ECDSO-E

DISTRIBUTED GENERATION FOR SELF-CONSUMPTION

KEY ASPECTS AND RECOMMENDATIONS OF GOOD PRACTICE

Author:	Dalibor Muratović, MH ERS
May 2017	

CONTENTS

1 INTRODUCTION

The power sector has been undergoing one of the most challenging changes for the last 70 years, with a share of the distributed energy sources being increased, thereby significantly changing network planning and operation philosophy.

Besides the impact from technical point of view, the distributed generation with self-consumption is additionally opening a set of commercial issues that need to be resolved with the least market distorting effects possible.

With increasing retail electricity prices and decreasing technology costs, the distributed generation is becoming more and more attractive from electricity customer perspective, who can choose to produce part of the electricity for own needs instead of purchasing it from the supplier.

The neologism ‘’prosumer’’ refers to an electricity customer that produces part of its electricity needs from his/her own power plant and uses distribution network to inject excess production and withdraw electricity when self-production is not sufficient to meet own needs.

Self-consumption is an additional tool to meet renewable energy targets, but also helps the network losses reduction, improves demand response and contributes to CO2 emissions reduction.

A number of commercial schemes had been developed all around the world, in order to regulate self-consumption and injection of excess production in distribution network.

Recent development of the distributed generation and self-consumption was not followed by uniform definitions of the most important terms, thereby making some inconsistencies in different policies marking and comparison.

With this paper, ECDSO-E Working Group (WG) addresses the need to define all important aspects of self-consumption with the focus on commercial issues and avoidance of cross-subsidization among consumer’s groups.

Primary goal of this paper is to recognize all important aspects that need to be regulated to make prosumers concept fully effective in practice.

Where possible, WG will provide recommendations that can be used as a good practice for policy makers in the Energy Community countries.

2 DEFINITIONS

The following definitions are used in this Paper:

''Self-consumption'' is a possibility for any electricity consumer to connect to the DG system, with a capacity corresponding to his/her consumption, to his/her own system or to the grid, for his/her own or for on-site consumption, while receiving remuneration for the non-consumed electricity which is fed into to the grid.

''Self-consumption scheme'' is the commercial arrangement used to valuate self-consumed energy and excess energy injected into the grid.

''Self-consumption rate'' is the amount of electricity actually consumed onsite as a percentage of the total electricity produced.

''Self-sufficiency rate'' is the ratio of total electricity needed by the consumer provided from his/her own renewable energy system.

''Value of excess energy'' is the value the prosumer receives for electricity injected into the grid.

''Net metering'' is a regulatory framework under which the excess electricity injected into the grid can be used at a later time to offset consumption during times when onsite renewable generation is absent or not sufficient, where the value of excess energy is equal to the retail electricity price.

''Net billing'' is a special form of net metering scheme with the difference that the value of excess energy is lower than the retail electricity price.

3 ACRONYMS

Acronym	Meaning
ACER	European Agency for the Cooperation of Energy Regulators
CAPEX	Capital expenditure
CEER	Council of European Energy Regulators
DG	Distributed Generation
DSO	Distribution System Operator
EC	European Commission
ECDSO-E	Energy Community Distribution System Operators Coordination Platform
ENTSO-E	European Network of Transmission System Operators for Electricity
GHG	Greenhouse gas
IEA	International Energy Agency
IEC	International Electrotechnical Commission
LCOE	Levelized cost of electricity
NPV	Net Present Value
OPEX	Operational expenditure
PV	Photovoltaic
TSO	Transmission System Operator

4 LEGAL FRAMEWORK

Stable, transparent and comprehensive legal and regulatory framework is crucial for development of the distributed generation for self-consumption purposes.

In many observed cases, regulatory framework can comprise indirect supports for DGs, thus making cross-subsidies and market distorting effects, as will be discussed in this paper.

The most important legal provisions concerning integration and support of the renewable energy sources, focussing on the network tariffs and state aid issues, are given in this chapter.

Directive 2009/72/EC concerning common rules for the internal market in electricity, sets in Article 36, that the General objectives of the regulatory authority are, amongst other:

''helping to achieve, in the most cost-effective way, the development of secure, reliable and efficient non-discriminatory systems that are consumer oriented, and promoting system adequacy and, in line with general energy policy objectives, energy efficiency as well as the integration of large and small-scale production of electricity from renewable energy sources and *distributed generation in both transmission and distribution networks''*.

Regulatory Authorities are also required to ensure that there are no cross-subsidies between transmission, distribution, and supply activities (Articles 37(1)(f)).

Directive 2009/28/EC on the promotion of the use of energy from renewable sources, in *Article* 16(8) requires from Member States to *''ensure that tariffs charged by transmission system operators and distribution system operators for the transmission and distribution of electricity from plants using renewable energy sources reflect realizable cost benefits resulting from the plant's connection to the network. Such cost benefits could arise from the direct use of the low-voltage grid''.*

''Guidelines on State aid for environmental protection and energy 2014-2020'' is published by the European Commission in 2014**.** Beside other issues and recommendations laid down by this document, support to energy from renewable sources is also considered as an important aspect of state aid provided in the energy sector.

In paragraph (112), Guidelines provides that *''Aid to energy from renewable sources can be granted as investment or operating aid''.*

Chapter 3.3.2. provides general framework for support schemes to be developed, as follows.

3.3.2. Operating aid granted to energy from renewable sources

3.3.2.1. Aid for electricity from renewable energy sources

(124) In order to incentivise the market integration of electricity from renewable sources, it is important that beneficiaries sell their electricity directly in the market and are subject to market obligations.

The following cumulative conditions apply from 1 January 2016 to all new aid schemes and measures:

(a) aid is granted as a premium in addition to the market price (premium) whereby the generators sell its electricity directly in the market;

(b) beneficiaries (65) are subject to standard balancing responsibilities, unless no liquid intra-day markets exist; and

(c) measures are put in place to ensure that generators have no incentive to generate electricity under negative prices.

(125) The conditions established in paragraph (124) do not apply to installations with an installed electricity capacity of less than 500 kW or demonstration projects, except for electricity from wind energy where an installed electricity capacity of 3 MW or 3 generation units applies.

With regard to the aid granting process, Paragraph (126) provides:

(127) Aid may be granted without a competitive bidding process as described in paragraph (126) to installations with an installed electricity capacity of less than 1 MW, or demonstration projects, except for electricity from wind energy, for installations with an installed electricity capacity of up to 6 MW or 6 generation units.

Energy Community Secretariat's Policy Guidelines published on 26 November 2015, confirmed the applicability of the "Guidelines on State aid for environmental protection and energy 2014-2020", to the Energy Community Contracting Parties.

Proposal for a Directive on the promotion of the use of energy from renewable sources (recast) published by European Commission on 23 February 2017 in new Recital (53), prescribes:

''With the growing importance of self-consumption of renewable electricity, there is a need for a definition of renewable self-consumers and a regulatory framework which would empower self-consumers to generate, store, consume and sell electricity without facing disproportionate burdens. Collective self-consumption should be allowed in certain cases so that citizens living in apartments for example can benefit from consumer empowerment to the same extent as households in single family homes.''

The Proposal also provides the definition of 'renewable self-consumer', as follows:

''renewable self-consumer means an active customer as defined in Directive [MDI Directive] who consumes and may store and sell renewable electricity which is generated within his or its premises, including a multi-apartment block, a commercial or shared services site or a closed distribution system, provided that, for non-household renewable self-consumers, those activities do not constitute their primary commercial or professional activity''.

New Article 21 provides the explicit legal framework for renewable self-consumers, as follows:

''1. Member States shall ensure that renewable self-consumers, individually or through aggregators:

(a) are entitled to carry out self-consumption and sell, including through power purchase agreements, their excess production of renewable electricity without being subject to disproportionate procedures and charges that are not cost-reflective;

(b) maintain their rights as consumers;

(c) are not considered as energy suppliers according to Union or national legislation in relation to the renewable electricity they feed into the grid not exceeding 10 MWh for households and 500 MWh for legal persons on an annual basis; and

(d) receive a remuneration for the self-generated renewable electricity they feed into the grid which reflects the market value of the electricity fed in.

Member States may set a higher threshold than the one set out in point (c).

2. Member States shall ensure that renewable self-consumers living in the same multi-apartment block, or located in the same commercial, or shared services, site or closed distribution system, are allowed to jointly engage in self-consumption as if they were an individual renewable self-consumer. In this case, the threshold set out in paragraph 1(c) shall apply to each renewable self-consumer concerned.

3. The renewable self-consumer's installation may be managed by a third party for installation, operation, including metering, and maintenance.''

5 TECHNOLOGY AND CAPACITY CRITERIA

5.1 Technology eligibility

The solar PV power plants are generally allowed for self-consumption purposes with no exception. In a number of jurisdictions, other types of small DG technologies are also allowed, like the biomass and biogas power plants, micro wind-generators, fuel cells etc.

5.2 DG capacity limitations

The net metering and net billing schemes are generally limited to small scale residential and commercial DG installations, while the other self-consumption schemes are not limited in size or have limits around or above 1 MW.

Under the netting schemes, DG size limitation is applied as a rule in all observed countries. Twofold limitations are commonly used, with the general threshold prescribed in advance and maximum individual DG size determined depending on consumer's demand and consumption. Prosumers are expected to optimize DG capacity in comparison with their load profile and total consumption, so that the annual production is lower than consumption.

Beside the individual capacity limits, system limitations can also be provided as a tool for limiting DG penetration for self-consumption purposes.

5.3 Self-consumption rate

The self-consumption rate generally depends on the prosumer's annual consumption, rated capacity and annual production of the DG system, consumer's load-profile and production profile.

Since the value of the self-consumed electricity is generally higher than the value of excess energy, prosumers are motivated to maximize the self-consumption rate and thus increase the revenues of a DG system. Increase can be achieved by changing the load profile or by storing electricity.

Otherwise, if the net metering scheme is applied, prosumers are not incentivized to maximize the self-consumption rate since the values of the self-consumed electricity and excess energy are the same.

Standard residential consumers are likely to have self-consumption rate of about 30%, with demand-side management and decentralized energy storage, the rate can be increased to 65-75%.[1]

Commercial consumers (e.g. department stores, office buildings etc.) with PV installations, can have high rates of self-consumption (e.g. 50%-80%), due to the relatively good match between the consumption load profile and the onsite production.

[1] EC, Best practices on Renewable Energy Self-consumption, Page 4

6 SELF CONSUMPTION SCHEMES

In general, three the most common used self-consumption schemes are:

1. Commercial arrangement with the selling of excess energy at the market, with/without premium for the self-consumed production,
2. Net metering,
3. Net billing.

6.1 Commercial arrangement

Under this scheme, the injection of electricity to the grid and the withdrawal of electricity from the grid are valued and invoiced separately. Separate invoices are being issued by supplier for the withdrawn electricity and by prosumer for injected electricity.

6.2 Net metering and net billing

Net metering is the term with a broad range of definitions provided in the relevant publications, where some discrepancies were found depending on whether it has technical, commercial or both perceptions.

Some definitions assume that ‘’Net metering’’ is a dominantly technical framework under which the injected and withdrawn electricity are measured by the electricity meter with single kWh register that counts backwards while electricity is being injected. Similar implicit meaning was found in document EC ‘’Best practices on Renewable Energy Self-consumption’’ where it was stated that ‘’*From the consumer perspective, net energy metering is attractive and easy to apply and to understand, as it relies on the use of one single meter*’’[2]. Because of the direct energy netting at the electricity meter, the value of excess energy is implicitly set at the level of retail electricity price.

To our understanding, this definition is not proper even from technical point of view, since we consider that separate two-direction’s measurement is a “must-have”. Definition of net metering, as given and used in this Paper, makes the metering framework for net metering and net billing completely the same. Under the both schemes, consumers use the grid as a backup system for their excess power production. In a situation when quantities of injected energy are greater than withdrawn energy during the billing period, prosumer is credited in kWh or in monetary units for the next billing period. The maximum timeframe for credit compensation varies, in a range from real-time compensation during the day, up to the multiyear period or indefinitely.

[2] EC, Best practices on Renewable Energy Self-consumption, Page 10

The difference between the net metering and net billing scheme is given by the commercial framework for evaluating the excess energy.

Under the net metering scheme, a net difference of the withdrawn and injected energy is invoiced by supplier, and any remaining surplus of the injected energy during the billing period is credited in kWh for the next billing period. As a result, total excess energy is valued at the retail electricity price, thereby exempting prosumer from paying the volumetric grid tariffs and other taxes and levies for entire DG production. As a consequence of hidden subsidies caused by exemption of the volumetric grid and other costs, a net metering scheme also has a negative effect on other consumers and makes market distortion. In its position paper on self-generation, CEER strongly recommends that net metering should be avoided as it implies that system storage capacity is for free[3]. Further arguments are related to the undermining efforts to enhance flexibility and to develop demand-side management, since the prosumer is not stimulated to optimize its demand to increase the self-consumption rate as the time value of generated energy is completely lost.

Under the net billing scheme, the invoice issued by supplier is based on the value of the withdrawn energy decreased by the value of injected energy. In this case, any remaining surplus of the injected energy during the billing period is credited in monetary units for the next billing period. The excess energy is valued at a level below the retail electricity price, using one of the methods described in chapter 6.3. Monetary credit settlement is strongly influenced by the type of supply contract (fixed or variable price) and supply price changes during the contract realization, also depending on the method used to evaluate the excess energy.

The presence of credit can be seen as the additional issue that need to be resolved when supplier switching occurs and final settlement should also include the value of outstanding credit. Another specific, credit related issue is raised in a situation when permanent decline in energy consumption occurs during the DG life time (e.g. factory closed or capacity decreased, changes in household demand, etc.). This situation can be seen as the additional project risk, decreasing the bankability of the DG systems with a higher premium risk charged by the banks. Regulatory framework is expected to provide a reasonable solution for those circumstances, thereby increasing investment security and bankability and reducing costs of financing.

Some observed countries have allowed the energy netting even if the generation and consumption locations are not the same, making the arrangement also known as a ‘’virtual net metering (billing)’’.

In some jurisdictions, energy netting can be applied in multi-family housing, where the net production in one site is split between several consumers.

[3] CEER, Position Paper of self-generation, Page 3

In most countries (Belgium, Denmark, Germany etc.), third party ownership is permitted as a situation when the generation assets are not owned by consumers, but are being owned by the third party. Leasing business models are used, where the consumer pays back the investment in installments via a lease and is typically given the option to purchase the system at the end of the lease. This option also gives the opportunity to low income consumers who do not have access to the bank loans, to make electricity savings out of which the investment can be paid off.

6.3 Value of excess energy

Very different options are applied worldwide in relation to the excess energy, depending on the subject in charge of electricity uptake and depending on the methodology used to calculate its value.

The value of the excess energy can be defined using the very different approaches, as follows:

1. Feed in tariff,
2. Wholesale electricity price,
3. Wholesale electricity price adjusted for supplier's costs,
4. Spot market electricity price,
5. Spot market PV electricity price,
6. Avoided costs of grid electricity,
7. Retail electricity price,
8. No value.

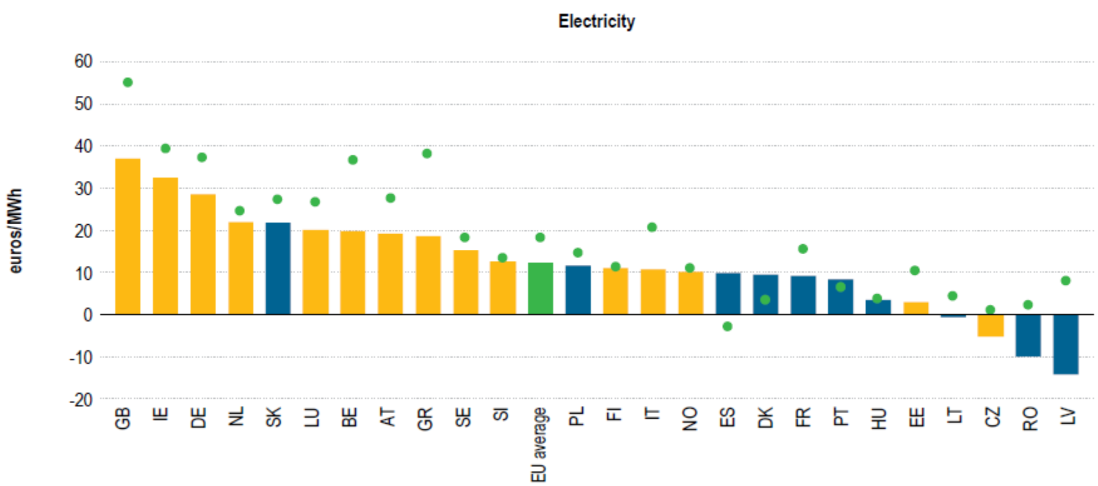
Feed in tariff and premium support scheme is the most common approach used at early stages of renewable energy policy development, but has recently been substituted with the more market oriented approaches. The uptake of excess energy is guaranteed with the price equal to the administratively set feed in tariff, where the self-consumed electricity can also be supported with the feed in premium. Initially, as a rule, feed in tariffs were higher than the retail electricity prices, but with the falling technology costs, these tariffs have been considerably decreased even below the level of retail prices. Feed in remuneration schemes are time limited usually in the range of 10-20 years.

Wholesale electricity price (option 2) is the varying reference price obtained from the wholesale electricity market in a longer period (week, month, year).

In some cases, this price is compensated for supplier's costs for energy transaction at the market (option 3).

At the competitive electricity market, it is expected that wholesale electricity price and energy component of retail electricity prices would normally converge; however, this is not the case in most of EU states. Wholesale electricity prices have been highly volatile for the last 10 years, while the energy component of retail electricity prices shows much more stability and predictability.

As a consequence, proper valuation of excess energy is additionally aggravated by the significant mark-up between the energy component of retail electricity prices and wholesale electricity prices in vast majority of countries[4]. Average annual mark-ups in retail electricity (2008–2015) for household consumers in EU member states and Norway and annual mark-ups – 2015 (euros/MWh) are provided in Figure 1.



Source: Agency for the Cooperation of Energy Regulators

Figure 1 Average mark-ups between the energy component and wholesale electricity prices

Blue bars in the previous graph are used to mark average (2008-2015) mark-up in countries with regulated prices, yellow bars are used for countries without regulated prices, while the green dots are representing the mark-ups in 2015.

Increasing number of countries links the excess energy with the spot market electricity price, thus reflecting the real value of electricity at the spot market (option 4).

[4] ACER, Market Monitoring Report 2015 - ELECTRICITY AND GAS RETAIL MARKETS, Page 43

A special form of this scheme is given in Germany[5] where the ''spot market PV electricity price'' is established in order to make true market assessment of the value PV electricity has in the power system (option 5).

Avoided costs of grid electricity method (option 6) sets the value of excess energy equal to the incremental costs to the electric utilities to generate and distribute comparable electricity. This method compensates excess energy for all the net avoided costs that the power system no longer has to incur as a result of lower consumption and demand. Avoided generation costs are driven by the variable costs of the marginal resource that is being displaced, which depend on that resource's fuel prices, variable operation and maintenance costs. Avoided network costs are avoided distribution capacity costs (if any) and avoided distribution losses. This method can be further extended to include social benefits, such as environmental and health benefits. Avoided costs method may not be as easy to implement as other methods, given the complexity of parameters to be taken into account.

Retail electricity price is a price that includes energy component and volumetric grid costs and other taxes and levies (option 7).

It is worth to emphasize that Spain does not validate the excess energy at all for DGs having installed capacity < 100 kW[6] (option 8).

Time of use price differentiation can also be used as an additional tool to properly valorise the excess energy and allow prosumers to receive a fair remuneration.

Depending on the principle applied to value the excess energy, a metering interval should also be aligned with the trading interval used for value determination.

6.4 Excess energy contracting party

Prosumer's supplier is in principle responsible for uptake of the excess energy under the prescribed conditions if netting schemes are applied. If netting scheme is not applied, different institutions can be obliged to purchase the excess energy, depending on the state's regulatory framework (e.g. system operator, market operator, public supplier, specific support system operator etc.). There are also some countries that do not oblige any party to uptake the excess energy, but leave it to the market mechanisms (Belgium).

---

[5] EC, Best practices on Renewable Energy Self-consumption, Page 13
[6] IEA PVPS, Review and Analysis of PV Self-Consumption Policies, Page 26

If prosumer's supplier is not the contracting party that purchases the excess energy, it makes the metering data management procedure very complex, since the DSO would be obliged to provide the data from a single meter to the different parties simultaneously.

7 GRID PARITY

Self-consumption model is based on the fact that in a growing number of countries renewable electricity – mainly solar PV – has achieved grid parity, that is the situation where an expected unit cost of self-generated renewable electricity matches or is lower than the per-kWh costs for electricity obtained from the grid, i.e. the variable part of a consumers' electricity bill.

Grid parity level depends also on the consumer category, because the electricity price differs between the categories, with households usually paying the higher prices compared to the industrial and commercial consumers.

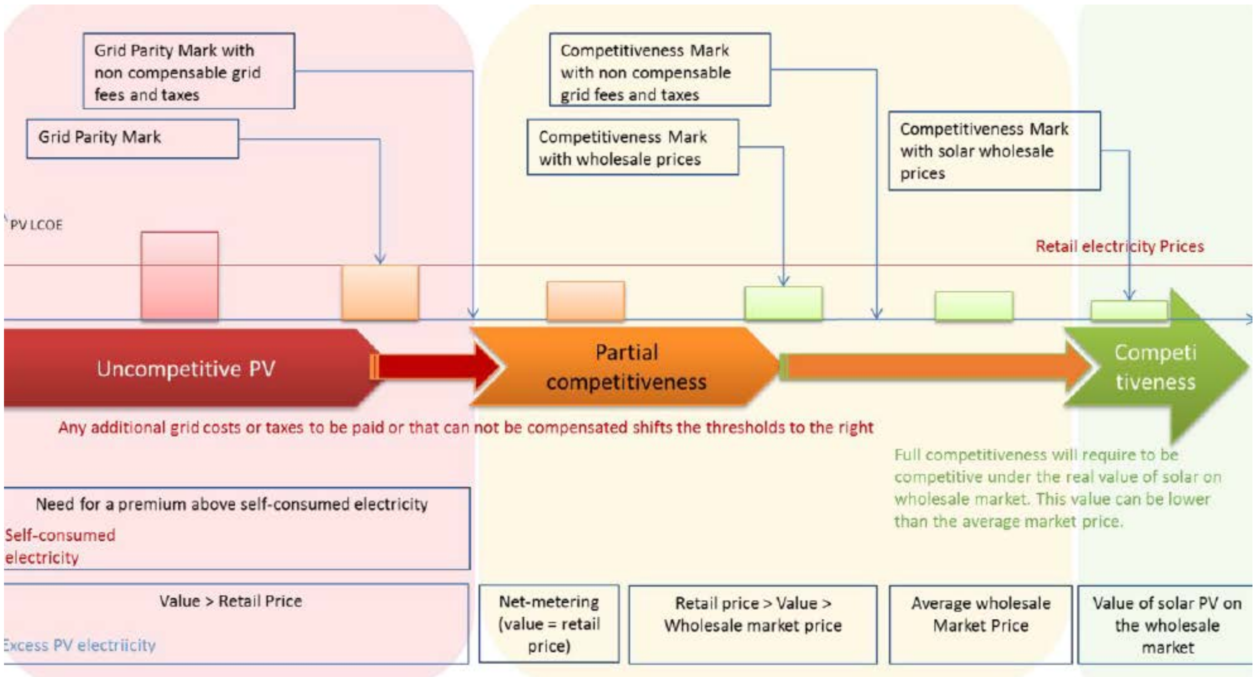
Grid parity assumes the optimal situation that 100% of the produced electricity is self-consumed, which is usually not the case, and a part of investment cost is to be recovered by receiving remuneration for excess energy injected into the grid. Additional assumption for theoretical grid parity is that the self-consumed electricity is fully exempted from variable grid costs and other levies. Since the both assumptions are not realized due to several reasons, one can conclude that grid parity can be seen as a milestone, but not the guarantee for competitiveness.

If prosumers are not exempted from some grid costs and levies, than the production costs (DG LCOE) should be more decreased to reach the next parity level.

Since a share of produced electricity is not to be self-consumed, but is injected into the grid as excess energy valued at a price lower than retail electricity price, the DG LCOE should decrease more to reach the third parity level.

The real competitiveness has not been achieved yet, since the true value of excess energy is lower than the market price, because of suppliers' energy transaction costs. Thereby, full competitiveness is reached when the DG LCOE is lower than the revenues from bill savings as a result of self-consumption and from sales of excess energy under the market conditions.

Illustrative chart showing parity levels for solar PV, as explained in previous text, is provided in Figure 2.



Source: International Energy Agency

Figure 2 DG PV Parity levels[7]

[7] IEA, Review and Analysis of PV Self-Consumption Policies, Page 56

8 GRID COSTS

The self-consumed electricity is mainly exempted from payment of variable grid costs and other system charges for the self-consumed electricity.

In theory, self-consumption could reduce the need for grid extension on a local level, however the consumption and generation profiles are generally not coinciding, or at least not every day or hour. Additionally, distribution system usually faces the peak demand in the evening hours when the PV production is not available and thereby does not have positive impact on the distribution system dimensioning.

Consequently, distribution grids are still dimensioned as if there was no self-consumption and the DSO must dimension the grid capacity to deliver the requested demand at any time during the year. The total grid costs are not decreased with the increased level of self-consumption, as the grid costs are mainly driven by the system capacity.

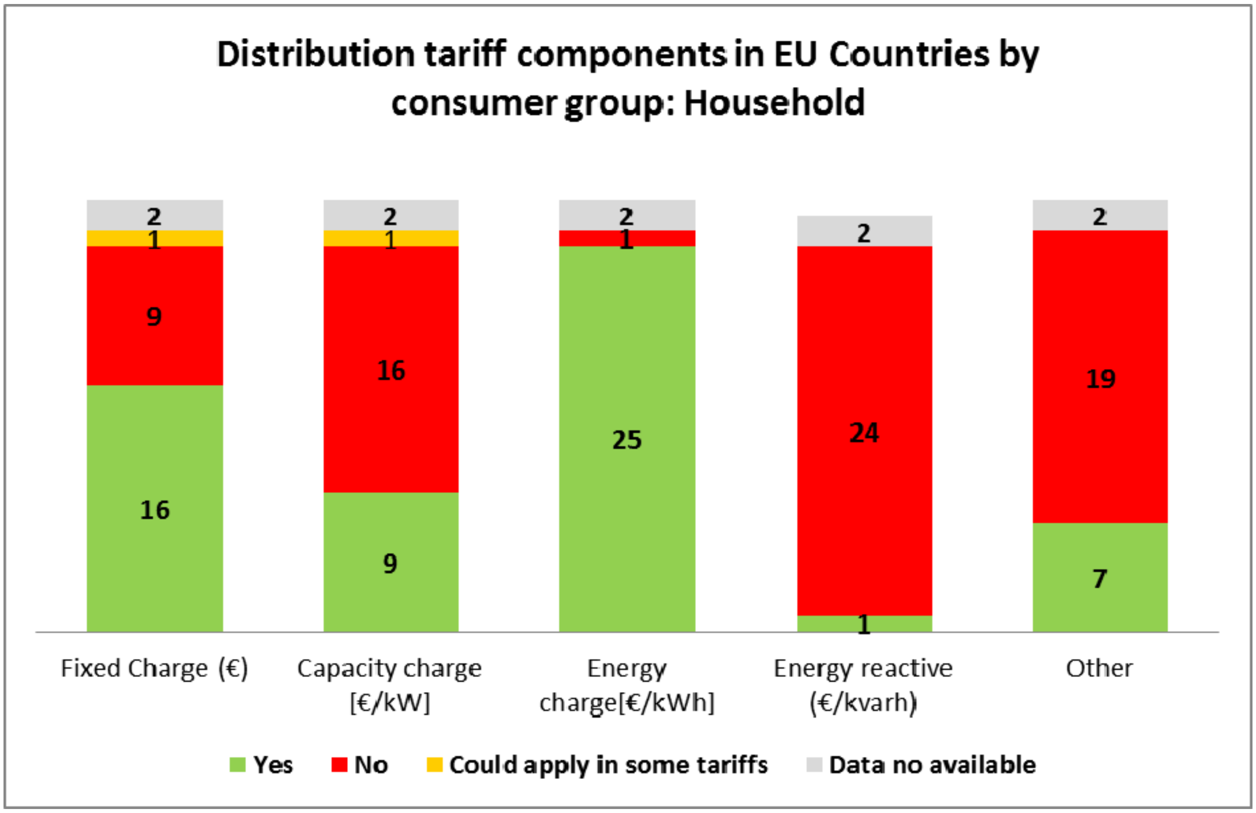
This issue is becoming more relevant with the large scale deployment of self-consumption and it incited some countries to make changes of legal framework with capacity tariffs to be paid by prosumers (Belgium Wallonia in 2015, France specific network tariffs for self-consumers under consideration) or to make retroactive introduction of additional system costs payment for self-consumed electricity (Spain for P>10 kW named as the ''grid back-up toll''). The retroactive changes in Spain incited a number of lawsuits before the national and international courts and petitions submitted to the European Commission. The European Commission position on those petitions can be summarized as the: ''Member States enjoy wide freedom regarding the choice of support schemes as long as they reach the indicative trajectory set out in Part B of Annex I of the Directive. This condition is presently met by Spain. The question whether changes to national renewable energy support schemes comply with EU General Principles of Law, needs to be assessed on the basis of relevant domestic legal frameworks and thus by national Courts''[8].

Questions of cross subsidization among consumers' categories and the DSO cost recovery are inherent to self-consumption, irrespective to the deployment level. The cross subsidization is of particular concern if volumetric grid tariffs are used instead of the capacity based tariffs. Self-consumption, if exempted from paying the grid costs, causes shifting of these costs to other consumers without own DG system.

[8] Directorate General for Internal Policies, Policy Department C: Citizens' Rights and Constitutional Affairs, Solar energy policy in the EU and the Member States, from the perspective of the petitions received, Page 32

Volumetric tariffs are directly encouraging self-consumption, as the grid cost are being fully avoided. If the grid costs are charged only through the capacity-based tariffs, grid costs for the prosumer are reduced if self-consumption reduces the peak-load. Between these two models of grid charging, there are also mixed models, with the flat components (€/consumer) charged in addition to the capacity and volumetric tariffs.

For household consumers, most EU Member States currently charge grid costs through mixed grid tariffs, as shown in Figure 3[9].



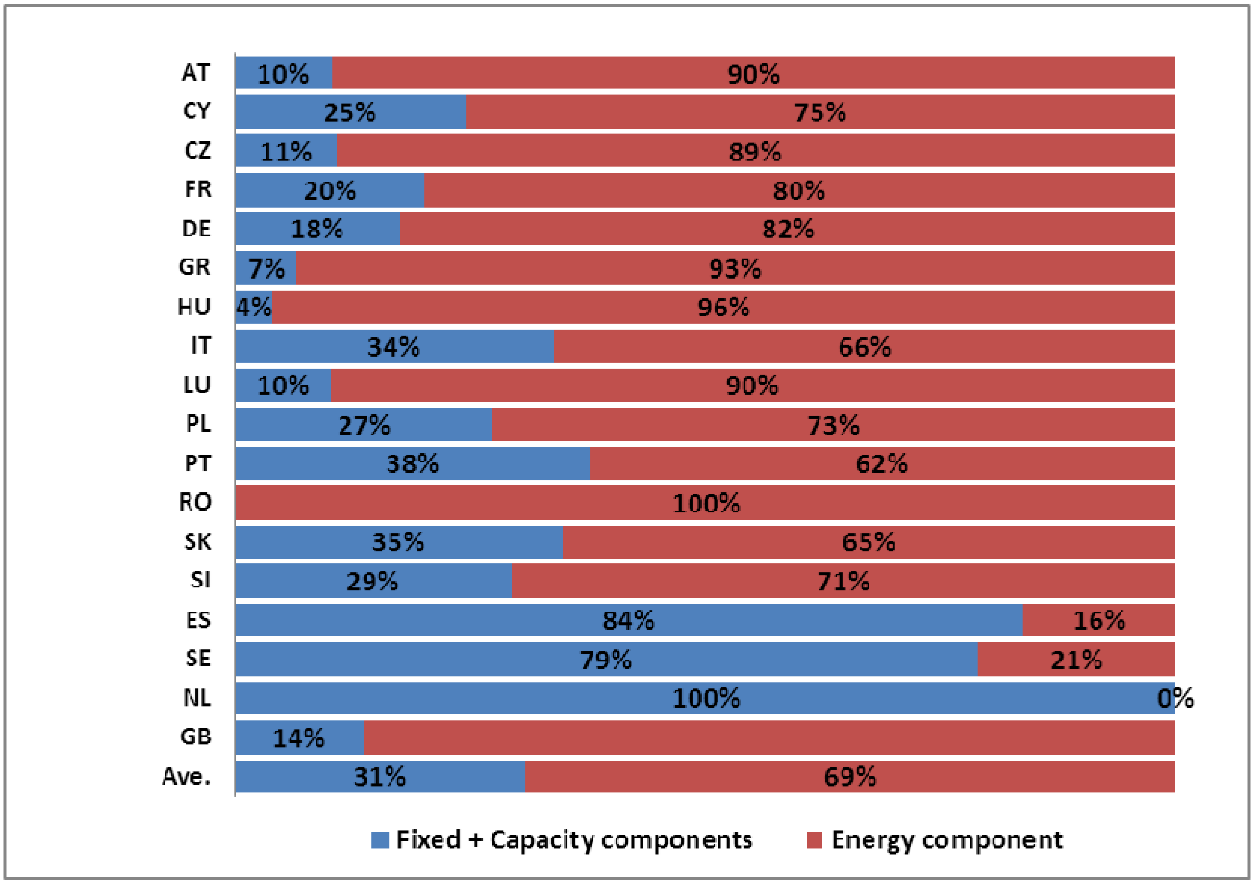
Source: European Commission, Directorate General for Energy

Figure 3 Distribution Tariff components in Household (Number of countries)

The tariff component weight in household's grid costs is the most important indicator for the quantitative analyses to be performed to reveal the level of cross-subsidization between the prosumers and other consumers.

The average active energy and capacity components weights in total grid costs for household consumers in EU member states in 2015 are shown in Figure 4[10].

[9] EC, Study on tariff design for distribution systems, Page 111



Source: European Commission, Directorate General for Energy

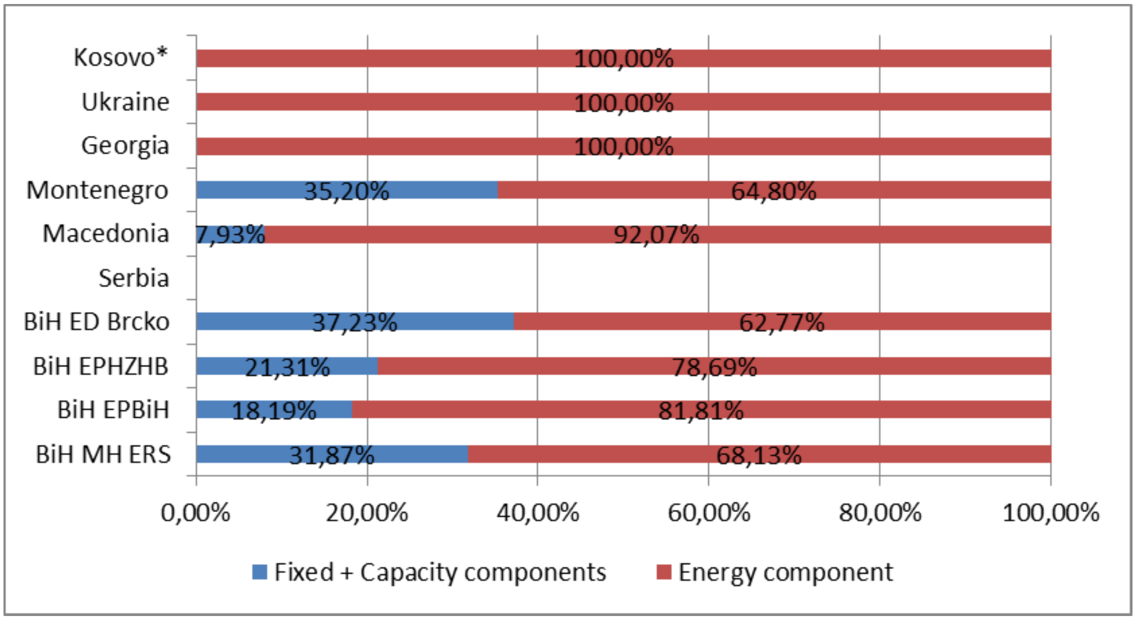
Figure 4 Distribution Tariff component weight in Households

For a household consumer, the average active energy component across EU member states (19 countries with data available) is above 69% of the total.

In only a few countries including Spain and Sweden the fixed or capacity component is dominant and around or above 80%, while in the Netherlands the totality of costs is charged through the capacity component for household consumers.

The average active energy and capacity components weights in total distribution grid costs at the power system level in the Energy Community countries are shown in Figure 5.

[10] EC, Study on tariff design for distribution systems, Page 114



Source: Energy Community Secretariat database

Figure 5 Distribution Tariff component weight in the Energy Community

As it can be seen from Figure 5, similar relative share between tariff components is observed in the Energy Community countries when compared with the EU countries, with the vast majority of DSOs having fixed and capacity components share under 35%.

On the other side, average share of fixed costs in the DSOs total regulatory approved revenues in the the Energy Community countries is around 80%[11].

In those countries with a higher share of active energy component, the prosumers contribute less to the grid cost recovery, because the net amount of electricity distributed is reduced for the self-consumed electricity. In a situation when net metering scheme is applied, this effect is even aggravated, since the total generated electricity is exempted from paying volumetric grid tariffs.

From network usage perspective, there is no difference between prosumer and standard consumer requiring the same capacity. As previously explained, grid costs are mostly capacity driven and volume of the electricity withdrawn has a minor effect on total grid costs. In that sense, prosumers should contribute to the grid cost recovery in the same way as other consumers, in full compliance with the cost reflectivity principle. Otherwise, the fixed grid costs should be socialized and covered by higher grid tariffs paid by other consumers without DG.

[11] Data collected from regulator's websites

An increased share of self-consumption has additional negative effect on DSO cost recovery, especially in countries with longer regulatory pricing period. In some of the observed countries, the net distributed electricity is significantly decreased and DSOs are exposed to the volume risk that they cannot control, with possible financial consequences. Total distributed energy in 2013 is significantly reduced when compared to 2011[12], which was mainly due to the increased self-consumption, energy efficiency and the economic crisis. During 2013, in Spain total distributed energy was reduced by 6,5%, in Italy 6,3%, in Netherland 17,4% and in Portugal by 6,4% compared to the 2011 level. Unfortunately, energy statistics at the EU level on the share of self-consumption are not reliable and comprehensive, because either the data are not available at all, or data are not updated or comparable[13].

Network tariffs that are capacity based, mitigate this risk and prevent making financial gap in the DSO revenues.

[12] EURELECTRIC, Prosumers – an integral part of the power system and the market, Page 14
[13] CEER, Status Review of Renewable Support Schemes in Europe, Annex 14

9 OTHER TAXES AND LEVIES

Electricity bill is usually used to collect a number of electricity and even non-electricity related taxes and levies, that are charged on a volumetric basis per kWh of the distributed energy. The share of taxes and levies has been continuously increasing for the last decade, reaching 23% of electricity bill for average European household consumer in capitals consuming 4.000 kWh/year in 2015[14], while the grid costs make 26%, energy costs 37% and VAT 15%. Higher taxes and levies accelerated the grid parity reaching, since they are usually invoiced per the distributed kWh.

In some countries, the volume risk for the DSO is even magnified since the other non-network related taxes and levies are included in the grid tariffs.

The taxes and levies are used as policy support charges, whereby the renewable support fee is the most frequently used add-on on electricity price, reaching 13% of the electricity household bill in 2015[15]. Other policies financed by the levies on electricity consumption are the combined heat and power generation, conventional back-up capacity, energy efficiency schemes, vulnerable consumers' protection, cross-regional DSOs compensations etc.

As a share of prosumers is increased, shifting of these costs to other consumers is inevitable, unless the regulatory framework is changed.

In Spain, the new law on self-consumption was introduced in 2015, prescribing that all the policy support fees are to be charged to the self-consumed energy.

In Germany, new PV installations since 2014 have been obliged to pay renewable surcharge for the self-consumed electricity. Installations below 10 kW are exempted, while other new installations had to pay 35% of the surcharge if installed in 2016, and 40% from 2017. The exemption is valid during 20 years. Plant owners, not importing any electricity from the grid and opting not to receive the feed-in tariff for exported electricity, are exempt from this payment.

In Denmark, a reduced public service obligation tariff is used for the self-consumed electricity. The reduction corresponds to the costs relating to subsidies for renewable energy and local CHP units.

---

[14] ACER/CEER, Annual Report on the Results of Monitoring the Internal Electricity and Gas Markets in 2015, Retail Markets, Page 15

[15] ACER/CEER, Annual Report on the Results of Monitoring the Internal Electricity and Gas Markets in 2015, Retail Markets, Page 15

In Portugal, since 2014 the self-consumption with an installed power higher than 1.5 kW and that is connected to the grid has paid a monthly fixed compensation in the first 10 years. This compensation integrates an amount for RES support.

10 VAT AND OTHER PUBLIC TAXES

The self-consumption legal and regulatory framework must also take into account the state tax policies, in order to properly evaluate the wider social impact of the self-consumption schemes.

It is a matter of energy policy to allow or not the netting schemes and subsequently to allow VAT charging only on the net value of energy supplied to the customer from the grid. Considerations and impact assessment include benefits from energy sustainability and affordability against costs made of less state income in VAT. The significance of VAT not charged on the netted electricity will depend on the specific solutions regulating the right of non-taxable person to produce electricity and feed it to the grid. Overall social benefits must not be underestimated too; smart initiatives towards aggregation and flexibility can contribute to lower network costs, lower balancing costs and even create new added value in the system through aggregation and provision of balancing services. In that sense, VAT legislation should not be rigid to deprive small customers and the whole system from exploiting these benefits.

10.1 Impact on the public tax authorities

To evaluate impact of the self-consumption schemes on the public tax authorities, different taxes should be considered: VAT on electricity consumption or similar taxes, but also VAT on the CAPEX investment (residential DG systems) and the OPEX costs, the corporate income tax for the installer company, OPEX related taxes, insurance taxes etc.

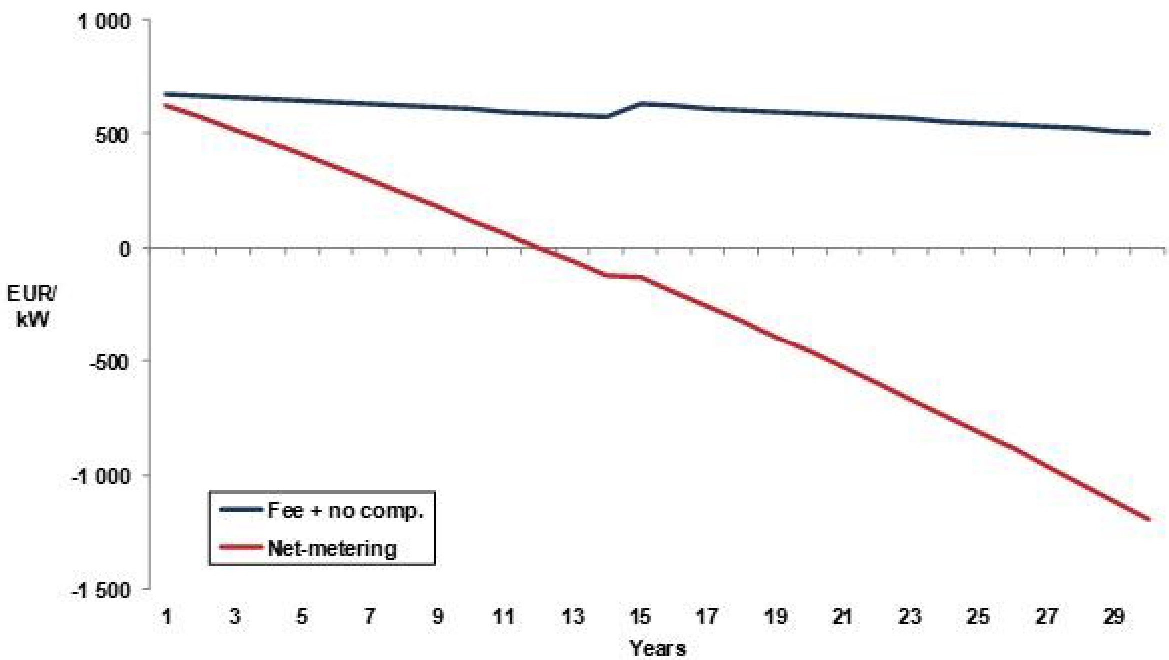
During the year of the DG system installation, the taxes collected will raise significantly while the taxes linked to electricity consumption, especially in netting schemes, will be reduced later during the lifetime of the DG plant.

The value added tax and its collection becomes an important issue with the introduction of self-consumption schemes, since the VAT cash flow is strongly influenced by the installation and operation of DG for the self-consumption purposes.

Besides it, another important issue is compatibility of net metering and billing schemes with VAT laws. As a general rule, before self-consumption schemes were introduced, energy taxes and VAT had been based on a customer’s total electricity consumption. With the introduction of self-consumption netting schemes, VAT is supposed to be charged and paid on the net difference between imports and exports during a certain billing period.

In that sense, concerns about non compatibility of netting schemes with the VAT laws have been reported in Sweden[16] and Norway[17], but also in Energy Community countries (Bosnia and Herzegovina). Notwithstanding the reported non-compatibility in a few jurisdictions, netting schemes are applied worldwide without tax obstacles (10 out of 26 EU member states[18], USA, Canada etc.).

To evaluate the effects on the public tax authorities, it is beneficial to provide illustrative analyses of VAT and other taxes cash flow, given per kW of installed PV power[19]. The analysis is performed for standard reference rooftop PV system having installed capacity 3 kW, with the set of assumed parameters based upon the market prevailing conditions.



Source: International Renewable Agency

Figure 6 Accumulated cash flows for the public tax authority

The upper line on the diagram shows the results for the case *"Self-consumption with constraints": there is a charge on each kWh of PV on-site self-consumption and there is no compensation whatsoever for the excess PV electricity fed into the grid.* This scenario is

[16] Energy Markets Inspectorate, Adapting Electricity Networks to a Sustainable Energy System – Smart metering and smart grids, Page 97
[17] Navigant, Net Metering Standard Industry Practices Study, Page 11
[18] CEER, Status Review of Renewable Support Schemes in Europe, Annex 15
[19] IEA PVPS, Review and Analysis of PV Self-Consumption Policies, Page 48

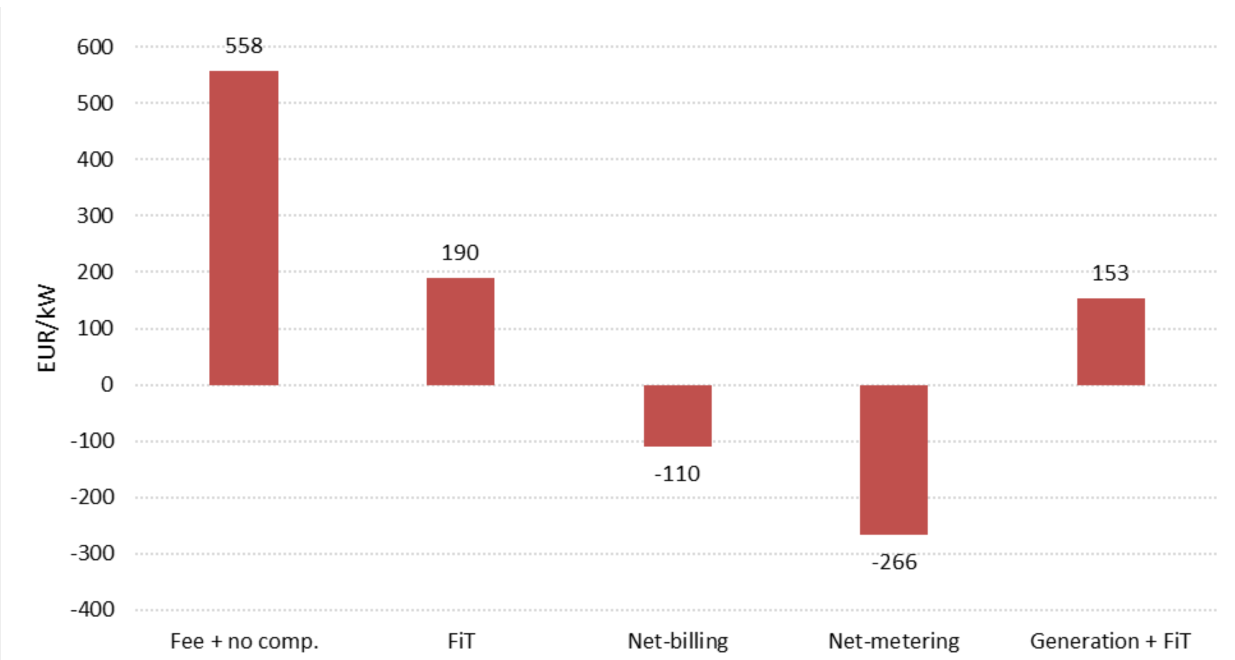
assumed to be the most unfavorable and the least profitable for the prosumers. This case could become profitable only with the PV LCOE significantly below the retail electricity price.

The lower red line on the diagram shows the results for the scheme case *"Net-metering" described as the: ''for each kWh of PV on-site self-consumption, the prosumer saves on the full variable cost of electricity from the grid (including taxes), and excess PV generation exported to the grid is valued at a price that is equal to the retail price of electricity''.*

As it can be seen from Figure 6, self-consumption has a positive impact on the tax authority, during a significant period of time, whereas the net metering scheme has a positive accumulated cash flow during the first twelve years for analyzed reference PV system and set of assumed parameters.

Net billing is logically expected to alleviate effects on VAT cash flow and to postpone ''VAT cash flow zero crossing'', since the value of excess energy is lower than retail electricity price and the tax basis is accordingly higher.

The impact of different self-consumption schemes on the tax authority over the 30 years, based on analysis provided by the International Energy Agency[20] and expressed as NPV per kW, is shown in Figure 7.



Source: International Renewable Agency

Figure 7 NPV per installed kW for the public tax authority

[20] IEA PVPS, Review and Analysis of PV Self-Consumption Policies, Page 49

As it was expected, net billing scheme has alleviating effect, but NPV over 30 years is still negative for the analyzed PV system.

Economic analyses provided are simplified as it does not include and quantify a number of benefits associated with the RES DGs, regarding the GHG emissions, energy security, health and wellbeing, energy affordability, job creation etc.

10.2 VAT on consumption of non-taxable persons

VAT on consumption and excess energy injection of non-taxable persons is an important issue in a situation when DG is operated by a household or small commercial consumer.

If the netting scheme wouldn't be allowed or applicable, then the prosumer should be invoiced for the electricity taken from the grid and it would invoice its counterparty for electricity feed into the grid.

Households may take part in this system only if there is a framework for their aggregation, which might be in the form of cooperatives or by means of mandatory buy-out by a statutory purchaser of the electricity fed into the system. However, non-taxable persons are not entitled to charge VAT in the invoices issued for the electricity fed into the grid, thereby making inconsistency in the reported VAT at the system level.

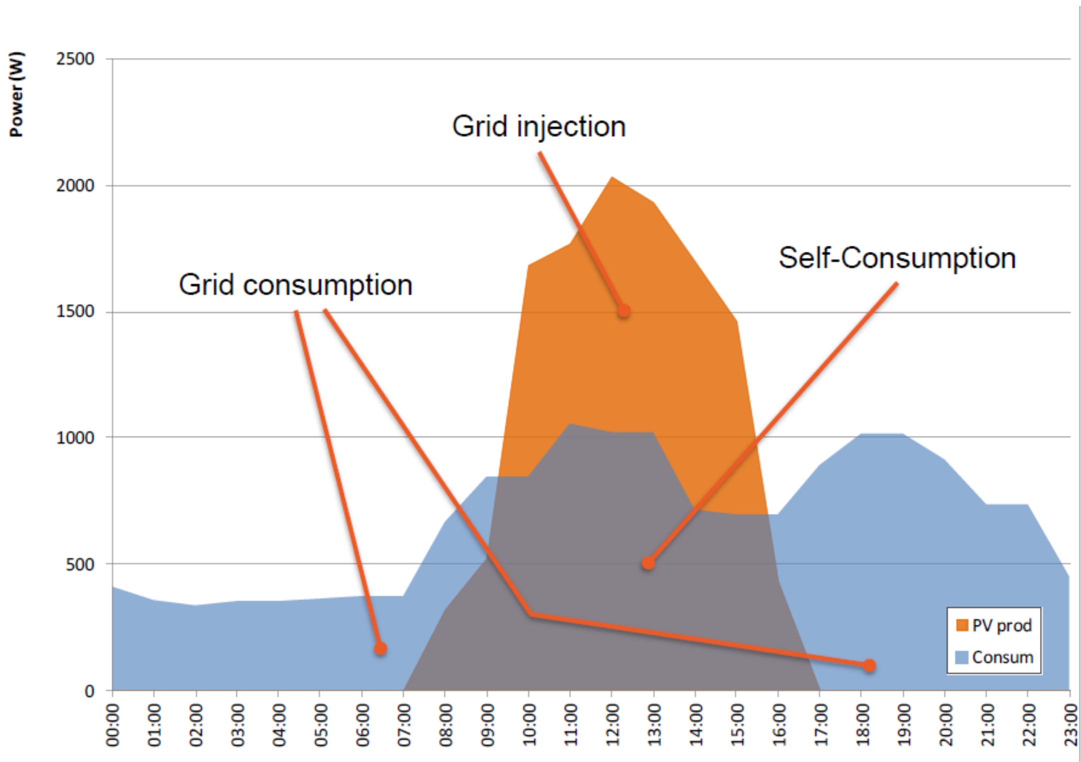
If the netting scheme is allowed, VAT revenues are decreased proportionally to the excess energy injection, but there is no inconsistency in reported VAT at the system level as long as the generation is lower than consumption for the VAT reporting period. If the netting scheme legal framework allows for prosumer to feed into the grid more than it consumes for a VAT reporting period, the procedure must be in place to ensure consistency of the reported and paid VAT by all involved stakeholders, from network operator, market operator, suppliers and balance responsible parties.

Netting schemes are expected to increase complexity in relation to VAT recording and payment, particularly if registered net consumption for VAT reporting period is negative, but in principle, individual households may take more active role and contribute to sustainable electricity from RES only if netting scheme is allowed for their DG.

11 IMBALANCE SETTLEMENT

Balance responsibility is generally binding for DGs that have a larger capacity[21] than the maximum threshold used for net metering and net billing schemes. On the contrary, capacity limit for the self-consumption commercial schemes can be higher than the minimum threshold, thereby subjecting those prosumers to standard balance responsibility.

For balancing purposes, household and small commercial consumers are generally modeled by standardized load profiles. In a situation when the consumer becomes prosumer, load profile is fully altered, depending on DG size and production profile, consumption optimization and demand side management. Figure 8 shows illustrative example of consumer's load profile, in the presence of solar PV daily production.



Source: EPIA

Figure 8 Prosumer's daily profile

Since the supplier or other energy purchasing body has balance responsibility and must take into account the changed load profile and injected energy too, implicit balance responsibility of

[21] Guidelines on State aid for environmental protection and energy 2014-2020, Paragraph (124) and (125)

prosumers is established as well. As the number and capacity of prosumers gets increased, the influence on system operation and balancing is proportionally growing.

Depending on the state energy policy, prosumers can be exempted from balancing costs payment, otherwise electricity uptake contract should take it into account with some price adjustment for suppliers' additional costs.

Since the balance settlement accounting period is very short (15 minutes or 1 hour), net metering and net billing schemes make this settlement even more difficult. Difficultness is caused by the netting scheme billing period that is only in a few countries equal to the balance settlement period and additionally by the energy or monetary credits that are transferred to the next billing period.

12 GRID CONNECTION

Installed capacity of the individual self-consumption DGs is generally very low when compared to the conventional generators or DGs not intended for self-consumption. In any cases, relevant grid codes provide technical and safety requirements that must be respected in order to prevent negative impact on the distribution network.

The most common requirements provided by the relevant grid codes concern the frequency ranges, frequency based power reduction, current and voltage harmonics, flickers, reactive power control, DC current injection and phase balancing.

Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators, represents the basic document that provides technical requirements for DG units to be connected at the distribution network.

DG units having installed capacity of 0,8 kW or more are classified as the Type A[22]. Maximum installed capacity of the DG units to be classified as the ''Type A'' is standardly 1 MW for Continental Europe.

''Type A'' DG units must fulfill the requirements relating to the frequency ranges and must have the rate of change of the frequency withstand capability. Additionally, as a consequence of large scale deployment, even the very small DG units are required to contribute to the power system stability and disturbance elimination. The technical functionality ''limited frequency sensitive mode — overfrequency (LFSM-O)'' is obligatory for ''Type A'' DG units, unless the relevant TSO chooses to allow automatic disconnection and reconnection of ''Type A'' at randomized frequencies, ideally uniformly distributed, above a frequency threshold. Other requirements are relating to the output power stability, allowable power reduction at falling frequency and automatic synchronization and connection criteria.

With regard to the electromagnetic compatibility, DGs are expected to fulfill requirements provided by relevant technical standards related to the harmonic emissions, flickers and DC current injections.

Voltage and current imbalances in the distribution network, caused by the single phase DG installations, are the reason for introducing the additional capacity limits that can be applied for single phase units.

[22] Network code on requirements for grid connection of generators, Article 5

The electricity meter should register both, the energy withdrawal and injection and metering interval should be aligned with the trading interval at the wholesale market in order to facilitate imbalance settlement, accurate generation forecasts, using the wholesale prices for excess energy valuation, optimization of the self-consumption rate etc.

Additional electricity meter installed to register total electricity generation is also needed, otherwise total generated electricity would only be estimated. Accurate measuring of the state progress in achieving renewable energy targets would be impossible without the meter at the DG's terminals. Vast majority of EU member states applies two meters in self consumption installations[23].

Streamlined and simplified connection procedure is desirable to decrease administrative costs related to the connection process. Nevertheless, all technical and safety criteria must be fulfilled and DSO must be informed about intended DG installation during the very initial phase of project realization. Generation equipment must be safe and must not cause any hazard for people's life and health as well as for DSO personnel.

As a consequence of demanding connection requirements, the installation of a plug-and-play PV modules that are currently available at the market, is not as simple as expected, as a number of technical and safety criteria is to be complied and fulfilled.

[23] CEER, Status Review of Renewable Support Schemes in Europe, Annex 13

13 RECOMMENDATIONS

1	**General**	
1.1	Legal framework	Self-consumption schemes should be allowed by Renewable energy law or other applicable legislation. If needed, primary VAT legislation should be amended to allow implementation of the self-consumption netting schemes. If needed, other laws and rules should be amended to set rules for connection and metering of consumer with installed DG, tariff system to allow additional customer category/group, contractual and billing system for DG and reporting system.
1.2	Support for energy from renewable sources	If applied, support for energy from renewable sources should be explicitly provided as the premium for the self-consumed electricity and/or premium on top of the excess energy price.
1.3	Support through grid costs exemption	Support through the grid costs exemption should be avoided, as it results in the cross-subsidies among network users.
1.4	Self-consumption statistics	Energy statistics on a share of the self-consumption should be established. Key statistic indicators should be defined in a comprehensive manner.
2	**Eligibility criteria and capacity limits**	
2.1	DG Technology	All types of DG technologies should be allowed for self-consumption purposes.
2.2	Consumer’s categories	Regulatory framework should provide precise definitions of consumer’s categories and their eligibility for self-consumption schemes.
2.3	Capacity limit Household and small commercial consumers	General maximum DG capacity limit should be applied and set in advance.
2.4		Individual DG capacity limit should be set depending on consumer’s demand and consumption.
2.5	Capacity limit Other consumers	General capacity limits should not be applied, maximum rated capacity should be determined on a case-by-case basis, corresponding to the consumer’s annual consumption in the previous year as the dimensioning criteria and also using constraints if raised from grid connection criteria.

2.6	DG production vs. consumption	DG's annual production should be lower than consumer's consumption in the preceding year.
2.7	Capacity limit at the power system level	It may be appropriate to set the total capacity limit at the power system level, particularly if the prosumers are entirely or partly exempted from paying grid costs and/or other taxes and levies.
3	**Self consumption schemes**	
3.1	General principle	Self-consumption schemes should be comprehensive and as simple as possible. Consumers should be provided with the all necessary information to calculate incomes and costs of the new scheme.
3.2	Household and small commercial prosumers	Net billing scheme should be applied, whereupon the net value of the supplied energy decreased by a value of the injected energy is to be invoiced by supplier; any remaining surplus of the injected energy during the billing period should be credited in monetary units for the next billing period.
3.3	Billing period	Monthly billing is recommended.
3.4	Credit compensation period	One year is recommended as a credit compensation period. Monetary credit surplus remained after annual compensation, should be annulled.
3.5	Consumption decrease scenario	In exceptional cases when prosumer's consumption has been permanently decreased during the DG life time, prosumers should be allowed to sell credit surplus to the grid or other consumers, thereby mitigating project risk for prosumers and financial organizations too.
3.6	Supplier switching scenario	Regulatory framework should set the rules for monetary credit settlement when prosumers decides to switch supplier.
3.7	Multi-apartment houses	At the initial phase of implementation, the net billing should not be allowed in multi-apartment houses, as it brings additional complexity and administrative costs.
3.8	Third party ownership	Third party ownership should be allowed in the net billing-scheme, as it provides new business opportunities and helps the low income consumers who do not have access to the bank loans, to make electricity savings.
3.9	Other prosumers	For other prosumers with larger self-consumption installations, ordinary commercial schemes should be applied with separate invoicing of the delivered and injected electricity performed by supplier and prosumer

		respectively.
4	**Excess energy treatment**	
4.1	Valuation method	Valuation should be based on the energy market value paid by consumer, taking into account supplier's (or other corporate body) energy transaction costs and benefits related to the distribution losses reduction.
4.2	Energy value	The energy component of the retail electricity price should be used to evaluate the excess energy as it appropriately reflects market value of electricity faced by consumer.
4.3	Network losses reduction	The reduced network costs as a result of the network losses reduction should be proportionally reflected in the value of excess energy.
4.4	Energy transaction costs	Reasonable costs of energy transaction incurred to supplier should be taken into account.
4.5	Excess energy unit price	Excess energy unit price should equal the energy component of the retail electricity price increased by network losses contribution unit price and decreased by supplier's energy transaction unit price. Network losses contribution unit price and supplier's energy transaction unit price can also be expressed as a percentage of the energy component of the retail electricity price.
4.6	Time of use differentiation	It should be applied for excess energy valuation provided that supplier includes time of use retail price differentiation.
4.7	Contracting party	Prosumer's supplier is by default in charge for purchasing the excess energy from households and small commercial prosumers, as the net billing scheme is to be applied. For other prosumers, supplier or other corporate body should be obliged to purchase the excess energy at the predefined conditions. Once the electricity market reaches a high degree of liberalization, it is possible to leave the excess energy purchase and valuation to the market mechanisms.
5	**Grid tariffs**	
5.1	General principle	Grid tariffs should apply to the self-consumed electricity in order to keep a fair distribution of costs between those who cause the costs.
5.2	Cost reflectiveness	Principle of cost reflectiveness in designing grid tariffs should be preserved and prosumers should pay grid costs as the other non-producing consumers of the same category.

5.3	DSO cost recovery	DSO risk on cost recovery should be mitigated by properly designed capacity tariffs to be paid by prosumers.
5.4	Grid costs exemption	For the self-consumed electricity, prosumer should be exempted from payment of variable network and system costs.
5.5	Prosumer's tariff group	Specific prosumer's tariff groups should be introduced corresponding to the consumer's groups of the same category.
5.6	Grid tariffs for prosumers	Prosumers should be charged for fixed grid costs through capacity tariffs for prosumer's tariff group. Volumetric grid tariffs for prosumer's tariff group should reflect the variable network and system costs.
5.7	Prosumer's revenue and investment recovery	Prosumer's revenue should equal the sum of electricity bill savings (as a result of self-consumption) and income from excess energy sale under the given conditions. Bill savings include the energy component of the retail electricity price, volumetric grid tariffs, taxes and levies for which exemption on the self-consumption is granted and VAT. Income from excess energy sale reflects the value of excess energy.
6	**Other taxes and levies**	
6.1	Regulatory framework	Other taxes and levies to be faced by prosumers, must be considered in a consistent regulatory analysis. In depth analysis is needed to determine whether the prosumers will have to contribute, and to what extent, to specific policy support scheme.
6.2	Prosumer's exemption	In general, prosumer's should not be entirely exempted from other taxes and levies payment.
7	**Imbalance settlement**	
7.1	Metering interval	Metering interval should be aligned with the imbalance settlement rules.
7.2	Exemption criteria	Prosumers with DG installed capacity under 500 kW should be exempted from balance responsibilities. Imbalance costs should be paid by prosumer's supplier or other corporate body in charge of purchasing the excess energy.
7.3	Standard balance responsibility	Prosumers with DG installed capacity above 500 kW should be liable for imbalances regarding the excess energy, as any other DGs of the same capacity.
7.4	Imbalance billing period	If the netting schemes are applied, imbalance settlement should be performed within the billing period, on the basis

		of physical energy flows in that period. Energy or monetary credits should not interfere the imbalance settlement.
7.5	Standardized profiles	Standardized production and prosumer's profiles should be developed to facilitate imbalance settlement.
8	**Grid connection**	
8.1	DSO approval	DG connection must be subject of DSO approval, as any inversed power flow and voltage source presence must be known to the DSO, thus eliminating hazard on DSO personal.
8.2	Technical criteria	Technical connection criteria should be prescribed, on the basis of the ENTSO-E Network code on requirements for grid connection of generators.
8.3	Electromagnetic compatibility	DGs should comply relevant technical standards for electromagnetic compatibility (i.e. series IEC 61000-3-x).
8.4	Single phase installations	Capacity limits should be used to avoid voltage and current imbalances in low voltage distribution network.
8.5	Network exchange metering	Electricity meter should separately register both the energy withdrawal and injection.
8.6	Generation metering	Additional electricity meter should be installed to register total electricity generation, otherwise state progress in achieving renewable energy targets could only be estimated.
8.7	Connection procedure	Streamlined and simplified connection procedure should be developed in order to shorten connection time and administrative costs.

14 REFERENCES

1. Directive 2009/28/EC on the promotion of the use of energy from renewable sources, European Parliament and Council, 2009,
2. Guidelines on State aid for environmental protection and energy 2014-2020, European Commission, 2014,
3. Best practices on Renewable Energy Self-consumption, European Commission 2015,
4. Position Paper of self-generation, Council of European Energy Regulators, 2016,
5. Market Monitoring Report 2015 - Electricity and Gas Retail Markets, European Agency for the Cooperation of Energy Regulators, 2016,
6. Review and Analysis of PV Self-Consumption Policies, International Energy Agency, 2016,
7. Solar energy policy in the EU and the Member States, from the perspective of the petitions received, Directorate General for Internal Policies, Policy Department C: Citizens' Rights and Constitutional Affairs, 2015,
8. Study on tariff design for distribution systems, European Commission, Directorate General for Energy, 2015,
9. Prosumers – an integral part of the power system and the market, EURELECTRIC, 2015,
10. Status Review of Renewable Support Schemes in Europe, Council of European Energy Regulators, 2017,
11. Annual Report on the Results of Monitoring the Internal Electricity and Gas Markets in 2015, Retail Markets, ACER/CEER, 2016,
12. Self-Consumption of PV Electricity, European Photovoltaic Industry Association, 2013,
13. Adapting Electricity Networks to a Sustainable Energy System – Smart metering and smart grids (translation), Energy Markets Inspectorate, 2010,
14. Network code on requirements for grid connection of generators, European Commission, 2016,
15. Net Metering Standard Industry Practices Study, Navigant Consulting Ltd, 2014.