Study on mapping of regulatory frameworks and barriers for individual and collective renewables self-consumption in EU Member States

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Mapping of regulatory frameworks and barriers for individual and collective renewable self-consumption in EU Member States

Final Report

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Mapping of regulatory frameworks and barriers for individual and collective renewable self-consumption in EU Member States

Trinomics

In association with:

Enerdata intelligence + consulting	schönherr	Fraunhofer

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Abstract

This report presents the findings of the project "Mapping of regulatory frameworks and barriers for individual and collective renewable self-consumption in EU Member States", carried out for DG ENERGY, European Commission, between January and December 2023. It shows that EU directives, recommendations and guidelines address some of the key challenges and barriers to the installation of new distributed generation and optimisation of self-consumption behaviours, as well as providing the framework for national actors to support self-consumption more widely. However, Member States, National Regulatory Agencies (NRAs), and private market actors could do significantly more to speed up the installation of distributed generation for self-consumption and to facilitate a more active participation of self-consumers, so that the full benefits of self-consumption can be realised. The report develops a set of recommendations concerning: the definition of self-consumption; permitting procedures; the phasing out of net metering schemes; dynamic pricing arrangements and Time-of-Use tariffs for the energy and network cost components of the energy bill; planning of the distribution Systems; alternative grid connection agreements; the deployment of storage, Building and Home Energy Management System.

1. Executive summary

1.1. What this report is about

This report presents the findings of the project "Mapping of regulatory frameworks and barriers for individual and collective renewable self-consumption in EU Member States", carried out for DG ENERGY, European Commission, between January and December 2023.

The project aimed at:
- Mapping the regulatory framework for self-consumption in Member States, focussing on provisions that may affect self-consumption.
- Analysing a set of case studies across EU prosumers, identifying challenges and opportunities to increase self-consumption.
- Based on 1 and 2, identifying and categorising barriers to self-consumption.
- estimating self-consumption rates by Member State and by type of consumer (individual, commercial and industrial), investigating data availability and applying new estimation methodologies.
- Providing an overview of system costs and benefits of self-consumption.

Based on the above, in particular from best practices emerging from case studies and Member States' regulatory frameworks, this study proposes a set of recommendations to improve the way self-consumption is regulated and supported by Member States;

1.2. Main findings

The concept of self-consumption has gained increasing recognition and support in EU directives and Member States' regulatory and policy frameworks. Since they were introduced by the 2018 Renewable Energy Directive and 2019 Electricity Market Directive, the concepts of individual and collective self-consumer have gained status and popularity. The proposed Energy Market Reform aims to further clarify the role and minimum rights of self-consumers to access offsite generated or stored electricity through energy sharing in the EU.

This support has been provided via policies such as net metering and net billing, which have driven significant consumers' investment in generation capacity (mostly PV). This has resulted in the steady growth of the number of self-consumers and of distributed generation capacity. Net metering has replaced feed-in tariffs as the most popular form of support for small consumers, largely households, while net billing schemes have driven the deployment of larger consumers.

The growing popularity of collective self-consumption is starting to reach households that would not engage in individual self-consumption for different reasons. These include aspects such as lack of physical space (e.g., households living in apartments), financial reasons, or because they are discouraged by the complex permitting process. Some collective self-consumption initiatives managed to involve many consumers by significantly reducing the administrative burden for them.

While Member States are successfully driving the installation of distributed generation for self-consumption, prospective self-consumers (and in particular collective self-consumers) still have to face some significant barriers to the installation of a generation plant for self-consumption. These barriers are of different nature and can vary substantially among Member States. In general, these concern the permitting process, consent requirement (for collective self-consumption in particular) and delays to obtain the network connection (more relevant for larger users).

While self-consumption can play a significant role in decreasing total energy system costs, it can also pose significant integration problems, linked to the variable inflows of power into the distribution network. Self-consumption reduces network costs by allowing the production and consumption of energy to happen in the same place, without the use of network infrastructure – or using only the lower-level distribution network in case of collective self-consumption; this reduces network management costs and can contribute to significantly reduce the need for network reinforcement. On the other hand, the increase in distributed generation can also pose significant integration problems when it is not accompanied by a corresponding increase in synchronous demand, especially at distribution level, and may require new network capacity in the short term. This is due to the need to manage highly variable outflows from single supply points, and due to the synchronicity of these flows (solar PV installations injecting into the grid all at the same time). Smaller DSOs in some Member States are already having difficulties in accommodating requests for new distributed generation capacity.

Regulatory provisions, government support schemes and energy pricing methodologies can support self-consumption practices aimed at maximising the benefits at system level, and *optimise* self-consumption. Policies and regulation aimed at ensuring that the full benefits of self-consumption are realised (and integration costs minimised) are still scarce in the national frameworks. The lack of policies to support the maximisation of the benefits of self-consumption results in higher integration costs, and slower deployment rates. If appropriately optimised, self-consumption can support grid balancing by extending the response "range" of consumers: while with demand response consumers can only cut consumption, with self-consumption consumers can also inject into the network in response to system needs.

However, Member States need to be mindful of the trade-offs resulting from some policies and regulatory choices, as well as the different costs imposed onto the system by collective self-consumption. For example, purchase grants and low remuneration for energy injected into the grid may incentivise consumers to install PV systems and maximise their self-consumption, but these would not provide an incentive to adjust consumption profiles so to minimise system costs. To provide users with such incentives, advanced metering technologies and dynamic prices and are needed. Collective self-consumption that flows through the public grid, especially in light of the new provisions of the proposed Energy Market Review that eliminates the locational element, is likely to generate network management cost higher than the cost deriving from individual self-consumption.

1.3. Conclusions and recommendations

EU directives, recommendations and guidelines address some of the key challenges and barriers to the installation of new distributed generation and optimisation of self-consumption behaviours, as well as providing the framework for national actors to support self-consumption more widely. However, Member States, National Regulatory Agencies (NRAs), and market participants could do significantly more to speed up the installation of distributed generation for self-consumption and to facilitate a more active participation of self-consumers, so that the full benefits of self-consumption can be realised.

In order to address the barriers identified, Member states should:

- ***Clearly define the concept of self-consumption in national regulatory frameworks;***

- ***Simplify permitting procedures in order to reduce barriers to the installation of distributed generation;***
- ***Accelerate the phasing out of net metering schemes;***
- ***Encourage dynamic pricing arrangements;***
- ***Consider time-of-use and dynamic network tariffs;***
- ***Support DSOs in planning the large-scale integration of distributed energy resources (DER);***
- ***Address distribution network congestion by introducing alternative grid connection agreements;***
- ***Encourage the deployment of storage, Building and Home Energy Management System (BEMS and HEMS).***

2. INTRODUCTION

2.1. This project

This is the final report for the project ENER/C4/2022-397 ‘Mapping of regulatory frameworks and barriers for individual and collective renewable self-consumption in EU Member States’ under framework contract ENER/2020/OP/0021 on Energy Efficiency and Renewable Energy.

2.1.1. *Objectives of the study*

The overall objective of this assignment is to ‘*elaborate a set of best practices to address regulatory and practical barriers to renewable self-consumption in the EU*’, while the specific objectives are:

- To **understand key aspects of the regulatory framework for self-consumption** in each Member State, and identify barriers that do not that allow to develop viable business cases that valorise prosumer flexibility potential, optimise energy efficiency, and ensure short pay-back periods (Task 1);
- To **identify regulatory and practical barriers to renewable self-consumption** as well as enabling conditions (Task 2);
- To **assess the past and current deployment of renewable self-consumption** across Member States and **provide estimates for 2026 and 2030** (Task 3);
- To conclude on **best practices to overcome legal and practical obstacles** (Task 4).

It is important to note that the study was not aimed at conducting a ‘transposition check’, i.e., assessing whether Member States are correctly transposing EU Directives and Regulations relevant for renewable self-consumption.[1] Instead, the study focuses on identifying the factors that are hindering a higher share of renewable self-consumption in Member States, and proposing solutions to overcome these factors.

2.1.2. *Scope of the study*

The study focuses on:

- Individual renewable self-consumption, to be understood as the activity performed by ‘renewables self-consumers’ as defined in Article 2(14) of the RED II recast[2];
- Collective renewable self-consumption, i.e. to be understood as the activity performed by ‘jointly acting renewables self-consumers’ as defined in Article 2(15) of the RED II recast (which refers to collective self-consumption happening within the same building or multi-apartment block or beyond in some jurisdictions where this is permitted).

Energy communities that do not engage in collective self-consumption are not the focus of this study, because energy communities best practices and barriers/drivers are already addressed through the Energy Communities Repository and Rural Energy Community

[1] However, it is relevant to mention that regulatory or institutional barriers may still exist in some Member States due to incorrect/inadequate transposition of EU legislation (e.g. the Renewable Energy Directive).

[2] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)

Advisory Hub, as well as because they engage in activities that go beyond self-consumption). However, some examples of energy communities have been analysed in this study as a solution to overcome barriers faced by self-consumers.

The study focuses on self-consumption of renewable electricity in households and SMEs, and in particular solar energy, as the most popular form of generation for individual and collective renewable self-consumption.

In terms of geographic scope, the study covers all EU Member States under Task 1 and Task 3, presents case studies from a selection of Member States under Task 2 (covering at least one third of the Member States), and includes best practices from both EU and non-EU countries under Task 4.

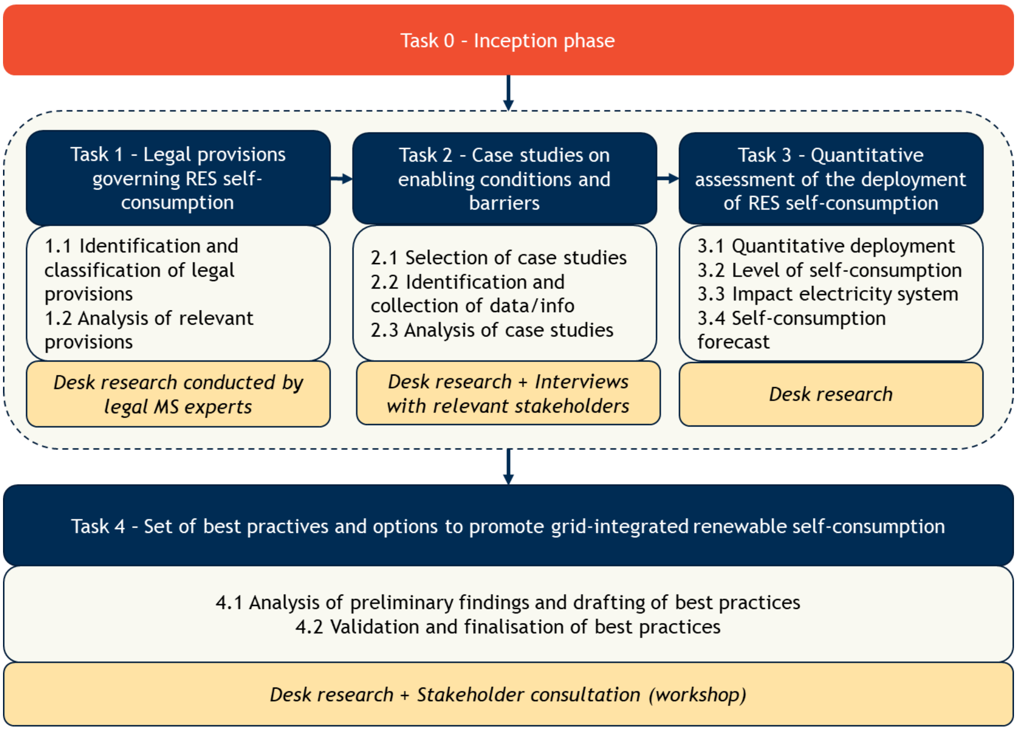
2.2. Approach and limitations

2.2.1. *Overarching approach*

The assignment was organised around four main tasks:

- Task 1 – Identification, classification and analysis of the legal provisions governing the individual and collection renewable self-consumption framework in each Member State. This task is mainly be desk-based, with the help of legal Member States experts.
- Task 2 – Elaboration of a set of case studies identifying viable business case, enabling conditions as well as barriers that are not necessarily derived from the existing legislation or support framework affecting renewable self-consumption. This task is a combination of desk research and stakeholder engagement to complement data gaps and provide more detailed information. The full set of case studies analysed as part of Task 2 are presented in Annex A of this report.
- Task 3 – Quantitative assessment of the deployment of small-scale renewable installations, their contribution to electricity production, the level of renewable self-consumption and its impact on electricity networks in each Member State. This task is mainly be desk-based.
- Task 4 – Set of best practices and options to effectively promote grid-integrated renewable self-consumption, providing access to the largest possible share of the population whilst ensuring a cost effective roll out and use of renewable electricity. This task is based upon the results of the first three tasks. It is primarily desk-based but also includes a stakeholder consultation (via a workshop organised by the project team).

Figure 2-1 Overview of overall methodological approach (steps, activities, output)



2.2.2. *Task 1 – Methodology*

An intensive legal desk research has been performed by the consortium on Task 1. The legal frameworks of the 27 Member States have been studied by national legal experts. To identify the legal and regulatory framework in the Member States, as well as the provisions which allow potential prosumers to establish a viable business case, national legal experts investigated seven main topics related to the different aspects of self-consumption: (1) installation of a generation plant for self-consumption; (2) operation of a generation plant for self-consumption; (3) maintenance of a generation plant for self-consumption; (4) distribution and allocation of self-generated energy; (5) remuneration and compensation for electricity fed into the grid; (6) network charges/fees for self-produced energy; and (7) surplus energy/self-consumption efficiency/energy storage. The input provided by national legal experts was analysed and used to draw conclusions on legal and regulatory frameworks as well as barriers to self-consumption in Member States.

2.2.3. *Task 2 – Methodology*

In Task 2, we first conducted a large literature review of practical barriers hindering self-consumption categorising them into institutional, economic/financial, social/behavioural and technical barriers. A set of 10 cases studies were then developed based on literature review and validated by national legal experts from Task 1 as well as other relevant stakeholders to the specific case studies. For each case study, barriers addressed, success factors and enabling conditions were identified using the PESTLE[3] framework. Where relevant, a business case assessment was conducted comparing the self-consumption against no self-consumption case.

[3] Political – Economic –Social – Technological – Legal – Environment

2.2.4. Task 3 – Methodology and limitations

The quantitative assessment provided in Task 3 is limited by the availability of data on self-consumption, i.e. little published information or data by Member States. For this analysis, current schemes and publications for each Member State were analysed in detail. Whenever the requested data (e.g., installed capacity, average size of installations, self-consumption rates) was not available, assumptions were made based on press articles, feedbacks from the local solar associations, approaches of similar countries. Therefore, the results presented in Task 3 **should be considered as an approximation**. This also highlights the **need for more data collection and transparency on self-consumption by Member States**.

1.1.1.1. Self-consumption rates

Due to a lack of information on self-consumption rates, different assumptions were used; these are presented in Figure 4-9. In particular, a custom analytical tool was used to simulate a typical consumption profile of residential households in each Member State. This tool is described in Annex B.

1.1.1.2. Forecasts

The forecasts presented in chapter 4.2, are based on estimated future deployment of photovoltaics in the EU, based on estimates provided by SolarPower Europe's and by Member States' national objectives (as stated in NECPs). The combined results are more conservative than the ones presented in SolarPower Europe's reports, but more ambitious than the national objectives only.

1.1.1.3. Segmentation

Photovoltaic installation segments presented in this report are detailed below.

Table 2-1 - Photovoltaic installation segments and their capacity thresholds

Category	Segment	Capacity thresholds
Small-scale installations	Residential	0 to 10 kWp
	Commercial	10 to 250 kWp
	Industrial	250 kWp to 1 MWp
Large-scale (or "Utility scale") installations	Large-scale	>1MWp

In several countries, segmentation choices of the national statistics differ from the one used in this report. For example, the residential segment in Italy includes installations up to 20 kWp. In such cases, all similar capacity ranges were aggregated into a common segment (residential, commercial, industrial, or large scale).

Assimilating capacity thresholds to a segment is an assumption. Not all installations between 250 kWp and 1 MWp are associated with industrial customers, while the large-scale segment can include some (rare) very large rooftop installations used for self-consumption. It is however in line with the segments used in existing sources (SolarPower Europe, IEA). Installations between 250 kWp and 1 MWp that are ground-based are included in our estimation as part of the non-self-consumers.

Large-scale installations are primarily targeted to grid injection, with occasional instances of self-consumption. For the purposes of this report, unless national statistics indicate otherwise (e.g., France, Germany), it was assumed that large-scale systems do not engage in self-consumption.

1.1.1.4.Direct Current (DC) vs. Alternating Current (AC) power (Solar PV)

Regarding solar PV, the installed power delivered by the panels corresponds to the DC power, while the maximum power that can be injected into the grid (after passing through the inverter) is represented by the AC power. This AC power is typically associated with the inverter's maximum capacity, or the limitations imposed by the grid connection.

The reported data on solar PV lacks harmonisation among member states, as highlighted by the International Energy Agency (IEA).[4] There is no harmonized definition of small-scale PV plants and of the associated sub-segments. Furthermore, each country has specific rules to convert DC into AC power in their national statistics (when they do it) with a difference that can vary **from 5%** (attributed to conversion losses, inverter set at the DC level) **to as much as 60%** (due to limitations imposed by grid regulations and restrictive connection requirements). While IEA recommends registering PV systems with both the DC power and the AC value, the available value usually depends on the source. PV registers or solar associations tend to provide DC values while network operators tend to provide AC values.

For this report, the AC capacity was used. When converting from DC to AC, we have employed (if available) the conversion rates available in IEA PVPS reports or given by national statistics. Otherwise, **a standard 5% loss rate was used.**

2.2.5. Task 4 – Methodology

To develop a set of best practices and recommendations, we have first prioritised the barriers to self-consumption identified in Tasks 1 and 2. Based on the case studies analysed in Task 2 and additional literature review, we have then identified solutions that have been implemented by Member States or by non-EU countries to overcome these barriers. This allowed us to develop policy recommendations for Member States but also for other market actors (e.g. NRAs, DSOs), accompanied with examples of how it can be implemented in practice. The methodology used to develop recommendations is further detailed in Annex F. The recommendations were discussed and validated during a workshop with several stakeholders from the European Commission and other organisations.

2.3. The concept of self-consumption

This sub-chapter aims to present the concept of self-consumption considering how it is defined in EU legislation and some implications that are necessary to understand how self-consumption takes place in practice, which also lays the foundations for the identification of barriers to self-consumption.

[4] IEA, 2023. Snapshot of Global PV Markets. Photovoltaic Power Systems Programme. Available at: https://iea-pvps.org/wp-content/uploads/2023/04/IEA_PVPS_Snapshot_2023.pdf

2.3.1. Framework for individual and collective renewables self-consumption in the EU

The concept of self-consumption has existed for a long time in practice, but has only been formally recognised in the EU in 2019 when definitions of 'renewables self-consumers' and 'active customers' were introduced by the Clean Energy Package. Table 2-2 provides an overview of the relevant EU legislations providing a framework for individual and collective (renewables) self-consumption. Further details on the relevant definitions and provisions introduced by these legislative texts and how they are interlinked are presented in the rest of this section.

Table 2-2 EU legislation providing a framework for individual and collective (renewables) self-consumption

Legislation	Description
Legislative texts in force	
Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (recast), or Renewable Energy Directive (RED II)[5]	The RED II provides a legal framework for final customers to engage in renewable self-consumption, as renewables self-consumer or jointly acting renewables self-consumers, by: • Introducing definitions of 'renewables self-consumer' and 'jointly acting renewables self-consumers' • Ensuring that Member States establish a regulatory framework for (jointly acting) renewables self-consumers (Article 21). It also: • Introduces the definition of 'renewable energy community' • Ensures that Member States establish a regulatory framework for renewable energy communities (Article 22).
Regulation (EU) 2018/1999 on the governance of the energy union and climate action, or Governance Regulation[6]	The Governance Regulation requires Member States to include in their integrated NECPR information on trajectories and objectives regarding renewable energy produced by renewable energy communities and renewables self-consumers as well as policies and measures to promote and facilitate the development of renewables self-consumption and renewable energy communities (Article 20).
Directive (EU) 2019/944 on common rules for the internal market for electricity (recast), or Internal Electricity Market Directive (IEMD)[7]	The IEMD opens the possibility for final customers to participate in the electricity market as active customers, by: • Introducing the definition of 'active customer' • Ensuring that Member States establish a regulatory framework for active customers (Article 15). It also: • Introduces the definition of 'citizen energy community' • Ensures that Member States establish a regulatory framework for citizen energy communities (Article 16).

[5] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001

[6] Regulation (EU) 2018/1999) of the European Parliament and of the Council of 11 December 2012 on the governance of the Energy Union and Climate Action. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999

[7] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity (recast). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02019L0944-20220623

Legislation	Description
Proposed revisions of legislative texts	
Directive EU/2023/2413 as regards to the promotion of energy from renewable sources, or revised RED[8]	The revised RED does not update the definitions and provisions related to (jointly acting) renewables self-consumers.
Proposal for a Regulation to improve the Union's electricity market design, or Electricity Market Design (EMD) revision proposal (2023)[9]	The EMD revision proposal revises the definition of 'active customers'. In addition, it: • Introduces the definition of 'energy sharing' • Ensures that Member States establish a regulatory framework for energy sharing (Article 15a).

1.1.1.5. Renewables self-consumers and jointly acting renewables self-consumers (RED II)

The RED II provides a framework for renewables self-consumption by introducing the definition of 'renewables self-consumer' and 'jointly acting renewables self-consumers' (see Textbox 2-1), which may be understood as the actors engaging in the activities of individual or collective self-consumption, although the activity per se is not explicitly defined. By introducing the definitions of '(jointly acting) renewable self-consumers' RED II aims to support and develop self-consumption also for those individuals that are not able to financially engage in self-consumption or that cannot for technical reasons (e.g., lack of space to install the generation plant).

Textbox 2-1 Definitions of (jointly acting) renewables self-consumers in RED II

According to Article 2(14) of the RED II **'Renewables self-consumer'** means a "*final customer operating within its premises located within confined boundaries or, where permitted by a Member State, within other premises, who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity*."

Renewables self-consumption can also be collective, involving a group of producers and consumers, defined as **'jointly acting renewables self-consumers'** in EU legislation. Article 2(15) of the RED II defines 'jointly acting renewables self-consumers' as "*a group of at least two jointly acting renewables self-consumers in accordance with Article 2(14) who are located in the same building or multi-apartment block*".

[8] Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413&qid=1699364355105

[9] COM(2023) 148 final. Available at: eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023PC0148

The terms 'individual self-consumption' and 'collective self-consumption will be used in the rest of this report to describe the activities engaged respectively by 'renewables self-consumers' and 'jointly acting renewables self-consumers'.

The definitions of (jointly acting) renewables self-consumers concern the location, the nature of the activities and the actors:

- Location – The definition of 'renewables self-consumer' explicitly allows Member States to extend the domain of individual self-consumption activities beyond the self-consumers' own premises. It is not the case in the definition of 'jointly acting renewables self-consumers', which refers to "the same building or multi-apartment block".[10] However, this is not to be intended as if collective self-consumption cannot be allowed beyond the building, but as a minimum limit that Member States can extend. Indeed, in some Member States, collective self-consumption is allowed to take place beyond the building limit.[11] Article 21(4) of the RED II states that "*Member States shall ensure that renewables self-consumers located in the same building, including multi-apartment blocks, are entitled to engage jointly in activities [of renewables self-consumers] referred to in Article 21(2) and that they are permitted to arrange sharing of renewable energy that is produced on their site or sites between themselves, without prejudice to the network charges and other relevant charges, fees, levies and taxes applicable to each renewables self-consumer*". This can be understood as the 'minimum requirements' that Member States shall ensure for collective self-consumption to take place. Given the nature of RED II (i.e. a Directive), slight variation in the interpretation are allowed as long as they do not jeopardize the results to be achieved.
- Nature of the activities – The definition of renewables self-consumers states that self-generated renewable electricity can be self-consumed, stored or sold. It excludes cases in which these activities represent a primary commercial or professional activity.
- Actors – Self-consumers can either be households or non-households, on the condition that storage and sale of self-generated electricity does not represent their primary commercial or professional activity. This is relevant as several articles and provisions of the same Directive obligate Member States to put in place measures in support of self-consumption. If self-consumers were to compete with commercial generators, it is possible that the measures put in place for self-consumers would distort the market, given the preferential conditions self-consumers are offered.

1.1.1.6. Active customers (IEMD)

The Internal Electricity Market Directive (IEMD) also defines the term 'active customer' (see Textbox 2-2). In essence, the definition of active customer aims to give status to final customers that participate more actively in the energy market than traditional consumers. Active customers and renewables self-consumers are closely related concepts, with the major difference being that electricity generated by renewables self-consumers for their own consumption must be generated from renewable energy sources.[12] In addition, renewables self-consumers are not explicitly entitled to participate in flexibility or energy efficiency schemes.[13] The focus of this paper is on renewables self-consumers, although some of the

[10] CEER (2019). Regulatory aspects of self-consumption and energy communities. CEER Report of the Customers and Retail Markets and Distribution Systems Working Groups. Available at: CEER report

[11] For example, in France, collective self-consumption can be extended to a perimeter of 2 km and under certain conditions, to 20 km.

[12] CEER (2019). Regulatory aspects of self-consumption and energy communities. CEER Report of the Customers and Retail Markets and Distribution Systems Working Groups. Available at: CEER report

[13] CEER (2019). Regulatory aspects of self-consumption and energy communities. CEER Report of the Customers and Retail Markets and Distribution Systems Working Groups. Available at: CEER report

recommendations presented in Chapter 7 are aimed at supporting self-consumers in playing a more "active" role in the energy market.

Textbox 2-2 Definition of active customer in IEMD

An **'active customer'** is a "*final customer, or a group of jointly acting final customers, who consumes or stores electricity generated within its premises located within confined boundaries or, where permitted by a Member States, within other premises, or who sells self-generated electricity or participates in flexibility or energy efficiency schemes, provided that those activities do not constitute its primary commercial or professional activity"*

1.1.1.7. Collective self-consumption and the concept of energy sharing (EMD revision proposal)

According to the Commission's proposal on the revision of the Electricity Market Design, energy sharing is a type of collective renewable self-consumption that takes the form of an arrangement between active customers, either through private contractual agreement or organised through a legal entity across the bidding zone. The concept of energy sharing has already been introduced in several EU Member States (e.g. Austria, Portugal and Spain), while in other Member States the concept of energy sharing is still inexistent. The business case for energy sharing is becoming more viable, as experiences and business models develop across the EU (see Chapter 6).[14]

In March 2023, the European Commission issued its proposal for a Regulation amending the Electricity Regulation and Directive to improve the EU's electricity market design, i.e. the Electricity Market Design (EMD) revision proposal. As part of its proposal, the European Commission introduces the concept of 'energy sharing', which is defined by Article 2 as "*the self-consumption by active customers of renewable energy either: (1) generated or stored offsite or on sites between them by a facility they own, lease, rent in whole or in part; or (2) the right which has been transferred to them by another active customer whether free of charge or for a price*". Further details on the link between the proposed concept of energy sharing and renewables self-consumption are presented in Annex C.

2.3.2. *Renewables self-consumption in practice: technologies, actors and location*

1.1.1.8. Technologies used for self-consumption

Self-consumption of renewable energy is possible using several technologies. This study focuses on self-consumption of renewable electricity, but self-consumption of heat or cogeneration is also possible. For example, solar water heaters are a very popular form of heat self-consumption, while farmers produce biogas for self-consumption of heat. When it comes to electricity, solar energy is the most popular form of individual and collective renewable self-consumption, and the focus of this study. However, other energy sources are

[14] RESCoop.eu-Position-Paper-on-the-Electricity-Market-Design.pdf

also available for decentralised power generation and self-consumption (e.g. wind energy, bioenergy, hydropower, etc.) and these are also briefly examined in Chapter 4.[15]

1.1.1.9. Actors of self-consumption

Different actors engage in renewable self-consumption, households (as individuals or in multiapartment buildings) and non-households (e.g. SMEs, businesses, industries, public authorities and services such as municipalities, schools or hospitals). Some generators use part of the electricity they generate as part of their electricity production process, but this is not considered self-consumption.

1.1.1.10. Location of self-consumption

Renewable self-consumption happens mainly in buildings, including multiapartment buildings. However, RED II allows for Member States to establish rules for self-consumption to include cases beyond the scope of the building: for example, virtual self-consumption (for individual self-consumers) and collective self-consumption to include generation facilities and consumers located within a certain area defined by specific parameters, e.g., km, or within the same local branch of the distribution network.[16]

2.3.3. *Generation and consumption profiles and their implications for self-consumption*

In practical terms, where an onsite renewable generation plant is present, the main issue that limits self-consumption (i.e., direct on-site consumption of self-generated electricity) is the mismatch between the generation and consumption profiles. These profiles refer to how much and when energy is generated (generation profile) and consumed (consumption profile). Figure 2-2 presents indicative generation and consumption profiles of a residential PV installation. The area under the green curve represents the total generation of a PV installation during a day (24 hours). As expected, all electricity is generated during sunny hours (e.g., from 8:00 to 18:00) and nothing is generated during the night. The red curve illustrates the total consumption of a typical household, which mainly consumes electricity in the morning and evening for cooking and lighting purposes and for the use of electrical appliances. The amount of self-consumption is thus shown by the bright green area [1], i.e., when consumption and generation curves overlap. The rest of the household's consumption [2] must be met by importing electricity from the grid. Similarly, the self-generated electricity that is not self-consumed [3] must be either stored, sold, or injected into the grid. Figure 2-3 presents the case where a battery is installed on the same site.

The figure shows how generation and consumption curves do not follow the same trend and there is thus a mismatch between typical generation and consumption profiles of a residential PV installation. However, the installation of a battery allows a substantial increase in self-consumed electricity (equivalent to the area under [5] in Figure 2-3).

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[15] Interred Europe (2020). Renewable energy self-consumption. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: [Energy_self-consumption__Policy_brief_final.pdf (interregeurope.eu)]

[16] However, in some MS (e.g. FR), electricity generated in a collective self-consumption project and transferred via the public distribution grid is also considered self-consumption. This form of self-consumption does not allow the grid to benefit from some of the advantages offered by self-consumption (i.e. release the pressure on the grid).

Figure 2-2 Indicative generation and consumption profiles of a residential PV installation[17]

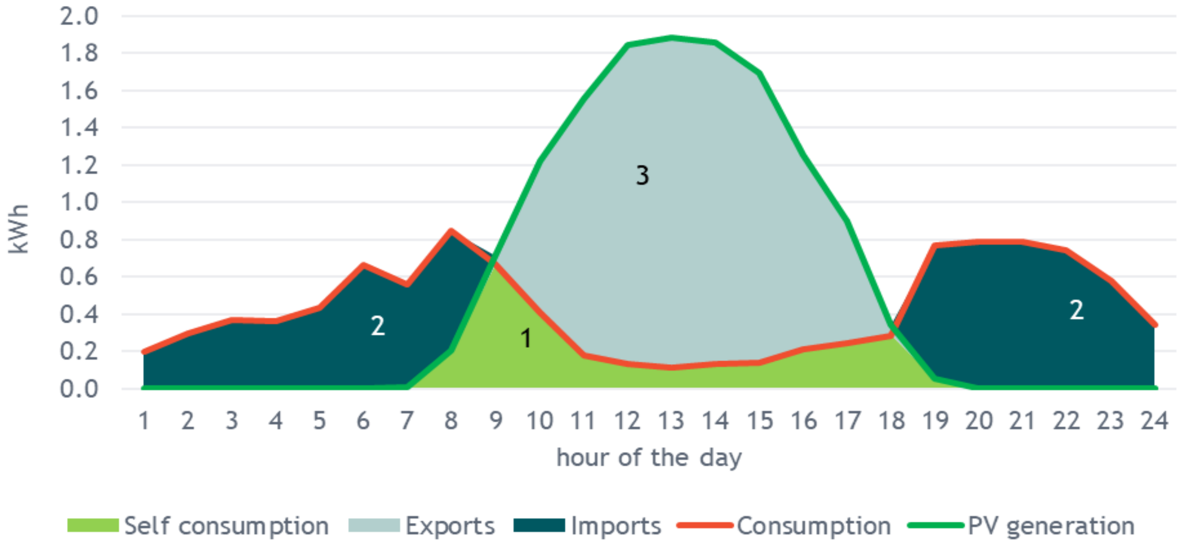
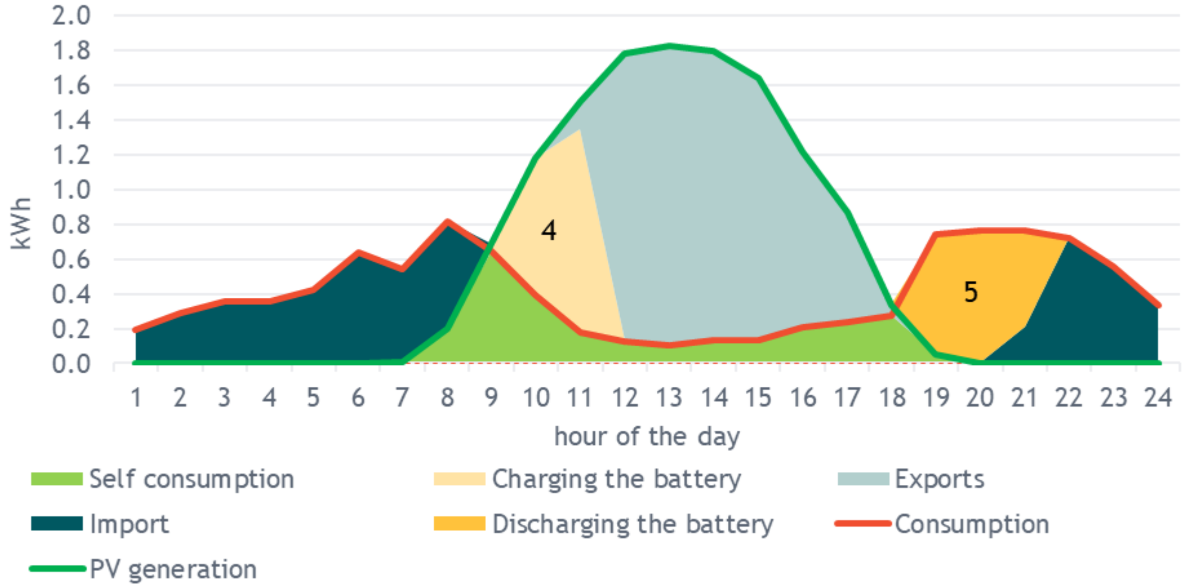


Figure 2-3 Indicative generation and consumption profiles of a residential PV installation with battery[18]



Source: Trinomics own analysis

2.3.4. *Measurement of self-consumption and other relevant definitions*

Self-consumption can be measured using two key indicators:[19]

- The self-consumption rate, which is the ratio between the self-consumed electricity (bright green area [1] in Figure 2-2) and the total self-generated electricity (entire area below the green generation curve in Figure 2-2) over a given period. It represents the share of the

[17] Assumption: generation from a 3 kW PV system installed in a Mediterranean country, in a household with consumption of 10 kWh/day.

[18] Assumption: 2 kW battery, no limitation to charging or discharging speed.

[19] Autoconsommation collective, principe et état des lieux en France en 2021 - Encyclopédie de l'énergie (encyclopedie-energie.org)

electricity that is self-generated that is directly consumed by the consumer.

$$Self - consumption\ rate\ (in\ \%) = \frac{Self - consumed\ electricity\ (in\ kWh)}{Total\ self - generated\ electricity\ (in\ kWh)}$$

- The self-generation rate, which is the ratio between the self-consumed electricity (bright green area [1] in Figure 2-2) and the total electricity consumption (area below the red consumption curve in Figure 2-2) over a given period. It therefore defines the proportion of consumption covered by the self-generated electricity.

$$Self - generation\ rate\ (in\ \%) = \frac{Self - consumed\ electricity\ (in\ kWh)}{Total\ electricity\ consumption\ (in\ kWh)}$$

It is important to further spell out some additional concepts used extensively in this report:

- The energy not consumed or stored is injected into the grid (light green area [3] in Figure 2-2). This is often referred to as "surplus energy", "exported energy" or "energy injected into the grid". However, some Member States define as *surplus energy* only the energy generated and injected to the grid above the self-consumption "limit". Some Member States have introduced a limit to the total amount that a self-consumer can inject into the grid, and be paid for,[20] in line with the RED II definition (*those activities do not constitute its primary commercial or professional activity*). Many Member States do so by imposing a limit of 100% of energy consumed (i.e., the plant cannot generate, over 1 year, more than 100% of the energy used in the building), while others have a limit based on total generated electricity (e.g., 20% of production). Other Member State impose no limits, but in some cases offer a lower injection price.
- The energy drawn from the grid and purchased from commercial generators (usually via energy suppliers) is called "imported" energy (dark green area [2] in Figure 2-2), to distinguish it from "self-consumption", i.e. the energy produced and consumed onsite (hence the reason why the term "consumed energy" is generally not used in this report, as it refers to the energy use on site without clarifying whether it was drawn from the network or produced on site).
- In this report, the term "billing/pricing methodology" is used to refer to the rules used to calculate the amounts customers are charged (or are paid) for the energy withdrawn or injected into the network.[21] A billing methodology is usually composed of different elements (components), which together define the "energy bill". These components can typically be grouped into energy cost (or revenues), network costs and other costs (generally taxes and levies, but may include other non-network costs, such as the cost of billing or a charge for equipment such as smart-meters). Billing methodologies can vary, but they are often grouped into:

    - Fixed, where the unitary cost of the energy is fixed.
    - Variable, where the unitary cost of the energy varies. Traditionally, suppliers have offered dual rate billing approaches (with a different energy price for day and night), but thanks to smart meters more sophisticated methodologies are available, including approaches where the price is not agreed in advance but is anchored to an index, such as day-ahead market price. These are called tracker prices.

  In some cases, the methodology can refer solely to the *energy* component or the *network* component of the energy bill. Also in this case, the term refers to both unitary prices and the

[20] With the exception of Czechia, no Member States forbids the injection into the grid in case of overproduction when technically feasible (i.e., there is a device able to regulate injection into the grid), but above certain thresholds the energy is not remunerated. In Czechia, PV systems smaller than 10 kW are not authorised to feed excess electricity into the grid https://www.zakonyprolidi.cz/cs/2016-16.

[21] While the term "tariff" is commonly used across Europe to indicate what is here called the billing methodology, this report uses the word tariff only in relation to regulated prices, which pertain the network component of the energy bill.

rules to apply such price. For example, a network billing methodology may include fixed elements, capacity-related elements and volume-related (e.g., proportional to consumption) elements, as well as the unitary price for these elements and the methodology for calculate the total network costs.

- The term "**energy tariff**" is not officially defined in the EU Aquis, although the word energy tariff is commonly used to identify what is here named *billing methodology*, such as fixed and variable tariffs. In this report, the term tariff is used in relation to network costs and regulated tariffs only (for example, the injection price is regulated in many Member States).
- The term "**price**", "**rate**" or "**charge**" (e.g., energy price or network price) refers to the unitary price of one of the elements included in the billing methodology, such as the energy consumed (or supplied) from (to) the energy grid and a fixed network cost per unit of time (sometimes referred as "**standing charges**"). The term *price* differs from *billing methodology* as the latter may include more than one unitary price, which are then multiplied by the relevant factors according to the defined methodology. For example, a pricing methodology may include an energy price of EUR 0.1 per kWh and a fixed network price of EUR 1 per day. Likewise, a pricing methodology for the energy component may include an energy price of EUR 0.1 between midnight and 6:00 and an energy price of EUR 0.3 between 6:00 and midnight.
- It is also possible to define the concept of "**overall unitary energy price**", by dividing the total bill by the amount of kWh consumed. For example, over the course of 1 year:
    - User 1 consumes 1000 kWh at a rate of EUR 0.2 per kWh (the energy price). The energy contract includes a fixed standing charge of EUR 1 per day. The total annual cost would be EUR 565.
    - User 2 consumes 3000 kWh at a rate of EUR 0.2 per kWh. The energy contract includes with a fixed standing cost of EUR 1 per day. The total annual cost would be EUR 965.

  While both users are on the same billing methodology and unitary rates, the different consumption means that the overall unitary energy price for user 1 EUR 0.565 while for user 2 is EUR 0.322.

Annex D presents some additional general statements that are useful to consider when discussing self-consumption.

3. The role of renewables self-consumption in the energy transition

As the energy system is shifting from centralised to decentralised energy production via distributed energy resources (DER), renewables self-consumption is likely to play an increasingly important role. The objective of this chapter is to describe the role of self-consumption in the context of energy transition, taking both the perspective of the energy system and the users. In addition, it presents some additional costs and benefits of self-consumption for society at large. Finally, the chapter also discusses how EU and Member States' policies can support, or in some cases become a barrier to, the uptake of renewable self-consumption.

This chapter is based on an analysis of available literature, of EU official documents and a series of interviews with key stakeholders, in particular for the part concerning energy system-level challenges. The analysis shows that an increase in self-consumption may indeed pose some significant challenges to network planning and management.

3.1. The energy system perspective

This sub-chapter explores the challenges for the energy system of the large-scale integration of DER, as well as the positive impact such integration may have from an energy system perspective.

3.1.1. *Challenges of self-consumption integration for the energy system*

The deployment of renewable self-consumption technologies poses certain challenges for the energy system because of 'bottom-up' injections of electricity into the grid. Electricity grids have been built to accommodate electricity produced by large, centralized generators connected to transmission lines and flowed to consumers in a single direction.[22] Hence, these **grids are not yet fit for the large-scale integration of DER**, requiring increased flexibility and bi-directional flow of electricity. This threatens the energy system's stability and leads to more frequent grid congestion and capacity management issues. To overcome these growing issues, there is a need for massive grid investments to upgrade the network and match the growth of low-carbon resources and applications (e.g. electric vehicle, heat pumps but also solar PV installations). However, passing–through rising grid costs arising from these massive investments to customers is an issue. Textbox *3-1* presents two examples to illustrate the impact that significant deployment of solar PV is having on the grid.

Textbox 3-1 Examples of strong impact of solar PV integration on the grid in EU Member States

The **Netherlands**[23] has revealed the limits of the current model where solar PV and electric vehicles are massively adopted by prosumers, while grid investments have not been able to follow the rapid pace of installations. As a result, and considering that flexibility options are not being full exploited, there is an urgent need for extensions and reinforcements before new installations can be accommodated.

[22] Distributed energy resources for net zero: An asset or a hassle to the electricity grid? – Analysis - IEA

[23] See for instance "The Netherlands' gridlock: a cautionary tale for the US" https://www.woodmac.com/news/opinion/netherlands-gridlock/

In **Poland,** the sudden uptake of more than 4 GW of solar PV installed in 2022 and the prediction of another 5 GW of solar PV per annum over the next years is raising major concerns among local DSOs.[24]

From a system operation point of view, low self-consumption rates mean that the **distribution and transmission system operators (TSOs and DSOs) have to deal with the uncontrollable[25] inflow of power** from the growing number of distributed generation units. This may be a benefit (for example, when the energy is injected in an area of high simultaneous consumption but with insufficient generation and transmission capacity) or a cost (for example, when an area sees an excess of generation that has to be moved somewhere else or that may force the curtailment of other generation, causing problems with ramp up and ramp down rates). In general, the ability of **network operators to reliably predict these inflows** (both on a short-term and long-term basis) is fundamental to plan short term corrective actions and long-term flexibility investments.

Self-consumption can impact the operations of both DSOs (with regards to local constraints, i.e. congestion, voltage issues, etc.), and TSOs (predominantly related to grid balancing issues, but regarding also transmission congestions on lower sub-transmission voltage levels, typically 60kV). In this context, the network planning processes of DSOs and TSOs may be affected, requiring a greater coordination for optimal grid capacity.

A distinction can also be made between the **impact on the energy system from different types of self-consumers**:

- *Individual household* consumers are likely to impose the biggest burden on the stability of the energy systems, given their potential number and consumption patterns (several users with matching consumption and network injection patterns, all at the lowest distribution level). These patterns often result in low self-consumption rates, which means high inflows and outflows of energy. Further, small generation plants in many Member States are not equipped with remote controllers for PV inverters, which means DSOs have no ability to switch them off (see further discussion on curtailment below).
- *Larger individual consumers* (commercial and business) can generally achieve higher self-consumption rates. This is often because of the lower ratio between the installed generation capacity and total consumption and because of their energy use being higher during the generating hours. As such, large individual consumers can play an important role in collective self-consumption, offsetting production during daytime on weekdays when residential consumers have a low electricity consumption. Further, large installations can usually be remotely controlled by DSOs, which again helps their management.
- *Collective self-consumers* may also be more likely to achieve higher self-consumption rates, but the impact on the network is significantly different based on whether the collective self-consumers are directly connected with a private network or use the public distribution networks. In the second case, when onsite generation is delivered to other consumers in the collective via the public network, the DSOs have to manage the entirety of the inflow and outflow of electricity. In the former case, DSOs only have to manage the residual load (onsite

[24] Speech of Patryk Demski (VP Tauron Group, representative of PKEE Polish Energy Association) at EDSO Webinar 'REPowering the Grid for Solar PV' on 20 September 2023.

[25] System operators have a certain control on commercial generators, in that they can be disconnected from the power network (curtailment) when there is an excess of generation. However, this is often not possible for many of the smallest systems installed.

generation minus collective consumption at any moment in time. Further clarification on this issue is provided further below). Data shows that local energy sharing allows to reduce grid injections during the mid-day generation peak by 17.2% and peak consumption in the evening by 13.7%.[26]

- *Virtual self-consumers* (*including virtual storage)* have a similar effect, in that the public network has to be used to deliver the energy from the generation to the consumption site and both loads have to be managed in their entirety.

Both **network-connected collective and virtual self-consumers have a larger impact on the network than self-consumers that do not use the public network**. However, their impact is still likely to be less than the impact of non-self-consumers, as the concept of self-consumption has a "location" element which means that medium and high voltage network are less involved (transmission lines may however still be used to transfer surplus from a distribution area to another, and the System Operator will have to ensure system overall balance). The locational element however is removed in the Commission's Proposal for an amending Regulation to improve the Union's electricity market design[27].

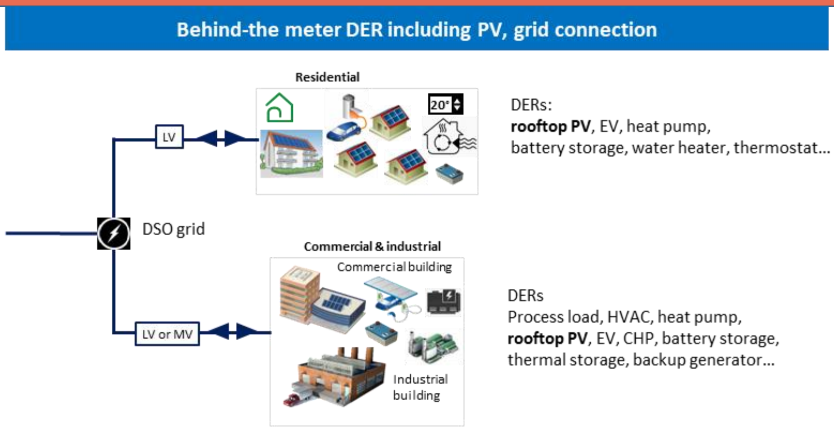
The issues generated by distributed generations and self-consumption can be distinguished between those associated with the *deployment of self-consumption and associated integration of solar PV* at distribution level and those associated with *grid balancing associated with the integration of solar PV*. Table 3-1 and Table 3-2 summarise these key challenges.

Table 3-1 Key challenges faced by system operators related to the deployment of self-consumption and associated integration of solar PV at distribution level

Key challenges	Description
The vision of DSOs on self-consumed "behind-the-meter" PV and prosumer behaviours	The impact of rooftop PV on the distribution grid is not the same as the one generated by ground-mounted PV farms. Grid operators see the impact of all "behind-the-meter" Distributed Energy Resources (DER - such as PV, storage, heat pump, EV, flexible loads…) encompassed in a wider definition of "Demand-Side Flexibility". They focus on the residual load of these systems combined, rather than rooftop PV alone. The ability to orchestrate all DER including PV via a customer energy management system (in homes HEMS or buildings BEMS) is a key enabler to optimize self-consumption and therefore limit the impact on grids. Still, the adoption of such technology is quite low, as indicated by recent research reports. Maximizing self-consumption has great potential benefits in grid capacity optimization in theory, but there is no certainty on the effectiveness of prosumer's ability to do so. The evolution of self-consumption schemes (i.e. net metering/billing, surplus monetization, virtual storage) is quite unpredictable at each country level. As a result, DSOs have to integrate those uncertainties in their planning strategies. The figure below depicts the scope of behind-the-meter DER.

[26] Liaqat, A., et al. (2022). Blockchain-Based Local Energy Market Enabling P2P Trading: An Australian collated case study on energy users, retailers and utilities.. Available at: IEEE Xplore Full-Text PDF:

[27] https://energy.ec.europa.eu/publications/electricity-market-reform-consumers-and-annex_en

Key challenges	Description
	 *Source: Enerdata own graphical interpretation*
Size of DSO as a critical issue for managing the integration of DER (including solar PV)	While large DSOs have the expertise and staff to support the growing complexity of the planning and connection request process, small DSOs tend to face a critical challenge for such tasks. In particular, connection requests to DSOs are supported by business processes and planning/engineering tools that tend to be inadequate to treat the growing number of requests in due time. Consequently, many DSOs adopt a worst-case approach, i.e., overbuilding unnecessary grid capacity. There is little transparency in the process, creating some frustration for customers having to pay for unjustified grid reinforcements or being delayed in their connection. Data management across different DSO departments and software systems, with the integration of third-party data like solar PV scenarios from local authorities, generates a high IT need. While large DSOs tend to have in-house capability to manage this complexity, smaller DSOs may adopt IT pooling strategies on some applications to reach a critical size for efficiency. This critical size issue was illustrated recently in Germany, in relation with the questionable ability of small DSOs to digitalize their networks.[28]
Types of loads connected to DSO networks (new and legacy)	In terms of grid planning, there are significant historical differences between countries with legacy electric heating (large capacity like France, Norway) and gas heating (smaller capacity like Netherlands, Italy…). The first category has inherited a larger capacity to cope with winter peak loading with resistor-based electric heating, which is used just a few days per annum. Each home has a large service connection, typically 6kVA and above, up to 15kVA. For the second category, there is less “headroom” available. Each home has a small service connection, typically 3kVA. This has an impact on the network's strength and its ability to host new capacities such as PV.
Unregistered solar PV installations	Most DSOs have put in place registration processes to ensure awareness and visibility on all new DER connected to their networks. Still, some solar PV installations may be unregistered or invisible by DSOs and generate wider issues: • Balcony systems are now installed in large quantities in Germany, and start picking up in other countries (Italy due to high retail price, but also in France more recently, as well as other countries). Those systems adopted by apartment owners or tenants, are small size portable systems (200Wp to 400Wp), which have no meter to measure self-consumption or injection surplus. Missing control instruments may generate electrical safety concerns. Some large size balcony PV installations may also be paired with a battery to maximize self-consumption, which is an even larger concern compared to small units. There is no official concern expressed at this point by DSO associations, but given the volumes of “hidden” PV at stake, it could

[28] See regional scenarios: https://vnbdigital.de/service/region

Key challenges	Description
	rapidly necessitate some stricter rules to avoid balancing issues on DSO and TSO systems. • Rooftop DIY kit owners may also bypass the registration process and be "hidden". • Incorrect mapping of customer connection in utility IT systems: typically a wrong phase allocation that leads to inaccurate load flow calculation. While traditional PV installations and some large loads (such as EV charging points) are subject to a formal registration and quality control process with the DSO, other DER such as battery storage or heat pumps do not have the same contractual requirement. Hence, the DSO lacks visibility on the actual total capacity and flexibility on the customer side. Some countries (e.g., Australia, the UK) are currently proposing a stricter holistic DER registration process, including for PV, visible to all grid stakeholders.
Firm and non-firm customer connections	Generally, today only firm connections are offered to consumer. Non-firm (or flexible) customer connections, which allow to limit PV injection (or EV charging) during constrained periods, or any other limitation measure, are still an exception and offered only in limited circumstances to specific customers.
Enhanced grid codes on PV inverters	The use of smart PV inverters with advanced volt-VAR-watt controls to support the grid is under-utilized in Europe, compared to Australia. Features like active power control (controlled by DSO) and reactive power provision are currently applied in some member states, and mostly on large commercial units.
Connection requests adapted to the complexity/size of the installation	Some countries may apply a harmonised template where no difference is made in the procedure between small and larger PV installations.

Table 3-2 Key challenges faced by system operators related to grid balancing required associated with the integration of solar PV

Key challenges	Description
Curtailment of prosumers installations	Some DSOs can curtail behind-the-meter solar PV via a control on the inverter in emergencies, but this is far from being the norm, especially for small-scale installations.
Participation of rooftop PV to market-based DSO flexibility programs for congestion management	PV could theoretically bid in such flexibility programs and get payments against their ability to ramp down during grid constraints. In practice, other resources than PV are better candidates.
Treatment of grid constraints (e.g. congestion, voltage issues...)	Congestions due to PV have been observed on distribution and transmission grids. However, the contribution of behind-the-meter PV in this congestion is unclear and hard to quantify in comparison with ground-mounted PV.
Grid stability issues	Countries with a very high PV penetration (both front- and behind-the-meter) like Germany[29] or the Netherlands, and potentially Poland may soon face an issue with grid stability as it is already the case for instance in South Australia[30]. As a consequence, the controllability of PV for security reasons may emerge soon also in Europe.
PV generation forecasting	PV generation forecasting for TSOs and DSOs to support grid operations (better situational awareness at short time horizons) is still an area of improvement. This was recently illustrated in the Netherlands during a sudden change in weather conditions with a massive ramp down of solar PV.
Cybersecurity issues	The issue of Cybersecurity is central when it comes to extending controllability to new distributed assets (including PV) via new communication channels and stakeholders.[31]
Data management	In some countries, data exchange procedures between DSOs and other parties like retailers and collective self-consumption organisers may still be an issue (data format, protocols...). Rules may be subject to quick and repeated changes, creating bureaucracy & bottlenecks.

3.1.2. Positive impact of self-consumption on the energy system

Renewable self-consumption can also have a positive impact on the energy system and enhance energy security. First, it **increases the resilience of the energy system**, as households and businesses are not entirely reliant anymore on external energy sources to satisfy the energy need of their building. At EU level, it also ensures increased energy security, as energy is locally produced so it reduces the EU's energy dependence on foreign countries.

Self-consumption can also contribute to **reducing network and system costs.** When users can produce their own electricity and self-consume it, they reduce the use of the network

[29] BMWK Germany: Electricity 2030, Long-term trends – tasks for the coming years. Available at: https://www.bmwk.de/Redaktion/EN/Publikationen/electricity-2030-concluding-paper.pdf?__blob=publicationFile&v=9

[30] "Rooftop solar in South Australia Causes Grid Issues", 2022, Available at: https://www.instituteforenergyresearch.org/renewable/solar/rooftop-solar-in-south-australia-causes-grid-issues/

[31] Example in NL: "Dutch agency investigates cybersecurity of PV inverters after hack". Available at: https://www.pv-magazine.com/2022/09/06/dutch-agency-investigates-cybersecurity-of-pv-inverters-after-hack/

(because consumption happens in the same place as generation), which means system operators may need to invest less in reinforcing distribution and transmission lines, and substations. It should be noted that network reinforcement costs are largely dependent on peak usage, rather than average use. This means that, given that the residual load has to be provided by an energy supplier in every situation (also when onsite generation is not available), network reinforcement will still be needed. Nonetheless, it is worth to mention that self-consumers are still dependent on the grid for peak consumption and this should be considered by system operators when planning grid investments (as mentioned in the previous section). Further, electricity generated by collective self-consumers often goes through the grid before being distributed among participants and this may lead to congestion issues at the lowest distribution level (this is also discussed in the previous section). However, when coupled with onsite storage and remote control, onsite generation can contribute to reducing network use and balancing costs. In the long-term, actors may increasingly employ onsite generation and storage, and adopt proactive behaviours that support system efficiency (e.g. demand response), reducing further system costs.

In addition, if self-consumption technologies, energy storage and accompanying ICT and microgrid systems can mature further, they also have the potential to **contribute to smoothing out demand-supply discrepancy** (increase system flexibility) without having to rely on fossil-fuel power plants.[32] No massive PV deployment can happen without associated storage and flexibility, both for ground-based PV and for prosumers. Overall, this means that self-consumption could be a driver to mitigate the impact of the integration of solar PV on the energy system, if adequately supported by technologies and policies.

To ensure that renewables self-consumption maximises the benefits for the energy system, **optimising self-consumption** (i.e. ensuring that self-consumption rates are maximised while supporting the reduction in overall system costs) **should be the ultimate goal** of policies supporting the uptake of self-consumption. To do so, the right framework, incentives, and technologies must be in place

3.2. The user perspective

This sub-chapter explores the challenges faced by self-consumers as well as the benefits self-consumption can bring them.

3.2.1. *Challenges of self-consumption for users*

From an individual point of view, a self-consumer (e.g., households or business) would strive to consume all of the electricity it generates, in order to maximise the return on the investment.[33] In theory, a perfectly rational prosumer would install a system that allows to meet 100% of the energy needs and then consume the energy at the moment it is generated (maximising both self-consumption and self-generation rates[34]).[35] However, **due to**

[32] What is self-consumption of electricity: Types and benefits | Repsol

[33] Interred Europe (2020). Renewable energy self-consumption. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: Energy_self-consumption__Policy_brief_final.pdf (interregeurope.eu)

[34] See section below on “Measurement and definition” for the definitions of self-consumption and self-generation.

[35] For this assumption to be true is also necessary that the energy injected in the grid is worth for the prosumer less than energy consumed. This is true when the marginal cost of self-generated energy is lower than the price offered by suppliers (total consumption cost) but higher than the export rate.

differences between generation and consumption profiles in most users (as explained in section 2.3.3), this is **hardly possible**.

3.2.2. *Benefits of self-consumption for users*

Self-consumption can provide **economic advantages to individual homeowners and companies**.[36] As consumers generate their own electricity, they would generally face lower energy costs and benefit from increased energy autonomy, which also means they become less exposed to high volatility of or increases in energy prices. The installation of self-generation equipment may also have a positive impact on property value, as well as promoting the installation of vehicle-charging equipment.

Self-consumption also represents a mean to include citizens and small businesses as part of the energy transition solution, by allowing them to **actively participate in the energy system** either individually or collectively (via collective self-consumption, energy sharing or energy communities).[37] Finally, with adequate support mechanisms (to decrease high upfront costs or to bridge the gap between the cost of self-generation and market rates), renewable self-consumption can increase the **affordability of energy** and **address energy poverty and vulnerability** by protecting consumers against volatile energy prices. The recitals of RED II also state that empowering collective self-consumers can advance energy efficiency at household level and help fight against energy poverty through reduced consumption and lower supply rates.[38] Examples of the usage of self-consumption to protect consumers exist in different EU countries.[39]

3.3. Other costs and benefits of self-consumption

Self-consumption can also bring other economic, environmental and social costs, as well as benefits for society at large; i.e. that are not directly associated with the energy system or users. These are briefly addressed in this section.

3.3.1. *Economic costs and benefits*

Self-consumption can contribute to **reducing network and system costs.** When users can produce their own electricity and self-consume it, they reduce the use of the network (because consumption happens in the same place as generation), which means system operators may need to invest less in reinforcing distribution and transmission lines, and substations.[40] Nonetheless, it is worth to mention that self-consumers are still dependent on the grid for peak consumption and this should be considered by system operators when planning grid investments. Further, electricity generated by collective self-consumers often

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[36] Interred Europe (2020). Renewable energy self-consumption. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: Energy_self-consumption__Policy_brief_final.pdf (interregeurope.eu)

[37] *Ibid.*

[38] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)

[39] Interreg Europe (2022). Tackling energy poverty with low-carbon interventions. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: Policy brief on tackling energy poverty with low-carbon interventions.pdf (interregeurope.eu)

[40] It should be noted that network reinforcement costs are largely dependent on peak usage, rather than average use. This means that, given that the residual load has to be provided by an energy supplier in every situation (also when onsite generation is not available), network reinforcement will still be needed.

goes through the grid before being distributed among participants and this may lead to congestion issues at the lowest distribution level(this is discussed also in the previous section). However, when coupled with onsite storage and remote control, onsite generation can contribute to reduce network use and balancing costs. In the long-term, actors may increasingly employ onsite generation and storage, and adopt proactive behaviours that support system efficiency (e.g. demand response), reducing further system costs.

In addition, self-consumption provides **economic advantages to individual homeowners and companies**.[41] As consumers generate their own electricity, they benefit from increased energy autonomy, which also means they become less exposed to high volatility of or increases in energy prices. The installation of self-generation equipment may also have a positive impact on property value, as well as promoting the installation of vehicle-charging equipment.

As self-consumption is a distributed production activity that takes place close to consumers, it **promotes economic activity** and **fosters local job creation**.[42] For example, the installation of rooftop panels would support more jobs (especially local jobs) than installing the same capacity in large scale commercial installations. For businesses and industry in particular, self-consumption can contribute to **increased competitiveness** thanks to independence from traditional electricity suppliers and reduced exposure to variations in electricity prices.[43]

On the other hand, self-consumption is **less cost-efficient** than large scale solar energy projects, among others because economies of scale exist (e.g. as mentioned earlier, more workforce is needed to install the same capacity in small scale solar PV than in large scale commercial installations).

Another challenge generated by self-consumption is that, although self-consumers benefit from the electricity grid, they may pay network tariffs which are insufficient to cover their fixed costs under some tariff regimes (volumetric network tariffs), leading to an **unfair distribution of costs among consumers**.[44]

3.3.2. *Environmental costs and benefits*

Renewable self-consumption contributes to the **achievement of renewable energy and climate targets**. Installations for self-consumption are a key tool to decarbonise the economy by decarbonising power consumption through renewable generation sources.[45] These installations already contribute significantly to the total renewable energy sources output in the majority of EU countries.

The initial focus of policies on renewable energy was on large-scale installations such as solar or wind farms. However, as technologies have matured and become more affordable, policymakers are increasingly supporting small-scale installations, which stimulates self-consumption at household/business level. This can collectively have a **large impact on**

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[41] What is self-consumption of electricity: Types and benefits | Repsol

[42] What is self-consumption of electricity: Types and benefits | Repsol

[43] How industrial self-consumption works and its advantages (enertika.com)

[44] Interred Europe (2020). Renewable energy self-consumption. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: Energy_self-consumption__Policy_brief_final.pdf (interregeurope.eu)

[45] What is self-consumption of electricity: Types and benefits | Repsol

carbon emissions reductions.[46] In addition, it helps to **reduce land usage for renewable energy** as the most popular form of small scale-installations for self-consumption are rooftop solar PV. More generally, self-consumption has a low environmental impact compared to large-scale energy production projects (fossil and RES) which can impact biodiversity, air and water pollution.

It also **promotes sustainable energy consumption through higher flexibility in consumption**. Consumers have been observed to adjust their consumption patterns to maximise the use of the energy they produce. As they are more informed about their own energy consumption and generation thanks to monitoring technologies, consumers are able to understand better energy and take up beneficial changes of behaviour.

Nevertheless, small-scale self-consumption may lead to increased environmental costs of supply chain compared to large-scale renewable projects as **indirect emissions deriving from the production and installation of small PVs** are likely to be higher than for large PV farms. This is due to the localised and distributed approach to self-consumption.

3.3.3. Social costs and benefits

Self-consumption **improves the acceptability of renewables** among the wider population, as households and business can invest and receive a significant return on their investment in generation equipment. Large public investment in renewables have often faced public opposition when undertaken by large investors and multinational engineering firms. Self-consumption includes citizens and small businesses as part of the solution, by allowing them to actively participate in the energy system either individually or collective (collective self-consumption and energy communities).[47] New business models are trying to involve further the local population, for example offering shares of the project or directly sharing electricity with them, which increase acceptability of renewables.

By contributing to **lifting energy poverty and vulnerability**, self-consumption provides multiple benefits for society at large (such as lower spending on health, improved comfort and well-being, improved households budget[48]).

3.4. Capturing the benefits of renewables self-consumption

As presented in the previous sections, renewables self-consumption can bring various economic, environmental, social and energy security benefits to market actors (households, businesses, grid operators) and to society a t large, and for the energy system. Nevertheless, a number of challenges should still be overcome to ensure that these benefits are appropriately captured. This section discusses how to capture the benefits of self-consumption by designing the most appropriate policies and measures able to lift the barriers and challenges to self-consumption faced by market actors.

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[46] Interred Europe (2020). Renewable energy self-consumption. A policy brief from the Policy Learning Platform on Low-carbon economy. Available at: Energy_self-consumption__Policy_brief_final.pdf (interregeurope.eu)

[47] What is self-consumption of electricity: Types and benefits | Repsol

[48] Commission Recommendation of 14 October 2020 on energy poverty. Available at: eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020H1563

There are essentially two stages of the self-consumption process at which benefits can be captured:

- The decision to install a DER, such as a renewable energy generation system for self-consumption – For renewable self-consumption to play a role in energy transition, a significant number of installations is necessary.
- The choice to self-consume:

  A. maximising the self-consumption rate under a non-dynamic pricing scheme – As prosumers increase their level of renewable self-consumption, the need for centralised energy production is reduced.

  B. optimising benefits for the energy system under a dynamic pricing scheme – Prosumers should not only maximise the quantity of self-consumed energy, but they should also maximise the value of self-consumption by adjusting consumption choices to reduce overall energy system costs. This means, for example, that prosumers should feed more energy to the grid when increased generation is necessary and self-consume more when there is an excess of generation.

With this in mind, it is possible to categorise policies and measures implemented by the EU and its Member States into three distinct cases. These policies and measures have different purposes and targeted functions and will therefore capture different benefits.

1. Policies and measures that incentivise the installation of generation equipment (generally, a solar PV system) or DER, but ignore or even disincentivise self-consumption. For example, a net-metering scheme[49] provides usually good incentives to the installation of onsite generation, but users have little incentive to self-consume, as they can use the energy they produce later by using the network as a storage device, usually only for the cost of network charges. This is a good deal for prosumers, but it has a cost for the system operator, which is then shared with all users. Another example is a feed-in scheme that pays a higher rate for the injection than the cost of using power from the grid. Users will be incentivised in feeding as much energy as possible, rather than self-consuming it.
2. Policies and measures that incentivise installation and self-consumption, but without aiming to optimise system benefits. This is for example the case for schemes that offer rather low remuneration for energy fed into the grid. Users have an incentive to self-consume as much as possible, given that grid power use is more expensive than what they would be remunerated for the surplus fed into the power grid (the strength of the incentive depends on the difference between the total purchase price and the injection price). The methodology to allocate and assign network costs also affects the incentive: when network costs are 100% calculated on volumes (volumetric), the incentive would be the greater, while capacity-based charges will reduce the incentive.
3. Policies and measures that incentivise the maximisation/optimisation of system benefits of self-consumption. This is the case of schemes where the remuneration of the surplus energy fed into the grid is not based on a static prices, but it is based on market signals and it would reward self-consumers with higher feed-in rates when generation is more needed, and lower injection price when there is an excess of generation. Such schemes are not only advantageous for the energy system but also provide financial benefits to consumers who would shift their consumption patterns in response to market signals. An example is the Spanish PVPC scheme, aimed at small consumers, where the feed-in rate is based on the day

[49] As per Article 15(4) of the IMED, Member States with existing net-metering schemes (i.e. "*schemes that do not account separately for the electricity fed into the grid and the electricity consumed from the grid*") cannot grant new rights under such schemes as of 2024.

ahead prices and is communicated to the users in advance.[50] Users will be incentivised to adjust their consumption choices by seeing the variation in the price they will receive, thus reducing overall system costs. Similarly, network tariffs can also have a dynamic element, which would further reinforce the incentive for prosumers to adjust their consumption (and grid injections) profiles. Overall system benefits will be further increased when the consumption prices and network rates are based on high-frequency market signals. These system benefits would reduce energy bills of all consumers, as network costs are lower than they would be in the absence of the response provided by prosumers exposed to dynamic energy prices and network tariffs.

The following chapters, and in particular the mapping of barriers (chapter 5) and the recommendations (chapter 6) make use of the framework above when assessing the extent that policies and regulations support or hinder self-consumption.

[50] https://www.ree.es/es/actividades/operacion-del-sistema-electrico/precio-voluntario-pequeno-consumidor-pvpc

4. SELF-CONSUMPTION DATA AND TRENDS

This chapter provides an estimate of the level of self-consumption across the EU and in each Member State. Due to a lack of precise data from Member States and to a lack of harmonisation, different assumptions were made to estimate data presented here. A more detailed list of those hypotheses can be found in Annex B.

Therefore the estimate is done by focussing on small-scale photovoltaic installations.[51] For these installations, this chapter:

- Evaluates the total small-scale photovoltaic capacity connected to the grid and estimates its production.
- Analyses the share of these installations participating in a self-consumption scheme.
- Estimates the self-consumption rate of those installations.
- The analysis also attempts to forecast the further development of self-consumption in the EU.

4.1. Deployment of self-consumption in the EU

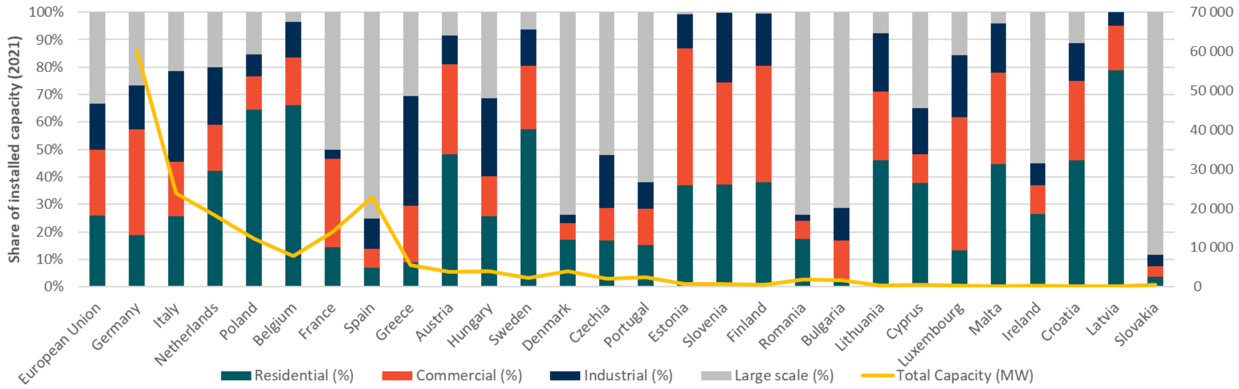
4.1.1. *Deployment of small-scale renewable installations*

1.1.1.11. Installed capacity

In order to estimate overall self-consumption rates and self-consumed quantities, is necessary to identify the amount of generation capacity dedicated to self-consumption. Typically, PV installations for self-consumption are usually smaller in size than those dedicated exclusively to grid injection, both because of the economics (larger systems benefits from economies of scale) and limitations in the rules that govern self-consumption schemes. As presented below, approximately 67% of the EU's photovoltaic capacity falls under the 'small-scale' category (see Table 2-1). By 2022, a total cumulative **small-scale PV capacity of 127 GW_{AC} was installed across the EU27.** There are notable variations among Member States, with the share of small-scale systems ranging from 12% to 100% of the total national PV capacity.

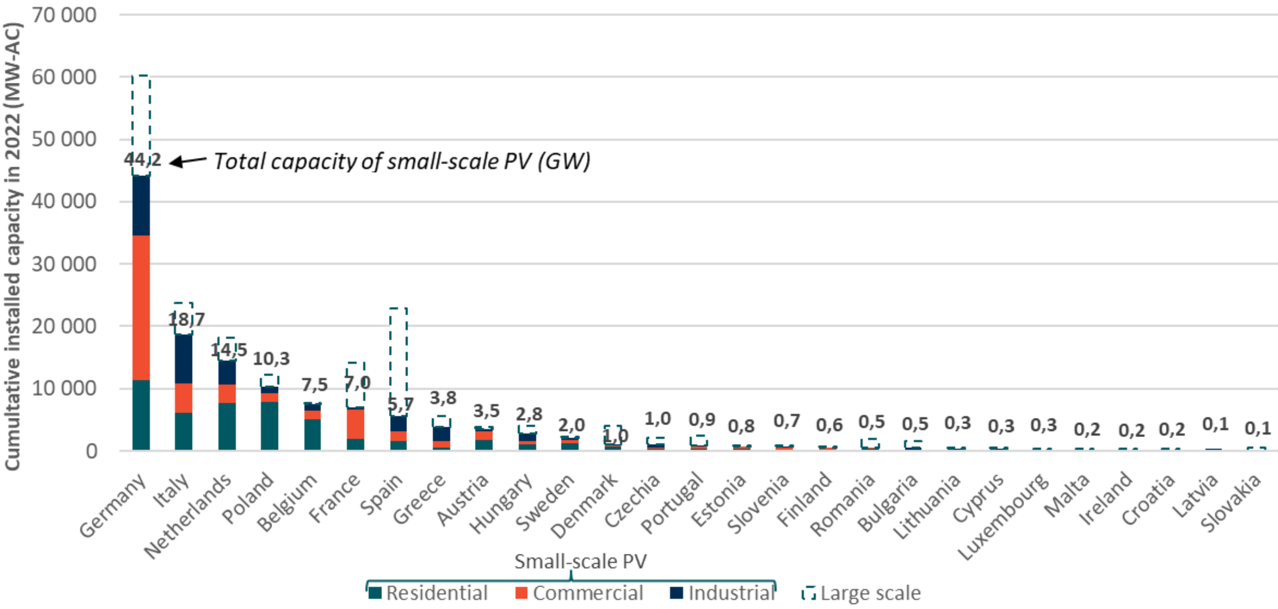
Figure 4-1 Installed photovoltaic capacities by country in 2022 (ordered by the share of small-scale PV)

[51] Photovoltaic self-consumption is almost always done by installations with a capacity below 1 MW_p (named "small-scale installations in this report"). We estimate that less than 2% of the energy produced in 2022 by self-consumers comes from large-scale installations. See "Methodology updates" for the exact definitions.



Source: SolarPower Europe 2023, Enerdata's analysis

Figure 4-2 Installed capacity of small-scale photovoltaic by country (2022)



Source: SolarPower Europe 2023, Enerdata's analysis

Most EU Member States' policies have favoured the development of small-scale PV over larger installations. Among the 14 countries with a total PV capacity over 1 GW, only four have a majority of large-scale installations: Spain (75% of large-scale installations), France (50%), Denmark (74%), Czechia (52%), and Portugal (38%).

The leading Member States in small-scale PV installations may differ from those leaders in the broader photovoltaic market. Only Germany, Italy, and the Netherlands managed to secure a position in the Top-5 for installed capacities in both categories. Poland and Belgium are key markets for the small-scale industry.

Table 4-1 Installed capacities of the top 5 leading European Member States in PV installations in 2022

	Total			Small Scale		
Rank	Country	Total installed capacity in 2022 (GW)	2022 growth (%)	Country	Total installed capacity in 2022 (GW)	2022 Growth (%)
1	Germany	60,3	*12%*	Germany	44,2	*9%*
2	Italy	23,8	*11%*	Italy	18,7	*11%*
3	Spain	22,8	*45%*	Netherlands	14,5	*28%*
4	Netherlands	18,2	*28%*	Poland	10,3	*52%*
5	France	14,1	*21%*	Belgium	7,5	*14%*
Share of the total installed capacity		73%			75%	

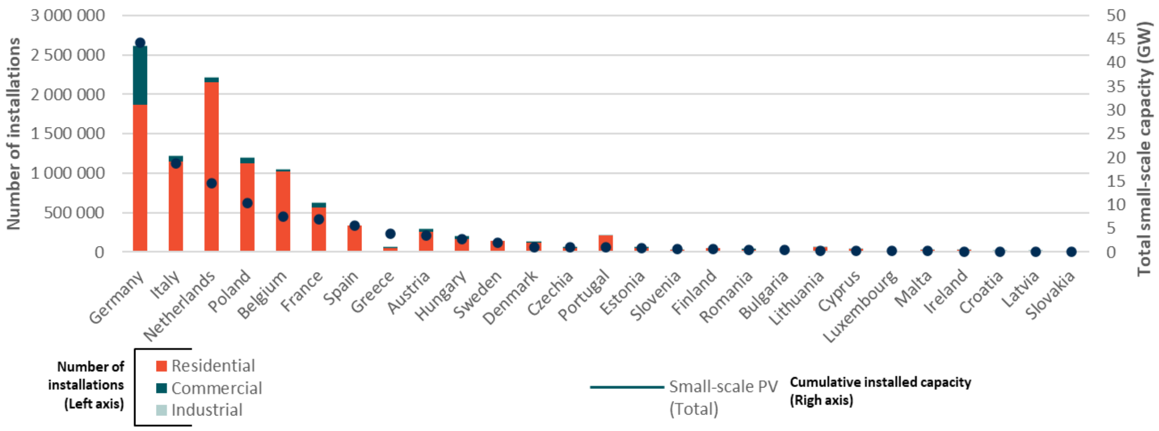
Source: SolarPower Europe, National statistics

This static picture does not clearly display very different dynamics currently happening across the EU. While Germany, Italy and the Netherlands are established major players of the small-scale PV market, Poland only made it to the Top 5 since 2022. Despite not being in the Top 5 players for small-scale PV, the Spanish market only started in the last 3 years and has been developing at a steady pace since.

1.1.1.12. Number of installations

In the EU27, 10.8 million small-scale solar installations have been identified, of which 88% are residential installations, 10.8% are commercial installations and less than 1% are industrial installations (> 250 kWp).

Figure 4-3 Number of small-scale photovoltaic installations estimated by Member State (2022)



Note: In several countries, the total number was estimated based on an estimated average size of installations by segment.

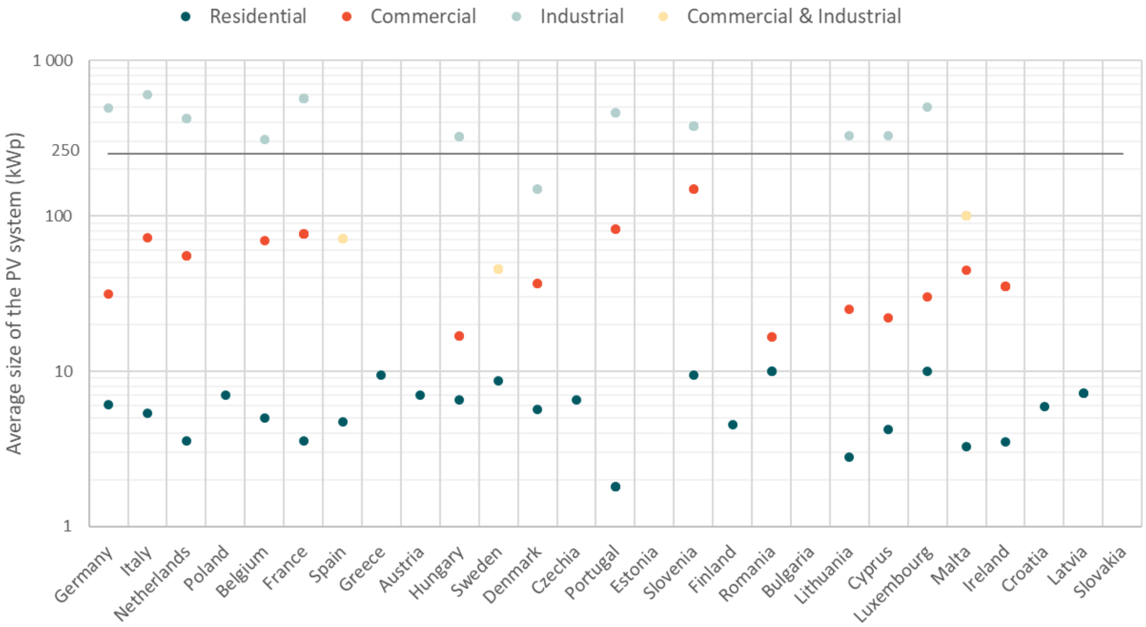
Note 2: The right axis (associated to the blue dots) represents the total installed capacity of small-scale PV (residential, commercial, and industrial).

Source: SolarPower Europe, National statistics, Enerdata's estimations

1.1.1.13. Average size of installations

In terms of the average size of photovoltaic small-scale installations, there are very large differences between Member States. The average size of installations is one of the key factors influencing the self-consumption rate. Portugal stands out as an exception and has a very low size of residential installations compared to the rest of the EU. This is mostly due to a policy framework which favours systems with the highest self-consumption rate.

Figure 4-4 Average size of photovoltaic small-scale system by segment and Member State (2022)



Note: When the average size was estimated using standard sizes, they are not displayed in this graph.
Note 2: A grey line has been added, illustrating the 250 kWp threshold that is the limit in this study between the commercial and industrial segments.

Source: SolarPower Europe, National statistics, Enerdata's estimations

4.1.2. *Contribution of small-scale renewable installations to electricity production*

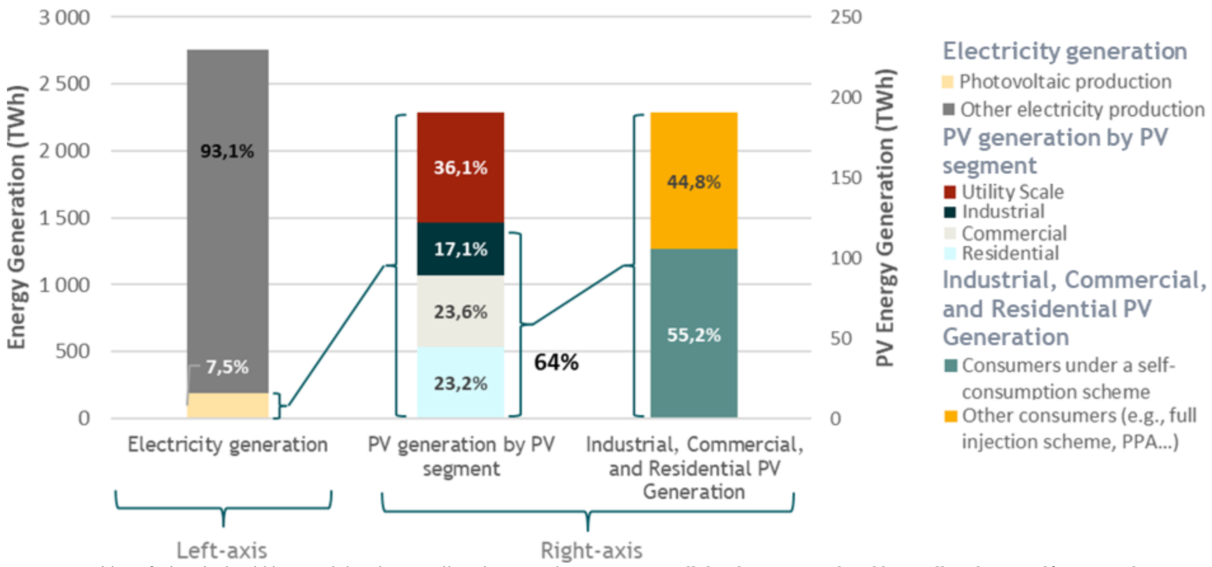
Figure 4-5 shows a breakdown of the estimated electricity consumption and production within the European Union. It analyses the input of self-consumers to European electricity production. It is worth noting that the figure does not distinguish between self-consumed and injected energy, only the overall share of generation by small scale installations. The 'Electricity generation' column presents the share of PV in the total electricity production. In 2022, photovoltaic production represented 7.5% of the electricity generation. This is a strong increase compared to only 5.8% in 2021.

The 'PV by segment' column illustrates that small-scale PV represented 64% of the total photovoltaic production in 2022. As it can be observed in the "Small-scale PV" column, only 55% of this production comes from installations actually self-consuming part of the produced energy[52].

The impact of collective self-consumption projects among the current production is negligible and has not been accounted in this analysis. In the future, with collective self-consumption becoming more popular, the rate of self-consumption is likely to increase further.

Figure 4-5 Relative share of self-consumers on the total energy consumed/produced in the EU27 (2022)

[52] Of the total electricity generated, 55% is energy produced in small scale PV which benefits from a feed-in tariff for the entire electricity injection, or whose production is entirely sold via Power Purchase Agreement (PPA) to a different consumer.



N.B: To avoid confusion, it should be noted that the "Small-scale PV" column represents all the electricity produced by small-scale PV, self-consumed or not. The self-consumed electricity is not represented in this figure. We make the hypothesis that all small-scale PV installations here are self-producers (but not necessarily self-consumers).

N.B 2: The production of photovoltaic electricity in each Member State was estimated using the average production ratio (GWh produced/installed capacity) of the past years (i.e., either based on national statistics or on the IEA Renewables 2022 report). An element of uncertainty in these estimates is the impact of PV curtailment on the injected production (in particular, in Germany).

Source: Enerdata Global Energy Demand, Country by country analysis.

4.1.3. *Level of self-consumption*

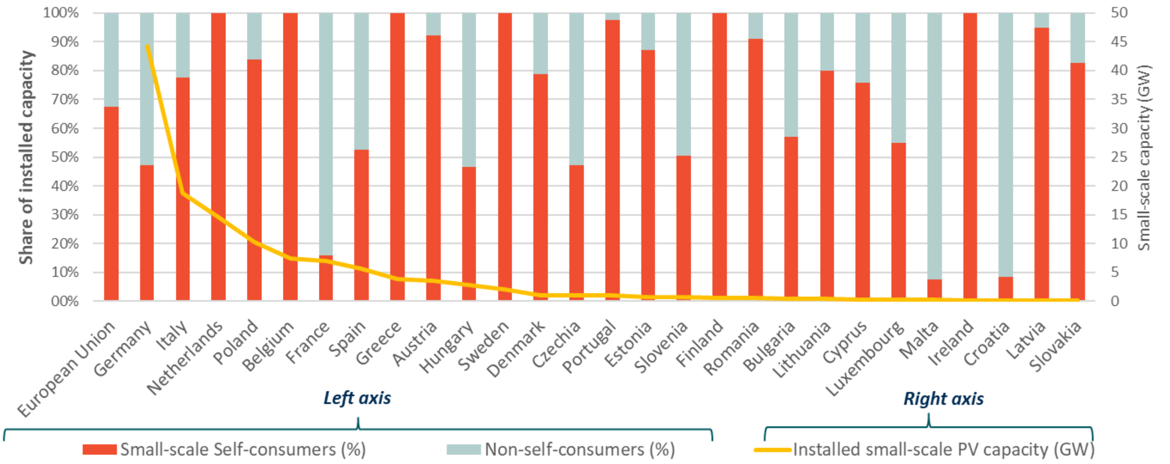
The overall level of self-consumption taking place at Member State level can be estimated via two key variables:

- The share of small-scale installations engaging in self-consumption;
- The self-consumption rate of those installations.

1.1.1.14. Share of small-scale installations engaging in self-consumption

In 2022, an estimated **67% (86 GW) of small-scale installations are self-consuming their electricity.** The rest of small-scale is installations that are injecting into the grid their entire production, either because of an existing or previous Feed-in tariff scheme[53] or because of a direct selling contract (PPA).

Figure 4-6 Share of self-consumers among the small-scale PV installation by country (2022)



Source: Enerdata's analysis, National statistics

The share of "non-self-consumers" shown in Figure 4-6 can be interpreted in different ways[54]:

- In Malta[55], Croatia[56], Luxembourg[57], and Hungary[58], the residential non-self-consumers are households benefiting from an outdated feed-in tariff.
- In Germany and France, the households can choose between the full injection of the energy produced into the grid and a specific remuneration for self-consumption. In this case, the choice will essentially depend on the electricity retail price, on the remuneration price and on the user's self-consumption rate.[59]
- In multiple countries, rooftop installations prefer contracting a Power Purchase Agreement with external consumers. This is for instance the case for farm hangars that do not always have a consumption source.

Where self-consumption is not the only option, the exact share of self-consumers is not always measured or publicly available. In this case, the share of self-consumers was estimated based on the existing frameworks and available data (see Table B- 2 in Annex B).

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[53] It should be noted that a feed-in tariff (FiT) can be either for the full injection of the electricity into the grid or for the remuneration of the surplus. Data shown here only concerns FiTs for full injection.

[54] The examples listed below are not exhaustive.

[55] For more information: https://www.rews.org.mt/#/en/sdgr/463-2021-renewable-energy-sources-scheme-active

[56] For more information: https://www.hep.hr/ods/UserDocsImages//publikacije/godisnje_izvjesce//godisnje2020.pdf

[57] For more information: https://gouvernement.lu/fr/actualites/toutes_actualites/communiques/2023/07-juillet/11-turmes-bilan-legislature.html

[58] For more information: https://cms.law/en/int/expert-guides/cms-expert-guide-to-renewable-energy/hungary

[59] For more information on France: https://www.photovoltaique.info/fr/tarifs-dachat-et-autoconsommation/tarifs-dachat/arrete-tarifaire-en-vigueur/

Among the 27 Member States, only 15 provide information of the total capacity of self-consumers' installations. The rest only provide partial or no data. The split between residential, commercial, and industrial self-consumers is only published in 8 countries.

Across all analysed countries, it is possible to observe a shift from remunerating generation towards schemes directly targeted at **self-consumption for small-scale PV systems** (See Figure 4-7). The only exception is Poland in which the share of self-consumers among small-scale installations was stable (from 86% to 85%) between 2021 and 2022. This does not indicate a slowdown of the self-consumption market (the number of prosumers has been growing) but rather a strong development of ground-based installations smaller than 1 MWp that are not self-consuming. [60]

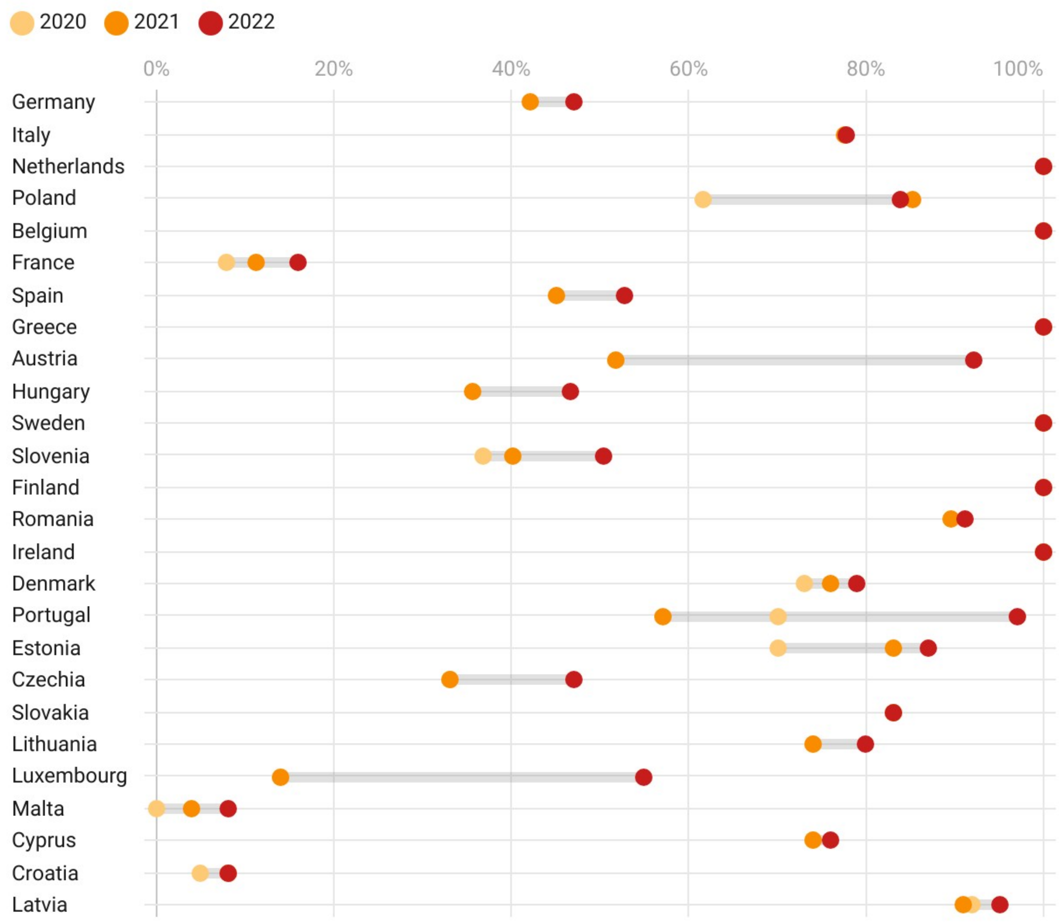
An interesting case is Austria where, in 2022, 93% of small-scale PV capacity installations were dedicated to self-consumption, a significant surge compared to 51% in 2021. This rapid transition can partly be attributed to a sharp increase in retail electricity prices for industrial consumers. This price increase encouraged most users previously reliant on full-injection feed-in tariffs to switch to a self-consumption scheme. Energy communities might drive this trend even further but do not explain the switch observed between 2021 and 2022. By early 2023, only 100 communities were founded[61].

Germany stands out as an exception to this pattern. In 2023, the country significantly raised its feed-in tariff to encourage consumers to prioritize larger systems with full injection over smaller systems with a high rate of self-consumption. Nevertheless, even with this policy adjustment, the growing electricity prices may continue to make self-consumption schemes the preferred choice for most self-consumers.

Figure 4-7 Evolution of the share of prosumers enrolled in self-consumption schemes among small-scale PV installation in EU member states (2020 – 2022)

[60] For more information: https://inzynierbudownictwa.pl/rynek-fotowoltaiki-w-polsce-2023-raport/

[61] For more information: https://www.energy-innovation-austria.at/article/energy-communities/?lang=en



Source: National statistics, Enerdata's analysis, Graph created with Datawrapper.

1.1.1.15. Self-consumption rates

Table 4-2 presents the self-consumption rates (see 2.3.4 for the definition) of the installations engaging in self-consumption schemes. Most of these rates have been estimated, either based on similar use case, on published incomplete data (e.g., total self-consumed energy), or on standard rates. The detail of the hypotheses used can be found in Annex B.

Table 4-2 ***Estimated average self-consumption rate estimated by country and segment in 2022***

Country	Residential	Commercial	Industrial	Utility scale
Austria	*31%*	*60%*	*70%*	*n.a*
Belgium	*38%*	*60%*	*70%*	*n.a*
Bulgaria	*27%*	*60%*	*70%*	*100%*
Croatia	*25%*	*n.a*	*n.a*	*n.a*
Cyprus	*34%*	*60%*	*70%*	*n.a*
Czechia	*23%*	*60%*	*70%*	*n.a*
Denmark	**20%**	**80%**	**80%**	n.a
Estonia	*33%*	*60%*	*70%*	*n.a*
Finland	*66%*	*80%*	*85%*	*n.a*
France	**31%**	**53%**	**62%**	**79%**
Germany	*16%*	*31%*	*36%*	*45%*
Greece	*15%*	*60%*	*70%*	*n.a*
Hungary	*25%*	*60%*	*n.a*	*n.a*
Ireland	**65%**	*75%*	**100%**	n.a

Italy	**28%**	**43%**	**45%**	n.a
Latvia	*19%*	*60%*	*70%*	*n.a*
Lithuania	*47%*	*60%*	*70%*	*80%*
Luxembourg	*26%*	*60%*	*n.a*	*n.a*
Malta	*52%*	*65%*	*75%*	*n.a*
Netherlands	*36%*	*49%*	*49%*	*n.a*
Poland	*20%*	*60%*	*n.a*	*90%*
Portugal	**94%**	**94%**	**94%**	**100%**
Romania	**27%**	**60%**	n.a	n.a
Slovakia	*27%*	*60%*	*70%*	*n.a*
Slovenia	*26%*	*53%*	*n.a*	*n.a*
Spain	*29%*	*60%*	*70%*	*n.a*
Sweden	**34%**	**59%**	**68%**	**n.a**
Average by segment	**27,9%**	**45,3%**	**54,4%**	**53,3%**
Average (Total)	**39,4%**			

Note: Data in bold is based on published data on the self-consumed energy. Data in italic is estimated. See Figure 4-9 for more detail.

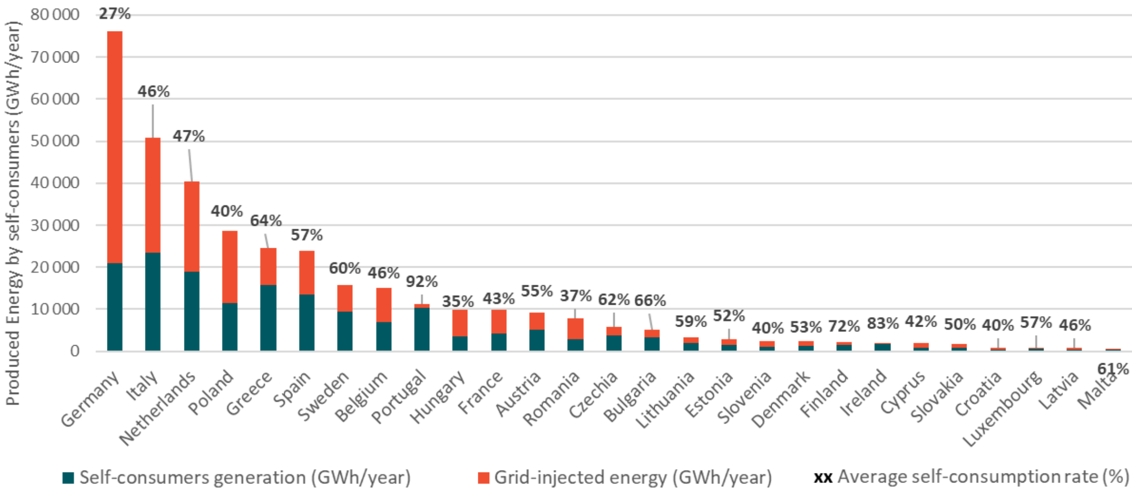
Source: Enerdata analysis, multiple national sources

Despite large differences between countries some key trends can be identified:

- Larger consumers tend to have higher self-consumption rate. In almost every country, the SC rate for industrial consumers is higher than the commercial one, which is generally higher than the residential one. This is because commercial and industrial consumers tend to have PV installations that only covers their baseload electricity consumption.
- The residential self-consumption rate is directly linked to the household's electric consumption and the size of its PV installation. The only significant influencing factor that was identified in the literature was the development of batteries (home batteries or electric vehicles). The presence of heat pumps is not a significant driver of the self-consumption rate. (See Annex B for more details).

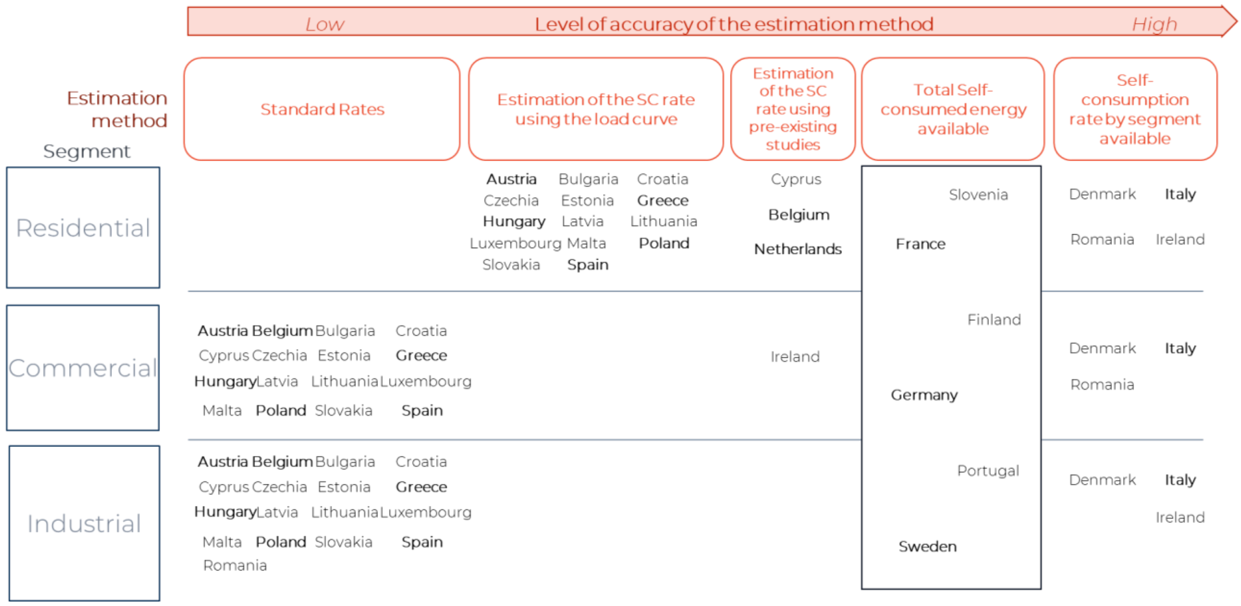
Overall, in the EU it was estimated that **40% of the electricity produced by self-consumers was self-consumed.** This represents **34 GWh/year** that are not injected into the grid.

Figure 4-8 Distribution of photovoltaic energy produced by self-consumers in Europe in 2022



Source: Enerdata analysis, multiple national sources

Figure 4-9 Synthesis of the methods used to estimate the self-consumption rates



Note: The countries in bold are the one with an installed capacity of self-consuming installations over 1 GW in 2022.

When examining self-consumption rates, it is crucial to note the limited availability of data published by the Member States on this matter. Nonetheless, approximately 50% of the energy covered by Figure 4-8 is derived from dependable estimations. (i.e., with at least the total self-consumed energy available).

The other half is estimated based on different methods depending on the available information and on the segment:

- When an academic or commercial publication was available with self-consumption rate estimations it was used.
- For residential consumers, a tool was developed to estimate the non-optimised self-consumption rate based on a simulated load curve and PV output. (More information in Annex B). If the country had a high penetration of batteries, the self-consumption rate

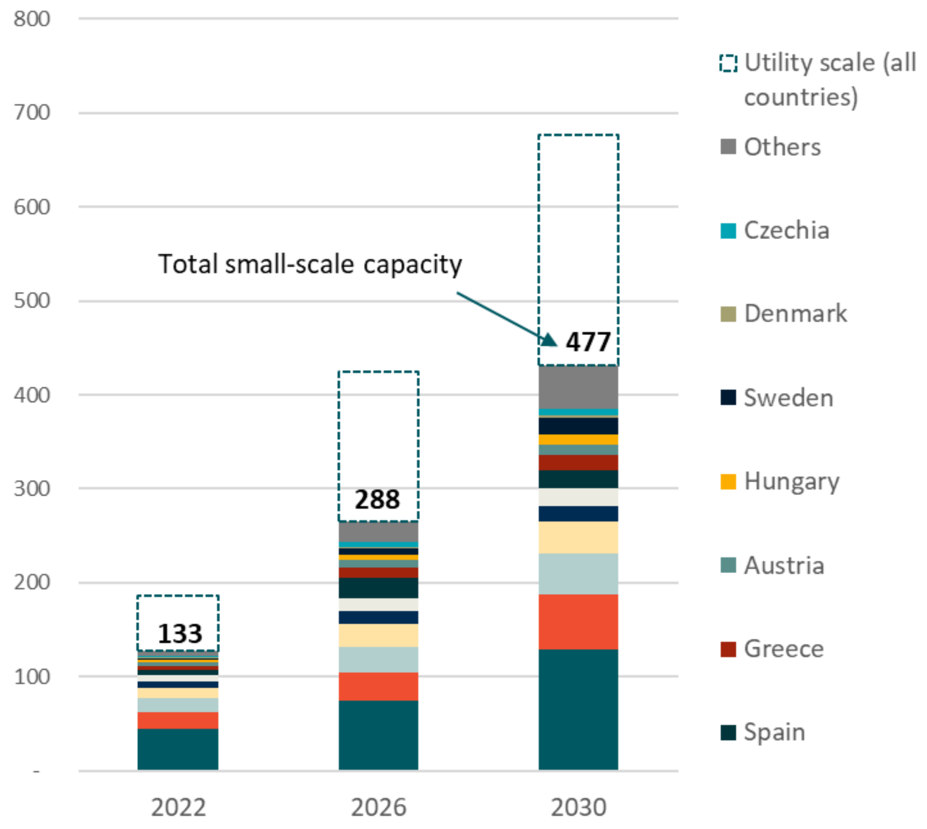
obtained was increased.

- For C&I consumers with no other data available, standard rates of 60% for the commercial segment and 70% for the industrial segment were used.

4.2. Forecast of the potential development of self-consumption in the EU

By 2030, the share of small-scale PV in the EU is expected to remain relatively stable (66% of small-scale capacity by 2030 vs. 70% in 2022). The ranking of countries by installed capacity is relatively stable in these estimations that are based on a mix of SolarPower Europe's estimated forecast, national objectives and Enerdata's Enerblue scenario[62].

Figure 4-10: Forecasted evolution of the small-scale photovoltaic installed capacity



Source: SolarPower Europe, National objectives, Enerdata's estimation (see Annex B for key hypotheses)

Based on these forecasts, the output from small-scale PVs can be estimated to increase by a factor of 3.5 by 2030. However, we do not expect a significant surge of self-consumption rates as they might face influencing factors that could either increase or lower the self-consumption rate (see Table 4-3).

A scenario where self-consumption rates would rise significantly higher than the ones shown in Figure 4-11 could exist if one or more of the following conditions are met:

[62] Based on Enerdata's Enerfuture forecasting tool. More information here: https://www.enerdata.net/research/forecast-enerfuture.html

- Home batteries installations rise significantly across Member States (this could be pushed by a significant rise of retail electricity prices and a drop of home batteries prices).
- The average size of the generation plant decreases compared to current standard. This would limit the development of solar.
- Collective self-consumption catches up, especially in apartment buildings.
- National law across key member states considerably limits the possible remuneration for injecting energy into the grid, pushing consumers to use more of their energy at the moment it is produced.

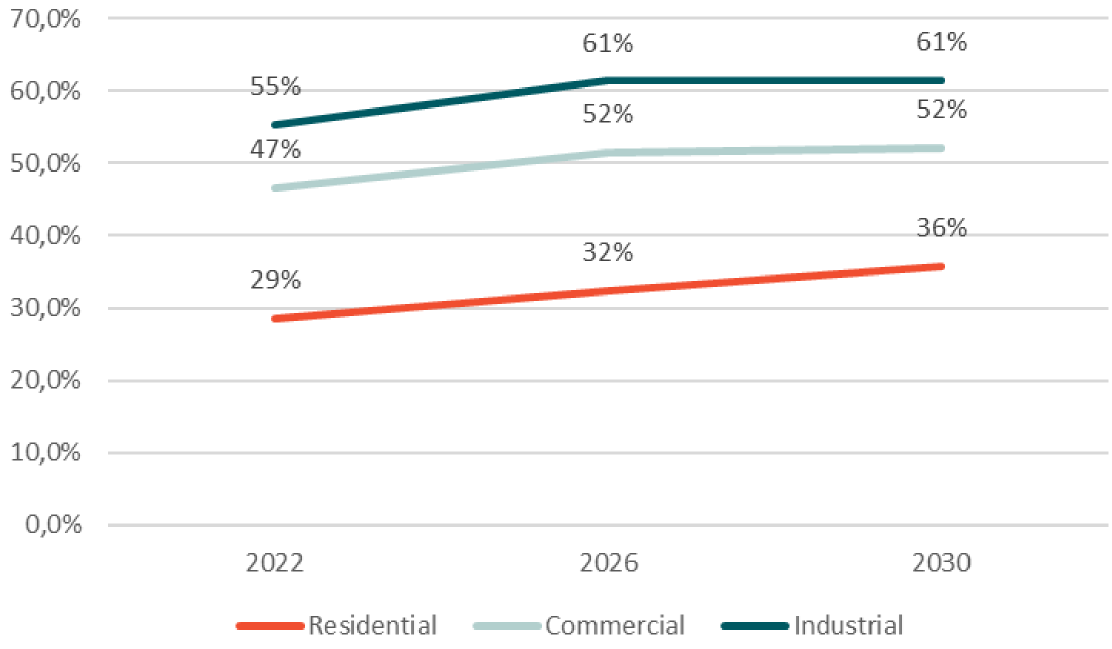
The averages self-consumption rates of countries like Portugal (with current estimated self-consumption rate of 90% in 2022) or Finland (76% in 2022) could then possibly be met at EU level. However, higher self-consumption rates do not necessarily mean an overall better outcome, as these may be achieved by a reduction total generation from self-consumers (essentially, reduce DER generation).

Table 4-3 Factors influencing the evolution of self-consumption rates

Factors that could raise the average SC rate	Factors that could lower the average SC rate
Electrification of consumption (e.g., heating), leading to a higher electricity consumption.	Efficiency measure reducing the total energy consumption.
Development of home batteries and electric vehicles that will allow for more demand flexibility.	Increase of the size of PV installations driven by lower module prices.
End of net-metering schemes (e.g., Netherlands) that can encourage self-consumers to optimize their self-consumption rate.	Already high self-consumption rates for C&I segments that will require high investments to be optimized.
The development of collective self-consumption might increase the average residential self-consumption rate (and to a more limited extent the self-consumption of businesses and public buildings).	

Self-consumption rates are expected to increase the most in the residential segment, because of the growing penetration of batteries. Based on our estimations, these rates could grow by up to 7 percentage points by 2030. Industrial and commercial installations tend to be small compared to the consumption of the site. It is thus easier for such installations to reach a high self-consumption rate, even without using storage solutions (e.g., batteries).

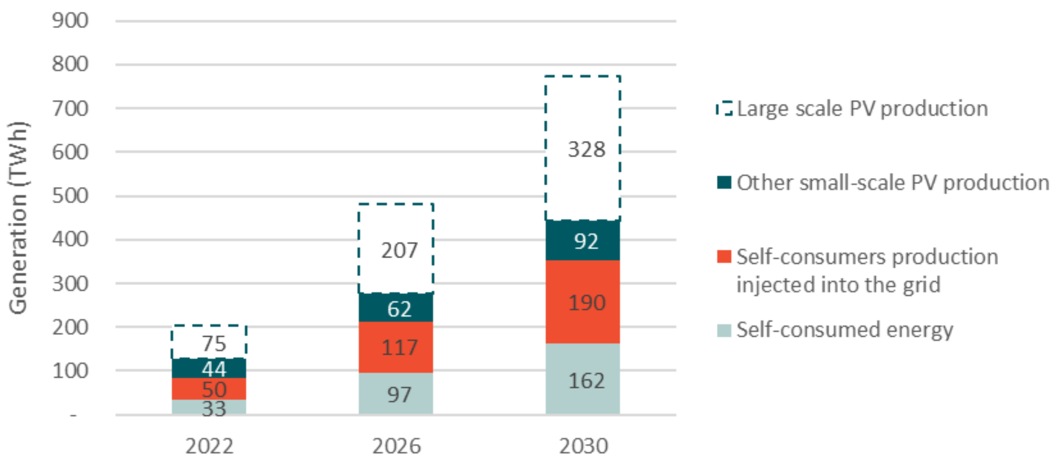
Figure 4-11 *Self-consumption rates estimated evolutions by segment*



Source: Enerdata hypotheses

With those estimated self-consumption rates, self-consumers could produce around 350 TWh/year of electricity by 2030), which represents a 3.5-fold rise compared to the production in 2022. According to the projected electricity production in Enerdata's Enerblue scenario**Error! Bookmark not defined.**, solar production could thus represent 19.4% of the EU total e lectricity production; 4.1% of the total electricity production would be self-consumed in 2030 vs. 1.3% in 2022.

Figure 4-12 *Forecasted production of electricity by photovoltaic in the analysed EU Member States by type of production*



4.3. Alternative estimate of self-consumption rates

In order to arrive at the estimate provided in the previous paragraphs, we used four distinct approaches to determine self-consumption rates by country, each contingent upon data availability:

1. Direct use of publicly available national self-consumption rates segmented by type of user;
2. Application of standard self-consumption rates adjusted to align with the total self-consumed energy at the national level (usually estimated by measuring the electricity injected into the grid);
3. Use of country-specific estimated self-consumption rates from relevant literature segmented by type of user;
4. For residential user
5. In case of data unavailability, standard self-consumption rates were used, with rates of 35% for residential, 60% for commercial, and 70% for industrial customers.

The detail of the methodology used for each country is detailed in Annex.

In order to validate the estimate for self-consumption of residential customers in countries were no data was available, a bespoke Excel tool was developed. This tool estimates self-consumption rates not based on assumed self-consumption rates at EU level, but based on typical PV generation and consumption profiles in Member States. This tool takes as input:

- The average electrical consumption of residential households by country (GWh/year/household)
- A typical load curve (hourly step) of a residential household. Four different load curves were used (Germany, Netherlands, Spain, France) and each country used one of those curves as a proxy (see table below for more detail).
- The solar production ratio of each country (MWh/kWh)
- A typical PV production curve (hourly step) based on PVGis[63] estimates for an average zone in each country.

The figure below illustrates the results obtained for the case of Germany for an average day.

[63] https://joint-research-centre.ec.europa.eu/photovoltaic-geographical-information-system-pvgis_en

Figure 4-13 Average production and consumption per day for a household consumer in Germany

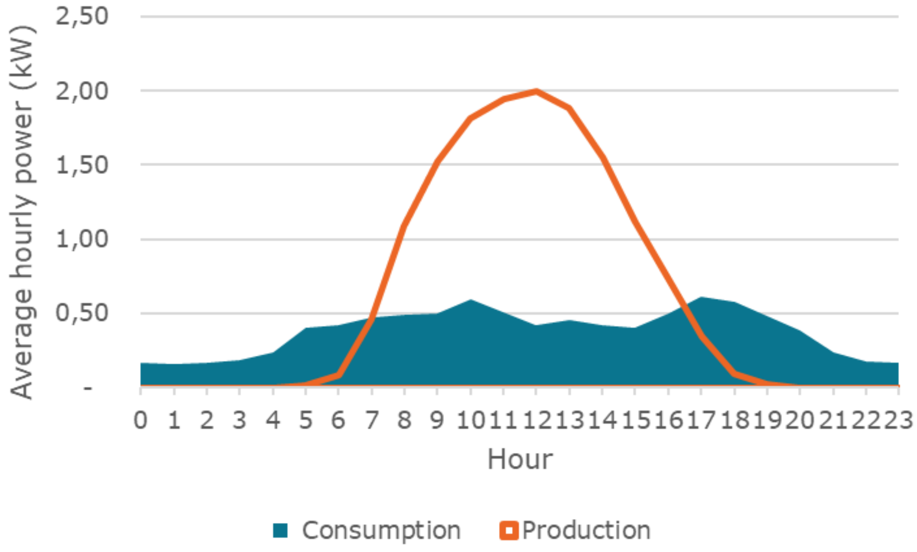


Table 4-4 presents the aggregated data used to characterise household consumers in each Member State.

Table 4-4 Input data used for the estimation tool

Country	Consumption / household (MWh)	Average PV size (kW)	Solar production (MWh/kW)	Proxy Zone
Austria	4,98	7,0	0,862	Germany
Belgium	3,82	5,0	0,994	Netherlands
Bulgaria	4,17	6,4	1,044	Germany
Croatia	4,53	6,0	1,077	Spain
Cyprus	3,94	4,2	1,490	France
Czechia	3,78	6,5	1,009	Germany
Denmark	3,70	5,7	0,780	Netherlands
Estonia	3,52	5,7	0,699	Netherlands
Finland	8,76	4,5	0,674	France
France	5,26	3,6	1,354	France
Germany	3,33	6,1	0,880	Germany
Greece	4,33	9,4	1,317	Spain
Hungary	3,09	6,5	1,432	Germany
Ireland	4,55	3,5	0,960	Netherlands
Italy	2,61	5,3	1,085	Spain
Latvia	2,19	7,2	0,699	Netherlands
Lithuania	2,68	2,8	0,754	Netherlands
Luxembourg	3,37	10,0	0,650	Netherlands
Malta	4,90	3,3	1,309	France
Netherlands	2,73	3,6	0,937	Netherlands
Poland	2,27	7,0	0,656	Germany
Portugal	3,46	1,8	1,361	Spain
Romania	1,94	10,0	1,218	Germany
Slovakia	3,18	6,0	1,261	Germany
Slovenia	4,33	8,9	0,983	Spain
Spain	3,86	4,7	1,238	Spain

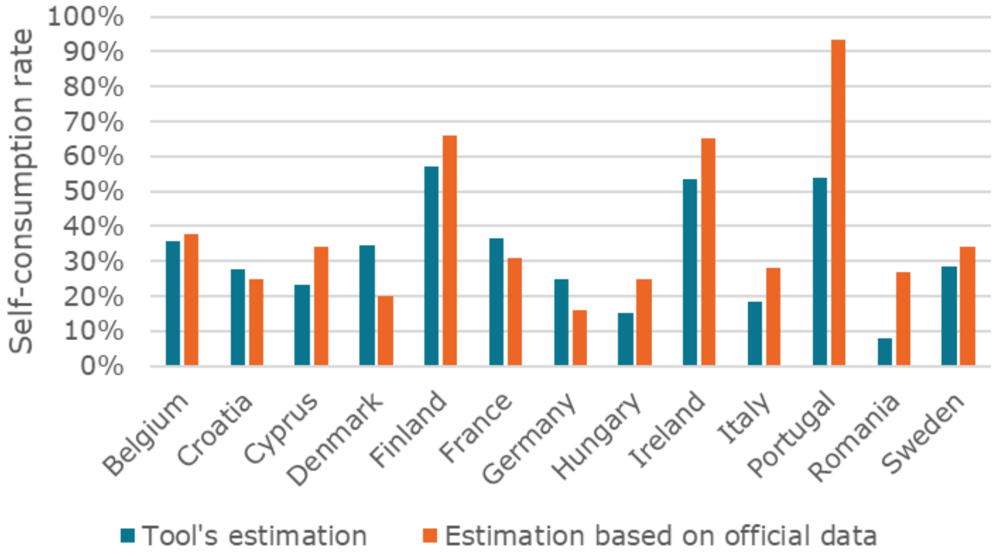
Country	Consumption / household (MWh)	Average PV size (kW)	Solar production (MWh/kW)	Proxy Zone
Sweden	8,87	8,7	0,936	France

Limitations

Due to the limited time allowed, this tool provides only an indicative estimate, and there is significant scope for further improvement. It is also important to clarify the limits of this approach: the tool aims to illustrate the self-consumption rate of the average household in each country, but this represents a household that does not optimise its self-consumption rate. If representative datasets covering energy use of residential prosumers with a hourly profile could be sourced, the precision of the estimate would significantly increase.

The figure below compares the self-consumption rate estimated through the tool with the ones published by the national authorities (or at least estimated based on public data). The widest differences can be observed in Portugal (probably due to a remuneration scheme limiting grid injection), in Romania (probably due to self-consumers having a higher electricity consumption than the average household), and in Denmark. Besides these countries, the tool seems to provide a relatively good approximation of household's self-consumption rate derived via other methodologies. As expected (due to the use of average consumption profiles, rather than prosumers' consumption profiles), the tool tends to underestimate self-consumption compared to the other sources, but this does not happen for every country observed.

Figure 4-14 Comparison of tool-estimated self-consumption rate vs published ones for the countries in which public data is available



4.4. How can Member States estimate self-consumption?

The analysis presented in this chapter highlights a significant lack of harmonised information concerning the measurement of self-consumption.

Even the countries with the highest quality of data available (Italy, France, Germany, Sweden) do not present the same information, which complicates comparisons and data aggregation. For a comprehensive reporting, the following data should be collected and made available by Member States:

- The AC and DC capacity of connected self-consumers by segments. While the AC capacity is key to estimate the maximum power that can be injected into the grid, the DC capacity allows to estimate the theoretical PV production using solar irradiation.
- The number of self-consuming installations by segment. This is already available in some countries that maintain an installation register (e.g., Spain, Germany). This information allows to estimate the average size of installations, which is a key indicator to derive the self-consumption rate.
- The number and capacity of installations that are not self-consuming by segment.
- The total energy injected into the grid by self-consumers installations. If self-consumers benefit from a centralised remuneration scheme, Member States (or national regulators or grid operators) are currently tracking energy fed into the grid. However, this information is rarely aggregated and made available to the public.

It is possible to reliably measure the self-consumption rate by segment and in total if the vast majority self-consumers use smart meters that measure this information, and if this information is correctly aggregated by segment. However, when this data is not available with sufficient coverage, Member States could estimate the **self-consumption rate by segment and type of customer based on a sample of users**. To do so, they should measure the self-consumption rate of a statistically representative sample of users. This can be done via smart meters, but may also be possible using inverters' data when smart meters are not available. It is also advisable to split the commercial and industrial segments not only by size of installation but also by type of user, for example using NACE codes.

This analysis could be complemented by the use of an estimation tool, similar to the one presented in chapter 4.3 is. The analysis presented in this report however should be improved by:

- Using a statistically significant set of consumption profiles of self-consumers (if available), or an aggregated profile of the measured total consumption of self-consumers.[64]
- Split the analysis geographically, by either using the localisation of each plant (if registered) or at least providing a regional split for consumers.
- Instead of using an average irradiation year, use the yearly measured irradiation for each year split at a regional or local level.
- Extend the analysis to commercial and industrial segments (by collecting consumption profiles for self-consumers belonging to these categories).

[64] In country with the highest variation in terms of level of consumption, self-consumers tend to be the highest energy users. In this case, the average consumption across all users is not a good fit to represent the consumption profile of self-consumers.

5. Mapping of the regulatory framework

This chapter presents the key aspects of the regulatory framework for self-consumption in each Member State, as well as the frameworks which allow to develop viable business cases that valorise prosumer flexibility potential, optimise energy efficiency, and ensure short pay back periods. This chapter does not provide a ‘transposition check’, i.e., assessing whether Member States are correctly transposing EU Directives and Regulations relevant for renewable self-consumption. Instead, its focus is on identifying the factors that are hindering a higher share of renewable self-consumption in Member States.

5.1. Key aspects of the regulatory framework

This section presents an overview over the key aspects of the regulatory framework relevant for renewables self-consumption and portrays the most important elements of the legal and regulatory framework for individual and collective self-consumption in the 27 Member States.

5.1.1. *General Aspects*

As set out above, the production of energy for the purpose of self-consumption is not limited to a specific type of generation plant. Depending on the form of deployment or type of generation plant, different regulatory requirements may have to be met. As such, the legal basis for the installation of PV plants may differ compared to the applicable provisions for the installation of wind turbines or hydropower plants. In general, our research revealed that overall PV plants are facing less barriers regarding the installation than other RES forms of deployment. The legal and regulatory framework for self-consumption and especially simplifications of the permitting process are focussed on solar PV.

Table 5-1 Possibilities regarding the form of self-consumption

Form of self-consumption	Member States	Description
Individual self-consumption	ALL	All adult natural persons AND legal persons
Collective self-consumption	ALL	Generally possible
	Austria, Croatia, Hungary, Latvia, Lithuania, Netherlands, Poland	Only possible within the same building or connected via direct line
	Cyprus, Greece, Italy	Virtual/remote self-consumption possible

Individual self-consumption is open to any adult natural person. Legal persons are also generally allowed to establish and operate a self-consumption plant. In this regard there are no legal or regulatory restrictions for self-consumption on an individual level.

Collective self-consumption is usually limited by physical and technical parameters, as well as legal restrictions. In general. collective self-consumption must not be the (main) commercial activity of any of the collective self-consumers. Collective self-consumption always requires an agreement regarding the allocation of the energy produced (which in general can be dynamic or static) and in some Member States (e.g. AT) a designated (third-party) operator has to be determined. In case the distribution grid is used by the collective-self consumers, additional requirements must be met.

5.1.2. *Installation*

Generally, most of the permits necessary for self-consumption concern the installation of the generation plant and connection to the grid. Based on the type, location, size, and capacity, different public law permits may be necessary to install a self-consumption plant. The most common and important permits include construction, electricity/energy, environmental/nature-protection, and water permits. Whereas in some Member States some self-consumption plants are exempt from the requirement of certain permits, in other Member States certain self-consumption plants may not even be eligible for approval based on the current regulatory framework.

Table 5-2 shows the different categories of permitting requirements and exceptions that Member States impose on PV installations for self-consumption. The permitting regimes vary substantially, from countries where PV plants for self-consumption must follow the full approval procedures like any other generator, to Member States where no permit is required (although at least a communication to the grid operator is needed).

Table 5-2 Permitting regime for solar PV for self-consumption

Permitting regime	Member State	Explanation
No exceptions	Croatia, Cyprus, Estonia, France, Luxembourg, Sweden	All installations have to follow the same permitting regime
Microgeneration	Austria, Germany, Latvia, Portugal	No permit required for microgeneration (up to 8 kW)
Household size	Austria, Czechia, Denmark, Germany, Hungary, Malta, Netherlands, Poland, Slovakia	Exceptions regarding permitting for installations between 8 kW and 50 kW
Commercial size	Austria, Germany, Greece, Finland, Slovakia, Slovenia, Spain[65]	Exceptions regarding permitting for installations between 50 kW and 200 kW
No permit requirement	Belgium[66], Ireland, Italy[67], Lithuania, Romania, Slovenia[68]	Individual requirements may apply.

The requirements to obtain an environmental permit or nature protection permit depends usually on the location of the plant. Ground mounted self-consumption plants in green or grassland are more likely to fall under the obligation to obtain an environmental permit compared to those located on the roof of buildings in city centres. However, depending on the location (e.g., on top or in proximity to historic buildings) and the Member State, the urban landscape might be protected too, and a special authorization or permit is required. Such

[65] Only for installations up to 100 kW without a surplus modality.

[66] In Flanders, no planning permit is required for PV panels, only for classified buildings. In Wallonia, no planning permit is required for rooftop PV, regardless of the size. Ground-mounted PV and PV on classified buildings require an authorization. In Brussels, no planning permit is required for rooftop PV that cannot be seen from the public space. Different rules apply to classified buildings.

[67] Permit required if installation is in a protected zone or building (historical, landscape protection, heritage).

[68] No building permit required for installations for self-consumption.

authorizations are required in BE, CZ, EE, IT, LU, MT, SE. Depending on the technology and the size of the generation plant, as well as the location in question, other (additional) permits may have to be obtained. In Hungary, the regulatory framework currently prohibits the installation of new wind power plants (both single turbines and whole power plants).

In case of rented or leased buildings, the consent of the property owner is required in order to install a RES generation plant. Regardless of whether the installation uses wind, solar or hydropower for the generation of energy, the person or group of persons intending to establish a generation plant must always obtain the consent of the property owner. Usually, this consent is obtained by means of a contract in which the conditions for the use of the property are determined. Special conditions apply in the case of multi-apartment buildings with multiple owners (each for one or more apartments). If amendments to such buildings - which also affect other apartment owners - are planned, the consent from the other apartment owners is usually needed. Thus, prior to the implementation of a generation plant on the roof-top of a multi-apartment building, the consent of (at least) the majority of the co-owners must be obtained. In some Member States (see Table 5-3), the consent of all co-owners is required, which complicates the establishment of self-consumption plants. On the other hand, in other Member States such as Italy, no consent is required for rooftop PV plants installed by ISC. However, the consent is required in case of collective self-consumption. Tenants usually do not have any voting rights when it comes to the decision to install a generation plant.[69]

Table 5-3 Consent requirements in multi-apartment buildings

Consent requirement	Member States
No consent required	Italy: If no alteration of the common area is needed; individuals have a right to installation under the condition that it does not interfere with the right of the other owners.
	Portugal: For ISC no consent required, mere notification to the condominium.
Simple majority	Croatia, Germany, Greece, Finland, Latvia, Lithuania, Luxembourg, Slovakia (ISC), Spain (CSC), Sweden
Two-third majority	Austria, Belgium, Czech Republic, Denmark, Malta (CSC), Portugal (CSC), Romania, Slovenia, Spain (ISC)
Unanimity	Cyprus, France, Greece, Hungary, Latvia (full co-ownership of the building), Netherlands, Poland, Slovakia (CSC)
Other consent requirements	Ireland: Common areas are owned by a management company and voting rights are determined under the articles of association of those companies.
	Malta: in the deed of sale of the apartment the use of the roof is already established. If the installation is not included, the apartment owner may be unable to install one.

5.1.3. *Financing and financial support*

There are various financing options for households and businesses that intend to install a generation plant in Member States, ranging from conventional and green loans (which are designed for environmentally friendly investments) to leasing options and contracting agreements. In the past years, Member States aimed to enhance the acceptance of RES

[69] The question whether a tenant is allowed to install a generation plant on the roof-top of the multi-apartment building is not within the scope of this study since the rights of the tenants is derived from the landlord and if the landlord must seek consent, then the tenant would too.

generation plants and to increase self-consumption. In order to support the installation of generation plants and to promote self-consumption, Member States provide investment subsidies (usually, grants given during the installation phase, or tax rebates on the investment cost to reduce the upfront costs). These subsidies aim to financially support potential self-consumers and bridge the gap between the initial investment expenditure and the expected future financial benefit deriving from the installation in the course of its operation.

Table 5-4 Financing and financial support possibilities for self-consumption

Financing / financial support	Member State	Description
No subsidy scheme	Czechia, Denmark, Hungary, Sweden	No subsidy scheme identified for the installation of a generation plant for self-consumption.
Limited subsidies	All other Member States	Subsidies limited to a certain percentage of the installation costs / maximum amount
Additional requirements	All Member States	Additional requirements and conditions to be met for subsidy.
Feed-in subsidies	See Table 5-8	Higher price for the sale of non-consumed surplus energy for several years.

5.1.4. *Operation*

Even though the day-to-day operation of a generation plant for self-consumption does not differ much from the operation of a generation plant for the exclusive sale of the produced energy, requirements for the owners may differ substantially. Usually, an electricity generation license is required for the operation of a generation plant and generators must comply with a long list of requirements. Compared to energy producers who are exclusively selling their produced energy in the energy market, self-consumers are usually exempt from the majority of these obligations, under the condition that the power plant does not exceed a certain maximum capacity of generated energy or installed capacity.[70] However, the rules applicable to liability for and maintenance of the generation plant for self-consumption do not differ from general provisions since general tort law applies.

Surplus energy – energy not consumed by the self-consumer directly - is usually fed into the grid. The provisions underlying the feed-in of energy vary in the different Member States. It is also possible to have a generation plant installed as a so-called “island solution”. This is commonly understood as a generation plant for self-consumption which is not connected to the grid and often uses a storage unit for surplus energy. In order to install energy storage units Member States often require them to be certified and approved.

Table 5-5 Operational requirement

Operational requirements	Member State[71]	Explanation
Restrictions on the sale of surplus	Ireland, Latvia, Romania	Sale to supplier
	Italy, Lithuania	Sale to DSO
Sale of surplus	All other Member States	Provide different options for self-

[70] In case all "self-produced" electricity is sold directly to the tenants of a multi-apartment building self-consumers become suppliers (e.g. *Mieterstrom* in Germany) and have to adhere to the respective requirements.

[71] This table only show those Member State which have reported any operation restrictions. Other Member States, without such restrictions are not listed here.

		consumers how and to whom to sell surplus energy.
Restrictions for CSC	Germany	In a multi apartment building, the owner of the generation plant takes the status of an energy supplier if energy is sold directly to the tenants or neighbours (*Mieterstrom*).[72]
Storage requirements	Belgium, Germany, Greece, Malta, Poland, Romania, Slovakia	Permit/approval required for storage
	Portugal	Definition of storage criteria for CSC
	Spain	Financial aid for storage limited to ration of installed nominal storage capacity to generation power of 5kWh/kW.

5.1.5. Grid connection

In general, generation plants for self-consumption are connected to the grid, as this provides self-consumers with extra revenues if they are paid for feeding-in. The grid connection process is regulated by national laws and regulations and by the process set out by the grid-operator itself. In most Member States, the grid-operator may at least determine some of the requirements for the grid connection process. Among these requirements, set out either by law or by the grid-operator itself, are for example studies on the capacity of the generation plant, compliance with the technical standards, provision of all required public law permits or other documents, assignment to a balancing group, etc. Upon either application or request for connection to the grid, a grid connection agreement, which sets out the technical and legal aspects of the connection, is concluded.

The allocation of grid capacity is an important topic – also for installations for self-consumption. Requirements vary (see table below). More intense requirements with regard to the grid connection are common for large installations. However, in some Member States even residential installations face capacity issues. Grid connection costs vary between the Member States. In some Member States grid connection costs are shared between the self-consumer seeking connection and the operator, in other Member States one side will bear all the costs.

Table 5-6 Connection process

Connection Procedures / Issues	Member State[73]	Additional Information
Auction	Hungary, Portugal	Capacity is auctioned for micro generation (50 kVA to 500 kVA).[74]
Reserved capacity	Ireland, Lithuania	Capacity is reserved for self-consumers
Capped connection capacity	Greece[75]	Households up to 10,8 kW Legal entities 100 kW

[72] German Regulatory Framework - Energy Communities Hub.

[73] This table only show those Member State which have reported any issues with connection procedures or specific connection requirements. Other Member States, without such requirements/issues are not listed here.

[74] However, until now only one has been performed. As a result, new applicants receive grid connection offers with a connection date in 2027 or later.

[75] Renewable self-consumers are not connected in case of congestion and the authority does not have to communicate a timeframe indicating when the connection will be established.

Connection Procedures / Issues	Member State[73]	Additional Information
		Virtual net-metering 2 GW
	Hungary	No connection for household-sized power plants (up to 50 kVA).[76]
Notification	Austria, Germany	Microgeneration up to 0.8 kVA
	Latvia	Up to 11.1 kVA
	Malta	Up to 1.92 kVA
High security deposit	Hungary	Network operator requires security obligation of HUF 4.5 Mio (EUR 12.000)/MW for micro generation which has to be provided in the allocation procedure (auction).
Burdensome connection process	Belgium	Above 10 kW a prior study on the impact on the network may be required.
	Bulgaria	Installations up to 400kW are by law excepted from standard grid connection process. However, grid operators set their own requirements for connection and corresponding network access contracts.
	Slovenia	Consent of the grid-operator required for every renewable self-consumption installation.
	Spain	Access and connection permits required for installations above 15 kW. Grid operators impose unjustified conditions and cause delays for self-consumers.[77]

5.1.6. *Network tariffs*

The accelerating energy transition and the increasing share of self-generation in the energy system requires an adjustment in the network tariff setting methodologies. Network tariffs – as part of the total energy costs - constitute a considerable cost to the network users and can have a strategic impact on creating incentives for self-consumers.[78] Effectively structuring the pricing of grid services through network tariffs, especially for newcomers like self-consumers, is crucial for optimising the grid's value, while ensuring adequate revenues and appropriate incentives for grid owners.[79] To provide the right economic signals in this changing energy system, a holistic view is necessary that not just reflects the traditional tariff-setting principles – recovering costs in a cost-reflective, transparent and non-discriminatory way – but also takes into account the impact that new types of users (the prosumers) have on the grid.[80] The competition between electricity and other energy carriers determines the pace and course of the energy transition on a fundamental level, and therefore it is important that the applied network tariffs promote and not hinder electrification and RES deployment. The technological development of smart meters gives TSOs/DSOs and the consumers new access to real-life information on consumption, and the opportunity to react and adjust their behaviour (price-setting and consumption patterns) accordingly, broadening the possibilities for more flexible pricing strategies. Self-consumption specifically affects (and decreases) the volumetric utilisation of the grid, while having limited effect on the

[76] This prohibition was envisaged to be lifted in Q3 2023; however, we cannot find evidence of the ban being lifted.

[77] New infringements for grid operators related to self-consumption have been recently introduced in the Spanish Electricity Act for this very reason.

[78] EC (2021), Economies of Energy Communities: Review of electricity tariffs and business models & CEER (2021). CEER Report on Innovative Business Models and Consumer Protection Challenges. Customers and Retail Markets Working Group & Distribution Systems Working Group Project team.

[79] Eurelectric (2021). The missing piece - Powering the Energy Transition Through Efficient Network Tariffs.

[80] Eurelectric (2021). The missing piece – Powering the Energy Transition Through Efficient Network Tariffs.

demand for capacity.[81] Tariff-setting methodologies require adjustment to reflect the different cost elements of TSOs/DSOs aim to recover from different end-users in line with the principle of cost-reflectivity.

Network tariffs are composed of a number of different elements aimed at recovering different costs of the network operators. These costs include infrastructure costs (mostly maintenance, renewal and extension), grid losses[82], system services and metering.[83] Setting network tariffs is the competence of the National Regulatory Authorities, as reinforced by the 2019 Electricity Market Directive of the EU.[84] The REDII (Article 21) of 2018 (which was to be transposed into national legislation by 2021 the latest) reiterated a provision on renewable self-consumers not being subject to network tariffs that are not cost-reflective.[85] The exact tariff setting methodologies, however, show great differences across Member States and transmission/distribution levels, with implications regarding the promotion of self-consumption. It is important to recognize that self-consumed electricity, often exempt from network costs, can affect the revenues of network companies, more so in systems with volumetric tariffs. On the other hand, self-consumption may not significantly impact costs of network companies, since costs depend primarily on the maximum capacity that they will need to provide for to network users, and renewable self-consumption is, at the moment, unlikely to significantly reduce peak demand on its own.[86] However, providing appropriate economic incentives and integrating self-consumption with other distributed resources such as storage or demand side response, can benefit networks by potentially reducing investments in infrastructure. [87]

Given the emerging nature (and therefore so far limited penetration) of self-consumption in the EU-27 energy systems, few Member States have dedicated nation-wide provisions for self-consumption in the network regulation. However, a number of Member States (Belgium, Croatia, Cyprus, Hungary, Ireland, Luxembourg) are at least considering the issue, and how their network regulatory framework may address them. For example, in Luxembourg, self-consumers are completely exempt from paying any network tariff on the portion of their renewable production that is self-consumed.[88] Another front-runner is Portugal, where collective self-consumption is subsidised, and so grid fees above the grid level of the CSC scheme do not need to be paid for collective self-consumption since June 2020, meaning that small-scale, low-voltage self-consumers pay a lower fee.[89]

It is important to acknowledge that tariff design is a complex process, especially at the distribution level, where national conditions and regulatory approaches must be considered.

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[81] Günther et al. (2021). Prosumage of solar electricity: Tariff design, capacity investments, and power sector effects.

[82] Grid losses could also be embedded on the retailer side, in some Member States.

[83] EURELECTRIC (2021). The missing piece – Powering the energy transition with efficient network tariffs.

[84] EUR-Lex. (2019). DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.

[85] EUR-Lex. (2018). DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL.

[86] CEER (2021). CEER Report on Innovative Business Models and Consumer Protection Challenges. Customers and Retail Markets Working Group & Distribution Systems Working Group Project team.

[87] CEER (2021). CEER Report on Innovative Business Models and Consumer Protection Challenges. Customers and Retail Markets Working Group & Distribution Systems Working Group Project team.

[88] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

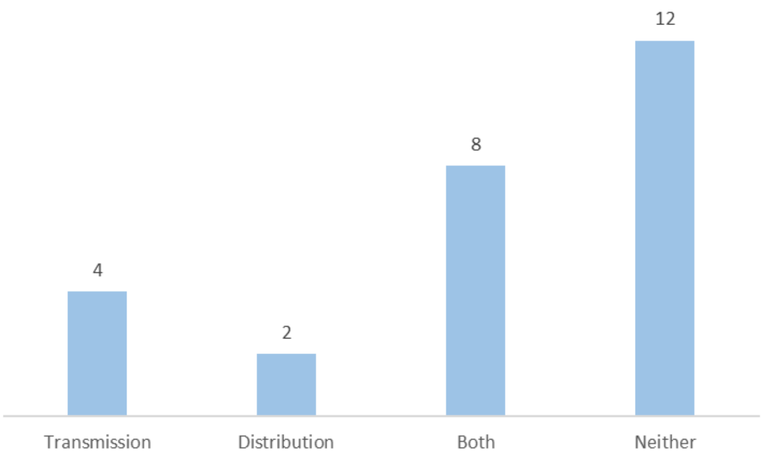
[89] EC (2021). Economies of Energy Communities - Review of electricity tariffs and business models

1.1.1.16. Injection charges

One common element of the network charges TSOs/DSOs collect is an injection charge. According to ACER, an injection charge is a network charge[90] applied to cover the costs associated with the use of the network for network users that inject (or are entitled to inject) into the grid.[91] On one hand, injection charges have a negative effect on the profitability of PV installations, as they increase the cost for generators and therefore pose an additional economic barrier for potential prosumers. On the other hand, volumetric injection charges, incentivise self-consumption, and in combination with a time-of-use pricing mechanism, could promote more efficient self-consumption, as long as users are able to react to the change in tariff.

Figure 5-1 shows the distribution between Member States where an injection tariff is applied to any connected network user who injects their generated electricity into the grid per the different levels of the network.

Figure 5-1 Number of Member States applying an injection charge for generators (either commercial or for self-consumption purposes) connected to the different levels of the grid (source: own elaboration based on ACER 2023[92])



**Germany is excluded from this analysis, as unlike in any other Member State, negative injection charges apply.*

Malta has no transmission network, and Germany is the only country where negative injection charges apply to subsidise for avoided network costs of the DSO (no injection charge on T-level) – but only to the non-intermittent distributed generators, thus excluding the most common renewable (solar, wind) generation (and self-consumption) capacities, and subsidizing others, like geothermal energy only. NRAs applying an injection charge typically do so for cost-reflectivity.

Almost half of the Member States (12) apply no injection charges on either level of the network, whereas in 8 Member States injection charges are applied for customers connected to the transmission and the distribution network both. In 4 Member States (Ireland, Denmark, Romania and Bulgaria), an injection tariff is applied to the transmission level of the network

[90] Even if it is not levied based on any contracted or measured energy or power injection (e.g. an annual or monthly lump sum payment which recovers only metering, administrative and/or management costs).

[91] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

[92] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

only, indirectly subsidizing the smaller scale prosumers/self-consumers – justified by the limited extent of PV penetration in these Member States (as also implied by the Romanian NRA).[93] Cyprus and Estonia do not apply an injection charge on either or both levels also to promote RES and distributed generation, including self-consumption.[94]

Furthermore, a number of the MSs that apply an injection charge provide an exemption for a sub-group of prosumers – mostly for household consumers, or based on connected power, installed capacity, or if the PV installation is supposed to be strictly for self-consumption (individual prosumers). The Member States that do not provide any exemption, and therefore charge all prosumers/self-consumers as well are: Austria, Denmark, Estonia, Latvia, Malta, the Netherlands, and Slovakia. [95] In Finland no unified regulation is applied, the DSOs can decide for themselves whether to apply an injection charge, and some provide an exemption for prosumers.

A volumetric network tariff (in contrast to a capacity based tariff) allows the self-generators to save on network charges, despite using the network for the same contracted capacity. An alternative is to compensate for grid availability e.g. by charging a fixed availability charge for self-consumption (e.g. Denmark).[96] Out of the countries, where there is not an outright exemption for self-consumers, a volumetric injection tariff is applied in two: Austria and Denmark. A dynamic injection charge based on peak/off-peak periods of the day/week could further incentivise self-consumption, however none of the Member States apply a time-of-use (ToU) injection charge as of now (except for some specific DSOs in Sweden).[97] Portugal applied peak and off-peak transmission injection charge before 2021. ToU pricing methodologies are much more popular in the withdrawal charge components of network tariffs, detailed below.

Injection charges are differentiated based on geography (not DSO areas) in 3 MSs (AT, IE, SE).

1.1.1.17. Withdrawal charges

Figure 5-2 below shows the number of Member States using a time-of-use (ToU) element in their network withdrawal charges. The motivation behind applying network charges differentiated based on the time of day/week/year is to provide a price signal for end-users based on the real costs incurred by excessive demand/over-abundance in supply of electricity. ToU pricing can promote self-consumption and demand response[98], i.e. if there are intra-day price signals for prosumers who can adjust their energy consumption accordingly, shifting load to the off-peak hours. There are certain technological pre-requisites for a successful implementation, i.e. consumers already equipped with the necessary metering equipment.

[93] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

[94] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

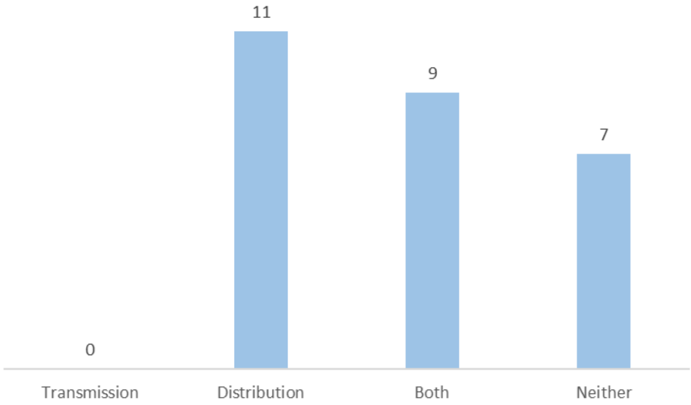
[95] On the respected levels on the network they apply an injection tariff at all. As mentioned above, Denmark does not apply an injection tariff on the distribution level, and Estonia does not apply one on the transmission level.

[96] Eurelectric (2021). The missing piece - Powering the Energy Transition Through Efficient Network Tariffs.

[97] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

[98] Eurelectric (2021). The missing piece - Powering the Energy Transition Through Efficient Network Tariffs.

Figure 5-2 Distribution of Member States applying ToU pricing in their network tariffs on different levels of the network



A relative majority, 11 of the Member States apply a ToU withdrawal charge on the distribution network only, whereas 9 Member States have it for both transmission and distribution networks. 7 Member States do not have a ToU charge at all (Bulgaria, Cyprus, Germany, Hungary, Italy, Lichtenstein, and Romania), and none of the Member States apply it only on the transmission level of the network. 15 Member States have an intra-day variation in this element of the network tariff – these are Austria, Belgium, Croatia, Estonia, Finland, France, Greece, Ireland, Latvia, Lithuania, Malta, Poland, Portugal, Slovenia and Spain. Out of these countries, Austria and Ireland reported to have less than 50%, and Lithuania to have less than 10% of network users with metering equipment capable of reporting in sufficient detail to actually apply ToU tariffs[99], limiting the efficiency of such policies. Almost half (7) of all Member States applying intra-day variation in the network tariffs, however, determined a peak period that stretches throughout the day (from 6-7am to 10-11pm), and uses a night-time off-peak electricity price only, giving very little/no room for the consumers for reflection on their self-consumption and adjusting their behavioural pattern to save electricity in the peak hours.

Additionally, 2 Member States use a dynamic ToU pricing method in their network tariffs (France and Sweden) reflecting intra-day and seasonal variability, while the rest uses the simpler and more predictable static ToU charges. However, Eurelectric did highlight that dynamic ToU tariffs are excessively complex for DSOs, retailers, and customers.[100]

The vast majority of Member States has a combined (volumetric-power) based withdrawal tariff. The exceptions are Cyprus and Romania, where the distribution tariffs are calculated on a purely volumetric basis. On the transmission level 6 countries (Bulgaria, Cyprus, Denmark, Estonia, Hungary and Romania) apply an exclusively power-based withdrawal charge. Some countries apply a fixed charge to some category of customers.

1.1.1.18. Connection charges

Connection charges are a one-time charge collected by the network operator for the physical assets required for establishing or upgrading the connection to the system (shallow connection charge). Some network operators also charge the (new) customers for the

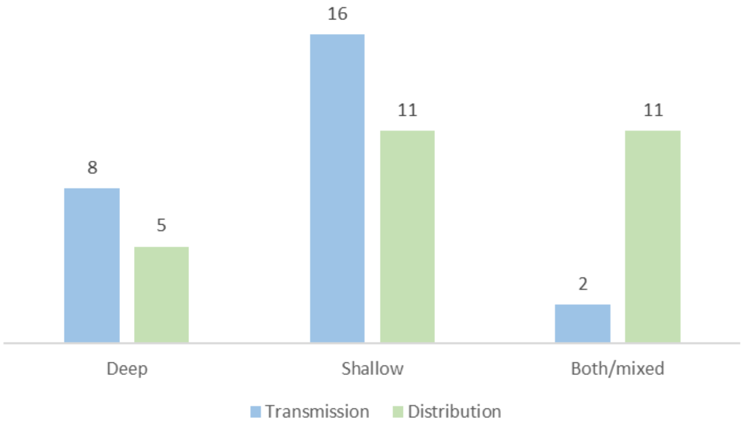
[99] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

[100] Eurelectric (2021). The missing piece - Powering the Energy Transition Through Efficient Network Tariffs.

necessary network reinforcement costs incurred by establishing/upgrading the connection (deep connection charge). Deep connection charges are meant to send price signals to (new) customers on the most in-demand geographic areas of the network, therefore encouraging the topological optimisation of the grid.

Figure 5-3 below shows the distribution of Member States based on the shallow/deep connection charges applied.

Figure 5-3 Distribution of EU Member States based on the type of connection charges applied on the different levels of the network



All the Member States apply a connection charge of some sort on both levels of the network. On the transmission level the clear majority applies a shallow connection charge only, whereas on the distribution level the policies are more differentiated based on voltage level or the type of connected network user (i.e. producers are required to pay deep charges, whereas consumers pay only shallow charges). Only in Lithuania does a reduced connection charge apply for prosumers (with a 50% discount).[101]

Connection charges also tend to vary based on the voltage level in most Member States, reflecting the actual differences between costs of connection, where incurred costs are charged at transmission level and pre-defined unit charges tend to be used at the distribution level).

Flexible or interruptible connection agreements - where the network user is not guaranteed with a firm connection over the entire period – are relevant for self-consumers in order to facilitate the connection process (see above). However, less than one third of the countries apply such contracts and only four reported specific rules for setting the network charge with this type of contracts (i.e. discounts on connection charges (FR, DK), discounts on use-of-network charges (BE’s Wallonia region) or discounts are subject to mutual agreement by TSO and network user (NO)).

1.1.1.19. Conclusions

The effective pricing of grid services and the promotion of self-consumption are essential to the optimisation of grid operation and the continued integration of renewables.

[101] ACER (2023). Report on Electricity Transmission and Distribution Tariff Methodologies in Europe.

The table below provides an overview of how different network charges may impact the installation of distributed energy resources, the maximisation of self-consumption and the optimisation of the energy use in the system. While we highlight where and how network tariffs can incentivise self-consumption, it is important to note that tariff design is a complex process, especially at the distribution level, where several other aspects need to be taken into account. Further, there is an important overlap with the recommendation on providing support to DSOs in network planning (see Chapter 7).

Table 5-7 Impact of different network charges for self-consumers

	Install DER	Maximise self-consumption	Optimise energy use
Connection charges	Negative impact (increases up-front investment); Flexible connection agreements can facilitate the connection process	No impact	Deep connection charges linked to local congestion may incentivise topological grid optimisation
withdrawal charges	• Positive impact if volumetric (improve the business case for installing DER by increasing the cost of consuming from the grid) • No impact if capacity-based or fixed	• Positive impact if volumetric (increase the cost of consuming energy from the network) • No impact if capacity-based or fixed	• Positive impact if ToU element is included • No impact if fixed
Injection charges	• Negative impact (reduces profitability of DER business case); • Exemptions at distribution level incentivise DER	• Positive impact if volumetric (increase the cost of consuming energy from the network) • No impact if capacity-based or fixed	• Positive impact if ToU element is included • No impact if fixed

As seen above, some elements of network tariffs (such as connection and injection charges) act as a barrier to the installation of PV. However, a connection charge linked to peak capacity and local congestion may send the right locational signals; at the same time, a volumetric injection charge acts as an incentive to the maximisation of self-consumption. All EU27 Member States apply some kind of a connection charge, which acts as an economic barrier to the installation of PV – although is not clear if Member States are using connection charges to send price signals aimed at the optimisation of the distribution network (through deep connection charges). Finally, network charges should be compliant with Art. 15.2(e) of Directive (EU) 2019/944: "*Member States shall ensure that active customers are subject to cost-reflective, transparent and non-discriminatory network charges that account separately for the electricity fed into the grid and the electricity consumed from the grid, in accordance with Article 59(9) of this Directive and Article 18 of Regulation (EU) 2019/943, ensuring that they contribute in an adequate and balanced way to the overall cost sharing of the system*".

While this analysis is not sufficient to clearly indicate what is the best approach in regards to network tariffs and self-consumption, we provide below four more detailed conclusions:

- **ToU charges**
  In theory, the combination of variable network tariff elements with dynamic energy prices might provide a significant incentive to optimise consumption and injection profiles – having a significant impact on the total energy cost. Though in practice, further research may be needed to understand how the "double variability" of differentiated energy price signals

(hourly pricing) and network tariff signals (ToU, based on congestion indicators) may impact self-consumption. Additionally, even though the regulation exists, a technological barrier for ToU pricing can be identified in several Member States (such Belgium, Bulgaria, Cyprus, Greece, Hungary)[102] where the installation of smart metering equipment is lagging significantly behind. A quarter of the Member States does not apply any time-of-use pricing at all, and another quarter applies a ToU pricing strategy that is not aimed at the promotion of self-consumption with the peak/off-peak periods covering half days each. This is because the time slots do not follow the typical demand profile of Member States – for example, with a peak in the morning and in the late afternoon hours for Nordic countries, with a corresponding grid congestion – and leaves little room for consumers to adjust their behaviour. Overall, it remains unclear to what extent ToU tariffs currently implemented may support self-consumption.

- **Injection charges**
  Injection tariffs are applied in 15 Member States of the EU, posing a barrier to the installation of PV panels and potentially limiting the development of the market in the early stages. Among the Member States that apply these tariffs to connected network users indiscriminately (including prosumers) both Estonia (395 MW), and Slovakia (194 MW) are lagging behind the rest of the EU in the installation of solar PV.[103] On the other hand, Austria (2.7 GW) and Denmark (3.25 GW) having a well-developed solar PV market further incentivizes the self-consumption of the established prosumers via a volumetric injection tariff.

- **Volumetric charges**
  Furthermore, volumetric charges incentivise the maximisation of self-consumption more than capacity-based tariffs, as long as they are charged on all imported energy (rather than only on net energy use)[104]. Within the injection tariff element – considering the Member States that apply one on self-consumers – only Austria and Denmark apply a volumetric method. For the withdrawal tariff elements the practice is very consistent across the EU, with almost all Member States (the exceptions being Cyprus, Denmark, Estonia, Hungary and Romania) applying a mixed method (with a volumetric and capacity element) both on the transmission level, and almost all of them applying a volumetric and capacity tariff element (except Cyprus and Romania) on the distribution level. Based on tariff principles, volumetric ToU tariff (both for injection and withdrawal) should be aimed at recovering the cost of congestion management, including grid reinforcement. When implementing this approach, tariffs should be proportional to the contribution of different users to peak costs, with appropriate consideration for vulnerable and energy poor users and for commercial users that are unable to shift loads.

- **Dedicated charges for collective self-consumers**
  As mentioned in Chapter 7, there is a lack of consensus across Member States on the interpretation of the concept, definition and approaches to collective self-consumption. However, given its emergence, dedicated network tariffs for local collective self-consumption could be considered. Such dedicated tariffs should "reflect the benefits of the collective self-consumption scheme in incentivising load shifting, reducing congestion on the grid, and

[102] https://publications.jrc.ec.europa.eu/repository/handle/JRC134988.

[103] Eurostat (n.d.). Electricity production capacities by main fuel groups and operator.

[104] See for example, paragraph 357 of ACER's 2023 Market Monitoring Report: https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_MMR_2023_Barriers_to_demand_response.pdf.

avoiding electricity grid losses."[105] CSC within multi-dwelling units could be exempt from grid tariffs when they are not considered part of the public grid.[106] Certain countries such as Portugal and Belgium already have discounts or exemptions on network tariffs in place for CSC consumers and Renewable Energy communities.[107]

An elaborated recommendation over network tariffs is provided in section 7.2.5.

5.1.7. *Surplus remuneration*

Although these schemes are being slowly phased out, in line with Article 15(4) of Directive 2019/944[108], most household and SME self-consumers are under a net-metering scheme. This system provides the possibility to offset produced and consumed energy within certain billing periods. The self-consumer then must only pay the difference of produced and consumed energy. Net-metering schemes are being replaced by the net-billing schemes, where the netting off is based on feed-in and consumption rates, rather than volumes of electricity.

The possibilities of remuneration for the feed-in of surplus energy differ widely among Member States. As already mentioned above, some countries have liberal rules on the sale of surplus energy, whereas others are more restrictive and limit the sale. The most common method of remuneration/compensation are feed-in tariffs (FiT). Produced energy which is fed into the grid is remunerated at a certain tariff per kW which is set according to a methodology stipulated by the laws of the respective Member State.

In some Member States residential self-consumers or small-scale installations have preferential treatment, in other Member States only one scheme is available for all self-consumers and no distinction between residential/small-scale or commercial/industrial is made. Throughout the EU, it is possible to identify different remuneration approaches for renewables self-consumers.

Table 5-8 Surplus energy remuneration approaches in Member States

Member State	Residential / Small-scale	Commercial / Industrial[109]
Austria	FiT for existing generation plants only, market price	Market premium
Belgium[110]	FiT/ no regulated tariff	Green certificates
Croatia	FiT (up to 500 kW)	Market premium
Cyprus	Net-metering / net-billing	Net-metering / net-billing
Czech Republic	FiT	
Denmark	Compensation scheme	Compensation scheme

[105] SolarPower Europe (2023). White paper – Regulatory framework for energy sharing.

[106] SolarPower Europe (2023). White paper – Regulatory framework for energy sharing.

[107] https://www.joanneum.at/fileadmin/user_upload/Publikationen/Life/Friedenetal.2020-CurrentstateofCSCandEnC.pdf, Section 52 (2a) Austrian Electricity Act (*Elektrizitätswirtschafts- und organisationsgesetz, ElWOG*) in combination with Section 5 (1a) System Charges Ordinance 2018 (*Systemnutzungsentgelte-Verordnung 2018, SNT-VO 2018*) in the current version from 2023.

[108] Art. 15(4) states that: 4. *Member States that have existing schemes that do not account separately for the electricity fed into the grid and the electricity consumed from the grid, shall not grant new rights under such schemes after 31 December 2023. In any event, customers subject to existing schemes shall have the possibility at any time to opt for a new scheme that accounts separately for the electricity fed into the grid and the electricity consumed from the grid as the basis for calculating network charges.*

[109] This column presents those Member States which distinguish between residential/small-scale and commercial/industrial with regard to the remuneration for the sale of surplus energy. Member States not indicated in this column did not report any differentiation.

[110] In Wallonia, a FiT has been introduced in 2024. No regulated tariff is available in the other two regions.

Member State	Residential / Small-scale	Commercial / Industrial[109]
Estonia	Market price	
Finland	Net-metering	
France	FiT	FiT
Germany	FiT up to 110 kW	Market premium
Hungary	Net-metering / net-billing	Market premium /CfD until 2021, market price
Greece	Net-metering / net-billing	
Ireland	FiT up to 50 kW	
Italy	Net-billing Premium tariff for collective self-consumption and energy communities[111]	Minimum prices
Latvia	Net-metering / net-billing	
Lithuania	Net-metering (potentially net-billing)	
Luxembourg	FiT up to 500 kW	
Malta	FiT for PV up to 40 kWp	
Netherlands	Net-metering up to 55 kW	
Poland	Net-metering / net-billing	
Portugal	FiT (until 2012), market price	
Romania	Net -billing (up to 200 kW)	Financial settlement scheme (200 – 400 kW)
Slovakia	FiT	
Slovenia	FiT up to 500 kW	Operating premium
Spain	Net-billing up to 100kW or sale in market[112]	Same as Residential / Small-scale
Sweden	Market price	

Taxation of individual and collectively self-consumed electricity is handled differently in the Member States. Some choose to apply exemptions (within limits) from electricity taxes, whereas others apply the full tax rate on all consumed electricity.

Table 5-9 Taxation specificities for self-consumers

Taxation	Member State[113]	Description
Electricity tax	Luxembourg	Final consumers including self-consumers pay electricity tax. Self-consumed or shared electricity from RES is excluded.
	Czech Republic	Exemption for self-consumers for installations with an output of up to 30 kW.
	Germany	Exemption for self-consumption up to 2 MW.
	The Netherlands	Only levied on the positive balance between electricity supplied minus electricity fed into the grid, without a minimum threshold.
	Spain	Self-consumed energy from RES is exempt from all charges/tolls.
Income tax on revenue of surplus	Austria, Cyprus, Czech Republic, Germany, Italy	Exemption for revenues of surplus energy up to a certain amount.

[111] Incentive tariff for the remuneration of renewable energy plants included in the experimental configurations of collective self-consumption and renewable energy communities https://www.gazzettaufficiale.it/eli/id/2020/11/16/20A06224/sg.

[112] If net-billing, no other energy sales mechanism possible.

[113] This table only show those Member State which have reported any specific tax regulations relevant for self-consumption. Other Member States, without a specific regime are not listed here.

Taxation	Member State[113]	Description
fed into grid	Poland, Sweden	
VAT on sale of surplus	Austria, Belgium, Germany, Greece, Italy, Malta, Slovenia, Sweden	Specific rules for self-consumers feeding in surplus with regard to VAT depending on the capacity of the installation.

5.1.8. *Peer-to-peer trading*

According to Article 2 (18) RED II '*peer-to-peer trading*' of renewable energy means *the sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant, such as an aggregator*. This study only covers the peer-to-peer trading of the surplus energy produced by self-consumption generation plants. Moreover, this study does not limit peer-to-peer trading to transaction automatically executed and settled, but rather defines peer-to-peer trading as direct sharing of energy between two (active) consumers. Peer-to-peer trading of other market participants is not included.

Peer-to-peer trading of self-produced energy is not possible in all Member States. Where possible, active consumers wanting to share energy with another (active) consumer must fulfil certain requirements. One requirement is for example that only another individual active consumer may be the recipient of the energy, otherwise the active customer will be categorized as energy supplier (including all related requirements). Where no specific rules on peer-to-peer trading exist, the general energy market regulations on supply, distribution, grid connection must be followed by the active consumer selling to a peer.

Table 5-10 Limitations to peer-to-peer trading

Limitation	Member State[114]	Description
Distance limits	Denmark, Spain	Distance between two peers must not exceed 500m for Denmark, 2000m for PV in Spain[115].
Direct line required	Denmark, Hungary	P2P only possible via direct lines or via peer-to-peer networks (Denmark).

5.2. Summary and mapping

This section presents the summary and mapping table of the Member States' regulatory framework relevant for self-consumption, and the identified regulatory barriers in chapter 6. The table shows the regulatory framework applicable to self-consumption in the 27 Member States. An X marks the application of the respective rule or concept in the Member State. An X* marks the application of the respective rule or concept but indicated that a limitation or explanation of the specific rule or concept may be found in the respective chapter above with regard to the Member State. An (X) marks the potential application of the respective rule or concept as set out above.

[114] This table only show those Member State which have reported any limitations to peer-to-peer trading. Other Member States, without a specific regulatory framework are not listed here.

[115] The self-consumers connected using the distribution grid (individual or collective) must fulfil at least one of the following criteria: 1) be located within the LV distribution grid derived from the same transformer station; 2) respect a maximum distance of 500m between production and consumption or 2000m in the case of PV; or 3) be in the same cadastral area. Source: IDAE (2023), Guía Profesional de Tramitación del Autoconsumo.

Table 5-11 regulatory framework applicable to self-consumption in the 27 Member States

EU Member	AT	BE	BG	DK	DE	EE	FI	FR	EL	IE	IT	HR	LV	LT	LU	MT	NL	PL	PT	RO	SE	SK	SI	ES	CZ	HU	CY
Form of self-consumption																											
Individual self-consumption	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Collective self-consumption	x*	x	x	x	x	x	x	x	x*	x	x	x*	x*	x*	x	x	x*	x*	x	x	x	x	x	x	x	x*	x*
Permitting regime																											
No exceptions		x				x		x				x			x						x						x
Exceptions for Microgeneration	x				x								x						x								
Exceptions for Household size	x			x	x											x	x	x				x			x	x	
Exceptions for Commercial size	x				x		x		x													x	x	x			
No permit requirement										x	x			x						x			x				
Consent requirement in multi-apartment buildings																											
No consent required											x*								x*								
Simple majority					x		x		x*			x	x	x*	x						x	x*		x*			
Two-third majority	x	x		x												x*			x*	x			x	x*	x		
Unanimity								x	x*					x*			x	x				x*				x	x
Other consent requirements										x*						x*											
Financing / financial support																											
No subsidy scheme				x																	x				x	x	
Limited subsidies	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x			x
Additional requirements	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

EU Member	AT	BE	BG	DK	DE	EE	FI	FR	EL	IE	IT	HR	LV	LT	LU	MT	NL	PL	PT	RO	SE	SK	SI	ES	CZ	HU	CY
Feed-in subsidies	x				x			x		x		x			x	x			x			x	x		x		
Operational requirements																											
Restrictions on the sale of surplus										x	x*		x	x*						x							
Sale of surplus	x	x	x	x	x	x	x	x	x			x			x	x	x	x	x		x	x	x	x	x	x	x
Storage requirements		x			x				x							x		x	x*	x		x		x*			
Connection Procedures / Issues																											
Auction																			x							x	
Reserved capacity										x				x													
Capped connection capacity									x*																	x*	
Connection Procedures / Issues (continuation)																											
Notification	x*												x*			x*											
High security deposit																										x	
Burdensome connection process		x*	x*																				x*	x*			
Remuneration for residential / small-scale installations																											
FiT	x				x					x		x			x	x			x			x	x		x		
No regulated tariff		x																									
Net-metering		x							x				x	x			x	x								x	x
Net billing									x		x		x	(x)				x		x				x		x	x
Compensation scheme																											
Market price																			x		x						
Commercial / Industrial																											
Market premium	x				x							x														x	
Green certificates		x																									

EU Member	AT	BE	BG	DK	DE	EE	FI	FR	EL	IE	IT	HR	LV	LT	LU	MT	NL	PL	PT	RO	SE	SK	SI	ES	CZ	HU	CY
Commercial / Industrial (continuation)																											
Net-metering / net-billing																								X			X
Compensation scheme				X																							
FiT								X																			
Market price																					X					X*	
Minimum prices											X																
Financial settlement scheme																				X							
Operating Premium																							X				
Taxation																											
Electricity tax					X*										X*		X*							X*	X*		
Income tax on revenue of surplus fed into grid	X				X						X							X			X				X		X
Limitations for collective self-consumption																											
Distance limits				X																				X			
Direct line required																										X	

6. IDENTIFYING AND CATEGORISING BARRIERS TO SELF-CONSUMPTION

Chapter 4 has shown that the deployment of DER is increasing exponentially. However, self-consumption rates are still relatively low and vary a lot among Member States. Various regulatory, institutional, economic and financial, social and technical barriers can explain these differences between Member States as well as the relatively low self-consumption in some countries. These barriers prevent the increase in the number of DER installations and the maximisation of self-consumption rates. The objective of this chapter is to provide an overview of the barriers that affect the deployment of self-consumption in many Member States. These barriers are categorised and then prioritised to ensure that the most adequate solutions to overcome them can be identified.

6.1. Overview of identified barriers to self-consumption

There are many barriers faced by the different actors involved in the self-consumption process, covering both regulatory and practical barriers. Barriers to individual and collective self-consumption have been classified into the following categories:

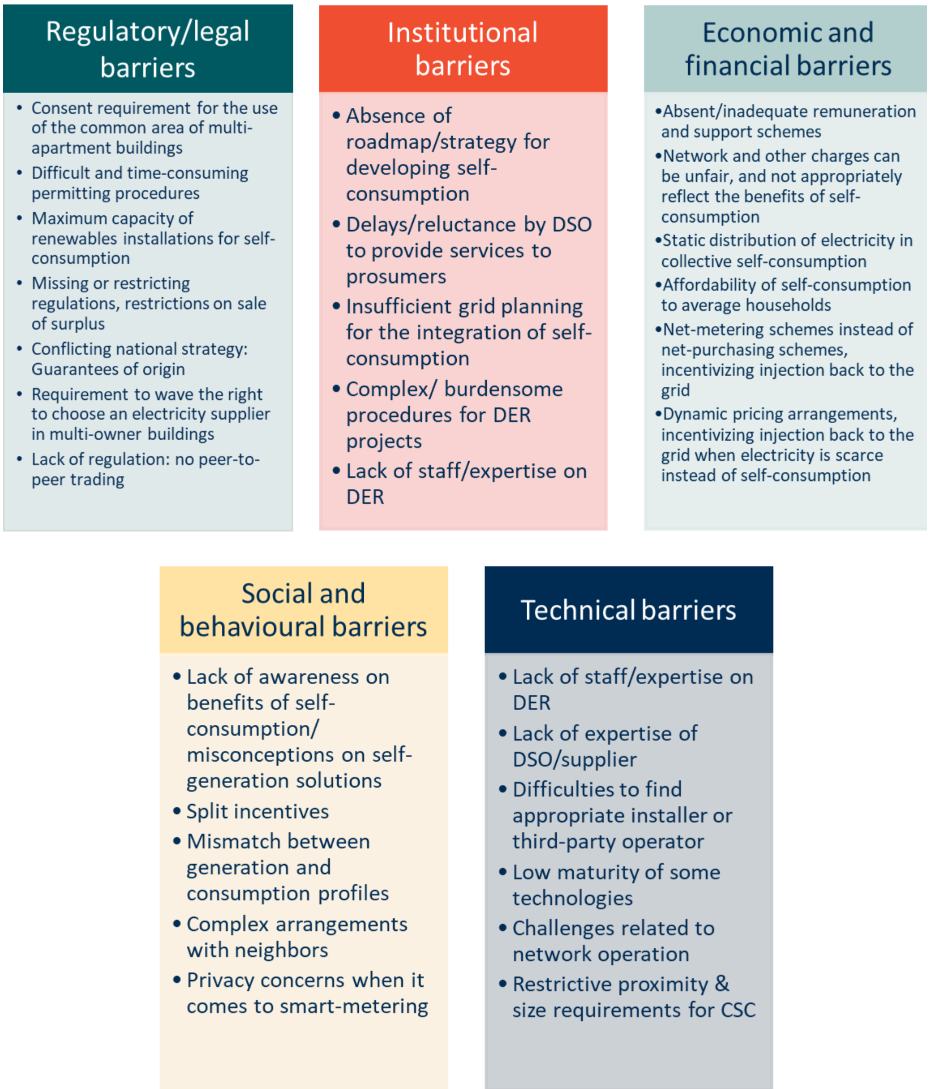
- Regulatory barriers, which refer to the provisions of the legal and regulatory framework identified in Chapter 5 that either (i) restrict the deployment of self-consumption or (ii) have a negative impact on the installation or operation of production plants for self-consumption.
- Institutional barriers, which refer to government decisions and policies that have a negative impact on the development of individual and collective renewable self-consumption. These often overlap with regulatory barriers.
- Economic and financial barriers, which refer to any factors that limit access to or reduce the benefit of economic opportunity and performance. These may stem from regulatory choices as identified in Chapter 5.
- Social and behavioural barriers, which refer to the social aspects, often linked to cultural trends, behaviour of market actors, demographics, population analysis, etc., that hinder the development of individual and collective renewable self-consumption.
- Technical barriers, which refer to issues related to the development and uptake of self-consumption technologies and technical limitations.

Figure 6-1 presents barriers to individual and collective self-consumption. This list of barriers has been elaborated based on various sources in the literature[116], desk research from national experts, along with feedback from SolarPower Europe, and served as basis to identify relevant case studies.

These barriers are further elaborated in the rest of this sub-chapter. It is worth noting that some barriers may be classified in more than one of the above-mentioned categories. When this is the case, it is clearly specified in the description of the barriers which other categories it may overlap with.

[116] European Commission, COM(2022) 221 final, EU Solar Energy Strategy; Climate Action Network (2022), Engaging citizens and local communities in the solar revolution – Rooftop Solar PV Country Comparison Report; Interreg Europe (2020), Renewable energy self-consumption, A Policy Brief from the Policy Learning Platform on Low-Carbon economy; Energy Community (2020), Policy Guidelines by the Energy Community Secretariat on the Integration of Renewables Self-Consumers; European Commission, SWD(2015) 141 final, Best practices on Renewable Energy Self-Consumption, SWECO (2019), Distributed electricity production and self-consumption in the Nordics.

Figure 6-1 Overview of barriers



6.1.1. Overview of regulatory barriers

Table 6-1 provides an overview of regulatory barriers that (i) restrict the deployment of self-consumption or (ii) have a negative impact on the installation or operation of production plants for self-consumption. During the study a mapping of the regulatory barriers identified was conducted and thus examples of the Member States facing the barriers are provided.[117]

Table 6-1 Regulatory barriers to individual and collective self-consumption

[117] A mapping of barriers in the different Member States was not conducted for the other categories of barriers (institutional, economic and financial, social and technical) as it was not part of the scope of this study.

Title of the barrier	Description	Member States	Type self-consumption
Consent requirement for the use of the common area of multi-apartment buildings	The installation of a PV plant on the roof (common property) of a multi apartment building requires the consent of all/majority of co-owners of the building. The consent requirement of (all) other apartment owners can be a barrier for individual self-consumption since it is not possible for the individual apartment owner alone to proceed with the installation of a generation plant without going through the (often lengthy) consent process. In case of collective self-consumption, the consent requirements are less burdensome to comply with, since already some of the co-owners want to install a self-consumption plant. However, the consent of (all) other (not-participating) co-owners may still be required.		Individual, Collective
	(i) Unanimous consent	CY, EL, FR, HU, NL, PL, SK (SCS)	
	(ii) consent of two thirds	AT, BE, CZ, DK, MT (CSC), PT (CSC), RO, SI	
	(iii) simple majority	EE, FI, HR, LT, LU, LV, SK (ISC), SE	
Difficult and time-consuming permitting procedures	The length and complexity of the permitting and approval process often acts as a barrier to the installation of generation plants for self-consumption. Most self-consumers are discouraged by the number of documents to be submitted, procedures to be followed, authorities to be contacted (planning authorities, network operators, legal advisors), and the risk of having the application rejected, for example because of local planning limitations. Some Member States have managed to significantly reduce this barrier, for example via the setup of one-stop shops, by unifying the permitting process, or by allowing installers to carry out the process on behalf of the consumers or providing exceptions for certain generation plants:		Individual, Collective
	(i) No permit requirement up to a certain capacity threshold of the installed generation plant	AT, CZ, DE, DK, EL, HU, IE, LV, PL, RO, SI, SK	
	(ii) No permit required for certain technologies	DE (solar PV), FI , MT and NL (rooftop PV)	
	(iii) Notification requirement only	MT, RO	
	(iv) Simplified permitting or no permit required in general for self-consumption PV	CY (simplified), PT (up to 1 MW surplus - simplified), IT.	
Maximum capacity of renewables installations for self-consumption	The limitation of the capacity of generation plants for self-consumption is perceived as a barrier. Renewable power plants above the respective capacity limit do not fall within the definition of self-consumption in the respective Member State. This leads to (i) more permit requirements, (ii) application of rules on suppliers and/or generators, (iii) (more) reporting requirements, (iv) energy license requirements and (v) loss of (financial) support.	CY, DK, EL, LI, LV, PL	Individual, Collective
Missing or restricting regulations: Restrictions on the sale of surplus	Being able to feed-in the surplus energy not consumed by individual or collective self-consumption is an important part of the appeal of self-consumption. In some Member States the sale of surplus is restricted in some way. Such		Individual, Collective

Title of the barrier	Description	Member States	Type self-consumption
	restrictions can be considered a barrier to the installation of new generation plants because they limit the return self-consumers are able to make, therefore discouraging the installation of a generation plant for self-consumption.		
	No sale to a third party: Only net-metering or net-billing available	CY, LI, LV, PL	
	Capacity limit for (favourable) feed-in tariff to 100 kW	DE	
	Sale limited to 20% of the total generated energy	EL	
	Sale limited to natural persons and non-profit organizations	MT	
Conflicting national strategy: Guarantees of origin	Belgium introduced a system of guarantees of origin (GO) for electricity produced by PV panels. The GO may be traded, consulted, and transferred via an online platform. The GO system in Belgium incentivizes the injections of electricity into the grid and leads to less self-consumption, because energy directly consumed or only transmitted via direct line will receive a GO that is marked consumed locally and not tradable.	BE	Individual, Collective
Requirement to wave the right to choose an electricity supplier in multi-owner buildings	The decision to install a collective generation plant on the roof of a multi-apartment building tampers with the right of the individual consumer to choose an electricity supplier. Even though the right to a free choice of electricity supplier is still maintained on paper, the residents must agree (i) to receive communal electricity generated from the rooftop and (ii) use one common electricity supplier for the remaining electricity. Thus, for collective self-consumption, the right to choose an individual electricity supplier must be waived and a collective electricity supplier must be chosen for the whole building.	DK	Collective
Lack of regulation: No peer-to-peer trading	Peer-to-peer trading of self-produced energy is not possible in all Member States. In some Member States it is theoretically possible, however; specific regulations are missing. In most Member States active customers wanting to share energy with another (active) consumer must fulfil certain requirements.		Individual, Collective
	No peer-to-peer trading possible	CY, EE, FR, IT, LI, LV, MT, RO (until 2026)	
	Peer-to-peer trading not possible for self-consumers	DE	
	Direct line required for peer-to-peer trading	DK , HU	
	Distance limits for peer-to-peer trading	DK (500m radius), ES (2000m)	
	Missing regulations on peer-to-peer trading	CZ, HR, PL	

6.1.2. Overview of institutional barriers

Table 6-2 provides an overview of institutional barriers that hinder the deployment of self-consumption in Member States.

Table 6-2 Institutional barriers to individual and collective self-consumption

Title of the barrier	Description	Actors impacted	Type self-consumption
Absence of roadmap or strategy for developing self-consumption	The absence of a roadmap or strategy with clear objectives and action points can hinder the development of individual and collective self-consumption. This is also linked to the lack of CSC framework at national level. Further it may imply a lack of coordination and engagement of relevant stakeholders (citizens, local authorities, DSO, energy system installers, energy suppliers, aggregators, etc.).	All actors	Individual, Collective
Delays/reluctance by the DSO to provide the services prosumers should have access to according to the legal framework (missing incentives for DSO)	Services that should be provided by the DSO to prosumers can include, e.g., providing access to the network, installing smart meters, conducting inspections, enabling injection of electricity into the grid, etc. When DSOs delay in providing these services in time, it hinders the development of self-consumption. The recent reports from E-DSO recognizes that customers still suffer from long response time to their connection request. In particular, the 'first come, first served' principle applied during high demand for connections may be seen as unfair and generate frustration for applicants.	Prosumers, DSO	Individual, Collective
Insufficient grid planning for the integration of self-consumption	One of the reasons why grid operators offer too little grid capacity to distributed energy resources (DER) is that their modelling is inadequate. They do not sufficiently account for the rapid growth of PV, EVs, and heat pumps. Realistic planning, enabled by DER registers by public authorities would allow them to make the required investments ahead of time. For more information, see section 3.1.1.	All actors	Individual, Collective
Complex and burdensome administrative and authorization procedures for distributed renewable energy projects	Permitting procedures for distributed renewable energy projects can be complex and burdensome. These shall be facilitated in order to increase the competitiveness of small-scale self-consumption projects.	Prosumers	Individual, Collective
Lack of harmonization of connection requests within a country	Countries with high number of DSOs may apply different procedures depending on the region served, which may be an extra complexity for prosumers (typically commercial or industrial) acting on the whole territory.	Prosumers	Individual, collective
Lack of staff and expertise on distributed renewable energy and related technologies	This barrier refers to the availability of appropriately trained RES systems installers and technicians, significantly reducing the speed at which renewables penetrate the market. There is also a lack of staff and expertise to perform grid-related works (e.g. network planning, installation and reinforcement). This lack of technical workforce working on the ground to meet the increasing demand requires more training and specialized courses. There is a need to finance and establish training programmes at all levels, modifying regulations related to certified diplomas, adapting existing curricula and vocational training programmes so that a sufficient number of installers and technicians may face the challenge of responding to the current and future demand for solar PV. In addition to the lack of trained professionals, there is also a lack of skills and expertise in public administration which may prevent from developing adequate measures to support the development of self-consumption. Further, his impacts the capacity to mainstream best practices. For more information, see section 3.1.1. This barrier can also be categorised as a technical barrier.	Energy system installers, Government	Individual, Collective

6.1.3. *Overview of economic and financial barriers*

Table 6-3 provides an overview of economic and financial barriers that hinder the deployment of self-consumption in Member States.

Table 6-3 Economic and financial barriers to individual and collective self-consumption

Title of the barrier	Description	Actors impacted	Type self-consumption
Counterproductive remuneration and support schemes for injection of electricity into the grid by self-consumers	Various remuneration and support schemes are used across the EU (feed-in-tariffs/premiums, net metering, net billing, fiscal incentives, etc.). The remuneration and support schemes need to support the financial feasibility of the self-consumption project, but at the same time incentivize demand-response. For example, high remuneration tariffs for energy fed into the grid may discourage self-consumption, while schemes that provide a purchase grant will retain the incentive to self-consume. In general, the remuneration and support schemes should aim at optimising self-consumption for the benefit of both the consumer and the energy system. This can mainly be achieved by increasing market information on prices (e.g. through dynamic prices).	Prosumers	Individual, Collective
Network and other charges can be unfair, and not appropriately reflect the benefits provided by self-consumption	Network charges and taxes have historically been a combination of volumetric (i.e., are charged based on the amount of energy a consumer imports from the network), capacity-based and lump-sum components. With the increasing popularity of self-consumption, many regulators are introducing fixed and capacity charges, which can be unfair for some users, as it decreases the financial benefits of installing generating plants for self-consumption.[118] However, fixed and capacity charges are considered good practices, especially when these are levied to cover the share of network costs which are independent of volumes distributed. For example, network reinforcement costs are often driven by peak capacity demand, which may or may not be affected by the installation of generating equipment onsite. On the other hand, there may be prosumers that, thanks to self-consumption, are able to lower their impact on the network during peak times and on the need to invest in network reinforcement, yet network tariffs do not reward this positive behaviour. This barrier can also be categorised as a social barrier.	TSOs/DSOs, Other consumers	Individual, Collective
Static distribution of electricity in collective self-consumption	Cost and benefit sharing agreements between prosumers involved in a collective self-consumption scheme may not be appropriate to incentivise self-consumption of each individual nor to allow for demand response in reaction to dynamic price signals.	Prosumers	Collective
Affordability of self-consumption	Upfront costs of investing in self-consumption technologies (e.g. solar PV) are relatively high. In addition,	Consumers	Individual

[118] For example, in Flanders, people may run into fees above 150 EUR to participate in energy sharing, charged upon them by suppliers. Source: 'Deliberately cutting corners': Energy suppliers charge more fees for energy sharing (brusselstimes.com)

Title of the barrier	Description	Actors impacted	Type self-consumption
technologies for average households	the return on investment of self-consumption is relatively low (long pay-back period). This prevents households, and in particular low income and vulnerable households to engage in self-consumption. This barrier is less relevant to collective self-consumption as costs can be shared among participants or there may be no investment requirement and excess electricity from self-consumer that can be shared for free or against a price for vulnerable and energy poor households. In some Member States, third party investors are not eligible to self-consumption support schemes. This can hinder the adoption of DER solutions by less tech-savvy or low- and medium-income households, which would benefits from third party investor models.		
Net-metering schemes instead of net-purchasing schemes, incentivizing inefficient use of the grid	Net metering schemes have originally been implemented to support the uptake of solar PV generation in the past and have been successful in doing so. However, such schemes lack in the promotion of energy efficiency/ conservation and demand-side optimization as they incentivize consumers to inject their energy back into the grid. Net-billing schemes instead incentivise demand-side optimization through a better compensation in peak demand hours, and demand shifting (where possible) to off-peak hours.	Prosumers, DSOs/TSOs	Individual, collective
Lack of dynamic pricing arrangements, incentivizing injection back to the grid when electricity is scarce instead of self-consumption	Dynamic pricing arrangements incentivise consumers to consumer their renewable energy production in an optimal way to provide maximum support to the grid, i.e. feeding energy to the grid when increased generation is necessary and self-consuming when there is an excess generation. Although dynamic pricing arrangements enable optimal self-consumption for the grid, it can be a barrier to the maximisation of self-consumption, as consumers will be incentivised to inject their energy into the grid when electricity is scarce instead of self-consuming.	Prosumers	Individual, collective

6.1.4. Overview of social & behavioural barriers

Table 6-4 provides an overview of social and behavioural barriers that hinder the deployment of self-consumption in Member States.

Table 6-4 Social and behavioural barriers to individual and collective self-consumption

Title of the barrier	Description	Actors impacted	Type self-consumption
Missing perception and awareness of benefits of SC and misconceptions on solar PV and on self-generation solutions	There is still a lack of awareness on the benefits of self-consumption for potential investors, citizens and SMEs and larger enterprises. In addition, a large share of the population does not trust self-generation technologies like solar PV. These significant psychological barriers harm the development of self-consumption.	All actors	Individual, Collective
Split incentives between tenants and landlords	Split incentives happen when the party able to invest is not the party directly benefitting from the investment returns. Tenants normally do not have the rights to make long-term	Prosumers	Individual

Title of the barrier	Description	Actors impacted	Type self-consumption
	changes to the rented property (and can hence not install solar PV), but landlords have little incentive to invest in switching to renewables, as rents are usually driven by factors other than energy use. On the other hand, if tenants are allowed to invest and decide to do so, they may be evicted from the property before they have recovered their investment. This barrier is less relevant for collective self-consumption, where a tenant can buy a share in an offsite solar PV park or access shared electricity produced by another prosumer.		
Mismatch between generation and consumption profiles	In order to self-consume, the onsite renewable plant must generate at the time in which the energy is being consumed, but the generation and consumption profiles do not always match. For example, households may need power mostly in the early morning and in the evening, but a PV system will generate the most during the afternoon. Feeding energy to the network and then reimporting means an increase in network congestion and the need to invest in network reinforcement, which means that some of the benefits of individual and collective self-consumption are lost.	Prosumers, Government, DSO	Individual, Collective
Complex arrangements with neighbours	Installing self-consumption systems (e.g. solar PV panels) in multi-owner residential buildings can be difficult and may demand considerable negotiations among neighbours (e.g. holding meetings to convince doubters, explain function and benefits of self-consumption to all, calculate costs and methodology to share it, get funding together, choose installer, etc.). This can result in complex arrangements, in particular when only some of the residents are interested (e.g. leasing part of the roof to uninterested residents). Distributional aspects also play a role, in particular when defining the mechanism to allocate generated energy among neighbours/ involved parties. This barrier can also be categorised as an institutional barrier.	Prosumers	Collective
Privacy concerns when it comes to smart metering	Privacy concerns arise with the use of new communication devices (such as smart meters), through which consumers' data are directly transmitted to suppliers. Appropriate data management and cybersecurity are crucial to ensure the safety of consumers' data. For more information, see section 3.1.1. This barrier can also be categorised as a technical barrier.	All actors	Individual, Collective

6.1.5. Overview technical barriers

Table 6-5 provides an overview of technical barriers that hinder the deployment of self-consumption in Member States.

Table 6-5 Technical barriers to individual and collective self-consumption

Title of the barrier	Description	Actors impacted	Type self-consumption
Lack of expertise of DSO and energy suppliers	These actors are not used to deal with a diversified, not always geographically concentrated and large number of prosumers. They will need to adapt their activities in	DSO, Energy suppliers	Individual, Collective

Title of the barrier	Description	Actors impacted	Type self-consumption
	order to account for these changes. For example, the administrative processes related to negotiating prices with local DSOs are complex for households. DSOs could impose pricing methods for smaller installations where socioeconomic benefits are identified. Additionally, the processes for allocating metering values – where grid operators need to adapt their operations – accounting for several electricity providers at one connection point. For more information, see section 3.1.1.		
Difficulties to find appropriate installer or third-party operator	There may be a lack of trained and certified installers able to install certain technologies in a certain area. In turn, this depresses demand for that technology, which means local installers may have little incentives to invest in selling and becoming experts in that technology. This barrier can also be categorised as a social barrier.	Prosumers	Individual, Collective
Low maturity and cost-competitiveness of self-consumption technologies, energy storage and accompanying ICT and microgrid systems	Some of the technologies for self-consumption (e.g. solar PV) are well developed. However, the overall cost competitiveness of technologies, which can be expensive to purchase and install, is not always guaranteed and investment decisions must be balanced. In addition, crucial energy storage technologies for the large-scale development of self-consumption are still in a low maturity phase. Also, the development of smart meters which provide consumers with information on real-time basis about their domestic energy consumption is slow. It is a precondition for collective self-consumption in order to keep accountability of the exchanges produced and helps electricity suppliers with system monitoring and customer billing.	Prosumers, DSO, Energy system installers	Individual, Collective
Challenges related to network operation	The integration of self-consumption into the distribution network is a challenge, as there is a disparity between electricity self-generated and peak demand in the system. In other words, self-consumption cannot cover all energy needs, requiring additional technologies and grid connection. Most electricity can be generated during the day when people are not (usually) at home – peak electricity use is instead in the mornings and the evenings. Consequently, self-consumption does not help the system when it is needed. Energy storage, heat pumps and other flexible devices are key technologies that can contribute to solving this issue. For more information, see section 3.1.1 In particular, there may be limited cooperation between grid operators and energy sharing service providers on congestion, which can lead to energy being shared independent of congestion events.	Prosumers, DSO	Individual, Collective
Restrictive proximity and size requirements	Proximity and size requirements for qualifying as collective self-consumption are restrictive, i.e. several kilometres of distance and up to a limited generation capacity. More specifically, in rural areas where habitat is dispersed and population is less dense, restrictive proximity and size requirements hinder the proliferation of collective self-consumption projects.	Prosumers	Collective

6.2. Categorisation and prioritisation of key barriers identified

The previous sub-chapter shows that there are numerous barriers affecting the deployment of self-consumption in Member States, which can be of various nature (regulatory, institutional, economic, and financial, social and technical). The barriers identified in the previous sub-chapter however do not affect the same stages in the process of self-consumption (as described in section 3.4). In other words, barriers can affect:

1. The decision to **install a generation system** for self-consumption (and more generally, to install DER);
2. The choice to self-consume and to **maximise the self-consumption rate**;
3. The choice to self-consume while **optimising benefits for the energy system**.

In order to identify the most appropriate solutions to overcome these barriers to self-consumption (as presented in the previous section) they have thus been further classified into whether they affect (1) the *installation of a generation device* for self-consumption, (2) the *maximization of self-consumption*, or (3) the *optimisation of self-consumption and maximisation of system benefits*. In order to arrive at a reasonable set of recommendations, the barriers identified in this study have been prioritised based on their recurrence (i.e. faced by many Member States) and importance (i.e. high impact on the deployment of self-consumption) using information from literature, the case studies, as well as through an internal assessment with the project team.

The table below presents an overview of the main barriers to self-consumption affecting different types of consumers (i.e. individual, collective, industrial/commercial) at different stages of the process of self-consumption. It is worth noting that barriers to a certain category (e.g. to the decision to install a generation system) can also be enabling conditions to another one (e.g. to the choice to maximise the self-consumption rate). For example, net-metering schemes have played a significant role in the uptake of distributed energy resources, however, they can be considered a barrier maximise self-consumption.

Table 6-6 Overview of main barriers (and enabling conditions) to self-consumption

		Scope			Install DER	Maximise self-consumption	Optimise energy use
Regulatory	• Complex and burdensome permitting process and other procedures for DER projects • Lack of regulation to address consent requirement to use common property for multi-apartment buildings	▲ ▲	▲ ▲	▲	✖		
Institutional	• Lack of staff/expertise with DER and storage (from installers, DSO, local authorities)	▲	▲	▲	✖		
Economic and financial	• Uncertainty of electricity prices • Low return on investment	▲	▲	▲	✖		
	• Net metering schemes • High FiTs	▲	▲	▲	✓	✖	
	• Low consumption energy prices	▲	▲	▲	✖	✖	✖
	• Lack of dynamic energy pricing	▲	▲	▲			✖
Social and behavioural	• Complexity of sharing energy		▲		✓ / ✖	✖	
	• Limited capacity to adapt consumption based on real time energy and pricing data	▲	▲	▲			✖
Technical	• Limited network capacity to accommodate new installations	▲	▲	▲	✖		
	• Lack of HEMS/BEMS	▲	▲	▲		✖	✖

Legend: ✖ Barriers ✓ Enabling conditions

Individual	Collective	Industrial/commercial

7. Findings and recommendations

7.1. Key findings

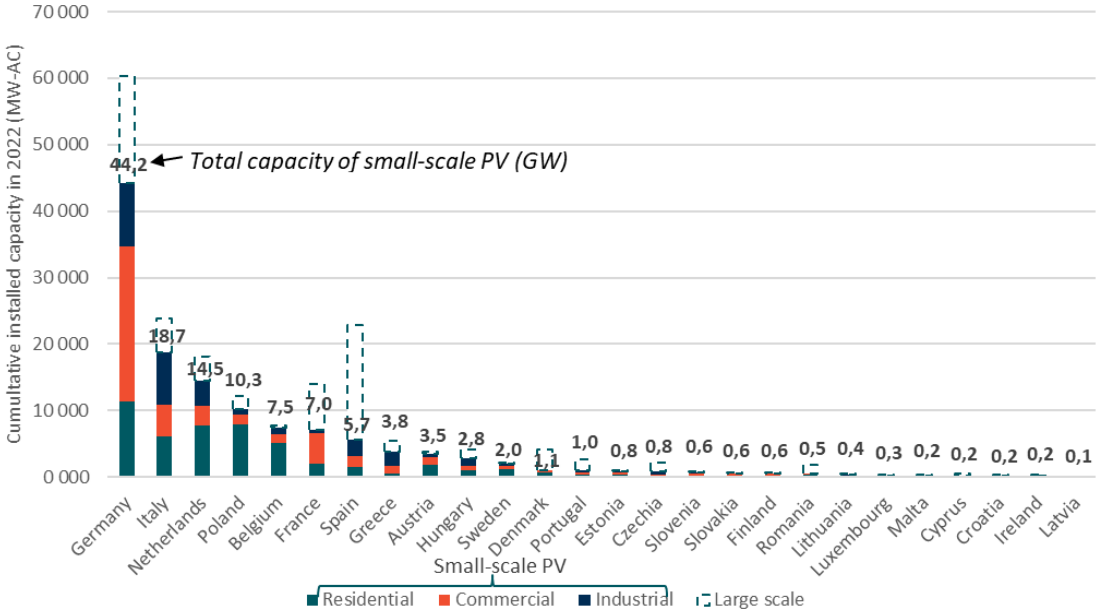
The concept of self-consumption has existed for a long time in practice, but has only been formally recognised in the EU in 2019 when definitions of 'renewables self-consumers' and 'active customers' were introduced by the Clean Energy Package. While the Renewable Energy Directive (RED II) provides a framework for individual and collective renewables self-consumption by introducing the definition of 'renewables self-consumer' and 'jointly acting renewables self-consumers', the Internal Electricity Market Directive (IEMD) defines the term 'active customer' which gives a status to final customers that participate more actively in the energy market than traditional consumers. Active customers and renewables self-consumers are closely related concepts, with the major difference being that electricity generated by renewables self-consumers for their own consumption must be generated from renewable energy sources and that active customers are entitled to participate more broadly in the energy market, for example by providing flexibility or energy efficiency schemes[119]. The focus of this paper is on renewables self-consumers, although some of the recommendations are aimed at supporting self-consumers in playing a more "active" role in the energy market.

The number of installations allowing to self-generate and self-consume keeps growing. The total cumulative solar photovoltaic (PV) installed capacity in the EU has doubled between 2018 and 2022, increasing from 100 GW to 209 GW.[120] One of the critical variables to assess the level of self-consumption is the deployment of small-scale installations, which are almost exclusively associated with self-consumption. Figure 7-1 shows the installed capacity of small-scale solar PV by country (equal to a total of 127 GW in 2022). Germany, Italy, and the Netherlands have the highest capacities.

[119] CEER (2019). Regulatory aspects of self-consumption and energy communities. CEER Report of the Customers and Retail Markets and Distribution Systems Working Groups. Available at: CEER report ; CEER (2017). Renewable Self-consumers and energy communities. CEER White Paper series (paper #VIII). Available at : white paper on sel-consumers and energy communities (ceer.eu)

[120] EU Market Outlook for Solar Power (solarpowereurope.org)

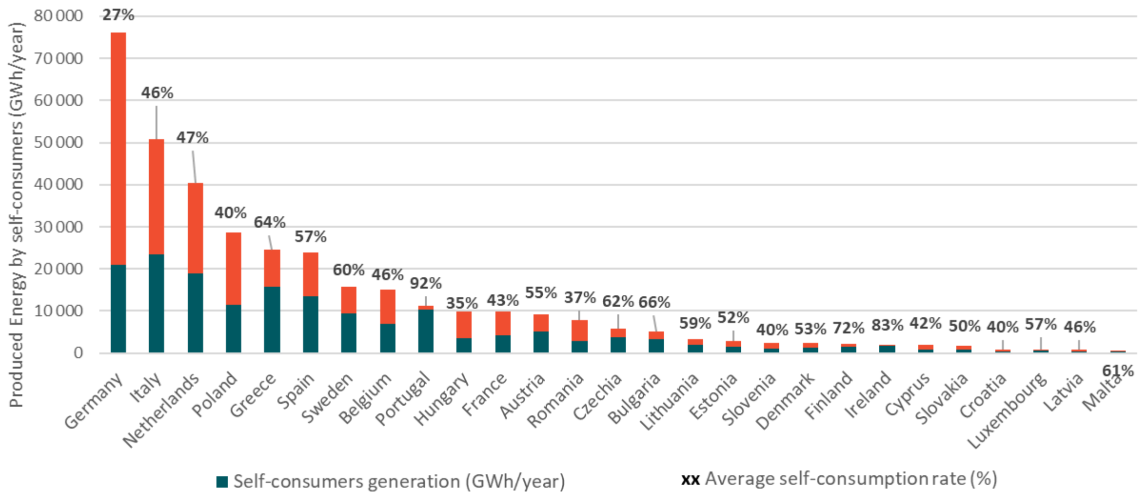
Figure 7-1 Installed capacity of small-scale solar PV by country (SolarPower Europe, 2023)



Source: SolarPower Europe, National statistics

Although there is a lack of data on the level of energy that is self-consumed by small-scale installations in the EU, our analysis has estimated that **self-consumption rates[121] vary significantly among Member States**. Figure 7-2 presents the distribution of PV energy produced by self-consumers and the rate of self-consumption in EU Member States in 2022. The average self-consumption rate is equal to 41% across the EU and ranges between 27% (in Germany) and 83% (in Ireland). The total estimated energy that was consumed by self-consumers is 34.1TWh in 2022.

Figure 7-2 Distribution of photovoltaic energy produced by self-consumers in Europe in 2022



Source: Enerdata's analysis, National statistics

To explain these differences between Member States as well as the relatively low self-consumption in some countries, a **number of regulatory, institutional, economic, and**

[121] The self-consumption rate can be defined as the ratio between self-consumed electricity and total self-generated electricity over a given period, or in other words, the share of the electricity that is self-generated and directly consumed by the consumer.

financial, social and technical barriers that affect self-consumption in the EU have been identified. These barriers can be classified into three categories, i.e. barriers that affect:

1. The decision to install a generation system for self-consumption (and more generally, to install DER);
2. The choice to self-consume and to maximise the self-consumption rate;
3. The choice to self-consume while optimising benefits for the energy system.

The **main barriers (i.e. most important and recurrent) to self-consumption** affecting different types of consumers (i.e. individual, collective, industrial/commercial) that have been identified in Member States are presented in Table 6-6. As mentioned earlier, barriers to a certain category (such as barriers to install a generation system) can also be enabling conditions to another one (e.g. to the choice to maximise the self-consumption rate).

The case studies analysed as part of this study have shown that some Member States have attempted to **address some of these barriers by implementing various policies and measures**, among which the following (some of these examples are developed into further details in section 7.2 and the complete case studies are presented in Annex A):

- The simplification of authorisation, licensing and connection procedures associated with the installation of a PV system, such as the simplified permitting procedure for microgenerators in Latvia or the 'Solar Ladder' in the Netherlands, which specifies a hierarchy of preferred locations for new solar PV. As rooftop solar PV are considered top-priority in the Netherlands, they benefit from the highest level of permitting exemption/simplification.
- The development of solutions to encourage collective self-consumption, for example in France where collective self-consumption can happen beyond the scope of the same building or apartment unit (up to 2 km, and even 20 km under certain conditions). Another example is the Klimaan energy community in Belgium and their project in the Otterbeek neighbourhood aimed at allowing people affected by energy poverty to participate in energy sharing;
- The implementation of appropriate support schemes for self-consumption, such as the net-billing schemes in Portugal or the Spanish simplified compensation mechanism, which compensates self-consumers for excess energy using dynamic prices (including a regulated dynamic hourly price for small consumers);
- The development of tools and frameworks to inform and support consumers willing to engage in self-consumption, such as the Central and Eastern European CLEAR X project, a One-Stop-Shop for renewable energy technologies or the platform 'On the Sunny Side' in Croatia which provides administrative support to both household and institutional consumers in the installation of solar PV panels by explaining the necessary steps and required documentation for the permitting procedures.

These different solutions as well as the literature have led us to develop recommendations for Member States and other stakeholders (e.g. NRAs and network operators), considering different policy and regulatory options that can be implemented to overcome barriers to self-consumption.

7.2. Recommendations

The methodology used to develop the following set of recommendations and the link with barriers to self-consumption is presented in Annex E.

7.2.1. *Clear and coherent definition of collective self-consumption*

There is a lack of consensus across Member States on the interpretation of the concept, definition and approaches to collective self-consumption. Providing further guidance to Member States on what can be considered as collective self-consumption, and clearly showing overlaps, links, boundaries and interfaces of the different concepts such as 'renewable and citizen energy communities' (and 'energy sharing' as proposed by the EC in the Electricity Market Design revision proposal), could support its uptake and allow Member States to set up support mechanisms that are proportionate to the benefits that collective self-consumption brings to the energy system. Collective self-consumption:

- Allows households and businesses that do not have access to a physical location to install a renewable generation plant, or that do not have sufficient financial resources, to access offsite renewable generation for purpose of self-consumption.
- May open up opportunities for larger users to access cheaper, local generation by planning consumption during the daytime on weekdays when residential self-consumers consume little electricity.
- Can provide significant benefits to the energy network (e.g. by achieving high self-consumption rates), but these are dependent on many factors. Providing a consistent definition that fully considers the benefits and costs of collective self-consumption would allow Member States to design coherent policies to support this practice, transparently considering network costs[122] that may end up being socialised.
- Encourages to maximise solar installations on available rooftop space. This limits the environmental impact of renewables and accelerates renewable deployment.

Further, a clearer definition may improve the way in which self-consumption is monitored. Understanding the contribution of individual and collective self-consumers, as well as their potential impact on the network, is necessary to efficiently use and plan the development of grid infrastructure (e.g. reducing and optimising network use).

- ➔ **Barrier(s) addressed**: The lack of a clear definition of collective self-consumption and insufficient implementation of collective self-consumption schemes at Member State level means that national rules are often unclear and may not be properly applied by DSOs and in multi-apartments buildings (or beyond, when this is allowed by Member States). This discourages the uptake of the activity by the many consumers that do not have the possibility to generate their own electricity.
- ➔ **Recommendation:**
  (Applicable to collective self-consumption, commercial sector)
  Member States (that do not yet have a proper definition of collective self-consumption) should clearly define the concept and its modalities (see the French definition of collective self-consumption in Textbox 7-1 as an example), and provide supporting measures adequate to the benefits that this practice provides to the energy system (i.e., considering that collective self-consumers may be entitled to the use of public networks, with associated costs, which is not the case for individual self-consumption). Member States should define a minimum set of rules that ensure the rights of collective self-consumers are guaranteed, also in the cases where consumers are unable to engage in self-consumption because

[122] Mostly associated with the use of distribution networks

limitations imposed by the administration of the building they live in do not allow them to install a generation plant. In addition, their rights to the installation of a generation plant should also be guaranteed (see also next recommendation). If national governments cannot accomplish this during the transposition process for the recast RED II, the Commission should consider issuing official guidance to Member States.

Textbox 7-1 Definition of collective self-consumption in France

In France, **collective self-consumption is defined by the Energy Law** as '*an operation in which electricity is supplied between one or more producers and one or more end consumers linked together within a legal entity, and whose extraction and injection points are located in the same building, including residential buildings*'.[123] The law also foresees an extended collective self-consumption defined as '*an operation in which electricity is supplied between one or more producers and one or more final consumers linked together within a legal entity, whose extraction and injection points are located on the low-voltage network and meet the criteria, notably geographical proximity, set by order of the Minister for Energy, after consultation with the Energy Regulation Commission. For extended collective self-consumption operations, where the electricity supplied is of renewable origin, the extraction and injection points may be located on the public electricity distribution network*'. The law sets clear criteria for extended collective self-consumption to take place: geographical distance is limited by a Decree to 2 kilometres and the installation capacity must be below 3 MW.[124] The electricity generated in an extended collective self-consumption project is always injected into the public distribution network and then distributed among participating consumers based on a defined distribution methodology. Further details on this example are provided in Annex A.

7.2.2. *Simplified permitting procedures*

Prospective self-consumers trying to invest in new generation capacities face burdensome administrative procedures in many of the Member States. This creates additional costs and a significant disincentive, especially for small-scale household consumers without the necessary knowledge and experience, easily overwhelmed and intimidated by complicated procedures. Simplifying the permitting procedure, or providing exemptions from it altogether for small consumers (with predictably small environmental/ technical impact and the least resources), in line with Directive EU/2023/2413, would significantly lower the perceived entry barrier and reduce the financial support that may be necessary to encourage the uptake of new generation plants. An example of permitting exemptions for rooftop solar PV in the Netherlands is presented in Textbox 7-2.

[123] Chapitre V : L'autoconsommation (Articles L315-1 à L315-8) - Légifrance (legifrance.gouv.fr)

[124] Arrêté du 21 novembre 2019 fixant le critère de proximité géographique de l'autoconsommation collective étendue - Légifrance (legifrance.gouv.fr)

➔ **Barrier(s) addressed:** Complex, lengthy and burdensome permitting processes discourages new DER installations.

➔ **Recommendation:**

(Applicable to individual and collective self-consumption, commercial and industrial sectors)

Continuing with the efforts already made as part of REPowerEU, and in line with the requirements of Directive EU/2023/2413, Member States should:

- ***work with local administrations and network operators to further reduce the burden of the permitting process for self-consumers, ensuring that the permit requirements, and the documentation demanded as part of the process, are proportionate to the size of the installation.***
- ***ensure that information about the permitting process is available and accessible to self-consumers, by establishing organisations or platforms dedicated to provide information, expertise and hands-on help with permitting processes (e.g. One-Stop shops, such as 'On the Sunny Side' platform in Croatia, see***

- ***Textbox*** 7-3***).***
- ***Consider to what extent the 'solar readiness for buildings' can be included in building codes as a mandatory minimum requirement for new buildings and major renovations; this would also help to address the rights of single owners in multi-apartment buildings.***[125]

Textbox 7-2 Solar Ladder and permitting exemption for rooftop solar PV in the Netherlands

The **Dutch Solar Ladder** specifies a hierarchy of preferred locations for new solar PV. Rooftop solar PV is at the top of the preference list. This is **paired with rooftop solar PV's exemption** from some of the permitting procedures providing substantial administrative ease. Permits are required in some specific cases only (i.e. in case of buildings of heritage/monument status, or if the panels do not fulfil the general technical criteria). In those cases, the rooftop PV installation requires an All-in-one Permit for Physical Aspects, just like any other (ground-mounted) PV installation. The standard procedure for this takes 8 to 14 weeks, complicated cases requiring an extended procedure could take up to 6 months. In all other cases, rooftop PV owners are required to apply for a grid connection permit only. After installation, no permits are required for PV operation. Further details on this example are provided in Annex A.

[125] If the predisposition for the installation of generation equipment is already included in the building's plan, single owners will not have to seek the approval of measures to structurally alter the building.

Textbox 7-3 Croatia's On the Sunny Side platform

Zelena Energetska Zadruga (Green Energy Cooperative, ZEZ) provides **administrative support to both household and institutional consumers in the installation of solar PV panels** in Croatia by explaining the necessary steps and required documentation for the permitting procedures. Using its in-house expertise the organisation guided more than 2.000 households so far in obtaining the necessary permits, free of charge. ZEZ is a non-profit organisation kick-started within the UNDP project Development of Energy Cooperatives in Croatia in 2013, and is supported by the 1000 Solar Roofs project of EIT's Crisis Response fund to operate the platform. Other than the permitting procedure itself, On the Sunny Side provides viability pre-assessments and connects the installers to the interested customers, providing support throughout the entire cycle of PV projects. Further details on this example are provided in Annex A.

7.2.3. *Moving from net-metering schemes to net-billing schemes*

Net-metering schemes have played a fundamental role in improving the popularity of distributed generation, but also created issues with unequal distribution of network costs, and have led to a perceived over-subsidisation of solar PV.[126] These support mechanisms, while indeed have led to an increased uptake of solar PV generation in the past, lack in the promotion of energy efficiency/conservation and demand-side optimisation.[127] Article 15(4) of the Directive 2019/944 on common rules for the internal market for electricity (IEMD) requires the gradual phase-out of any existing support schemes in the EU Member States that does not account separately for the electricity fed into the grid and the electricity consumed from the grid.[128] This means that, after 31 December 2023, new rights under net-metering schemes should not be granted in the Member States according to EU legislation. On the other hand, alternative support mechanisms, such as net-billing schemes, offer a compromise between the support for solar PV uptake and other system-wide considerations as, usually, net-billing schemes offer lower injection prices compared to the energy price consumers pay, which incentivises self-consumption. Further, net-billing is also more able to account for and integrate innovative and cost-reflective pricing methodologies. For example, net-billing could incentivise demand-side optimisation by providing a variable compensation for grid injection, and thus supporting demand shifting (see recommendation in section 7.2.4). Several Member States have already introduced a net-billing scheme to replace net-metering schemes with success, although only few examples are available of variable injection prices.

- ➔ **Barrier(s) addressed:** Net-metering schemes do not provide incentives for self-consumers to maximise their level of self-consumption.
- ➔ **Recommendation:**

  (Applicable to individual and collective self-consumption)

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[126] Londo et al. (2020). Alternatives for current net metering policy for solar PV in the Netherlands: A comparison of impacts on business case and purchasing behaviour of private homeowners, and on governmental costs

[127] Oliver et al. (2023). Microeconomics of the Solar Rebound Under Net Metering

[128] Official Journal of the European Union (2019). DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)

Member States should:

- ***Discontinue the offering of net metering schemes as soon as possible, in line with Directive 2019/944;***
- ***Encourage consumers currently enlisted in net-metering schemes to move towards net-billing arrangements or into aggregator services; to do so, some of the conditions of the current net-metering contracts could be amended, such as the maximum amount of power that can be injected and withdrawn for free (e.g., a monthly limit to the share of energy injected that can be counted towards the balance[129]);***
- ***Encourage suppliers to also offer to consumers market alternatives to net-billing (i.e., compete in offering customers different price for the energy they inject);***
- ***Consider the possibility to reward injected electricity at a variable price that reflects generation scarcity at different point in time (see next recommendation).***

Textbox 7-4 Portugal's net-billing scheme

Portugal introduced its first net-metering scheme in 2014, replacing the feed-in tariff system and countering the back-then declining interest for PV installations. As per the more recent (2019) Portuguese self-consumption regulations, however, net-billing is applied instead. Electricity consumers who generate renewable energy are allowed to offset their electricity consumption with the excess energy they produce by feeding back directly into the grid. Within the net billing scheme, the quarterly-hour balance is the difference between the consumption data in kW and the data injected into the network in kW, in each 15-minute period. This means that everything that is produced in that 15-minute interval must be consumed in that same interval. What is not consumed is injected into the network and another 15-minute cycle begins. The excess electricity that is injected into the grid is settled at 90% of the local spot price, with 10% being deducted to cover the network costs. The rise in wholesale electricity prices in 2021-2022 (from 45-55% of the final consumer electricity price to 75-90%) has made the net-billing scheme more attractive to consumers, and led to an uptake of installed capacity of self-consumption generation units in Portugal. Further details on this example are provided in Annex A.

7.2.4. Encouraging dynamic pricing arrangements

Prosumers, even when under net-billing, are exposed to "muted" market signals: the energy price they receive for injecting is generally estimated based on expected wholesale costs over a long period of time, or is set via regulated formula. Dynamic pricing arrangements help getting consumers more involved in reducing price volatility by financially rewarding end-

[129] For example, 70% of average monthly generation can be counted towards self-consumption. Assuming an average monthly production per kWp installed is 110 kWh, a prosumer may, at most, inject and withdraw for free 77 kWh per kWp installed each month.

users who conserve energy during peak demand hours (when the electricity is most expensive) and use electricity when it is abundantly available. Similar (but opposite) incentives could be provided to self-consumers in respect to their injection into the network. In Spain, a compensation mechanism for excess electricity using dynamic prices has been implemented (see example in Textbox 7-5). Dynamic pricing approaches create a more socially fair system than static feed-in tariffs and net-metering schemes, as consumers that impose higher total system costs (for example, because they consume the most when total demand is higher at local or national level) pay higher prices and vice-versa. It also creates a more stable system, that in turn can support more self-generation capacity, furthering the environmental goals. As an additional benefit, dynamic pricing would significantly reinforce the economic case for the installation of behind-the-meter storage.

➔ **Barrier(s) addressed:** The lack of direct exposure to market prices means that prosumers have little interest to optimise the use of their generation plant to maximise system benefits.

➔ **Recommendation:**

(Applicable to individual and collective self-consumption, commercial and industrial sectors)

Member States and NRAs should work with energy suppliers to increase the offer of competitive variable energy prices that cover both the injection and withdrawal of electricity. Energy suppliers should test the offering of more granular variable pricing for electricity withdrawal and injection from the grid, supported by adequate communication mechanisms to ensure that self-consumers can fully engage with market signals. The offering should be sufficiently granular, and customers should be informed in advance so that they can take action; for example, hourly prices communicated to customers one day before via a mobile app. The variation in the price could be based on the day-ahead market price, but consumers should be shielded from some extreme scenarios (for example, introducing a maximum and minimum charge) and generally protected in line with Directive 2019/944.

Textbox 7-5 Simplified compensation approach in Spain

Self-consumers in Spain with a surplus have the option to choose between selling their excess electricity in the market or make use of the **simplified compensation mechanism**, allowing them to get a compensation for their excess energy as a deduction in their energy bill instead. The simplified compensation mechanism uses dynamic compensation prices, including a regulated hourly price for small consumers (PVPC) which is indexed to the wholesale market. Further details on this example are provided in Annex A.

7.2.5. *Considering time-of-use and dynamic network tariffs*

Historically, energy costs make up between 30% and 40% of the final energy bill[130], with network costs accounting for another 30% (the remaining part being VAT and taxes & levies). While dynamic pricing of the energy component, both when using power from the grid and when feeding power into it, will provide a signal for prosumers to act, this may be insufficient. Therefore, there is scope to consider a revision of network tariffs to provide an additional dynamic signal, although this should reflect volume-related network congestion and balancing costs, rather than a scarcity price as in the case of energy costs (the two are likely to align often, but not always). A recent ACER review of barriers to demand response and DER[131] concludes that "*The use of time signals can be a useful tool for reducing network peak-load, thereby promoting network efficiency, while it can also provide incentives for consumers to invest in generation/storage assets and/or to engage in demand response*" and that "*Member States should apply differentiated network tariffs for active customers providing explicit demand response as long as they reflect the different network costs triggered by their network use and they are not discriminatory vis-à-vis other network users*".

➔ **Barrier(s) addressed:** Network and other charges can be unfair, and not appropriately reflect the benefits provided by self-consumption; affordability of self-consumption technologies for average households; lack of dynamic pricing arrangements, incentivizing injection back to the grid when electricity is scarce instead of self-consumption.

➔ **Recommendation:**

(Applicable to individual and collective self-consumption, commercial and industrial sectors)

NRAs should work with DSOs and TSOs to investigate the joint application of dynamic energy pricing and more sophisticated ToU network charges (i.e. via the determination of peak/off-peak periods more closely following network congestion) and their joint impact on self-consumption. As part of this review, they should:

- ***consider exemptions from injection charges to renewable generators engaged in self-consumption at distribution level;***
- ***consider which elements of the grid tariffs should be volume-based to incentivise self-consumption;***
- ***evaluate the impact of self-consumption in reducing network costs which show correlation with contracted or peak capacity, and adapt the power-based component of prosumers' tariffs accordingly;***
- ***define dedicated, cost-reflective grid tariffs for local collective self-consumption.***

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[130] https://www.acer.europa.eu/Publications/2023_MMR_Energy_Retail_Consumer_Protection.pdf . Note the exception of 2022, when energy prices increased significantly, thus reaching 54% of the total energy bill.

[131] https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_MMR_2023_Barriers_to_demand_response.pdf

7.2.6. Supporting DSOs in planning the large-scale integration of DER

The large-scale deployment of DER (including renewable self-consumption technologies), and associated 'bottom-up' injections into the grid, require a level of flexibility that traditional electricity grids do not have. To prepare the grid for a massive roll-out of solar PV and self-consumption mobilising all flexibility options, an adequate level of grid planning is necessary. As part of the planning, DSOs should ensure the growth of DER devices is fully accounted for, and anticipate investment needs. Article 32 of Directive (EU) 2019/944 on common rules for internal market for electricity already requires electricity DSOs to prepare and publish, at least every two years, distribution network development plans (NDP).[132] This requirement was implemented to support the integration of installations generating electricity from RES and facilitate the development of energy storage facilities and the electrification of the transport sector.[133] The obligation applies to all DSOs, but Member States may choose to exempt small DSOs (i.e. serving less than 100 000 connected customers or small isolated systems).

The size of DSOs can indeed have an impact on the way DER proliferation is managed. Due to a lack of expertise and staff to support the growing complexity of the planning process, the cost and administrative burden of grid planning for small DSOs is proportionally higher.

➔ **Barrier(s) addressed:** Electricity grids are not fit for the large-scale integration of DER and there is a lack of staff, expertise and resources at DSOs to engage in the necessary grid planning development. As a result there is limited network capacity to accommodate new installations.

➔ **Recommendation:**

(Applicable to individual and collective self-consumption, commercial and industrial sectors)

Member States and NRAs should:

- ***Support small DSOs in planning the necessary investments to accommodate DER into their grid by issuing guidelines, providing training about grid planning, and by encouraging small DSOs to pool their resources to reach a critical size for efficiency and manage the complexity of grid planning and data management (e.g. pooling of IT capacity with several small DSOs, or outsourcing of IT functions to a service unit that is financed by cooperating DSOs, as a joint-IT service).***
- ***If small DSOs are exempt from grid planning in line with Directive (EU) 2019/944, ensure that a minimum level of information on network development and some development actions can be requested by NRAs (when deemed appropriate).[134]***

  Encourage DSOs to establish registers/databases/maps with information on installed DER to provide increased visibility of where DER are

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[132] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity (recast). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02019L0944-20220623

[133] CEER (2021). CEER Views on electricity distribution network development plans – Distribution Systems Working Group. Available at: 2da60a45-6262-c6bc-080a-4f24b4c542cd (ceer.eu)

[134] CEER (2021). CEER Views on electricity distribution network development plans – Distribution Systems Working Group. Available at: 2da60a45-6262-c6bc-080a-4f24b4c542cd (ceer.eu)

connected and support the planning and operation of the grid (see example of the DER register in Australia in Textbox 7-6 and the grid capacity map in the Netherlands in Textbox 7-7*).*

- ***Ensure that DSOs engage in realistic planning, enabled by these DER registers, aimed at making the required investments ahead of time in line with Directive (EU) 2019/944.***

Textbox 7-6 DER register in Australia (Source: AEMO, 2023[135])

The Australian Energy Market Operator (AEMO) established in 2020 a **register for DER**. This register is a database including information about DER devices that are installed, on-site at a residential or business location, on the national energy market. The aim of this register is to allow AEMO to have an increased visibility on the deployment of DER and thus be able to better manage the electricity grid. The information is requested by network operators to qualified electrical contractors and solar installers at the time of DER installation. The AEMO is obliged to report on the number and installed capacity of DER devices installed across the national energy market. A dashboard presenting aggregated collected data is publicly available and updated on a quarterly basis. The DER register is foundational to AEMO's **DER Program** which aims at creating the tools and protocols necessary to address the challenges that arise from DER and preparing AEMO to facilitate an energy market with high levels of DER integration.[136]

Textbox 7-7 Grid capacity and congestion maps in the Netherlands (Source: Netbeheer Nederland, 2023[137] and TenneT, 2023[138])

The Dutch association of national and regional power network operators, Netbeheer Nederland, has set up a **congestion map of the high- and medium voltage grid**. The map shows which areas are seeing increasing constraints for the deployment of large-scale wind and solar power plants. The map is publicly available on Netbeheer Nederland's website.

7.2.7. Addressing distribution network congestion by introducing alternative grid connection agreements

One of the key barriers to the installation of new generation plants for self-consumption, in particular for larger users (commercial and industrial) is the availability of sufficient capacity

135 AEMO | Distributed Energy Resource Register

136 AEMO | About the DER Program

137 Capaciteitskaart elektriciteitsnet (netbeheernederland.nl)

138 Grid capacity map - TenneT

at the local distribution level, which result in the connection requests being rejected or delayed. DSOs can procure flexibility via alternative connection agreements to address network congestion. According to CEER (2023)[139], alternative connection agreements imply a deviation from agreements with firm capacity rights (i.e., where system users should always access their full contracted capacity). Alternative grid connection agreements can be considered in case of underdeveloped flexibility markets (as a mechanism to access flexibility) or as a temporary instrument to connect new users that can only be connected on a firm basis once network reinforcements are realised. In the latter case, these alternative connection agreements lead to faster connection and lower connection charges, preventing welfare loss. They can also enable and encourage self-consumers to align with network conditions using their available flexibility (i.e. via batteries, advanced inverter functionalities, or behavioural change). Examples of flexible grid agreements in Norway, Great Britain and Australia are presented in Textbox 7-8, Textbox 7-9 and Textbox 7-10.

➔ **Barrier(s) addressed:** DSOs are unable to accept new connection requests in congested areas due to limited network capacity. This results in slow connection processes.
Most existing flexible connection contracts apply only to large MV connected customers.
Many DSOs do not have the technical capability to control customer DERs.

➔ **Recommendation:**
(Primarily applicable to commercial and industrial sectors, but potentially also to individual and collective self-consumption)
NRAs should work with DSOs to ensure that, where grid constraints exist, flexible grid connections are offered to prospective self-consumers, together with remote control software allowing DSOs to control customer DERs. All classes of renewable self-consumers, whether large or small industrial & commercial, whatever the voltage level of their connection, should be able to benefit from flexible connection contracts. Further, the "no-export" obligation existing in some countries should be removed and replaced by a flexible connection contract.

Textbox 7-8 Flexible grid agreements in Norway (Source: CEER, 2023)

In Norway, DSOs and end-users can bilaterally enter into an **agreement for flexible connection**. This applies for new consumption connections and the legislation explicitly states that no compensation shall be given to the end-user upon entering into such an agreement. Therefore, the main benefits for the end-user are: 1) faster connection, and 2) lower connection charge. These types of contracts are voluntary from both sides and the private agreement must outline the criteria for disconnection or curtailment, and the rights, duties and consequences of the agreement for both parties. Similar agreements between producers and DSOs have been a part of the regulation since 2019.

[139] CEER (2023). CEER Paper on Alternative Connection Agreements – Distribution Systems Working Group. Available at: CEER Paper on Alternative Connection Agreements

Textbox 7-9 Flexible grid agreements in Great Britain (Source: CEER, 2023)

Great Britain has recently undergone a **significant grid code review for grid access and forward-looking charges** to accommodate the transition to a low-carbon energy system at the lowest cost. The amendments ensure that there is a standardised option available for non-firm access for larger network users going forward, and that the flexible connection agreements will have clear curtailment limits and end dates for non-firm access arrangements. Crucially, smaller network users have been deemed out of scope. These changes are also accommodated by significant changes to the distribution connection forward-looking charges where, going forward, the need to contribute to wider network reinforcement costs is removed for demand connections and reduced for generation connections. This will reduce the overall connection charges for those connecting to the distribution network, and demand connections are only charged for network expansions.

Textbox 7-10 Dynamic operating envelopes in Australia (Source: DEIP, 2022[140])

Dynamic operating envelopes (DOE) are a form of alternative connection agreement that are being implemented in Australia in response to network capacity issues associated with the growth of solar and other DER. The Distributed Energy Integration Program report (2022) defines DOEs as follows: "*DOEs vary import and export limits of a system user over time and location based on the available capacity of the local network or power system as a whole*". In other words, network capacity is managed by allowing dynamic variations in customer feed-in limits. DOEs are at an early stage of development, with various pilot projects and trials at different scales and maturity being developed by distribution networks service providers (DNSP).

7.2.8. *Encouraging deployment of storage, BEMS and HEMS*

Building Energy Management Systems (BEMS) and Home Energy Management Systems (HEMS) in combination with dynamic pricing can automate the prosumer's response, adapting self-consumption based on real time energy and pricing data to optimise the energy systems. These systems can optimize energy consumption patterns within buildings or homes and limit the impacts on grids. They can monitor energy production from renewable sources and coordinate the use of appliances and devices to ensure that self-generated energy is consumed, stored or exported when is more convenient. Further, they may help reducing overall reliance on the grid. BEMS and HEMS can also balance the intermittent nature of renewables by storing excess energy in batteries or by using smart algorithms to determine when to consume renewable energy or when to feed it back into the grid. As a precondition for the optimization of energy use via BEMS and HEMS, Member States should ensure the availability of dynamic tariffs as well as a strong business case for consuming electricity

[140] Distributed Energy Integration Program (2022). Dynamic Operating Envelopes Working Group – Outcomes Report. Available at: dynamic-operating-envelope-working-group-outcomes-report.pdf (arena.gov.au)

behind-the-meter, instead of injecting it into the grid. In addition to the deployment of BEMS and HEMS, storage can also serve as a solution to increase self-consumption, instead of injecting surplus energy into the grid. Given the cost competitiveness and maturity of storage technologies is still low, it is hardly accessible to average households can be expensive. Providing support to the purchase and installation of support solutions would contribute to their deployment.

- **Barrier(s) addressed:** Even if consumers may potentially be interested in more proactive behaviours, often it would be time consuming and complex to properly engage with market signals and adjust consumption behaviours accordingly. It therefore reduces incentives to self-consume in a way that optimises the energy system benefits .
- **Recommendation:**

  (Applicable to individual and collective self-consumption, commercial and industrial sectors)

  Member States can use several strategies to create a supportive environment for the widespread deployment of storage, BEMS and HEMS, such as:

  - ***As part of programmes to support other energy efficiency measures, elaborating support schemes (subsidies, tax credits) to incentivise the purchase of BEMS and HEMS and storage devices, in particular for larger users, to exploit to the maximum the benefits of self-consumption. The eligibility to support schemes should be conditioned on the interoperability and remote controllability of devices ;***
  - ***Consider provisions to ensure that compatibility with storage, BEMS and HEMS is ensured when incentives and subsidies related to building interventions are awarded;***
  - ***Setting up awareness raising campaigns and education to inform about the benefits of BEMS and HEMS and storage devices;***
  - ***Providing technical support and training to both installers and end-users;***
  - ***Addressing data privacy and security concerns (i.e. GDPR).***

  The European Commission, Member States and industry body should:

  - ***Put in place actions to ensure standardisation of technologies and communication protocols to increase interoperability and remote controllability (i.e. Smart Readiness Indicator);***
  - ***Include compatibility with storage, BEMS and HEMS as part of Ecodesign requirements for buildings.***

Textbox 7-11 EcoGrid and EcoGrid 2.0 in Denmark (Source: EcoGrid 2.0[141])

EcoGridEU project installed **equipment for control and management** of electric heating and heat pumps. EcoGrid 2.0 uses this equipment to **demonstrate flexible power consumption management** in private households. The project remotely oversees 1,000 heat pumps and electric radiators on Bornholm Island, Denmark, optimizing their energy use according to real-time power availability. Their focus is on ensuring resident comfort while

[141] Website of Ecogrid 2.0: Ecogrid

exploring homeowner willingness to regulate power consumption. The project also introduces a new market player, the aggregator, to facilitate the connection between private households and the electricity market.

ANNEX A - CASE STUDIES

See separate report.

ANNEX B – DATA AVAILABILITY AND ANALYTICAL METHODS

This annex presents an overview of the methodology and key limitations to the estimate of self-consumption rates in Member States presented in Chapter 4.

Key assumptions

Key acronyms used:

SC = self-consumption
SPE: SolarPower Europe
NECP: National Energy and Climate Plans
C&I = Commercial & Industrial

Legend:

[red]: Data is not available.
[yellow]: Data is only partially available (e.g., for one segment only or not for the whole country)
[green]: Data is available.

Table B- 1 Data availability & key hypotheses on self-consumption rate by country

	Available data		Key Hypotheses
Member State	**Total self-consumed energy**	**Self-consumption rates by segment**	**Self-consumption rates hypothesis**
Austria	[red]	[red]	Residential: Estimated rate (tool) C&I: Standard SC rates
Belgium	[red]	[yellow]	Residential confirmed by estimation and literature C&I: Standard SC rates
Bulgaria	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Croatia	[red]	[red]	Used Hungary as a proxy, confirmed by estimation tool
Cyprus	[red]	[yellow]	Residential: Based on existing literature (55 households) C&I: Standard rates
Czechia	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Denmark	[yellow]	[yellow]	Danish Energy Agency estimation
Estonia	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Finland	[yellow]	[red]	Literature self-consumption rates adjusted to match the estimated total (based on 40% of installed capacities). DSO : 65% for residential.
France	[green]	[red]	Standard SC rates adjusted to match the total self-consumed energy
Germany	[green]	[red]	Standard rates adjusted to match the total self-consumed energy
Greece	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Hungary	[red]	[yellow]	Residential: Estimated rate (tool). C&I: Standard rates
Ireland	[red]	[red]	Residential: SC rate of 65% (DSO estimation) Commercial: No remuneration below 70% sc rate. Estimated at 75%. Industrial: No grid injection (100% rate)
Italy	[green]	[green]	n.a.
Latvia	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Lithuania	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Luxembourg	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Malta	[red]	[red]	Residential: Estimated rate (tool) increased due to high battery penetration. C&I: Standard rates (+5% due to the high battery penetration)
Netherlands	[red]	[red]	Residential: Estimated rate of 36% (multiple sources) C&I: Estimated from Verticer register of installations (but incomplete list)
Poland	[red]	[red]	Residential: Estimated rate (tool). C&I: Standard rates
Portugal	[green]	[red]	All self-consumers have the same (high) SC rate.
Romania	[red]	[yellow]	Measured self-consumption rate for <200kW Standard rate used for commercial to do the split

	Available data		Key Hypotheses
Member State	Total self-consumed energy	Self-consumption rates by segment	Self-consumption rates hypothesis
Slovakia			Residential: Estimated rate (tool). C&I: Standard rates
Slovenia			Standard SC rates adjusted to match the total
Spain			Residential: Estimated rate (tool). C&I: Standard rates
Sweden			Average SC rates adjusted to match the total self-consumed energy

Table B- 2 Data availability & key hypotheses on the share of self-consumers by country

	Available data			Key Hypotheses
Member State	Number of self-consumers	Capacity of self-consumers	Capacity Split of self-consumers by segment	Self-consumers hypothesis
Austria				Segment distribution done to match the total average size of self-consumption
Belgium				All small-scale installations are self-consumers (very low FiT)
Bulgaria				All users after 2021 are self-consumers.
Croatia				Only residential SC today. C&I developing over time.
Cyprus				n.a.
Czechia		2015 only		Almost all consumers self-consume (Outdated distribution grid specificities lead to an incentive to self-consume).
Denmark				n.a.
Estonia				75% of self-consumers in 2020. All new consumers since 2020 are SC.
Finland				All small-scale installations are self-consumers (no alternative)
France				n.a.
Germany				n.a.
Greece				All small-scale installations are self-consumers
Hungary				All rooftop PV after 2018 are in SC No self-consumption for >250kW consumers
Ireland				100% of new small scale installations are in SC
Italy				Aggregated from statistics on the various SC mechanisms.
Latvia				70% of C&I are SC. Share increasing over time.
Lithuania				All residential installations are SC. 50% of C&I are SC, share increasing over time.
Luxembourg				No SC before 2021.
Malta				No SC before 2020 (FiT). After, 50% of new installations in residential and C&I are in self-consumption (Subsidy).
Netherlands				All small-scale installations are self-consumers
Poland				Most residential and small-scale businesses are self-consumers
Portugal				Recent stats extended to historical consumers
Romania				All residential and commercial installations are self-consumers
Slovakia				No self-consumers (Low development of small-scale PV and FiT, no existing data).
Slovenia				100 % of current residential installations are self-consumers Commercial estimated from the total (measured) No industrial self-consumer.
Spain				All small-scale installations are self-consumers
Sweden				All small-scale installations are self-consumers

Table B- 3 Data availability & key hypotheses on the forecast hypotheses by country

Member State	Source of capacity forecast (2026)	Source of capacity forecast (2030)	Self-consumption rates evolution hypothesis
Austria	National objective	National objective	Increase of SC rates due to battery penetration and development of heat-pumps.
Belgium	SPE	Average between Enerblue scenario and SPE's trend	Increase to 40% by 2026 stable in 2030. High residential prices and battery penetration.
Bulgaria	SPE	SolarPower Europe	Progressive increase of SC rates as home batteries slowly start to deploy. Heating already well-advanced in its electrification (38,5% of homes).
Croatia	SPE	SolarPower Europe	Progressive increase with the deployment of batteries but at a moderate pace, due to the lack of strong support by local authorities
Cyprus	SPE	SolarPower Europe's trend. 2026's distribution	Self-consumption rate expected to increase with the development of batteries and consumption flexibility
Czechia	SPE	NECP	95% of new residential PVPP in H1 2023 equipped with batteries.
Denmark	SPE	NECP	Progressive increase as batteries are deployed, uses are electrified and

Member State	Source of capacity forecast (2026)	Source of capacity forecast (2030)	Self-consumption rates evolution hypothesis
			consumption flexibility is deployed
Estonia	SPE	SolarPower Europe	Standard hypothesis
Finland	SPE	National objectives 50% share of utility scale in 2030 (Fingrid) 30% share of residential in 2030 (Sweco)	SC rates are stable due to their current high value.
France	SPE	Average between low and high national targets for 2028, rounded up. Distribution in line with national objectives	No increase of self-consumption rates. (low electricity tariffs)
Germany	SPE	National objective	Since 2023, bonus for installation fully feeding into the grid Strong penetration of BtM batteries expected
Greece	SPE	Average between SolarPower Europe's trend and Enerblue scenarios	Growth of the SC rate of residential customers due to a high battery penetration.
Hungary	SPE	SolarPower Europe's trend. 2026's distribution	No evolution of SC rates. (Low energy prices)
Ireland	SPE	National objective. Distribution in line with feedbacks from the local solar association.	Residential: stable. Increase of SC rates will be balanced by the increase of system size. Commercial: 15% increase due to high prices.
Italy	SPE	National objective	Progressive growth of the SC rates (+5% in 2026 and +5% in 2030) due to higher battery penetration and EV expected
Latvia	SPE	SPE	Standard hypothesis
Lithuania	SPE	NECP	Progressive increase due to the development of stationary storage (incentivized), and demand flexibility.
Luxembourg	SPE	SolarPower Europe's trend. 2026's distribution	With the development of batteries in the C&I segment, the self-consumption ratio is expected to increase.
Malta	SPE	SolarPower Europe's trend. 2026's distribution	With the development of batteries in the residential and, C&I segment, the self-consumption ratio is expected to increase.
Netherlands	SPE	Average of grid operators announced installed capacity, government target.	Residential: Expected increase of SC rates due to the progressive end of net-metering
Poland	SPE	SolarPower Europe's trend. 2026's distribution	Progressive increase expected since the uptake of heat pumps and stationary batteries is accelerating in the country.
Portugal	SPE	NECP	SC-rate already sky-high.
Romania	SPE	Enerfuture/Enerblue scenario	No evolution of self-consumption rates
Slovakia	SPE	SolarPower Europe's trend. 2026's distribution	Self-consumption rates should have a relatively strong tendency to increase in the future.
Slovenia	SPE	NECP	Possible increase (+10% by 2030) of SC rates (high grid fees and powerful incentive for home batteries)
Spain	SPE	National objective ; 2026's distribution.	No evolution of self-consumption rates
Sweden	SPE	2030: Enerfuture Scenarios (Enerblue) with 2026's distribution	Progressive growth of the SC rates (+5% in 2026 and +5% in 2030) due to higher battery penetration and EV expected

Self-consumption rates literature

The main methodology used in this study to estimate self-consumption rates at national level was to search data provided by national authorities (covering number of self-consumers, capacity installed, and self-consumption rates, either provided directly or calculated, for example comparing capacity installed for self-consumption with grid injection from self-consumers) and align it to common categories of self-consumers. When no relevant data was available at national level, we used established self-consumption rates to estimate the proportion of self-consumed energy.

These rates were identified and validated through desk research, as reported in the first interim report of this assignment. A total of 43 pertinent sources were analysed, which yielded 88 self-consumption rate values across three categories: residential, commercial and industry. Most of them (88%) belonged to the residential sector. In this set, 17 rates include values for systems equipped with batteries and EVs.

Using the average rates identified via desk research, we empirically defined standard self-consumption rates to be used if no other information was available:

- 35% for residential consumers;
- 60% for commercial consumers;
- 70% for industrial consumers;
- 90% for large-scale installations.

The approach used to estimate self-consumption rates varied among Member States based on data availability:

- In Member States where **self-consumption rates were provided by national sources**, these existing rates were used instead of standard self-consumption rates;
- In Member States where the total amount of self-consumed energy was available, we applied a correcting factor to the standard self-consumption rates, to match the existing data on total self-consumed energy.

Overall, standard rates were only used in three Member States (Poland, Spain, and Belgium), representing 24% of self-consumers' installed capacity.

Impact of Heat Pumps

Heat pumps offer a source of flexibility that could theoretically increase the self-consumption rate. However, their effectiveness in this respect depends widely on the temperature profile and the presence of a Home Energy Management System (HEMS).

Several studies have examined the impact of heat pumps for domestic hot water, combined with demand-side management, on the self-consumption ratio, but the results are as yet not clear. For example, a recent study on residential photovoltaic and heat pumps in Poland[142] suggests that such installations can increase the self-consumption ratio by up to 10%. The same study found significant differences in self-consumption values between winter (with lower insolation values) and summer: self-consumption in houses without an air-source heat pump ranged from 14.0% to 20.8%, while the self-consumption rate in homes with an air-source heat pump ranged from 17.0% to 21.5%. However, another study, also based in Poland,[143] contradicts this finding. For instance, a Polish study[144] (MPDI) conducted on a residential building in Poland These **contrasting results** highlight the challenges associated with quantifying and predicting the impact of heat pump deployment in the absence of these systems, which can vary considerably (see example below).

Consequently, we have decided **not to include the impact of heat pump deployment on self-consumption rates.**

---

[142] Energies | Free Full-Text | Increasing Energy Self-Consumption in Residential Photovoltaic Systems with Heat Pumps in Poland (mdpi.com)

[143] Energies | Free Full-Text | Impact of DSM on Energy Management in a Single-Family House with a Heat Pump and Photovoltaic Installation (mdpi.com)

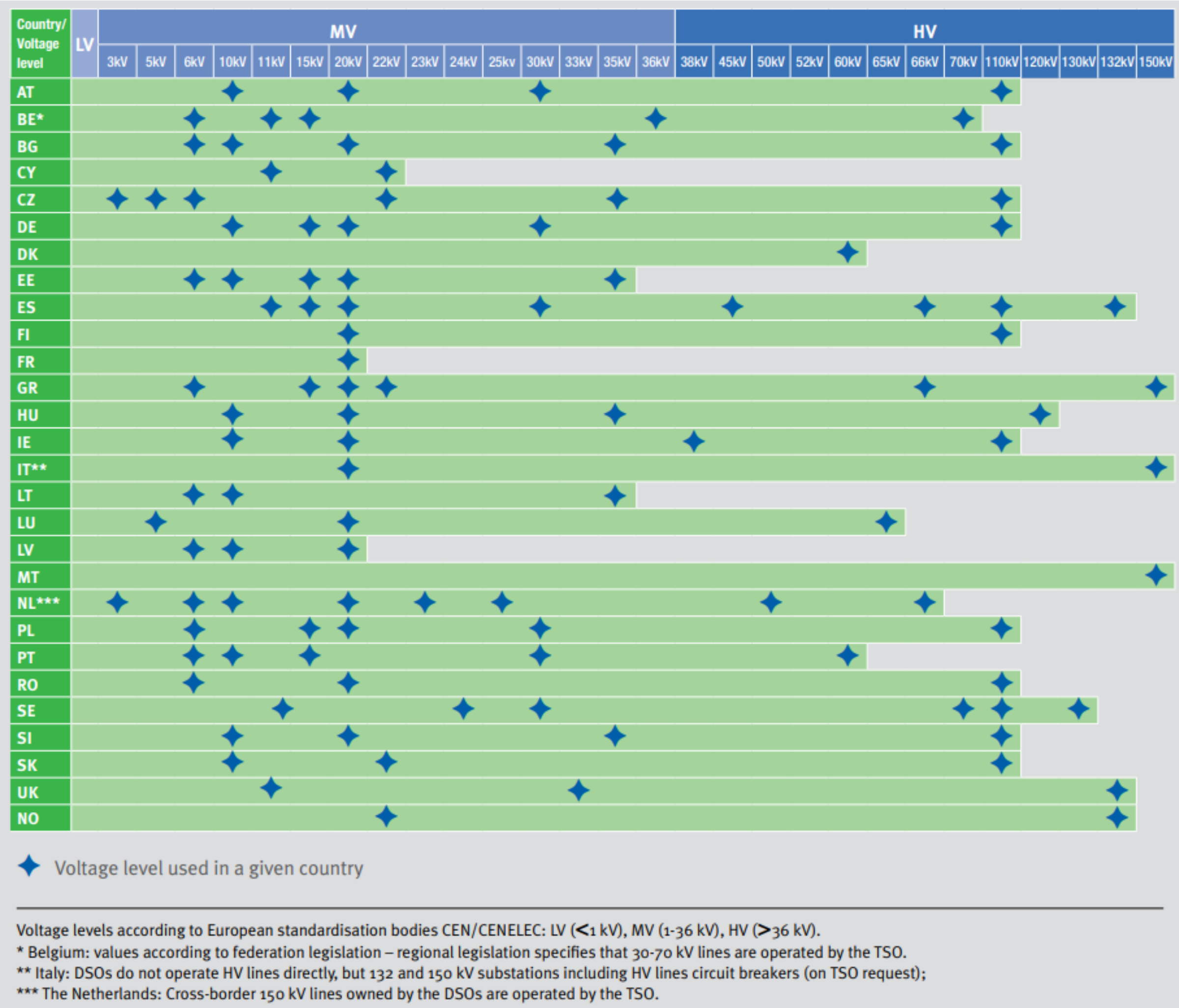
[144] Energies | Free Full-Text | Increasing Energy Self-Consumption in Residential Photovoltaic Systems with Heat Pumps in Poland (mdpi.com)

Alternative possible segmentations

There is not a clear cut definition of what a **"small-scale" renewable installation is.** The study team initially considered to focus on capacities connected to the distribution grid (Low Voltage and Mid-Voltage). However, several issues were identified:

- This information is not available in every country;
- For non-PV energy (in particular wind power) used the connection level can lead to the inclusion of large capacities that are not, and are not expected to be associated with, self-consumption;
- DSOs do not necessarily manage installations connected to Low of Mid-Voltage grids (only 6 Member States do) making it very difficult to identify such installations.

Figure B- 1 Voltage levels managed by Distribution System Operators in European countries (Eurobserv'ER 2013[145])



[145] https://cdn.eurelectric.org/media/1835/dso_report-web_final-2013-030-0764-01-e-h-D66B0486.pdf

An alternative option would have been to focus on **rooftop photovoltaic installations**. However, self-consumption installations are not always rooftop, and this level of detail is rarely given at national level.

ANNEX C – THE CONCEPT OF ENERGY SHARING

By proposing a definition for the concept of energy sharing, the EMD revision proposal introduces a new model for the consumption of electricity produced from renewable energy sources, collectively and remotely.[146] In the recitals of the proposal, the European Commission indicates that energy sharing should allow to:

- Create resilience against the effects of high and volatile wholesale market prices on consumers' energy bills;
- Empower a wider group of consumers that do not otherwise have the option of becoming an active customer due to financial or spatial constraints, such as energy poor and vulnerable consumers;
- Lead to increased uptake of renewable energy by mobilising additional private capital investments and diversifying remuneration pathways.

However, this expanded definition appears to further enlarge the concept of self-consumption by including offsite generation and storage beyond strict geographic limits, included in facilities not owned by the self-consumer. Further, it confirms the sale of electricity from another consumer can also count as self-consumption (already possible under RED II, Art. 21 Renewables self-consumers, peer-to-peer trading).

The EMD recast revises the definition of active customer by replacing the sentence "(…) or, where permitted by a Member State, within other premises(…)" (as defined in Article 2 of the IMED) by "(…) or self-generated or shared electricity within other premises located within the same bidding zone (…)". Hence, it introduces the geographical limit of the 'same bidding zone' for self-generated or shared electricity which was not foreseen by the IMED.

As per Article 15a of the EMD revision proposal, stakeholders that have the right to participate in energy sharing as active customers are all households, SMEs and public bodies. To facilitate energy sharing, they may also use a third party (which is not necessarily considered as an active customer) that owns or manages a storage or renewable energy generation facility. This is already possible in the framework of renewables self-consumers (as provided in Article 21 of the RED II) and allows for commercial energy companies to engage in energy sharing and their facilities be used to support self-consumption. In addition, the EC proposal foresees a role for relevant TSOs/DSOs, which have to monitor, collect, validate and communicate metering data about shared electricity with final customers and market participants at least every month. They must also provide a contact point responsible for energy sharing issues (i.e. registration of arrangements, provision and reception of information, validation of calculation method). Finally, the EC proposal requires Member States to take measures (e.g. financial support, production allocation quota) to ensure that people affected by energy poverty and vulnerable households have access to energy sharing.

In July 2023, the ITRE Committee of the European Parliament has proposed an amendment to the Commission proposal and agreed on its common position.[147] The Council is still

[146] BEUC-X-2023-104_Energy_sharing_whats_in_it_for_consumers.pdf

[147] Carriages preview | Legislative Train Schedule (europa.eu)

finalising its position and agreeing on its negotiating mandate. Trialogues are expected to start in Autumn 2023 in order to finalise the reform of the EMD by the end of the year.[148]

[148] European Parliament vote sends strong positive signal for renewables investments | WindEurope

ANNEX D – GENERAL CONSIDERATIONS

In general, the following statements apply to self-consumption:

- For the same level of consumption, the self-consumption rate is inversely proportional to the size of the generation system. The smaller the generation system, the easier it would be to reach higher self-consumption rates.
- In the absence of a storage device, the self-consumption rate is proportional to the average energy consumption of the building during the generating hours. The higher the hourly consumption during generating hours, the higher the self-consumption rate would be.
- Adding a storage device will significantly increase the self-consumption rate because consumers will be able to store the electricity during high-generating hours (instead of injecting it into the grid) and use it later during low-generating hours. Losses arising from the storage process should however be considered.
- Commercial buildings and offices used during daytime are often able to reach high self-consumption rates because their activity is focussed during sunny hours. This is however not the case during, e.g. week-end or public holidays, when there is no self-consumption in commercial buildings and offices. On the other hand, there is often a mismatch between the hours of peak consumption (generally, the morning and evening) and the hours of peak generation in residential buildings.
- The possibility to share electricity with neighbours (collective self-consumption) is likely to increase the self-consumption rate, as the combination of different consumption profiles may be a better match for the overall consumption curve.
- Some Member States allow for virtual self-consumption (when generation and consumption do not happen in the same site) and for collective self-consumption, even when the distribution network is used to distribute the energy among users. The network-related benefits of self-consumption are inversely related to the extent that the distribution network is used to transport the energy from the generation plant to the consumer. The higher the distance between generation and consumption, the lower the network benefits of self-consumption.
- Once a renewable generation system is installed, the main incentive to self-consume is given by the cost of consuming 1kW from the grid[149]: the higher the cost, the higher the incentive to self-consume. However:
    - If the energy injected into the grid is remunerated, the strength of the incentive depends on the difference between the total cost of importing 1kW from the grid and the remuneration for injecting 1kW into the grid. In the case of net-metering schemes, the differential is either zero or is given only by network charges and other costs, which is why this approach offers little incentive to self-consume. The highest incentive to self-consumption is when energy injected into the network is not remunerated (or a fee is charged). In this instance, prosumers have an interest to maximise their energy use during generating hours.
    - Volumetric network costs and other volume-related costs in the energy bill also play a significant role in the strength of the incentive to self-consume. This is because by reducing the amount of imported energy these costs will decrease as well. On the other hand, capacity-related and fixed charges discourage self-consumption, because these will not decrease with reduced consumption from the network.
- In order to exploit the benefits of self-consumption for the energy system, consumers should

[149] This is to be understood as total cost, i.e. including energy costs, network costs and taxes.

be fully exposed to market prices, both when consuming from and when injecting into the network. In general, the higher the granularity (frequency) of the exposure to market prices, and the frequency of update of these prices, the more effective the incentives would be. For example:

- A billing methodology which offers a different price for each hour of the day is more effective in providing the right incentives than a model where only two rates per day (peak and off-peak) are offered or a model where prices only vary once per month.
- In order to remove barriers to the optimisation of self-consumption, it is necessary to have in place the right regulatory conditions and the right economic incentives. However, to fully realise the potential of self-consumption it is necessary to consider other potential aspects, such as prosumers' understanding of self-consumption and the availability of technologies that can support prosumers in adapting their behaviours (for example, smart appliances that react to market data).

ANNEX E – METHODOLOGY FOR THE RECOMMENDATIONS

Figure F- 1 presents the methodology used to develop recommendations based on the legal and practical barriers identified in this study.

Figure F- 1 Methodology used to develop recommendations

The flow diagrams below explain the link between the barriers to self-consumption, the potential solutions, and the policy recommendations. The recommendations that have been prioritised and further developed in this report are highlighted in light blue.

Figure F- 2 Recommendations to address the barrier 'Complex and lengthy permitting processes'

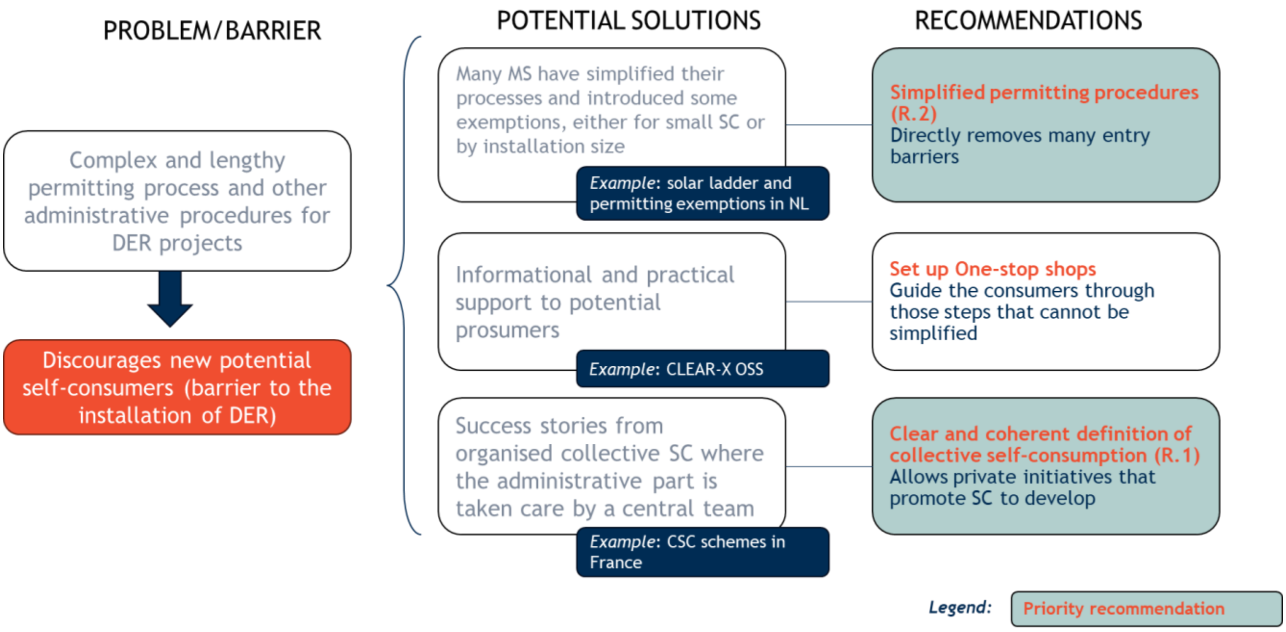


Figure F- 3 Recommendations to address the barrier 'Lack of regulation to address consent requirement to use the common property for multi-apartment buildings'

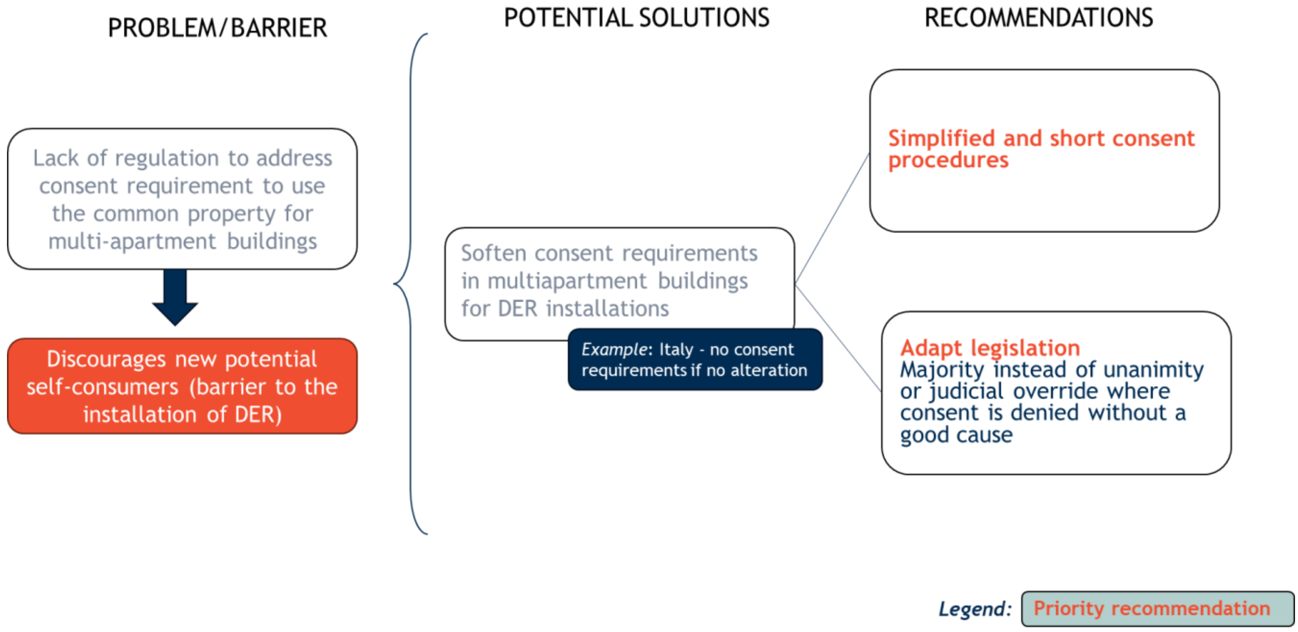


Figure F- 4 Recommendations to address the barrier 'Lack of staff/expertise with DER and storage'

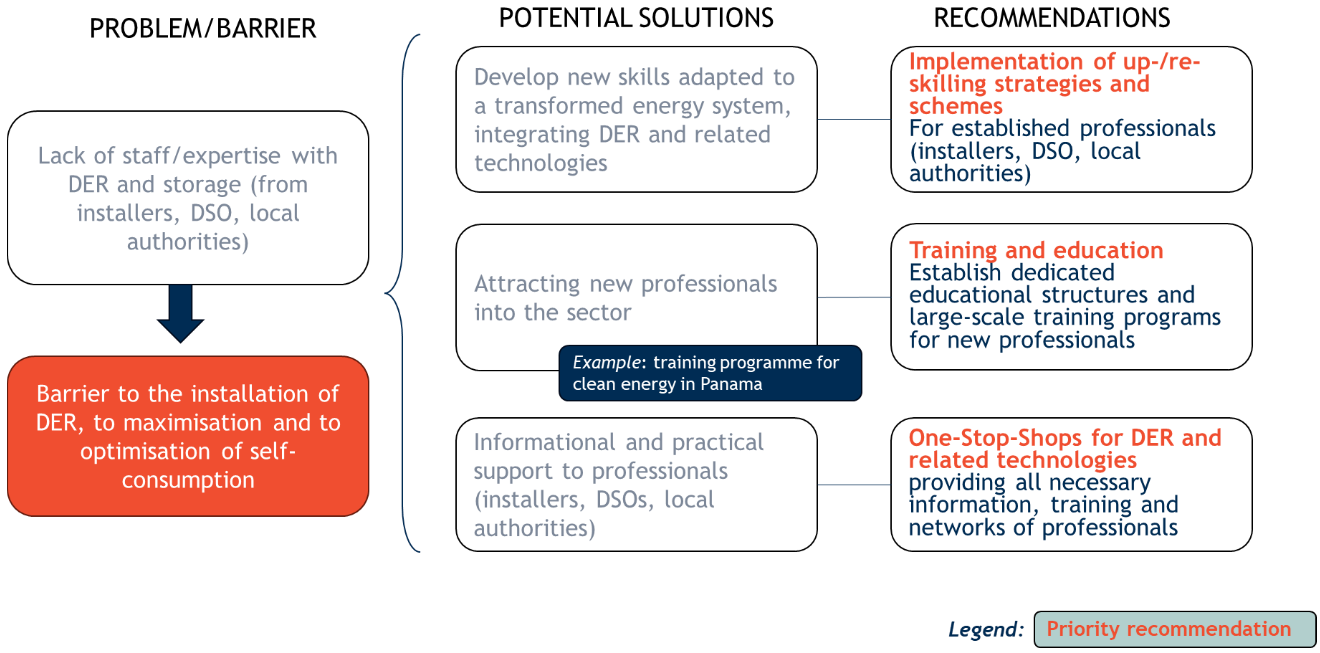


Figure F- 5 Recommendations to address the barrier 'Complexity of energy sharing'

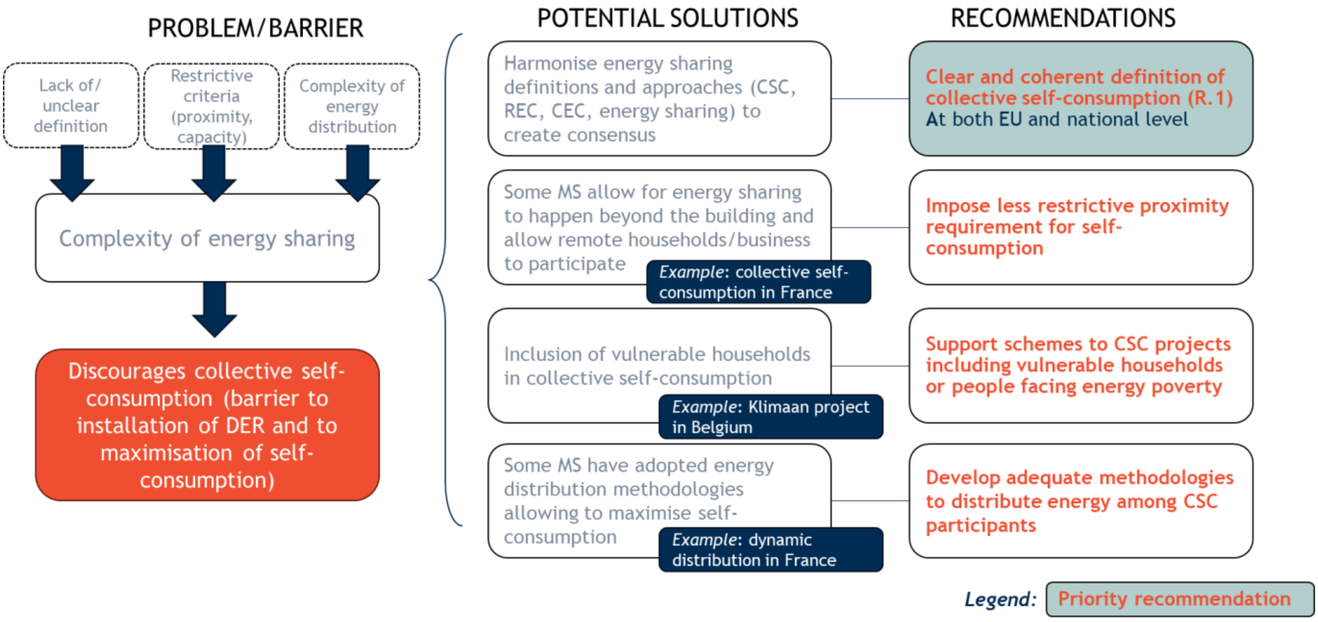


Figure F- 6 Recommendations to address the barrier 'Limited network capacity to accommodate new installations'

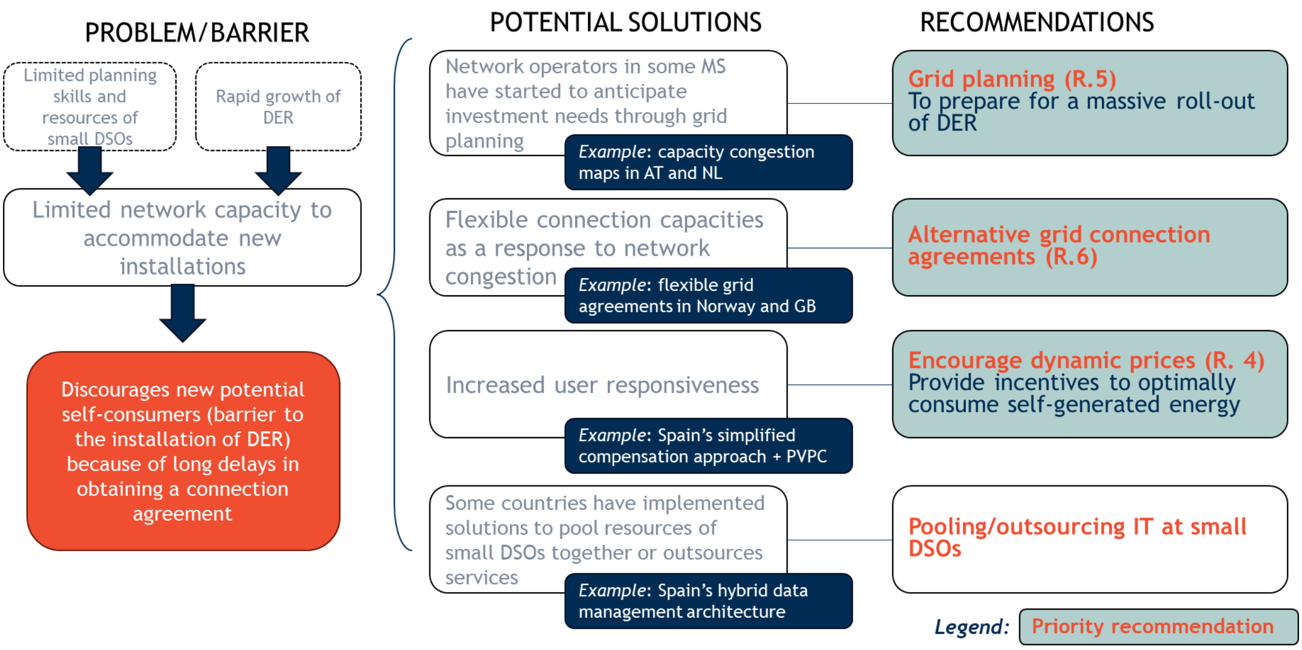
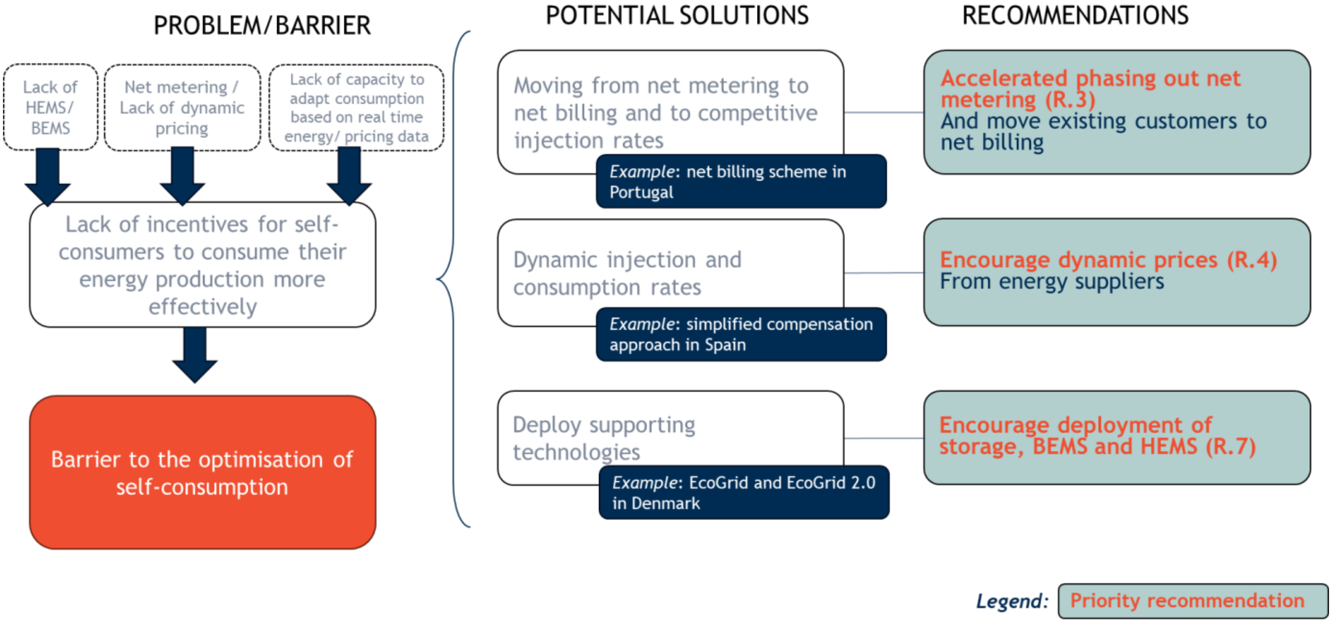


Figure F- 7 Recommendations to address the barrier 'Lack of incentives for self-consumers to consume their energy production more effectively'



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