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Best practices on Renewable Energy Self-consumption

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Delivering a New Deal for Energy Consumers

{COM(2015) 339 final}

BEST PRACTICES ON RENEWABLE ENERGY SELF-CONSUMPTION

1. INTRODUCTION

The Energy Union strategy[1] places consumers at the core of the EU energy policy, encouraging them to take full ownership of the energy transition, to benefit from new technologies to reduce their bills and participate actively in the market, while ensuring protection for the vulnerable ones. At the same time, the achievement of the Energy Union requires a fundamental transformation of Europe's energy system. Renewable energy is essential for this transformation to take place as it contributes to all of the Energy Union objectives: the delivery of security of supply, a transition to a sustainable energy system with reduced greenhouse gas emissions, industrial development leading to growth and jobs and lower energy costs for the EU economy.

Thanks to technology development and innovation driven by EU and national policies, over the last few years we have seen the realization of effective renewable energy technologies, for both large and small-scale use, alongside considerable cost reductions[2]. As a result, businesses and households can increasingly produce and consume, some or all, their own electricity, either instantaneously or in a deferred manner through decentralized storage, behind the connection point with the grid (i.e. the meter). Through the process of 'self-consumption', passive consumers are therefore becoming active *'prosumers'* (i.e. producers and consumers of renewable energy).

The emerging self-consumption model opens new cost-containment opportunities for energy consumers, particularly for Small and Medium-Sized Enterprises (SMEs), which are faced with high electricity prices, allowing them to increasingly control their energy bills. Amongst residential consumers, new behavioural patterns are emerging ranging from in particular roof-top solar photovoltaic (PV) systems owned by individual households or third parties, to self-consumption projects developed by RES COOP (i.e. citizen-led renewable energy cooperatives). This document gives insight into lessons learned from national schemes on self-consumption of renewable energy (see Annex) and illustrates best practice in this relatively new policy area. It focuses on micro and small-scale renewable energy systems, typically with an installed electricity capacity below 500 kW[3].

2. SAVINGS FROM SELF-CONSUMPTION

The self-consumption model is based on the fact that in a growing number of countries renewable electricity – chiefly solar PV – has achieved grid parity, that is the situation where an expected unit cost of self-generated renewable electricity matches or is lower the per-kWh costs for electricity obtained from the grid, i.e. the variable part of a consumers’ electricity bill. Under grid parity, consumers can save money by generating their electricity rather than buying it from the grid.

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1 Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM/2015/080 final.

2 For example, the costs of solar PV modules dropped by 80% between 2008 and 2012.

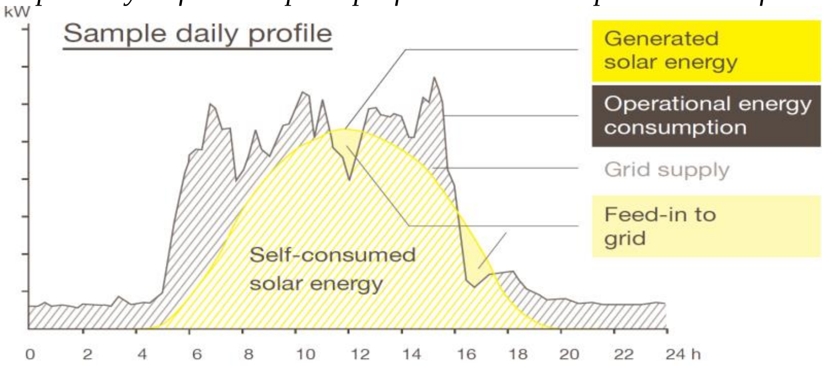
3 This document is without prejudice to the application of State aid rules.

Where the consumption patterns align well with onsite renewable generation, high rates of self-consumption[4] and self-sufficiency[5] can be achieved jointly. In this situation, renewable energy self-consumption can result in a number of benefits for both consumers and the whole energy system. It can facilitate consumer empowerment by allowing active participation in and profit from energy markets, as well as encouraging smarter consumption patterns[6]. Self-consumption can also lower energy system costs e.g. solar PV generation in sunny countries can help reducing grid peak demand for electricity driven by air conditioning. By generating and consuming electricity locally, system losses can be reduced[7]. Finally, self-consumption can make an important contribution to finance the energy transition[8].

Box 1: Self-consumption benefits for commercial consumers

An Italian food processing company located in the province of Rome , with an annual consumption of about 850.000 kWh and a demand profile shifted strongly in the daytime, has installed a roof-top PV system with a capacity of 320 KWp, producing about 420.000 kWh per year. Thanks to the self-consumption mechanism, this SME is able to use 89% of the solar PV electricity produced onsite (self-consumption rate), resulting in an annual electricity bill saving of about 35% and in a annual reduction of CO2 emissions by over 200 tons. A German plastics-manufacturing facility located in Hessen, with an annual electricity consumption of ~320,000 kWh and a roof-top PV system with a capacity of 63 kWp, has been able to directly self-consume ~87% of the electricity generated onsite (i.e. 60,000 kWh) - see Figure 1. As a result, the company reduced its electricity bill by over 15% (~50,000 kWh/year).

Figure 1: Sample daily self-consumption profile in a German plastics-manufacturing facility



Source: Kraftwerk 2015, Q-cell 2015

Commercial and residential consumers

Commercial consumers (e.g. department stores, office buildings, SMEs) can attain high rates of renewable electricity self-consumption (e.g. 50%-80%). This is primarily due to the relatively good match between the energy consumption profile and the onsite renewable

4 The self-consumption rate is the amount of electricity actually consumed onsite as a percentage of the total electricity produced.

5 The degree of energy self-sufficiency measures how much of the total electricity needed by the consumer can be obtained from their own renewable energy system.

6 Research has generally found that both energy reductions and load shifting activities have taken place in households following an installation of micro generation of solar PV.

7 The PV parity study found that the losses reduction is between 0.25% and 0.75% depending on the characteristics of the distribution networks and the share of solar PV generation.

8 Bloomberg New Energy Finance estimates that in Europe small-scale solar systems will increase their share of the electricity capacity mix to 22% by 2040, from 6% in 2014 (BNEF 2015). In Italy, analysts project for the coming years an additional installed capacity of solar PV self-consumption systems of 1 GW/year, worth € 1.5 billion /year (SunCity 2015).

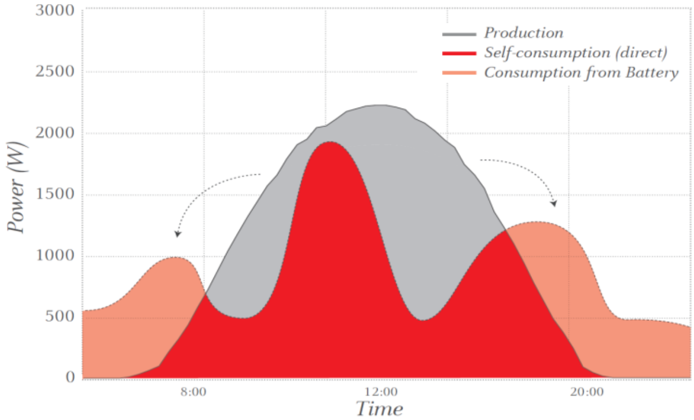
generation curve (see Figure 1). As a result, commercial self-consumption systems are increasingly viable in a growing number of Member States (e.g. Germany and Italy), given that PV solar rooftop system can produce electricity at a price of €95-100 MWh – which is less than retail electricity tariffs for commercial consumers.

With demand-side response and decentralized energy storage (see section 3), the self-consumption rate of an average Central European household running a PV system can go up to 65-75%. In absence of such flexibility measures, however, residential consumers are more likely to obtain self-consumption rates in the range of 30% (see Box 2). The excess electricity injected into the grid may create new challenges for the operation of the electricity network, that can be addressed through the application of smart grid technology.

Box 2: Self-consumption benefits for residential consumers

Considering a single family household with an annual consumption of 4,000 kWh, typically a 30% annual self-consumption rate can be obtained with a PV system with a capacity of 3.5 kWp, 3 kWp and 2.75 kWp, respectively in the North, Centre and South of Italy. Assuming a total installation cost of 2,200 €/KW + VAT of 10%, under the existing net metering scheme an household can save (for all cases) about €720 per year on its electricity bill, with a pay-back period of about 7-9 years, depending on the region. In Germany, by installing a 4 kWp PV system, a typical four-person family household with an average annual electricity consumption of 3,600 kWh could save almost 680 € each year (~316 € from self-consuming 30% of the electricity produced onsite plus ~360 € in additional income from the selling of surplus electricity into the grid).

Figure 2: Effects of electrical storage on direct self-consumption. Source: Fronius, SMA 2015.



There is an important potential for renewable energy production in apartment buildings that can be realised if.self-consumption is allowed also at a multi-dwelling building level, and if cost-efficient procedures are in place for residual electricity needs. Furthermore, access to capital and/or financing is a key determinant of whether or not residential consumers can enjoy the benefits of self-consumption. Therefore, business models and financial instruments need to be developed to make self-consumption widely accessible to consumers from all income levels, including special programmes for vulnerable consumers.

Furthermore, it should be highlighted that complex and burdensome administrative and authorisation procedures still represent an important barrier for the competiveness of small-scale self-consumption projects. On-line information platforms and applications are so far used in only a few Member States (e.g. Portugal, Hungary, Italy and Sweden). While several

Member States have introduced facilitated notification procedures for small renewable energy installations such as roof-top PV installations[9], additional national action is required.

3. SELF-CONSUMPTION – A DRIVER FOR FLEXIBILITY

As explained above, consumers have an interest in maximising the rate of energy self-consumption in order to increase their energy savings and reduce their exposure to electricity prices . In the context of a smart grid environment, self-consumption has therefore the potential to drive consumers' uptake of flexibility measures, while at the same time help facilitating the system integration of variable renewable energy[10]. Flexibility can be realized through two main set of measures: a) demand-side response and b) energy storage, including thermal and electricity storage (see Figure 2).

Demand-side response

Demand-side response can be applied to distribute a part of a consumer's energy demand to hours of onsite renewable energy generation so as to increase the self-consumption rate, while also avoiding demand peaks. A common application of DSR in commercial buildings is the installation of smart thermostats that regulate electricity demand to avoid high peaks. In some cases, it might not even be necessary to install any device, since the re-arranging of energy-intensive processes from the evening/night to day hours might be sufficient to distribute energy consumption to better match onsite renewable generation.

Demand-side response in households can involve the use of smart appliances (e.g. washing machine, tumble dryers, dishwasher, refrigerator etc.). It is estimated that the volume of controllable smart appliances in the EU by 2025 will be at least 60 GW – shifting this load from peak times to other periods can reduce peak-generation needs in the EU by about 10%[11]. Research has found that an effective use of demand-side response may yield annual savings in the order of €60-80 billion by 2030[12]. However, multiple factors condition the ability of households to participate actively in demand-side response markets[13].

Functioning electricity wholesale and retail markets will incentivize demand-side response via the price signals, as prices will be low in periods of abundant generation and high in periods with high demand and limited supply. Automated load shifting through demand-side response measures could be enabled through home energy management infrastructure (e.g. gateways/smart energy boxes, that can coordinate supply and -ready home equipment for demand-side response using a smart meter[14]). Consumers self-generating renewable energy should therefore not only be enabled and encouraged to adapt their consumption to the availability of their electricity production but also to offer flexibility to the wider energy system, including through aggregators.

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9 *Renewable energy progress report,* SWD(2015) 117 final.
10 The PV Parity project has found that self-consumption extended by storage and demand response can reduce the additional system costs of the EU integration of solar PV at high penetration levels by around 20%.
11 Seebach, 2009, *Costs and benefits of smart appliances in Europe*.
12 DNV-GL 2014, *Integration of renewable energy in Europe.*
13 Working Group on consumers as energy market actors (2015), *Interim report*.
14 *Commission Recommendation on preparations for the roll-out of smart metering systems*, 2012/148/EU.

Energy storage

Energy storage installed by consumers helps storing excess onsite renewable generation in period of low demand (e.g. when residential consumers are not at home) for use in periods when energy demand is high and renewable production is low (e.g. peak-time in the morning and in the evening). Thus, storage can enable consumers to capture and utilize the electricity generated by their renewable energy systems more effectively by decoupling time of generation and consumption, while also supporting the grid, e.g. by reducing local voltage fluctuations as well as congestion problems.

Energy storage includes power-to-heat systems such as hot water boilers or more efficient heat pumps that can cost-effectively convert excess electricity to heat (normally by heating water) to be stored for later use. The potential for power-to-heat solutions is potentially significant. If the EU Member States replaced the current installed base of night storage heaters, this could provide 55 GW of controllable demand by 2050 (18 GW for hot water and 37 GW for retrofitting all traditional Night Storage Heaters)[15]. This can be compared to the current storage capacity of 51 GW in the EU, which is mainly provided by pumped hydro systems.

Stationary batteries represent another increasingly common storage option. For instance, the integration of a family-size PV system with a battery with a peak capacity of 1.5 kWp and two hours of storage capacity (3 kWh) can increase the self-consumption rate from 30% to 45% and even 75%, depending on the demand profile. As a result of technology development and economies of scale, battery costs have declined significantly in recent years (down by 50% since 2011), and an additional reduction by 50% or more is projected by 2020[16]. Decentralized electricity storage can be also provided by the increasing penetration of electric vehicles (EVs) and plug-in hybrids[17].

Most benefits for the grid arise when distributed storage is managed to reduce the peak power of the decentralized renewable energy installations, such as in Germany where battery incentives are linked to grid-optimal solar PV feed-in[18]. Furthermore, distributed storage systems could be adopted on a neighbourhood or community basis, thereby reducing the cost-per-kWh and allowing individual regions to integrate higher volumes of distributed, consumer-driven renewable energy.

Besides the above-mentioned flexibility measures, smarter renewable generation can help facilitating the market integration of distributed renewable energy generation. As shown by the MetaPV project[19], intelligent control of PV inverters by distribution system operators (DSOs) can increase the capacity of the network for hosting distributed generation by 50%. In Germany, new-built small-scale PV systems (with a capacity below 30 kWp) should either be

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15 KEMA, 2013, *Potential for smart electric thermal storage contributing to a low carbon energy system*. Estimate based on EU-27 data.

16 IRENA, 2015, *Battery storage for renewables; market status and technology outlook*.

17 A 10% EVs market share with an amount of 50 % of electric vehicles simultaneously connected to the grid via typical 3.6 kW-household sockets could offer a peak power/load of 7.6 GW and about 22 GWh per day for load shifting in Germany (based on daily trips and a mid-sized battery electric vehicle with a 25 kWh battery). JRC, 2013, *Projections for electric vehicle load profiles in Europe based on travel survey data*.

18 The German energy storage incentive programme provides PV owners of systems up to 30 kW with a 30% rebate and low interest loans from the German development bank (KfW).

19 MetaPV Study, 2014, *Cost-effective integration of photovoltaics in existing distribution grids*.

able to be curtailed remotely, or must permanently limit power injection into the grid to 70% of rated AC capacity, the rest being either self-consumed or curtailed. This kind of capacity-based regulation is also applied in many U.S. net metering schemes.

Best practice includes:

- *Establishment of simplified authorisation procedures, including through simple notification, for small-scale renewable energy projects.*
- *Allowing renewable energy self-consumption and decentralized storage.*
- *Promotion of demand side flexibility, including demand-side response and distributed energy storage, through price signals (e.g. dynamic pricing) and other incentives.*
- *Deployment of adequate smart meters and allow for aggregators to facilitate consumer participation in the wholesale market.*

4. CONTRIBUTING TO THE GRID

Renewable electricity that is self-consumed is often exempted from grid costs and other system charges. On the one hand, this may be understandable as such electricity remains within the customer's premise without touching the public network. On the other, unless the generated electricity is self-consumed during peak hours, Distributed System Operators' (DSO) costs may not decrease. In fact, the latter are driven by the peak capacity (i.e. the maximum amount of electricity installed that distribution grids need to deal with) and not by the variations in the distributed volumes of electricity[20]. Consequently, concerns have been raised about the risk that a large-scale deployment of self-consumption could impact the remuneration of DSOs and generally the electricity tariffs of consumers[21], particularly in countries with high volumetric grid tariffs (see Box 3)

The various grid tariff structures provide different incentives for energy consumers. A progressive volumetric tariff encourages self-consumption, as it increases the per kWh electricity price that can be substituted by self-consumed electricity. Furthermore, it provides the strongest incentive to save electricity, which is an important EU policy objective. Time-of-use volumetric tariffs incentivise self-consumption to react to system conditions indicated by the tariff, thus leading to a reduction of the daily/seasonal peak consumption.

Under capacity-based tariffs, network costs for the consumer are only reduced if self-consumption reduces the peak-load taken from the grid. The transition to capacity-based tariffs might also require transitional measures to mitigate financial implications on low-consuming customers. For instance, when such tariffs were applied to Dutch households in 2009, the differences in bills for household customers caused by the move from volumetric to

[20] The main driver for network investments is the peak power at connection point and grid segment levels: the network is generally dimensioned in a way that enables the DSO to cope with all demand withdrawn from and production injected into the grid at any time throughout the year and at any point while still adhering to all (security and technical) parameters.

[21] Rate increases attributed to prosumers should be put in perspective with rate increases attributable to other sectors. Many countries, for example, provide subsidized electricity rates to energy-intensive manufacturing industries which other ratepayer classes must absorb through higher rates. Such industrial cost shifting can significantly outweigh the magnitude of cost shifting attributable to residential prosumers.

capacity tariff were compensated as much as possible by changes in the applicable energy taxes[22].

Box 3: Network charges models

Network tariffs are price components paid by electricity consumers to finance the past and future costs of building, and the cost of operating the electricity grid. They are raised by the Transmission System Operators (TSO) and Distributed System Operators (DSO) and are regulated in the context of the EU Electricity Directive (2009/72/EC). The latter leaves room for Member States to develop their own grid tariff methodology, reflecting the particularities of national electricity systems. Apart from the fixed component that is typically charged for services such as metering and other administrative costs, tariff structures generally are reduced to one, or a combination, of the following basic alternatives:

- *Capacity tariffs* depend on the peak load as grid costs are mainly capacity driven. Therefore consumers with high peak loads pay the highest network costs. Different models of capacity tariff exist: a) flat: a fixed charge based on connection capacity (kVA) or measured capacity (kW); b) variable: different capacity with different tariff per level; and, c) time-of-use: different tariffs in line with the available grid capacity (peak/off-peak), requiring a smart meter.
- *Volumetric tariffs* are charged for each kWh of electricity consumed from the grid and are easier to implement with conventional meters. Volumetric tariffs can be: a) proportionate: consumers pay per kWh, independent of volume level; b) progressive: the tariff per kWh increases with an increasing consumption level; c) regressive: the tariff per kWh decreases with an increasing consumption level; and, d) time-of-use: different tariffs in line with the available grid capacity (peak /off-peak). A day/night tariff is possible without smart meter whereas more complex peak and off-peak tariffs are only possible with smart meters.

Hybrid models combining both capacity and volumetric tariff also exist. For instance in Spain and in Italy the electricity distribution grid tariff for household customers consists of three components: a flat component (€/point of delivery), a component billing the connection capacity (€/kW), and a progressive volumetric component (€/kWh). For an average Italian household consumer, about 80% of the whole electricity bill is volume related and 20% capacity based. The combination of volume and capacity elements is also currently applied for industrial consumers in other countries like Belgium, France and the Netherlands.

Most EU Member States currently charge grid costs through volumetric grid tariffs, although there is increasing interest in charging part, or all, of such costs through the capacity component of the tariff. For instance, in 2009 the Netherlands introduced capacity-based network tariffs for residential consumers. In July 2015, the Belgian region of Flanders has imposed a specific grid fee for self-consumption systems up to 10 kWp (approx. €70 per kW of installed solar PV). Furthermore, in Italy self-consumption projects are gradually called to contribute to the grid costs, depending on their capacity[23]. In Portugal, when self-consumption

[22] With the introduction of capacity tariffs, the fixed amount of tax reduction was increased with (nearly) the same amount of the new capacity tariff, while the volume-based tax was also increased with (nearly) the same amount of the volumetric tariff of 2008.

[23] While micro-generation projects are fully exempted, systems with a capacity equal or above 20kWp (connected to low-voltage grid) will pay approximately €36/year, while projects of 200 kWp or above (connected to the medium voltage) will pay about €237/year. Source: Qual'energia 2015.

systems will reach the equivalent of 3% of the total installed power capacity, new projects will have to contribute in part to the grid cost according to a given formula.

Overall, given the large variety of tariff structure models across the EU and given the differing local conditions, there may not be one-size-fits-all solution. Tariff setting should be based on objective and non-discriminatory criteria, which apply consistently to all users who are in the same situation. The different models should also correctly reflect the impact of the consumer on the electricity grid[24], while ensuring that regulated assets contribute to the energy transition by supporting the EU policy objectives on energy efficiency and renewable energy.

Best practice includes:

- *Avoidance of discriminatory charges for self-consumption projects.*
- *Acknowledging the different national conditions, ensuring that possible future grid tariff reforms promote both renewable energy and energy efficiency objectives, are based on objective and non-discriminatory criteria and reflect the impact of the consumer on the electricity grid, while guaranteeing sufficient funding for grid and system costs.*
- *Ensuring predictable conditions by announcing caps of installed capacities after which grid cost exemption are revised.*
- *If modifications to the tariff structure are deemed necessary and appropriate, take into account the need to ensure stability for previous investments in self-consumption projects.*

5. VALUING SELF-CONSUMPTION

Grid parity assessments for direct self-consumption assume the optimal situation that 100% of the produced electricity is self-consumed, which is usually not the case for residential or commercial consumers. Therefore, consumers producing renewable energy may still need to feed the non-consumed electricity into the grid and receive value for it in order for the project to be viable (in many MS small renewable generators are eligible for some kind of premium tariff - see Annex). The following approaches on how to value prosumers' excess electricity can be identified.

Self-consumption and feed-in tariff/premium approach

Here prosumer receives support for non-consumed electricity that is fed into the grid. In order to encourage consumers to look for ways to increase their direct consumption of self-generated electricity over injecting it into the grid, only electricity self-consumed above a given rate (e.g. 30%) can receive a premium tariff. This approach can work as a bridge to grid parity, however past experience with feed-in tariffs shows that there is a need for close monitoring of the development of renewable energy markets so as to to adjust tariffs to the

[24] Article 16(8) of the Renewable Energy Directive requires 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 realisable 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*'.

declining costs in order to avoid overcompensation and limit the overall financing cost of the support.

This model was applied in 2009-2012 in Germany, with the introduction of a premium tariff for self-consumed electricity generated from roof-top PV systems (up to 500 kW). The rapid decrease in generation cost of PV has prompted the German authorities to eliminate the premium tariff and value the self-consumed electricity at the retail price[25]. Until July 2013, under the 'Fifth energy account', Italy also had a premium dedicated to self-consumption similar to the one in Germany. In the UK, smaller-scale PV systems (<30kWp) eligible to receive a Feed-in-Tariff are given not only a generation tariff for the PV production (that is self-consumed) but also a bonus for the excess electricity fed into the grid.

Net metering approach

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 their onsite renewable generation is absent or not sufficient. In other words, under this scheme, consumers use the grid as a backup system for their excess power production. Generally, net metering approaches have limited the system size to which it is applicable, with limits ranging from 20 kW to 2 MW or expressed in proportion to customer’s power capacity use. The applicable billing period can extend from one hour over long periods of time (e.g. one billing period) or one year, renewable.

Net metering schemes have proved to be effective to jump-start distributed generation markets and are progressively being introduced in a number of Member States. Outside the EU, net metering forms the basis of support for solar PV across most US states (43 of them) and Australian states. 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. From a system perspective, however, net metering raises concerns when large deployment levels are reached. This is because remuneration of the excess production from onsite renewable energy systems is made at a retail price that in most cases exceeds the value of that generation to the electricity system.

Under this model, consumers with self-generation are using the grid to artificially store electricity produced at one point of time to consume it at another point of time, without reflecting the value of electricity which may vary substantially between the time periods. An alternative approach is provided by the Italian 'net billing' scheme which calculates the value of the excess electricity fed into the grid (at wholesale price). Such value can be used as a credit for subsequent period or is paid to the consumer[26].

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[25] Feed-in-Tariff for small-scale systems are currently lower than the retail electricity price (~13 €cent /kWh vs ~29 €cent /kWh).

[26] The amount of the net billing grant includes an energy component that varies with the value of energy exchanged and a service component, updated regularly, that depends on the cost of services and the energy exchanged. Net metering is only possible when the owner of the renewable energy system and the self-consumer are the same entity (i.e. it is not possible to have net metering when the plant’s owner is a third party).

This challenge explains why a number of countries in the EU and states in the USA[27] have put different forms of limits to their net metering programmes. For instance, following a surge in net-metering deployment in 2012, Denmark reformed its system to allow netting withdrawals with injections only on an hourly basis – resulting in much less netting to occur. In the Netherlands, yearly-based net-metering is allowed for 'small users'. This applies to systems up to 15kWp with a grid connection limited to 80A in three phases, but compensation is received for only a maximum of 5000 kWh[28]. In Belgium, all regions have chosen a net-metering scheme for systems up to 10kW (10kVA) but no remuneration is foreseen for the excess electricity generation that is injected into the grid.

Self-consumption and market value approach

As the market design is reformed, further self-consumption deployment will occur on a pure market basis: the electricity that is not self-consumed but injected into the grid would be rewarded at a market price. By offering a lower tariff for electricity injections into the grid during certain parts of the day, for instance, consumers could be incentivized to consume more of their electricity onsite. If sufficiently high, price-based incentives could begin to increase the generation and consumption in a way that is more optimal for the grid, deferring or avoiding altogether the need for upgrades and investments.

From a policy standpoint, this approach may be the most sustainable. From a consumer perspective, it can also be attractive particularly for commercial and industrial customers that can reach high self-consumption rates. For instance, in Italy for a commercial customer with a large rooftop solar PV system (1 MW) this approach appears today already as an economically attractive scheme[29]. However, more research is needed to assess the implications of such a model on the financial viability of self-consumption systems for residential consumers.

Variable renewable energy systems cannot always recuperate their investment costs on the energy market alone. Furthermore, getting the true market prices for numerous but small installations may entail significant transaction costs[30]. This could be done through market aggregators, but more often it is done with rates that average market prices – possibly with time-of-use variations. Under the recent Portuguese self-consumption regulation, electricity injected in the grid will be paid at 90% of an average Iberian spot price to cover integration costs.

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[27] In California, the largest US solar market, a bill is about to implement a new net-metering scheme, introducing time of use rates by 2019, i.e. creating a variable cost for kWh depending on actual wholesale price of electricity. Some important, and very sunny, US states (e.g. Arizona, Colorado, and New Mexico) have not put any limit.

[28] This requirement naturally limits the size of a system to meet this consumption in order to maximize the rate of return. Excess electricity generation can be sold at a price similar to wholesale prices (€0.05/kWh).

[29] The Italian self-consumption scheme (*Sistema Efficiente di Utenza*) allows the direct sale of electricity to the final residential or commercial consumer, although in most cases the excess renewable electricity will be fed into the grid and receives a much lower price than the retail price.

[30] Furthermore, when there is a large premium between the retail electricity price and the price paid for excess electricity generation, consumers have an incentive to size the renewable energy systems to maximise the proportion of self-consumption versus injection into the grid, if the systems are still expensive as compared to the market price. This can be fostered with investment in a relatively small renewable system. However, the benefit of this smaller system option should be weighed against the transaction costs involved and the customer's own internal rate of return.

Best practice includes:

- *Monitoring of market developments and overall system impacts in order to ensure cost-effectiveness and avoid overcompensation.*
- *Preference for self-consumption schemes over net metering schemes.*
- *Limiting net-metering to phase-in periods and regular review in a transparent and predictably way.*
- *Avoidance of retroactive changes to support for existing self-consumption projects to guarantee investment security.*
- *Phasing in of short-term market exposure by valuing surplus electricity injected into the grid at the wholesale market price.*

6. CONCLUSIONS

The rapid decline of renewable electricity investment costs is creating new opportunities for consumers to become energy producers, allowing them to profit from and contribute to the efficient functioning of the energy market. As grids and markets become smarter, this emerging model of self-consumption is set to play a growing role in reducing consumers' energy bills, particularly of commercial consumers such as SME, and promoting market integration of variable renewable electricity. Member States can proactively anticipate and accommodate the emergence of this self-consumption model, while promoting energy security, efficiency and decarbonisation.

ANNEX 1: OVERVIEW OF NATIONAL SCHEMES FOR SELF-CONSUMPTION OF RENEWABLE ENERGY

1. Self-consumption (SC) schemes. Various sources, including information provide by MS.

Member State	*Remuneration for self-consumed or surplus electricity sold to the grid*	*Grid and system cost contribution*
Austria	Private purchase agreement (PPA)	>25 MWh/y pay 1.5 € cent/kWh on SC electricity
Croatia	PV system <300 kWp, 80% at the FiT rate	Exempted
Denmark	FiT (0.08 €/kWh)	< 50kW: no taxes or PSO charge > 50kW: no RES surcharge
Cyprus	PV system< 500kWp, 5 MW yearly cap (under revision), no compensation	Fixed Network charges: H. Voltage 1,31 € cent/kWh M. Voltage 1,63 € cent/kWh L. Voltage 2,01 € cent/kWh RES levy 0.5 € cent/kWh Public service obligation 0,134€cent/kWh
Germany	< 90% production: applicable FIT or FIP rate > 90% production, either: a) average spot market price for solar energy (4-5 €ct/kWh) b) income from electricity sale (market or PPA) plus management premium of 1.2 €ct/kWh (decreasing to 0.7 €ct /kWh by 2015) PV system > 100 kWp (from 2016): market price	Before 01/08/2014 : exemptedAfter 01/08/2014 : exempted if < 10 kWp and < 10 MWh/year If >10 kWp or > 10 MWh/y : subject to reduced RES-surcharge: 30% by end 2015 35% by end 2016: 40% by end 2017
Germany	< 90% production: applicable FIT or FIP rate > 90%production, either: a) average spot market price for solar energy (4-5 €ct/kWh) b) income from electricity sale (market or PPA) plus management premium of 1.2 €ct/kWh (decreasing to 0.7 €ct /kWh by 2015) PV system > 100 kWp (from 2016): market price	Before 01/08/2014 : exempted. After 01/08/2014 : exempted if < 10 kWp and < 10 MWh/year. If >10 kWp or > 10 MWh/y : subject to reduced RES-surcharge: 30% by end 2015, 35% by end 2016, 40% by end 2017
Finland	Private purchase agreement (PPA)	<100 kVA or 800.000 kWh, exempted from electricity tax, electricity transfer fee, and VAT - fixed part of the grid charge applies
France	Under discussion	
Italy	<20 MWe: private purchase agreement (PPA)	< 20kW, exempted from grid and system costs 20-200kW partially exempted >200kW exempted only from system costs
Latvia	Regulation still to be adopted	
Malta	Private purchase agreement (PPA)	Exempted
Portugal	Average Iberian electricity market price minus 10%	If SC systems capacity <1% of total power capacity (TPC): SC exempted >1% and <3%, SC pays 30% grid fees, >3%, SC pays 50% grid fees
Spain	Up to 100 kWp, regulation still to be adopted	
Slovakia	Household with voltage level <0.4/0.23kV, connection capacity<16 A No compensation for excess power	Regulations still to be adopted
United Kingdom	PV and wind systems < 50 kWp: generation tariff + export premium of 4.77p £/kWh for up to 50% of excess power fed into the grid > 50 kWp and < 5 MWp : Feed-in-tariff	Exempted

2. Net metering schemes. Various sources, including information provide by MS.

Member State	*Eligibility requirements*	*Netting period*	*Electricity compensation*	*Capacity cap*
Belgium	RES systems connection <10 kVA (5 kVA in Brussels) ~ +/-12 kWp	Yearly	All categories of PV owners.	N/A
Cyprus	Household and municipal PV systems < 3 kW	Yearly	- Retail price - Subsidy of 900 Euro/kW for vulnerable consumers	10 MW per year
Denmark	Non-commercial RES systems <6 kW	Hourly	Retail price	N/A
Greece	PV systems <20 kWp	Yearly	Retail price	N/A
Italy	RES systems: <200kW (after 31/12/2007) <500kW (after 1/01/2015)	Yearly	Net-billing system: remuneration based on time-of-use price	N/A
Hungary	Household and commercial RES systems <50 kW, connection size <3x63A	Negotiated with DSO (monthly, half-yearly or yearly)	Retail price, which is free from system charges.	N/A
Latvia	Household RES systems <11 kW, with installation <400V and <16A per connection	Yearly	Retail price	N/A
Netherlands	Connection size <3x80A	Yearly	Retail price	N/A
Poland	RES systems <40kW	Half-yearly	< 10 kW : Feed-in tariffs (15 years): ~ €0.18 per kWh per below 3 kW; €0.11 per kWh for below 10 kW projects. > 10 kW and < 40 kW: 100% of the average sales price of electric energy on the competitive market in the preceding quarter	300 MW for systems <3kW; 500 MW for systems <10 kW
Sweden	RES systems connection size <100A	Yearly	Tax reduction: 0,60 SEK (~6 €cent) per kWh of RES reduction, but at least an equal amount of electricity should be bought from the grid. Tax reduction for delivery up to 30 MWh/y	For up to 30000 kWh, or 18000 SEK per year