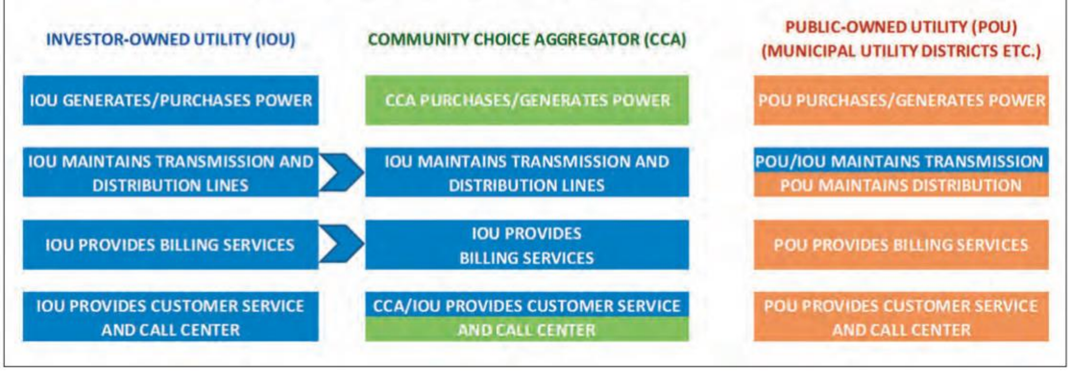
CCA, also known as Community Choice Energy (CCE), Municipal Aggregation or Government Energy Aggregation, *‘enables local entities to aggregate electricity contracts within a specific jurisdiction to procure electricity as a group, rather than individuals’*. LEAN Energy US describes CCA as a concept or an energy supply model that *‘allows local governments and some special districts to pool (or aggregate) their electricity in order to purchase and/or develop power on behalf of their residents, businesses, and municipal accounts’*. As Brophy (2016) states, electricity that is aggregated by counties or cities is purchased from independent energy service providers and not from utilities. Therefore, any CCA can purchase and generate and schedule its own electricity load for its customers.

In California, this policy was established in 2002 by **Assembly Bill 117**, which enabled local governments to provide electricity to their communities. According to the status quo, citizens (customers) of the respective region are automatically enrolled to the CCA when their representatives on the local level vote to form or join a CCA with an option to opt out. Furthermore, counties and cities can join together to participate at the CCA programme that results in their more favourable position compared to investor-owned utilities. For instance, according to the study of seven Bay Area communities, one joint CCA programme, which is based on a Joint Powers Agreement (JPA), instead of seven individual ones could have led to additional savings of 34%. The common CCA programmes have also another positive, for example, they result in the reduction of variability in electric loads, reduction of GHG emissions, broaden electricity customer choice, etc.

The main pros of CCA include lower electricity rates (thanks to lower financing costs, e.g. feasible studies of California Energy Commission of CCAs were lower by 7.4% compared to the ones of investor-owned utilities) as well as local control of its setting, further economic growth and finally, increased utilisation of RES. It has to be highlighted that CCAs do not pay state or federal taxes since they are not non-profit entities. Despite that there are significant start-up costs that hinder the development of new CCAs, e.g. Preparation of Feasibility Reports, Implementation Plans or JPA establishment.

According to the legislature, **CCAs** are not considered to be utilities and the legal definition states that they are electric service providers. As a result, California Public Utilities Commission (CPUC) has legally limited competences regarding their operations, however, it has still control over their compliance related to resource adequacy or fees' assigning. As Brophy (2016) further notes, publicly-owned utilities (POU) are not eligible to form CCA. Please see the retail electric delivery alternatives for California on the picture below.

Figure 1. Retail Electric Delivery Alternatives for California



Source: Brophy, P. 2016. *Community Choice Aggregation in California - An Opportunity for the Geothermal Industry*. Available at: https://geothermal.org/PDFs/Articles/16JulyAug.pdf.

The interactive map below, which is updated on a weekly basis, provides cumulative data on all 58 counties and 482 incorporated cities in California regarding their status of CCA involvement. According to the up-to-date data, there are eleven agencies that operate in California (e.g. MCE Clean Energy, or Los Angeles County Clean Power Alliance and Pioneer Community Energy that launched in February 2018), and six more belong currently to emerging (close-to-launch) ones.

Source: Clean Power Exchange (CPX). *California Community Choice: An Interactive Map (Status as of 23 February, 2018)*. Available at: https://cleanpowerexchange.org/california-community-choice/

Example 4 - Subscriber Solar programme, Utah

Subscriber Solar programme helped Utah residents operated by Rocky Mountain Power to directly fund their new PV installations. The initiative represents a shared solar programme that offers to Utahans who are unable to install solar on their own roofs access to off-site solar energy. According to Utah Clean Energy (2016) report on **A Bright Future: A 10 Year Solar Deployment Plan for Utah** from December 2016, this type of program could be expanded, replicated by municipal utilities and rural electric cooperatives, or Please find more details on solar **PV in Logan** on the following link: http://www.logan.qld.gov.au/environment-water-and-waste/sustainable-living/solarpv modified to serve low-income customers, and there are more than 50 municipal and cooperative utilities across the state that serve approximately 20% of Utahans, three of which currently offer community shared solar projects. According to Community Solar Hub (2018), in case of community shared solar projects, an array is built on land or a rooftop located within the community and interconnected to an electric utility's grid, and residents and businesses within the community can purchase panels within the array.

The database of Community Solar Hub (2018) registers three projects in Utah:

1. SunSmart Programme (St. George, 250,000 W, available on: http://www.sgsunsmart.com/);

2. Logan Array (Logan) and
3. Logan City's Community Solar Size (Logan, 19,200 W).

All three aforementioned projects are already sold out.

All investor-owned and cooperative electric utilities in Utah (municipal utilities are excluded) are required to allow residential customers to connect renewable energy systems of up to 25 kW to the grid to the grid and to credit them when excess electricity is generated.

Example 5 – City of Boulder, Colorado

City of Boulder (municipalizing its electricity system)

Seeking to capitalize on innovation in decentralized generation and demand-side management, the city of Boulder, Colorado is currently attempting to municipalize its electricity system. Boulder hopes to "create the 'utility of the future,'" which would support the city's goals of "democratization, decentralization and decarbonization of its power supply."

At least the first two of these goals are directly related to prosumption. Boulder hopes to "increase citizen participation in democratic decision making regarding their use of electricity" and "decentralize their energy source[s] through expanded distributed generation." The process is complex, however, and Boulder has run into concerted opposition from the investor-owned utility currently serving the city. If successful, however, Boulder may serve as a test case for other localities hoping to municipalize in order to increase prosumption and further.

Example 6 – CityNOW project, Denver, Colorado

On the outskirts of Denver, Colorado, not far from Denver International Airport, a grand experiment is underway. Panasonic company has teamed up with a consortium of local partners to transform a 400-acre patch of greenfield land into a smart district.

The project, which falls under Panasonic's wider CityNOW smart cities initiative, has started two years ago with construction well underway and completion planned for 2026.

The project is centred on a new light rail line that connects the area to both the airport and downtown Denver. The project has already built a solar-powered microgrid to provide energy and back-up storage for Panasonic's new 120,000ft² technology and operations centre, which is the anchor tenant in the development and the largest component built so far.

For the next years, Panasonic is working with the Xcel utility and the NREL to develop the US's first carbon-neutral district energy plan. Other key project partners include Colorado property developer LC Fulenwider, Denver International Airport and the city of Denver.

According to the president for CityNOW, George **Karayannis** (2018), the land is a living lab for all stakeholders to evaluate emerging technology and to vet vendors, as many of these public-private partnerships will be 10 to 20-year relationships. This may create some trust challenges among the partners that should build a long-term commitment to be able to conclude a 10- 20 years agreement, and most importantly, to create a business case for broader deployment.

Technological mix and operation of the Panasonic building (microgrid and storages)

There is a unique mix of technologies in this development. The technology mix starts with a microgrid. It's a portfolio microgrid, which is composed of a 1.6 MW solar canopy above the parking lot, a 2 MWh battery and 260 kW of PV on the roof of the 120,000ft² building. The airport owns the parking lot and so the airport and the city paid for the steel of the canopy. The utility partner Xcel paid for the panels and the battery, and Panasonic paid for the PV on the roof. Panasonic works with Xcel and the National Renewable Energy Lab to create what they say the country's first carbon-neutral district energy plan.

The building management system is tied directly to the battery management system controller. Thus, when they are islanded, as that state of charge reduces, the building load automatically and dynamically reduces. Not only is it very advanced demand response, it's tied directly to the battery's state of charge.

The 1.6 MW solar canopy feeds the distribution feeder, and the 260 kW on the roof feeds the battery. Thus, when the grid is islanded, the solar canopy goes to ground, and they operate off the battery exclusively, recharging the battery during hours of sufficient sunshine. Then it's quite possible that they could operate indefinitely in islanded mode; Colorado's got 300 days of sun, and with a load tied dynamically to the state of charge of that battery – when islanded– they could still operate.

Business model for the integration of all these smart energy systems on a large scale

Panasonic gives the utility (Xcel) the justification in the data to go to the PUC (Public Utilities Commission) and with it they want to create a new "resiliency services tariff". Because that allows them to healthy maintain their balance sheet and put their steel in the ground, so that the vertical developers have to invest less. That opens up Xcel's business model, giving them a viable path going forward when everything is net zero.

This gives the developer an opportunity to differentiate their dirt. If this development is carbon-neutral, it attracts those sustainable tenants who would be willing to pay a slight premium, and it allows the developer to reduce the capex they would put into building, because of fewer mechanicals.

Biggest challenges

Stakeholder alignment: They're certainly not technology challenges. The number of stakeholders– the airport, the city, Xcel, the developer, Panasonic – in the project are all equally tied at the hip and should make progress together. Microgrids and carbon-neutral districts are not technology challenges, these are business model challenges. Business model are unlocked and optimised through stakeholder alignment.

Scalability of this kind of smart development

Panasonic has announced a second official smart city, Colorado Springs. They sell to cities, to developers, to utilities and to state departments of transportation and sometimes it's a utility-led engagement, or a developer-led engagement, or a city-led engagement, as in Denver and Colorado Springs.