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Multi-supplier models and decentralized energy systems: Energy sharing approaches

Report – Multi-supplier models and decentralized energy systems

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Content

Abstract

Energy sharing is the activity of administratively attributing renewable energy to consumers, where the renewable energy asset is controlled by those consumers in a shared role as a non-professional or non-profit producer. The main objective of energy sharing is to give all consumers access to renewable energy assets, i.e. the opportunity to participate in renewable energy projects and to benefit from the control of these assets. Energy sharing has already been implemented in various Member States.

By studying these implementations, we have identified that energy sharing facilitation requires to have the following elements in place:

- Agreements between energy sharing group members on how to share
- Validation of the sharing agreements
- Calculation of the results of energy sharing
- Administration of the results of energy sharing
- Settlement of the financial effects of energy sharing including compensation of stakeholders such as the Energy Supplier.

Energy community, energy suppliers and system operators can have a role in the facilitation of energy sharing. Recommendations for managing innovation through initiatives by

- DSOs can stimulate energy sharing by making it known and accessible to target consumers.
- Regulators should implement energy sharing with a view to both short term (what is needed to get it started) and long term (what is needed to scale it up and integrate it well with energy supply, flexibility services, etc.).
- Regulators should consider energy sharing in the context of network tariff reform: Energy sharing is not primarily about incentivising local consumption of energy, but energy sharing processes show when energy is shared locally. This makes it possible to incentivise local consumption of renewables, and this should be taken into account in network tariff reforms. Such an incentive (which should not be limited to shared energy) makes energy sharing more attractive and supports the integration of renewable energy in the electricity grids.

Recommendations for harmonisation:

- Integrate information exchange processes for energy sharing and multi-supplier models into the Harmonised Role Model (Entso-e, ebIX, EFET).
- Consider the use of more specific roles (such as used in the HRM) in EU and Member State regulation.
- Have open source projects that implement steps in the facilitation process and are independent of who the facilitator is.

Acronyms

Acronym	Full description
BRP	Balance Responsible Party
CEC	Citizens Energy Community
CIM	Common Information Model
DSO	Distribution System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity
ESCO	Energy Service Company
EU	European Union
GSE	Gestore dei Servizi Energetici
HRM	Harmonised Role Model
ICT	Information and Communication Technology
ISP	Imbalance Settlement Period
JARSC	Jointly acting renewable self-consumers
kWh	Kilo watt hours
LFC	Load frequency control
MDC	Metered data collector
MS	Member State
MV	Medium Voltage
MWh	Megawatt hours
PV	Photovoltaics
REC	Renewable Energy Community
RES	Renewable Energy Sources
TSO	Transmission System Operator
VAT	Value Added Tax

1 Introduction

In light of the EU climate targets, the energy system will face a profound transformation with respect to energy sources, digitalisation, actors and business models. The traditional generation and consumption structure will be complemented by more decentralised generation and storage facilities, and flexible consumption. The REPowerEU Plan has further promoted energy savings, diversification of energy supplies and scaling-up of the use of renewables energies. Therefore, decentralised production installations, digitalisation and other technological developments have progressed even more quickly than anticipated when the clean energy package was proposed. New business models, which increase consumer control over local electricity supply outside of the wholesale market context, will help consumers to access green power at an affordable price.

One group of such business models is established by implementing energy sharing, which already exists or is under development in various Member States. Since energy sharing is not defined nor coupled to an enabling framework, there is a lack of clarity about what energy sharing is and how it should be implemented on a European level. The goal of this study is to provide insights into this.

1.1 Energy sharing in EU law

Directive (EU) 2018/2001 (Article 2(15)) introduces the concept of jointly acting renewable self-consumers (JARSC). This is a group of at least two cooperating renewables self-consumers who are located in the same building or multi-apartment block. A renewables self-consumer is defined in Article 2(14) as "a final customer … 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."

The same Directive 2018/2001 defines a Renewable Energy Community (REC) in Article 2(16) as an autonomous legal entity based on open and voluntary participation and effectively controlled by shareholders or members located in the proximity of the renewable energy projects (which are owned and developed by that legal entity). The shareholders or members of RECs are natural persons, small- or medium-sized enterprises or local authorities, including municipalities. The primary purpose of RECs is to provide environmental, economic, or social benefits, for its shareholders or members or for the local areas where it operates, rather than financial profits.

Finally, Article 2 of **Directive (EU) 2019/944** (Internal Electricity Market Directive), introduces the concept of a Citizens Energy Community (CEC) as a legal entity based on voluntary and open participation whose primary purpose is to provide environmental, economic, or social benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits. In other words, the concept of CEC is very similar to that of the REC.

A feature that appears in all three concepts is energy sharing. As for CEC, Article 16 of Directive 2019/944 mentions the ability to arrange "the sharing of electricity that is produced by the production units owned by the community" among their members or shareholders based on market principles, even over the public network. For RECs, Directive 2018/2001(71) states that "Renewable energy communities should be able to share between themselves energy that is produced by their community-owned installations". Similarly, the same Directive states for JARSC that "Member States shall ensure that renewables self-consumers located in the same building, including multi-apartment blocks [...] are permitted to arrange sharing of renewable energy that is produced on their site or sites between themselves".

1.2 Current status of energy sharing

Energy sharing has already been implemented in various Member States, although on a small scale. The development of energy sharing implementations is ongoing in almost every member state. Interestingly, in Member States that already have energy sharing implementations in place, additional supporting tools are planned. This shows that energy sharing is in transition and evolving.

The **current implementations of energy sharing** in the Member States **are diverse**. For example, in Italy, energy volumes consumed and produced simultaneously on lower voltage parts of the grid are registered at a central entity such that the participants can request a pay-back of part of the grid charges. Here energy sharing has a delayed effect on the energy bill. This means at present, the consumers receive the bill from their energy suppliers but receive the benefits of sharing via a separate cash-back process.

A different example can be found in Flanders (Belgium). Here, energy can be shared at no cost from collective buildings (offices, apartment buildings, etc.) among the active consumers. The consumers benefit in terms of cost savings with respect to the energy component in their energy bill while grid costs and taxes still need to be paid, and their energy suppliers are compensated for the impact.

In this study, we explored the implementations and ongoing developments in selected countries that already have energy sharing implementations in place (Italy, Belgium, Luxembourg, Portugal, France and Slovenia) through literature and interviews with distribution grid operators and regulators. In addition, the preliminary result of a questionnaire among all Member States made available through DG ENER was used.

1.3 Societal and environmental benefits of energy sharing

Two benefits that are in focus in most energy sharing concepts are the reduction of CO_2 emissions and consumer empowerment.

Recent case studies reveal that energy sharing could significantly **reduce CO_2 emissions** and primary energy consumption due to the associated mobilisation of additional renewable capacity. Emission and energy savings are materialised, especially if cross-sectorial flexibility options such as heat pumps and e-mobility are included[1]. In the short term, flexibility options can increase local self-consumption and, thus, autonomy and, in the long term, reduce renewable surplus and curtailment on a system level.

Energy sharing can be an effective means to **empower consumers** that do not have access to roofs or other available space, or financial means to self-generate and/or store renewable electricity. Energy sharing enables them to own/rent/lease or otherwise have (shared) control over renewable installations. The empowerment of consumers leads to a growth in renewable energy investment (and so to CO_2 reduction), but also to financial benefits for these consumers: self-consumption of renewable electricity can dampen the effect of high and volatile wholesale markets on consumers' energy bills.

1 see Open District Hub Bochum-Weitmar, https://www.vonovia.de/de-de/wohnungen-in-bochum/odh-projekt-weitmar

1.4 Energy sharing in this report

In this report, we define energy sharing[2] as the activity of administratively attributing renewable energy to consumers where the renewable energy installation is controlled[3] by these consumers in a shared role of a non-professional or not-for-profit producer (e.g. as a member of an energy community)[4]. The (administrative) attribution of renewable energy empowers the consumer to take part in renewable energy generation or installations since participation would otherwise not be feasible or not attractive enough.

The main goal of energy sharing is to give all consumers access to renewable assets, meaning they have the ability to participate in renewable energy projects and benefit from them. This goal of consumer empowerment is in line with the description of energy sharing in the EU Directives 2018/11 and 2019/944 (see Section 1.1). It is important that non-professional consumers have control of the produced renewable energy by ownership of the production installation or via leasing, or renting the installation.

In this study, we explore various energy sharing implementations using an illustrative example:

Sharing in a multi-apartment building. Participants in this sharing arrangement are the following:
(1) five apartments with PV panels on their private terrace, consuming part of the production within the apartments and injecting the rest into the network,
(2) five apartments without PV panels, taking electricity from the grid;
(3) a photovoltaic system located on the roof of the building, which injects production directly into the public network – the PV system is owned and operated by the ten residents involved in the sharing arrangement (not necessarily all the apartments in the building).

In Figure 1, we show what energy sharing means using this example:

- The apartment building residents can share energy from the PV-installation on the multi-apartment roof because they have shared control over this installation. For example, they jointly own this installation.
- The apartment building residents can share energy from the PV installations on the balconies of some of the apartments because some or all residents of the other apartments have shared control over this installation. For example, the balcony owner owns the PV-installation and he rents part of the installation to his/her neighbours.
- The apartment building residents have a contract with at least one Energy Supplier. Together (as shared owners of the PV-installation on the multi-apartment roof) they have also concluded a contract with an Energy Supplier to feed in the electricity from this PV-installation.

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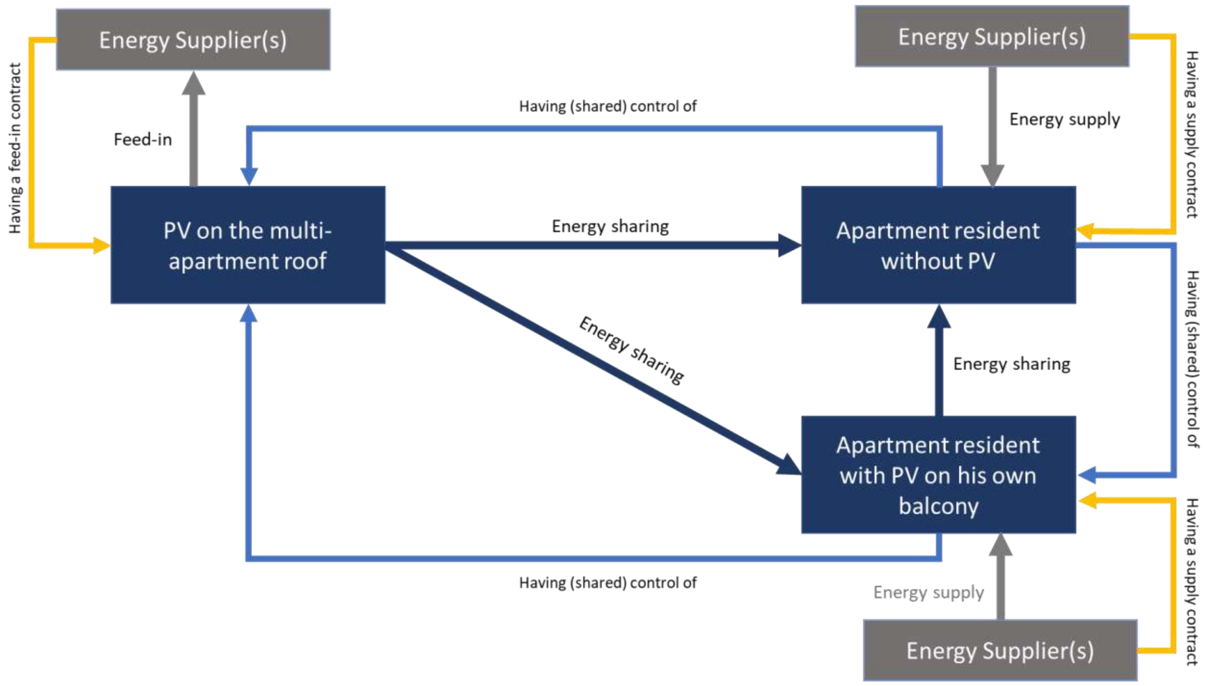
2 This definition is defined by the authors based on the EU directives mentioning energy sharing (see 1.2) and the lessons learnt in this project and should be seen as a suggestion to be discussed further.

3 The EU directives (2001/2018 2019/944) do not define energy sharing. The directives speak of energy sharing between members of an energy community or between jointly acting self-consumers. An important aspect is that the group of self-consumers or members of the energy community have some form of control over the production installation. Both directives speak of a production installation owned by the community and of self-consumers that generate energy for their own use. However, the RES directive also mentions that the production installation of the self-consumer can also be owned or managed by a third party, as long as the self-consumer maintains control; the third party is subject to the self-consumer instructions. To conclude: as long as there is a form of control over the production unit by the members/ shareholders or group of consumers that is engaged, sharing is possible.

4 The definition of a non-professional or not-for-profit producer is not clear and is an open question (see Chapter 5).

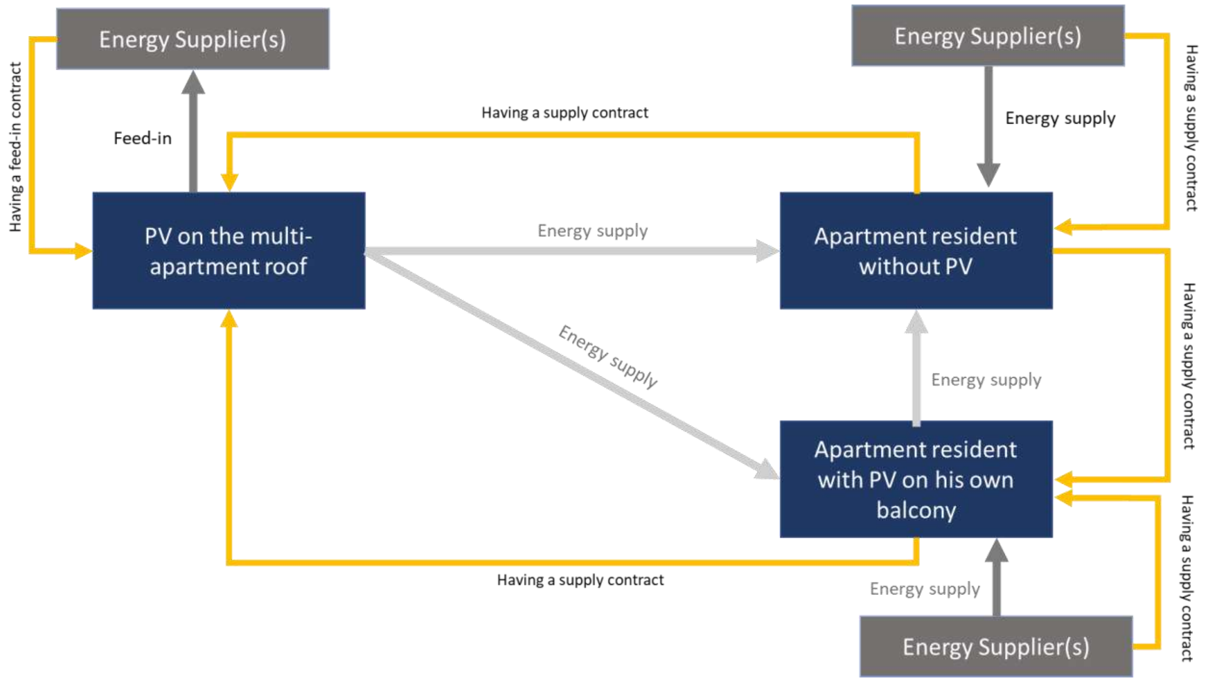
Figure 1 **Illustrative example where energy is shared from the PV installation of a multi-apartment building**



The situation of energy sharing is different from the situation of energy supply as shown in Figure 2. Having control of the renewable production assets is a requirement for sharing; having a supply contract is a requirement for supplying.

Distinguishing energy sharing from energy supplying can be difficult, since sharing can be implemented in multiple ways, including ways where sharing is implemented as a subtype of energy supply. This will be discussed in Chapter 3.

Figure 2 Same situation as in Figure 1 but now energy is supplied but not shared



1.5 Goal of the study

The goal of this study is to provide insights into the characteristics of various energy sharing implementations such that the following aspects can be evaluated:

- What is the economic impact on Energy Suppliers, network system operators and consumers (passive & active) of enabling final customers to receive both shared and supplied electricity?
- What is the appropriate allocation(s) of rights and responsibilities for system operators, service providers (Energy Suppliers, aggregators) and active customers that will allow different energy sharing implementations to emerge across Member States, while ensuring energy sharing can be universally operationalised in a cost-effective manner?
- What contracts and financial transactions are needed, and which data has to be exchanged between stakeholders?
- The answers to these questions should lead to a better understanding of what energy sharing is and what the implementation choices imply.

1.6 Scope of this study

This study discusses the complexity of having multiple parties supplying energy from the perspective of energy sharing. Other multi-supplier activities such as peer-to-peer trading are beyond the scope of this study.

This being an exploratory study, the geographical scope of this report is limited to a small number of countries. The energy sharing implementations in these selected countries are described and analysed. Based on these observations, current approaches and concepts are linked to efficient future implementation pathways, and recommendations for upcoming regulations are provided, together with remaining gaps.

Key aspects in the analysed cases are:

- Allocation of balancing responsibility (if applicable) for shared electricity.
- Allocation of the responsibility to collect grid charges and taxes.

- Metering requirements and ICT implementations in new and existing systems.
- Definition and set-up of how energy is shared (using sharing keys[5]) between stakeholders.
- Geographical and locational boundaries for energy sharing.

A broad assessment of implementation pathways in EU Member States is not foreseen and goes beyond the scope of this study.

1.7 Terminology in this study

This study uses the definitions of roles and responsibilities mentioned in EU directives 2018/2001 and 2019/944. In addition, we use the ENTSO-E Harmonized Role Model (HRM)[6] to describe the role of parties involved in energy sharing implementations more specifically. The HRM is useful in this study since it "has identified a given role whenever it has been found necessary to distinguish it in an information exchange process". See Table 1 for the definitions of the HRM roles used in this study. Sometimes we also introduce new roles and definitions, just for the purpose of this report. They can be found in Table 2.

The term Distribution System Operator is also used in this study. According to the HRM, the DSO frequently plays the role of a System Operator, a Metering Point Administrator and the role of a Grid Access Provider.

Table 1 Harmonised Role Model definitions used in this study

Harmonised Role	Definition
Producer	A party that generates electricity. This is a type of Party Connected to the Grid.
Consumer	A party that consumes energy. This is a type of Party Connected to the Grid.
Party Connected to the grid	A party that contracts for the right to take out or feed in energy at an Accounting Point (see for definition the role Energy Supplier).
Energy Supplier	A party that supplies electricity to or takes electricity from a Party Connected to the Grid at an **Accounting Point**, which is a domain under balance responsibility where Energy Supplier change can take place and for which commercial business processes are defined. An Accounting Point is also a **Metering point**, which is an entity where energy products are measured or computed. A Party Connected to the Grid can have more than one Energy Supplier but only one at each Accounting Point. When additional suppliers are needed, the Energy Supplier delivers/takes the difference between established (e.g. measured or calculated) production/consumption and the (accumulated) contracts with other suppliers.

5 Members of the sharing arrangements "can share their generated power using static or variable allocation coefficients... static coefficients allocate their generated power every hour with the same sharing ratios. In turn, ... variable coefficients can assign different percentages to each user on each hour." (Manso-Burgos, A., Ribó-Pérez, D., Gómez-Navarro, T., & Alcázar-Ortega, M. (2022). Local energy communities modelling and optimisation considering storage, demand configuration and sharing strategies: A case study in Valencia (Spain). Energy Reports, 8, 10395-10408.)

6 https://eepublicdownloads.entsoe.eu/clean-documents/EDI/Library/HRM/Harmonised_Role_Model_2022-01.pdf

Harmonised Role	**Definition**
System operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.
Balance Responsible Party	A party that is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment within a given imbalance settlement period[7].
Balancing Service Provider	A party with reserve-providing units or reserve-providing groups able to provide balancing services to one or more LFC Operators who is responsible for the load frequency control for its LFC Area or LFC Block. This role is typically performed by a TSO.
Energy Service Company (ESCO)	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. The Energy Service Company (ESCO) may provide insight services as well as energy management services.
Metered data responsible	A party responsible for the establishment and validation of measured data based on the collected data received from the Metered Data Collector. The party is responsible for the history of metered data for a Metering Point.
Meter administrator	A party responsible for keeping a database of meters. A **meter** is a physical device containing one or more **registers**, which are physical, or logical counters measuring energy products.
Metering point administrator	A party responsible for administrating and making available the Metering Point characteristics, including registering the parties linked to the Metering Point.
Metered data administrator	A party responsible for storing and distributing validated measured data.
Metered data collector (MDC)	A party responsible for meter reading and quality control of the reading.

[7] The imbalance settlement period (ISP) is defined in Commission Regulation (EU) 2017/2195 as the time unit for which the imbalance of the balance responsible parties is calculated (Article 2(10)): https://emissions-euets.com/internal-electricity-market-glossary/603-imbalance-settlement-period#:~:text=Commission%20Regulation%20(EU)%202017%2F,(Article%202(10)).

Table 2 Other definitions used in this study

Roles defined for the purpose of this study	Definition
Energy Sharing Group	A group of Consumers and Producers that share energy between their members (e.g. an energy community or the owners association of a multi-apartment building).
Energy Sharing Group Representative	A party or person representing the Energy Sharing group (single point of contact for other stakeholders).
Sharing Request Validator	The role in charge of the validation of a sharing arrangement.
Sharing Result Calculator	The role in charge of calculating the result of the energy sharing.
Sharing Result Administrator	The role in charge of registering the amount of energy shared.

2 The advantages of energy sharing for consumers

Energy sharing will be attractive if the consumers involved benefit from this activity, mostly in monetary terms. In other words, there should be a financial incentive to share energy. These financial benefits can be found in various elements of the prosumers'[8] energy bill.

2.1 Energy bill elements

The prosumer's energy bill contains various cost elements: sourcing costs, network charges, taxes, and balancing costs, and, although this is not always explicit, the prosumer also pays for the administration and billing.

For simplicity and in line with the 2016 Ecofys study Prices and costs of EU energy[9], we group all energy costs into three categories: **energy** (sourcing/wholesale energy costs for either consuming or feeding in energy, including balancing and administration fees), **taxes** (VAT, energy taxes and possibly levies for sustainable energy support) and **network-**related costs (grid charges including costs for grid losses).

2.2 Location matters?

A *locational constraint* for energy sharing arrangements could apply when the ability to share energy between a production location and a consumption location is limited, due to the 'distance' between the two. The distance can be described in **kilometres, address distances** (postal codes / house numbers) or by **grid topology distances** (same LV grid area, behind the same transformer, etc.).

It is interesting to notice that energy sharing implementations are intended to take grid topology distances (according to memoranda of national regulatory frameworks) into account but in the actual implementations (this is what is validated in reality) address distances or kilometres are used.

A locational constraint can apply to energy sharing in general or to a certain benefit such as network costs reductions. In this chapter, we discuss the financial benefits in relation to these locational constraints so we cover both options. We use a generic description of locational constraints (**house, building, close proximity and whole country)** instead of how the distance is calculated to allow comparisons between various Member States.

2.3 Reference energy bills

To show the financial benefit of energy sharing, we compare the energy bill of prosumers in the case of energy sharing with relevant *reference energy bills*. These references represent situations that are relevant to compare the situation of energy sharing. What is relevant depends on the motivation to implement energy sharing:

- If the main motivation is to improve the current baseline situation for consumers with no access to renewable energy, it is relevant to compare energy sharing against the situation where these consumers consume electricity via their Energy Supplier.
- If the motivation is equality in access to renewables, a relevant reference situation is the situation of reference consumers (e.g. consumers that already have access to a roof or financial means and so can invest in renewable energy).

[8] Here, we use the word prosumer since energy sharing affects both feeding in energy and consuming energy.
[9] Prices and costs of EU energy – Ecofys BV study, 2016, https://energy.ec.europa.eu/prices-and-costs-eu-energy-ecofys-bv-study_en

For the purpose of this study, we assume that both motivations can play a role. Table 3 shows the reference energy bills we take into account.

Table 3 Reference cases for assessing the energy bill effect of energy sharing of a certain energy sharing implementation in a specific Member State

Energy sharing	Reference i (**baseline** situation)	Reference ii (situation of **reference consumers**)
Consume shared energy by using a certain form of energy sharing implemented in the Member State	Consume supplied energy from a typical commercial Energy Supplier active in the Member State.	Self-consume renewable production behind the meter in the Member State.
Produce shared energy by using a certain form of energy sharing implemented in the Member State	Feed in energy via a typical commercial Energy Supplier active in the Member State.	None

The consumer should have shared control of the production asset, so he can also be seen as the producer. When looking at the energy bill effect mapping, we split these two perspectives (as shown in Table 3). However, to fully evaluate the effect on the energy bill of e.g. typical household prosumers, both views must be combined.

2.4 Visualising the energy bill effect per kWh

In the energy bill, costs and revenues are not all calculated per kWh, but can also depend on peak load. For example, to compare energy sharing implementations in various Member States, we simplify our view on the energy bills by looking only at the marginal price per kWh: What are the costs of an extra kWh consumption shared vs supplied vs self-consumed? What are the costs and revenues of an extra kWh production shared vs. sold via an Energy Supplier?

The costs and revenues per kWh for all situations are visualised in a graph where the x-axis shows the energy bill categories **energy, network and taxes**[10]. The y-axis shows the constraints by location (**house, building, close proximity and whole country)**.

For the example case introduced in Chapter 1, we assume a certain energy bill effect. These effects are introduced only for the purpose of illustration of the energy bill effect mapping, and so represent an energy sharing implementation in a fictive Member State:

- In Figure 3, the energy bill effect mapping for consuming shared energy (by both the apartment building residents with and without PV) is visualised: shared energy in this example is compared to reference i (supply from the Energy Supplier). The effect on the **network costs**, the **energy** costs, and the **taxes** (only the VAT) is reduced compared to reference i. Compared to the reference ii ('self-consumption behind the meter'), we illustrated a situation where **taxes** apply

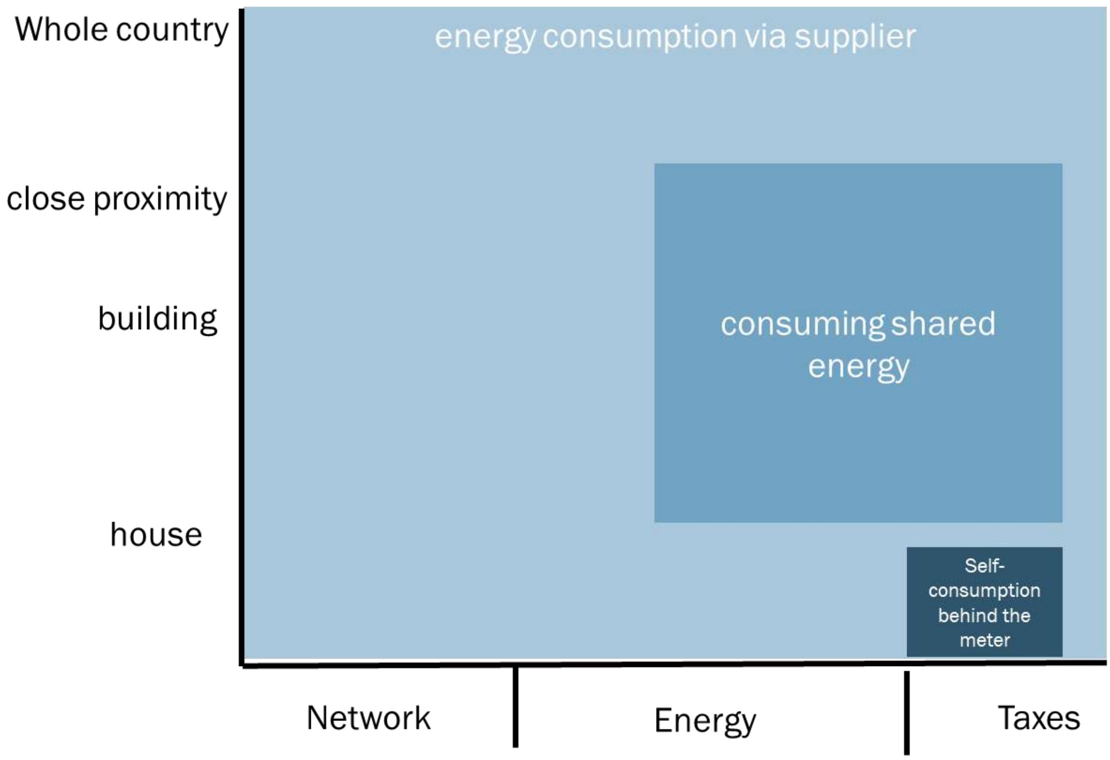
[10] Since a qualitative comparison of the reference situations was out of scope of this study, the size of the axes is arbitrary: the size of the axes is not representing how the energy bill categories relate to each other in size. For future work, we advise to include also a qualitative comparison.

to self-consumption behind the meter[11]. Compared to reference ii, energy sharing is less attractive per kWh, however, more kWh could be potentially shared than self-consumed.

- In Figure 4, the energy bill effect mapping for producing shared energy is visualised (by the households with PV on the balcony and the multi-apartment roof PV installation). In this illustrative example, the residents with PV receive more energy revenues for shared energy (they receive a better price from the consumers they share the energy with) than for feed-in via the Energy Supplier, and also all **network** costs[12] are reduced.

To assess the combined effect of this energy sharing implementation on the residents of the multi-apartment building, insights from Figure 3 and Figure 4 need to be combined[13].

Figure 3 Example of energy bill effect mapping for consuming shared energy



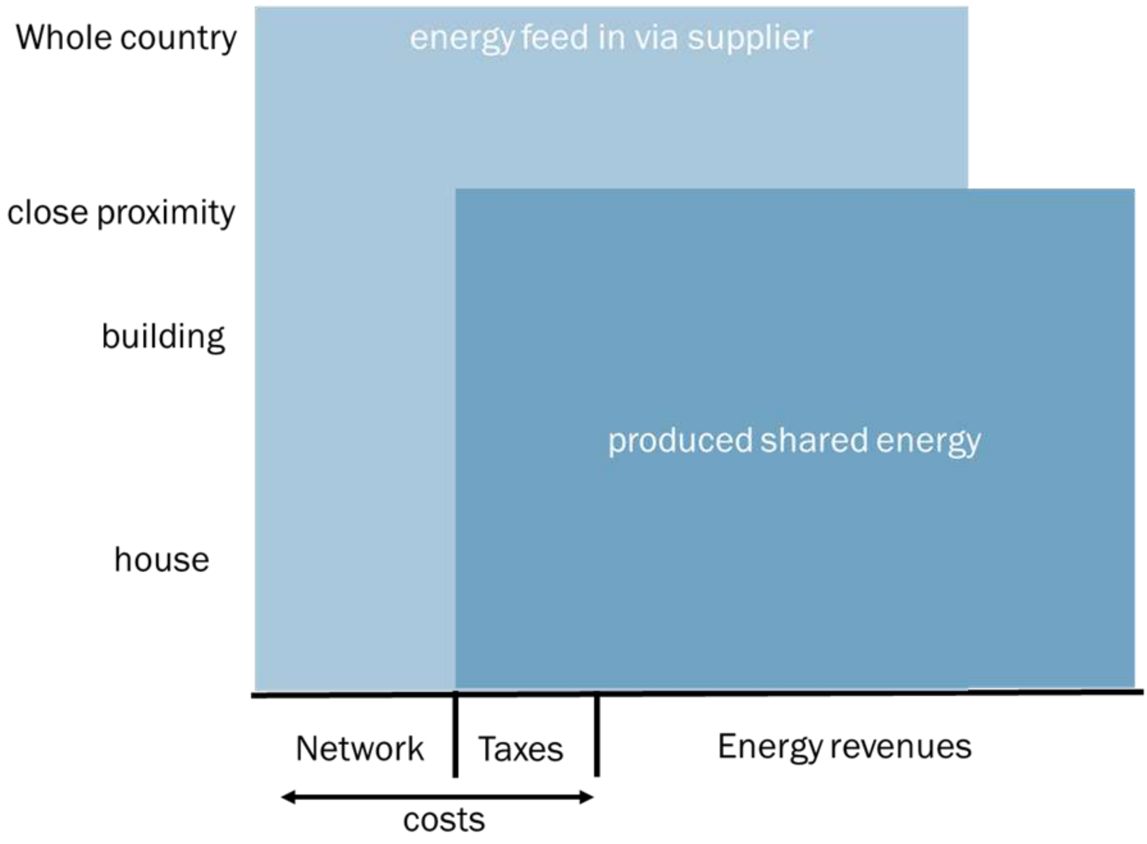
The x-axis is not scaled and only illustrates the difference in the energy bill in three hypothetical situations (energy consumption via a commercial Energy Supplier, consuming shared energy and self-consumption behind the meter). The y-axis, also not scaled, provides insight into whether the type of activity is only possible in case of certain proximity between consumer and producer.

[11] Taxes can apply to self-consumed electricity under conditions outlined in Article 21 RED II, however in practice, self-consumption behind the meter is not measured and so no taxes can be charged.

[12] In the example case, we assume that for the feed in of energy grid costs also apply, however, this is not the case in many Member States.

[13] For the example case, we did not quantify the energy bill effects, the impact described here is assumed to follow from such a quantitative comparison from the perspective of the majority of the residents in the multi-apartment building. In practice, this requires an individual assessment: e.g. for a resident with PV on his balcony, who spends a lot of time at home, during solar peak hours, energy sharing may not be more attractive than self-consumption behind the meter.

Figure 4 Energy bill effect mapping for producing shared energy



The example illustrated here shows a difference between sharing produced energy and feeding in electricity via the supplier. The producer of shared energy receives more for his energy and sustains no network cost.

3 The process of energy sharing

This chapter provides a first rough answer on what needs to be in place such that energy can be shared. In other words: what is the scope and precondition of an energy sharing implementation? In the example introduced in Chapter 1 the multi-apartment energy sharing group is used to illustrate what needs to be done in each step of the process. The steps outlined in this chapter are discussed in more detail in the remainder of this study.

Figure 5 Steps of the process that facilitates energy sharing

3.1 Step 1 'Energy sharing contract'

The consumers in the multi-apartment building agree on sharing energy with each other and define the details of their sharing arrangement in a contract. We assume that the consumers have already arranged the control of both the roof-top PV installation and the PV panels on the balconies of some of the residents: it is clear who owns/rents/leases the installations.

One element of the contract is the definition of how the amount of energy shared will be calculated (see Step 3). Another element of the contract is to define a sharing group representative: this role can be taken by one of the members of the sharing group but they can also decide to hire a professional that can represent that sharing group. The tasks of the sharing group representative will be discussed for each step in the process.

Under this step, we also include all updates of the energy sharing contract, e.g. when new members enter the sharing group or a different sharing calculation method (see Step 3) is chosen.

The residents of the multi-apartment building agree on sharing the energy produced by the PV installation at the multi-apartment roof and the PV panels on the balconies with the residents of the 10 apartment buildings. Every resident has an equal stake in these PV installations, so they decide to share the energy equally between all residents up to the amount of energy consumed by a resident at the moment in time. If for example 10 kWh is produced by the PV installations, every resident receives 1 kWh if it has at least 1 kWh consumption at the moment in time. If a resident is not at home and his consumption is 0.1 kWh, the remaining 0.9 kWh are divided over the nine other residents. In the contract, they also assign a professional company as the energy sharing group representative.

3.2 Step 2 'Sharing arrangement validation'

The sharing group representative requests the *Sharing Request Validator* (in Chapter 7, we discuss who can take this role) to validate the sharing arrangement, i.e. to check if it does not violate constraints set by the regulator: for example, he/she needs to check the *location constraints* (see Section 2.2) or the *metering requirements* (see Section 4.3). The sharing group representative provides the information required for this validation: e.g. the identifiers of the Metering Points involved, information about the residents, and the sharing contract.

In the fictive Member State where the multi-apartment energy sharing group resides, energy sharing is possible within multi-apartment buildings. The DSO is assigned the role as Sharing Request Validator by regulation and will check if the members of the sharing group live indeed in a multi-apartment building.

3.3 Step 3 'Sharing result calculation'

The Sharing Group Representative requests the *Sharing Result Calculator* (in Chapter 7, we discuss who can take this role) to calculate the result of the energy sharing in one or more time windows. The sharing group representative provides the Sharing Result Calculator the identifiers of the Metering Points needed for the calculation and the type and parameters of the sharing calculation method. The Sharing Result Calculator applies the sharing calculation method to the data and returns this back to the Sharing Group Representative.

In the example, the DSO in its role as Sharing Result Calculator calculates the amount of energy shared to each resident at a certain time window, for example, between 15.15 and 15.30 on the 13 February 2023. First, the DSO calculates the total production of all PV installations (on the roof and the balconies) which is 10 kWh. Second, the DSO calculates the amount each resident can receive which is 1 kWh. One resident is not at home and his/her consumption is 0.1 kWh. 0.1 kWh is assigned to this household and the remaining production, 9.9 kWh, is divided among all other 9 residents. The DSO provides the result to the Sharing Group Representative.

3.4 Step 4 'Sharing result administration'

The sharing group representative requests the Sharing Result Administrator (in Chapter 7, we discuss who can take this role) to register the results of the sharing calculation at a location where it should be registered such that it leads to financial benefits for the members and ensures that all stakeholders that should be informed about the sharing receive the information. In Chapter 5, we discuss what these locations could be.

The Sharing Group Representative[14] *provides for the multi-apartment sharing group the results of the sharing calculation (see step 3) to the Sharing Result Administrator which in this example is the DSO. The Sharing Result Administrator registers the result of the energy sharing in the central data hub of the Member State such that it leads to a change in the energy bill that the consumers receive from their Energy Supplier.*

3.5 Step 5 'Settle implications of sharing'

Settlements resulting from energy sharing include:

- Settlement of the reductions of grid charges and taxes by the *Charges and Levies Responsible Party*.
- Paying fees to the energy sharing facilitator(s). These compensations are provided by the *Stakeholder Settlement Provider*.
- Compensation of stakeholders on which the energy sharing has an impact on their revenues or responsibilities. These compensations are also provided by the *Stakeholder Settlement Provider*.
- Financial settlement between the energy sharing group members by the *Sharing Group Settlement Provider*.

The settlement of the reduction of energy costs, grid charges and the VAT is taken care of by the Energy Supplier of each consumer. As a result of step 4, the Energy Suppliers are informed (via the central data hub) about the energy sharing volumes. The Energy Suppliers charge the residents a lower price for the shared energy. This price should cover for administrating the shared energy on

[14] or the Sharing Result Calculator in case the results can directly be send by the party taking up this role (e.g. a DSO who both is the Sharing Result Calculator and the Sharing Result Registrar.

the bill, collecting the remaining taxes and for sourcing[15] the energy. The Energy Suppliers of the producing Accounting Points (the roof-top and the produced electricity of the balcony residents) also charge taxes but will not ask for a price for the administration and sourcing/balancing, etc., since they (the Energy Suppliers) takes these costs into account on the consumer side. There is no financial settlement between the energy group members required since they assume each member will consume what they produce on average. The extra energy revenues, as shown in Figure 4, are therefore an estimation based on the profits from the investment in the PV installations.

[15] In this example, we assume the Energy Supplier is aware of the sharing contract of his customers so that he can take this into account in his sourcing strategy. Since the sharing arrangement of the multi-apartment building residents includes dependencies on what other consumers do (if someone is not at home, this consumer receives less and others receive more), this makes the sourcing strategy more complex, in particular, when he has no access to the metering data of the other residents (who might have another Energy Supplier).

4 Calculating the amount of energy to be shared

Determining the amount of energy shared from multiple production installations to multiple consumers is not straightforward. The Sharing Result Calculator, the facilitator of this task (this can, for example, be a DSO or the representative of an energy sharing group) has to collect the relevant data and should apply on this data rules or an optimisation procedure to determine the volume shared to each consumer.

We saw in Section 3.3 that the example multi-apartment building residents like to distribute the energy equally over each other but will only share energy with residents that use that energy at that moment. In this chapter, we categorise this and other calculation methods, discuss the pros and cons of each category, and discuss the measurement requirements for these calculation methods.

4.1 Calculation methods

We distinguish three sharing calculation methods:

1) The calculation method 'proportional sharing keys' is defined as: the volume measured at a production installation is attributed to the consumers by calculating the product of the volume and the sharing key. The sharing key defines the proportion of the total produced electricity that should come to this consumer, for example 1/10 for each of the residents in our example of the multi-apartment sharing group.
2) The calculation method priority list of consumers attributes energy using an order. First, energy is attributed to the first consumer on the list until his maximum is reached. For this methodology, you also need to define this maximum. This can be a fixed value or it can be dynamically defined as the measured consumption of the consumer.
3) The third calculation option is to use pro-rata sharing keys. This calculation option uses the consumption of the consumers to calculate the amount that should be attributed to each consumer. This approach distributes the shared energy such that all consumers get the same percentage of their consumption as production.

There are also sharing calculation methods applied by Sharing Result Calculators that optimise the energy sharing[16]. These kind of optimisation approaches do not need to be defined in detail, since the underlying calculation methods are proportional sharing keys. However, the sharing keys will be defined dynamically for every time window.

For example: a variation on the proportional sharing key is to add a cap to the shared energy for each consumer as the measured consumption, as is the case in our "multi-apartment sharing group" example. The energy that cannot be shared with a certain resident is shared among the other members (using the same proportional sharing keys).

The introduction of optimisation approaches brings us to a second aspect of the calculation process: what are the time constraints for changing parameters (meters, the calculation method, or the sharing keys)? To keep it simple, we distinguish between two categories; (1) the frequency of revision of parameters is seen as **static** if the change should be fixed for a longer period of time (year, month, day), and (2) the frequency of revision is **dynamic** if the parameters can be changed also for different time windows during the day.

[16] For example, in Portugal, a DSO is piloting an optimal sharing calculation method.

4.2 Pros and cons of the calculation methods

Consumers need to have control over the renewable energy installations that produce the energy they want to share. An easy way to divide the control is to define proportional sharing keys: define for each consumer the share he has in the installation. If a consumer controls 1/10 of the installations, he/she also has the right to receive 1/10th of the renewable energy produced by these installations. The straightforward link with the control is an advantage of proportional sharing keys.

Since renewable production is volatile, there are both moments of excess production and moments of shortage. We assume that at the moment of excess the members can (still[17]) feed in the energy of PV installations via an Energy Supplier or Energy Trader[18]. As shown in Chapter 2, this results in less financial benefits per kWh for the energy sharing group. At moments of shortage, we assume the Energy Supplier (still[17]) supplies the energy, this also results in less financial benefits than when energy is shared. Since there are financial benefits for the whole sharing group, optimising the amount of energy shared makes sense. The calculation method's priority list and pro-rate sharing keys do this, but they cannot take into account the proportional stake that each member has in the renewable energy installations. The 'proportional sharing key with a cap' can provide both the optimisation of sharing the produced energy and the proportional shares, but a choice for such a key adds some complexity to the calculation.

Optimising the sharing of the produced energy can also provide an incentive for consumers to shift their demand or use energy storage to shift their net consumption in time. This can be seen as a form of implicit demand response. Individual consumers that provide this flexibility to the sharing group might like to receive the benefit (or enough money to cover the cost of the flexibility activation) instead of spreading it over the whole sharing group. Proportional sharing keys that can be defined dynamically by an optimisation algorithm can provide this, but the support of this kind of optimisation is complex and, therefore, more cost-intensive.

In case the energy sharing has an impact on the amount of energy supplied by the Energy Supplier, the dynamic frequency of revision (of sharing keys or other parameters) will also make the Energy Supplier's task to source energy more complex and may, thus, add extra costs to the energy sharing.

4.3 Metering requirements

The most important input of the calculation method are measurements of renewable energy production. This requires that participating renewable energy installations should be measured at least at the time scale that applies for energy sharing which is typically within the Imbalance Settlement Period[19]. Many calculation methods also require consumption measurements, and these should also be measured at this time scale. Smart meters and metering installations at renewable energy production site are suitable.

The question is whether production measurement should be completely separated from consumption, meaning that dedicated metering installations are required instead of a Smart Meter that registers the (near real-time) difference between production and consumption behind the meter. This question is mainly about whether or not to allow stacking of self-consumption behind the meter and energy sharing.

[17] It depends on where the registration of energy takes place whether the Energy Supplier supplies during sharing or not.
[18] This includes also aggregators
[19] https://emissions-euets.com/internal-electricity-market-glossary/603-imbalance-settlement-period

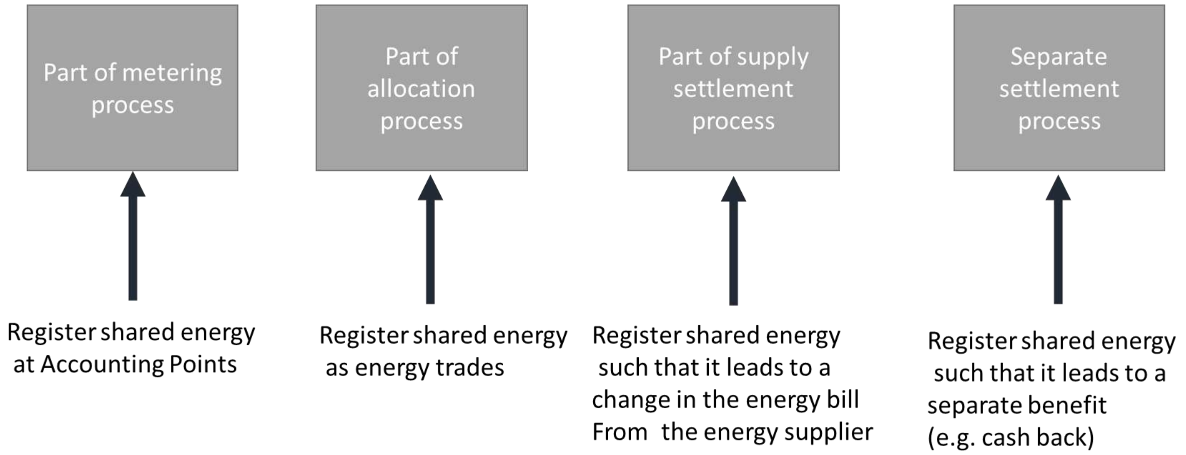
5 Registration of energy sharing

Energy sharing is an administrative process. The physical flow of energy will not be affected by sharing energy; it only attributes production to certain consumers. To make this attribution (calculated by the Sharing Result Calculator) result in the intended benefits (as we defined in Chapter 2 for our multi-apartment residents), the result should be registered so that these benefits will be realised. The Sharing Result Administrator facilitates this step in the energy sharing process, which can be a dedicated professional administrator or a DSO.

5.1 Where to administrate energy sharing results?

The administration of the energy sharing results can take place at various places, see Figure 6. Where it is registered determines the level on which energy sharing and energy supply administration processes are integrated: the *supply-sharing administration integration levels*. The figure shows the sequential order of the supply business processes from left to right. In the text below, we describe what it means to register energy sharing in these processes from the right to the left since the complexity increases when going left.

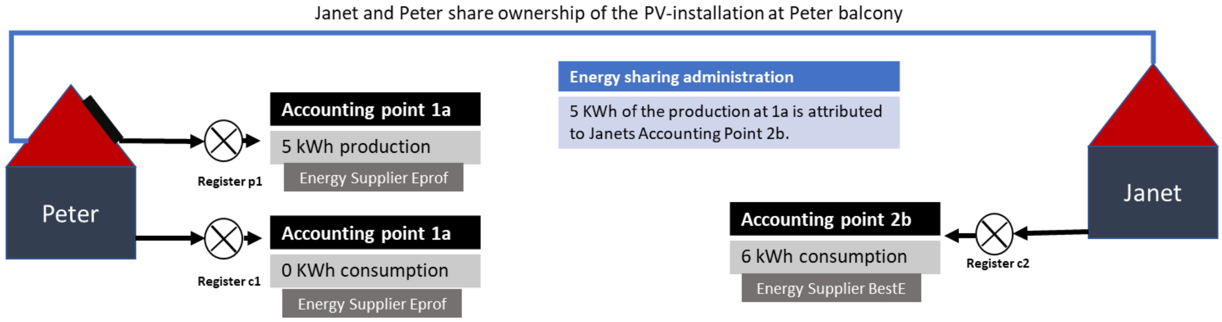
Figure 6 Registration of shared energy: where to do the administration?



First, energy sharing can be registered in an administrative process that is separated from the registration of supply (see Figure 7). Energy that is shared is registered separately – and does not follow the business processes for registration of energy supply. In this case, energy sharing can only indirectly affect the responsibilities of the Energy Supplier. For example, energy sharing could lead to a consumer using his home battery to increase the amount of energy he can share.

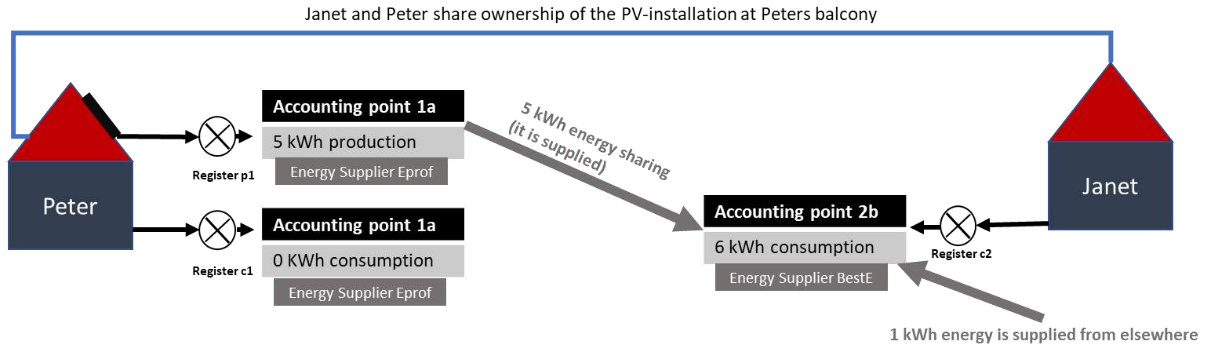
Figure 7 **Administration of energy sharing separately from the allocation processes for registration of energy supply**

The administration can 1) be integrated in the settlement process for energy supply such that the benefits of energy sharing come via the energy bill of the Energy Supplier, or 2) result in an extra settlement process.



Second, the results of energy sharing can be administrated as part of the supply settlement process (see also Figure 7). In this way, the benefits of sharing come via the Energy Supplier's energy bill. In this case, it is important to identify how sharing impacts the business processes of the Energy Suppliers and whether new processes (notification processes, compensation processes) and/or obligations for Energy Suppliers should be implemented to ensure that this impact will not become a barrier for energy sharing.

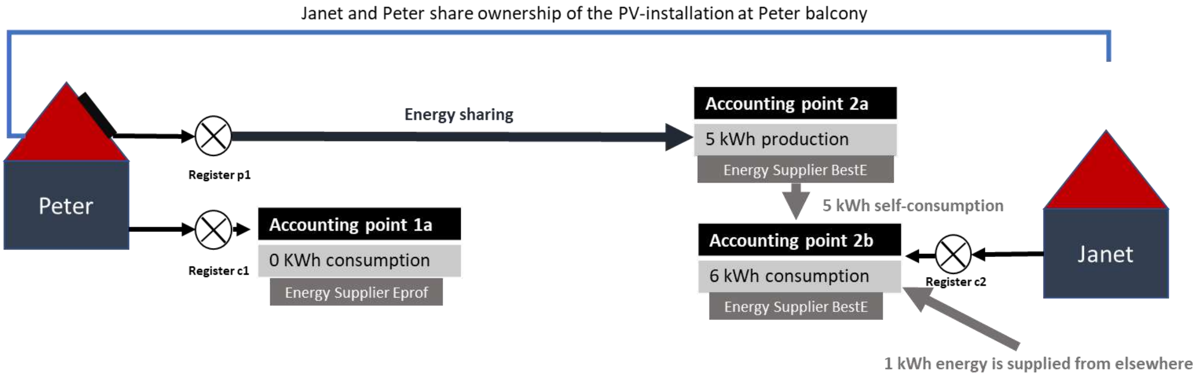
Figure 8 **Administration of energy sharing as part of the allocation process. In this case, energy sharing is a subtype of energy supply**



Third, Energy sharing can be registered as supply. Here, sharing is a subcategory of supply (see Figure 8): shared energy is also supplied, which means the parties that share energy are also each other's Energy Suppliers. This type of sharing requires a regulatory framework and supply administration systems to support this **multi-supplier** situation. It is important to define how the responsibilities (e.g. balancing responsibility and collecting grid charges and taxes) between the different Energy Suppliers are divided.

Fourth, energy sharing can be registered as part of the process of administrating production and consumption measurements (see Figure 9). In this case, sharing is seen as a process of registering calculated production and consumption at Accounting Points, which define the amount of supply or feed-in a certain Energy Supplier is responsible for. Shared energy is registered at an Accounting Point of the consumer instead of being registered at an Accounting Point of the producer. This means that the energy production that is calculated as the shared production of a certain consumer is registered in a similar way as the production of renewable energy behind the meter.

Figure 9 Energy sharing is registered at an Accounting point of the Consumer instead of an Accounting Point of the Producer



5.2 Requirements for information exchange

Depending on where energy sharing is administrated it can lead to an impact on responsibilities of the Energy Supplier. Where such impact applies, there is a need to share information about the impact. This is shown in Table 4. Energy sharing can have an impact on other responsibilities such as billing and providing insights into the sources and environmental impact of the energy supplied. These are not considered in this report.

Table 4 The impact of the registration of energy sharing on Energy Suppliers' responsibilities

Sharing is registered as part of	Balance responsibility	Collection of grid charges and taxes
Metering process	Yes, the energy sharing leads to a change in volumes that fall under a certain Energy Supplier and so a certain BRP.	If a reduction on grid charges or taxes applies for energy sharing, the Energy Supplier has to take this into account when he invoices his customers involved in sharing arrangements.
Allocation process	Idem.	Idem.
Supply settlement process	No, volumes on the perimeter of the BRP do not change under influence of energy sharing.	Idem. Furthermore, the Energy Supplier might change his procedure to calculate the volumes that apply to grid charges and taxes, since he should also take into account the energy sharing: he cannot take the values registered at the Accounting Points.
Dedicated settlement process	No impact.	No impact. If a reduction of grid charges or taxes applies, this is taken care of in the dedicated settlement process.

5.3 Pros and cons of supply-sharing administration integration levels

To what extent should the administration of supply and sharing be integrated depends on the maturity of energy sharing.

Option 1, a dedicated administration process is the easiest option to implement since it does not impact the processes of energy supply and, therefore, has no impact on the Energy Supplier's responsibilities. A disadvantage of this option is that the result of the energy sharing is not directly integrated in the consumer's energy bill. Another disadvantage is that the Energy Supplier still supplies the shared energy. Therefore, a reduction in the energy component cannot be realised and so this dedicated process can only be used to settle discounts on the network charges and taxes.

Option 2, to administrate the energy sharing such that it changes the volume on the consumer’s energy bill but has no impact on the balancing position of the Balance Responsible Party, shows the impact of energy sharing on the bill that the consumer receives from his Energy Supplier. This advantage also has a drawback: the Energy Supplier should cooperate here (either voluntarily or forced by regulation), and resettlement is needed to compensate Energy Supplier that can invoice less energy than supplied. This compensation can be provided by a zero-sum redistribution (see Section 8.1.6) for how this is done in Flanders). Still, it is challenging to make this redistribution accepted by both the Energy Supplier of the consumer and the Energy Supplier of the production installation unless this is the same party.

The third option, to implement energy sharing as energy supply has the advantage that it creates a way to consume the energy shared directly and not via the Energy Supplier. In many cases, energy sharing cannot completely replace energy supply: consumers sharing energy still need an energy supplier that supplies energy when there is not enough renewable energy production available in the energy sharing group. Also the energy sharing group or the individual consumers cannot take up the responsibilities of an Energy Supplier.

This third option requires a **multi-supplier model**, where responsibilities typically associated with the Energy Supplier can be divided over multiple parties that are an Energy Supplier or are supporting energy supply. Multi-supplier models can be optional, which means it is possible to divide responsibilities if the Energy Suppliers and other relevant parties contractually agree on the division or can be regulated: the regulator specifies how the division of responsibilities should take place.

The fourth option, registering the energy shared between the Accounting Points of the consumers, requires changing the meaning of an Accounting Point, which nowadays is a measured and not a calculated volume. These virtual Accounting Points cannot be used to calculate the load in a certain grid area, so this option requires a design that takes into account other business processes using measurements registered at Account Points. This option fits well with the essence of controlling a renewable installation. Therefore, it can also work in a single-supplier model. However, we see in Table 4 that it impacts the Energy Suppliers' responsibilities.

6 Impact on stakeholders

As introduced in Section 3.5, settlements resulting from energy sharing include the compensation of stakeholders, whose revenues or responsibilities are influenced by energy sharing.

In this chapter, we take a closer look on what the effect is on these stakeholders and identify the associated costs for three selected 'impacts'.

Table 5 shows what the impact is on the Energy Supplier and Balancing Responsible Party (BRP) in relation to sourcing and balancing. There might be more responsibilities, so this is not a complete inventory.

Table 5 Impact of energy sharing on stakeholders

Impact	Associated cost
Supplier made costs for sourcing the energy but did not receive benefits from the consumer.	The energy price paid otherwise to the Energy Supplier, without grid charges and taxes.
Balance position changed by energy sharing since renewable energy is removed or added to the balancing perimeter of a BRP. See Table 4 when this is the case.	The associated costs depend on the mismatch between the (at BRP-level) forecasted consumption or production and the actual consumption and production. If the BRP is not informed ahead, this imbalance is the total volume of energy sharing. If the BRP is informed, there is still a change that energy sharing will have higher balancing costs. First, because renewable production has in general higher balancing cost than household consumption, and second, because the effect of energy sharing is more complex to predict. In many Member States, the balancing costs of small prosumers are socialised, so this extra cost is shared with other consumers (who might not share energy).

In a multi-supplier model, it is possible to shift the responsibility of sourcing or balancing to another Energy Supplier.

7 Costs of energy sharing facilitation

All steps of an energy sharing implementation (Chapter 3) need to be facilitated. In the previous chapters, we introduced the facilitation roles and briefly mentioned what kind of party could take such a role. In this chapter, we look at the costs of the facilitation of energy sharing, which requires us to look at what it means for parties like the DSO, the Energy Sharing Representative, or the Energy Supplier to have this role.

First, we identify the costs of the facilitation without looking at who is the facilitator; second, we discuss these costs in the context of three implementation options and describe the pros and cons of each implementation option.

7.1 The costs of energy sharing facilitation

The facilitation of each step in the process comes at a certain cost. Both variable costs and investments costs can apply. Table 6 describes per step in the process what needs to be implemented and what kind of investments or operational costs are associated with the facilitation. The investment costs in ICT systems come also with operational costs for maintenance, security, and monitoring of these systems. These costs we do not mention in the operational cost table, only specific costs for energy sharing are mentioned.

Table 6 Description of costs of the facilitation of energy sharing

Step in the process	Investment costs	Operational costs
Contracting	The Energy Sharing Group has to agree on the sharing arrangement. There might be costs of involving a notary or other professional in this process. Requests for mandates from members to changes parameters of the calculation method might require an information exchange process (API, (e)-mail).	
Validation	Automated validation checks need to be implemented.	There might be operational costs related, especially if there are manually checks required.
Calculation	ICT should be in place for: collecting the relevant metering data[20], read input parameters provided by the sharing group representative (e.g. via API or file sharing), apply the calculation method on the data. Report the results of the calculation to the sharing group representative and/or the Sharing Result Administrator.	

[20] We assume that all which will be used is already verified for other purposes

Step in the process	Investment costs	Operational costs
Administration	A dedicated administration may need to be set up (option 1) or a process should be implemented that provides the facilitator the rights to add information about energy sharing to supply business processes (options 2 and 3) or metering processes (option 4).	
Settlement		
Grid charges and taxes (if applicable)	ICT functions should in place that can calculate the grid charges and taxes that apply to shared energy volumes.	If a separate invoice needs to be send, additional operational costs (mainly financial aspects .e.g. dealing with non-paying customers) are due.
Paying fees to facilitator (if applicable)	Integrate the fees into the energy bill or create a dedicated process to calculate and invoice the fees.	idem
Compensation of stakeholders (if applicable)	A dedicated calculation and invoicing/cash-back process for compensation of stakeholders should be implemented.	idem.
Intra-sharing group (if applicable)	When the energy sharing group is the facilitator, it is possible to do this less professional. If a regulated party settles the intra-sharing group payments, this requires a much larger investment in ICT.	idem

7.2 Facilitators of energy sharing

We identified three parties that can play a role in the facilitation of energy sharing. The energy sharing group representative, the Distributed System Operator (DSO) and the Energy Supplier[21].

Three energy sharing prototypes are developed to explore the differences between three fundamental different implementations. For each of these prototypes, we discuss the pros and the cons. An assessment of all combinations of facilitators is out of scope of this study. In general, we would expect that adding more facilitators will lead to more costs since this involves more (privacy- and competition-sensitive) information exchanges. Therefore, we limit the scope of our study to energy sharing implementations that are facilitated mainly by one party.

[21] It is also possible that a dedicated professional party facilitates a specific step in the process, but this option will not be further discussed. We assume that this option will have similar costs compared to the option that the DSO takes that role in the process, except for the fact that the DSO has already ICT in place to read, mutate and process meter data.

7.2.1 The DSO as main facilitator

In this prototype, the DSO is the main facilitator. By assigning the DSO as the main facilitator, the amount of actions is minimised for the Energy Supplier and the Sharing Group Representative. In this prototype, the DSO facilitates steps 1-5. The energy sharing group representative's task is limited to requesting the DSO to start the facilitation, providing the details of the members and their entry point as well as the sharing calculation method and related parameters such as sharing keys.

Such implementation fits best with a situation where energy sharing is highly regulated and/or energy sharing needs a boost. In such a situation, Energy Suppliers will not offer energy sharing propositions because this impacts their business cases, and new companies providing energy sharing propositions cannot set up the required facilitation processes. Therefore, this option is good for kick-starting energy sharing in a Member State.

7.2.2 The Energy Supplier as main facilitator

In this prototype, the Energy Supplier(s) of the involved Consumers and Producers are facilitating energy sharing. We consider a situation with minimal regulation, assuming that Energy Suppliers are not forced by law to facilitate energy sharing, but have enough incentive to offer energy sharing propositions.

For each task, one of the Energy Suppliers will be assigned to take care of the facilitation. The assignment and also the division of responsibilities between the Energy Suppliers can be arranged via contractual agreements (maybe there is generic agreement that most Energy Suppliers in the market agreed on).

This way of facilitation is possible without involving the regulator. However, reductions of grid charges or taxes require regulation. We expect that Energy Suppliers will first start supporting energy sharing between their own customers. Energy Suppliers can facilitate all steps in the process, however, audits and control may be needed to check correct implementation and to prevent misuse.

The advantage of this implementation is that it requires less regulation and the facilitation investment is made by Energy Suppliers (maybe with subsidy). The question is whether Energy Suppliers start offering energy sharing propositions. Availability of information exchange standards and processes that support facilitation or the introduction of a reduction in grid charges or taxes for energy sharing may provide the trigger. Given that energy sharing is defined in EU directives, Member States cannot wait for Energy Suppliers to provide energy sharing propositions. Furthermore, a negative side effect of facilitation by Energy Suppliers can be that the right to switch Energy Suppliers is limited in practice.

7.2.3 Energy Sharing Group as main facilitator

In this prototype, the Energy Sharing Group is the main facilitator. Only the validation and formal administration is carried out by a regulated party, such as the DSO or a dedicated party. This is a key difference from the Energy Supplier prototype: we consider Energy Sharing Groups as less professional parties than Energy Suppliers.

The advantages of the Energy Sharing Group as main facilitator are that the requirements for the systems to be implemented are lower compared to the other two prototypes. However, it is not sure if this leads to lower total costs of implementation, since each Energy Sharing Group has to organise the sharing facilitation. Probably, professional companies offering energy sharing facilitation software are needed because the facilitation is still quite complex.

A disadvantage is that this option requires much more effort from consumers who want to start sharing energy. They not only need to organise themselves, but they also need to organise the facilitation.

8 Current energy sharing implementations in Member States

Selected current or planned energy sharing implementations in Member States are mapped. This report provides a detailed analysis on Belgium (Flanders) and Italy.

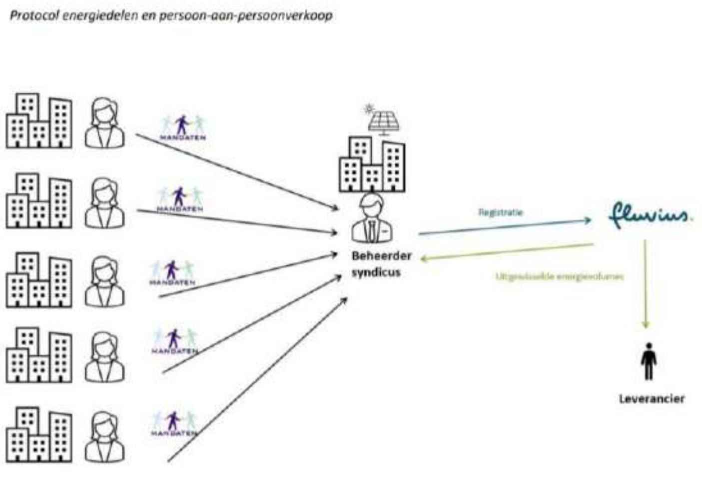
8.1 Belgium (Flanders)

In Flanders (Belgium), energy sharing is defined as a 'costless' allocation within one Imbalance Settlement Period of all or part of the self-produced renewable energy injected into the distribution grid or other local grid between active consumers in a building, members of energy communities, or between grid entry points owned by the same active consumer[22]. A prosumer cannot share energy with himself/herself but can be both producer and consumer in a sharing group.

Energy sharing is mainly facilitated by the DSO. Furthermore, the consumers and producers sharing energy should select a sharing group representative, so the DSO has one point of contact.

In addition to energy sharing, it is also possible in Flanders to sell energy peer-to-peer. When selling energy peer-to-peer, it is allowed that the producer receives a payment for the energy sold. Energy can only be sold 'peer-to-peer' between two entities or between multiple producers to one consumer.

Figure 10 Sharing energy in a community in Flanders: the participants assign a sharing group representative (‚Beheerder') who communicates with the DSO (‚Fluvius'), the main facilitator of energy sharing



8.1.1 Energy bill effect

In Belgium, energy can be shared by[22]:

- Active consumers in a shared building: sharing renewable energy produced on the roof of the apartment building with consumers that are residents of the building. This applies also to shared office buildings: energy can be shared with the companies using the building.
- Between grid entry-points owned by the same active consumer: the renewable energy produced at your (first) house can be shared with your holiday house. This applies to all buildings with the same owner including, for example, municipalities.

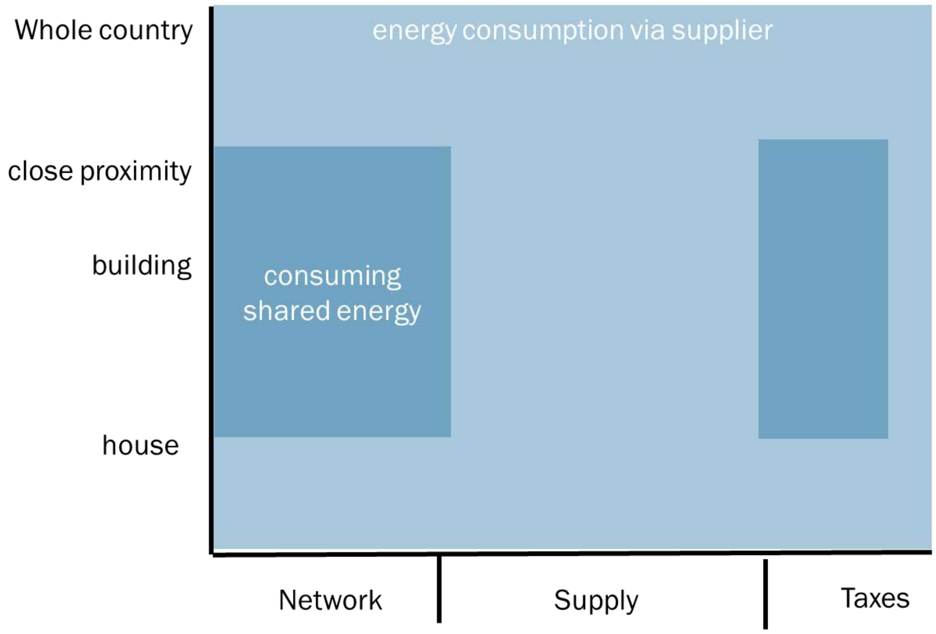
[22] https://www.vreg.be/sites/default/files/document/bijlage_1_-_protocol_energiedelen_en_p2p_-_derde_versie.pdf

- Members of a Citizen Energy Community or Renewable Energy community: the renewable energy produced by the community is shared with the members of the community.

All of these implementations have in common that sharing is at no cost ('kosteloos'): the producer cannot charge any price for the energy shared from the consumer. In this way, sharing is mainly attractive for production sites owned by, or otherwise linked to, the consumers of the shared energy. Network charges and taxes are not affected by sharing: the consumer should pay the network charges as if the shared energy was supplied by the Energy Supplier.

The consumer of shared energy receives energy without paying any costs for the supply: no sourcing costs, no administration costs, and no VAT (which we consider as part of the taxes). Figure 11 illustrates what this means for the consumer's energy bill compared to consuming energy via the Energy Supplier. Compared to the case of self-consumption behind the meter (which has no kWh-related costs), we observe that sharing is less beneficial, since network charges and taxes still apply.

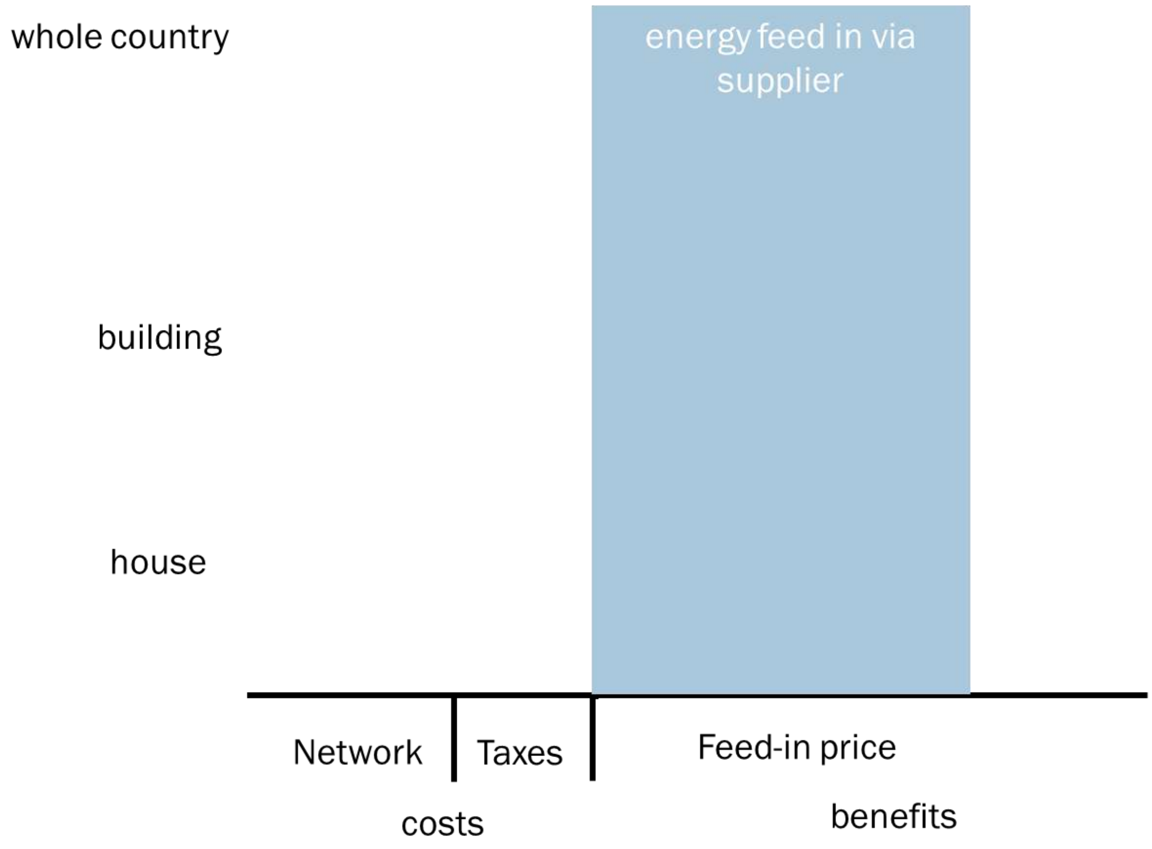
Figure 11 Energy bill mapping consuming prosumer in Belgium (Flanders)



The producing prosumer(s) cannot ask a fee from the consuming prosumer(s). Compared to the situation of energy feed-in via the Energy Supplier, this reduces the income of the producing prosumer. If the producer and consumer of shared energy are the same entity or are connected in another way, this might not be a problem: the benefits of sharing are higher than the losses of not receiving a feed-in price for the shared energy.

Figure 12 Energy bill mapping producing prosumer in Belgium (Flanders)

From this perspective, energy sharing is not beneficial, since no feed-in price can be charged (we cannot visualise it in the figure since the costs and benefits are zero). For small producers, grid charges and taxes do not apply.



8.1.2 Contract

The members of the sharing group have to assign a sharing group representative, which can be either one of the members or a third party. This sharing group representative can request the DSO to facilitate the energy sharing for the group. The DSO will ask all members of the sharing group to verify the mandate of the sharing group representative. The sharing group representative has the mandate to add new members to the sharing group or change parameters of the sharing calculation: the sharing keys.

8.1.3 Validation

The DSO performs some 'ex-ante' tests to verify meter requirements (a digital meter or equivalent (for MV grid connections) is required). Furthermore, the DSO checks the fact that the energy shared is produced by a renewable installation and whether the grid entry points of the members of the sharing group are part of an energy community, have the same owner or are in the same building. The calculation method will also be verified: the sum of sharing keys should be 100%.

8.1.4 Calculation

There are three types of sharing keys, which can be changed daily:

- Static proportional sharing keys with a cap on the amount of consumer consumption. The production that cannot be shared stays (pro rata) at the producers, they can sell it via a feed-in contract.

The DSO also offers two optimisation services using dynamic proportional sharing keys (the DSO can change it for every time window when using these optimisations):

- Single-step optimisation: This option shares pro rata the unused share of a prosumer (a grid energy point), who acts both as producer and consumer.
- Iterative optimisation: first, energy will be shared using the proportional sharing keys up to the amount of consumption of each member. In a few iterations (since multiple maxima can be reached), the production will be shared pro rata to all other members that have not yet reached their maximum (the consumption in that ISP).

8.1.5 Administration

The level of integration of the supply-sharing administration depends on the level of compensation: the shared energy is administrated as part of the compensation processes for supply by taking the shared energy into account on the (monthly) energy bill, but without any impact on the balancing position of the involved BRPs.

8.1.6 Compensation

In Flanders, the only billing process is that of compensating stakeholders on which the energy sharing has an impact on their revenues or responsibilities (see Table 7).

Table 7 Compensation in Flanders

Compensation type	Does it apply?
Compensation of the reductions of grid charges and taxes	No, since there is no difference in grid charges and taxes.
Compensation of stakeholders on which the energy sharing has an impact on their revenues or responsibilities.	Yes, the Energy Supplier is compensated for the sourcing of energy.
Paying fees to the energy sharing facilitator(s).	No, the cost of the facilitation is settled with the participants and is so in fact socialised over all customers of the DSO.
Financial settlement between the energy sharing group members	No, this is not allowed since energy sharing should be at no cost.

The Energy Suppliers of the producers of shared energy do not need to pay the feed-in tariff and Energy Suppliers of the consumers of shared energy receive less energy revenues. Energy Suppliers are compensated for this via an ex-post financial settlement process. Since January 2023, there is no longer a restriction on having the same retailer/supplier. A regulated price applies for the settlement between different Energy Suppliers.

8.1.7 The cost of energy sharing facilitation

The largest costs are for the DSO to implement the facilitation. Currently, these costs are socialised, but with the 4-yearly update on grid fees, however, this might change. The 15-minute meter data platform costs are considered not to be part of the energy sharing implementation but of the generic investment in digitalisation of market processes.

8.2 Italy

In Italy, energy can be shared within time windows of 60 minutes. JARSC must be located within the same building or multi-apartment block, and RECs consumers and producers must be connected to low-voltage grids connected to the same medium- to low-voltage transformer substation (extension to primary high to medium voltage transformer station is under discussion).

The DSO takes on all of the activities related to data management and computation of tariff reductions generated by the sharing arrangement.

8.2.1 Energy bill effect

The regulator has defined the elements of the regulated tariff components, which are not applicable to shared electricity because they represent avoided grid losses and costs. The Italian Ministry of Economic Development defined an incentive tariff (in €/kWh) for the remuneration of renewable production from power plants included in the sharing configurations (limitations apply for size and year of construction).

Shared electricity is measured in hourly intervals and defined as the minimum between (1) the electricity produced and injected into the public grid by the renewable plants belonging to the collective scheme, and (2) the electricity withdrawn from the public grid by the consumers participating in the collective scheme.

Figure 13 Example of energy bill effect mapping for the prosumer that consumes shared energy in Italy

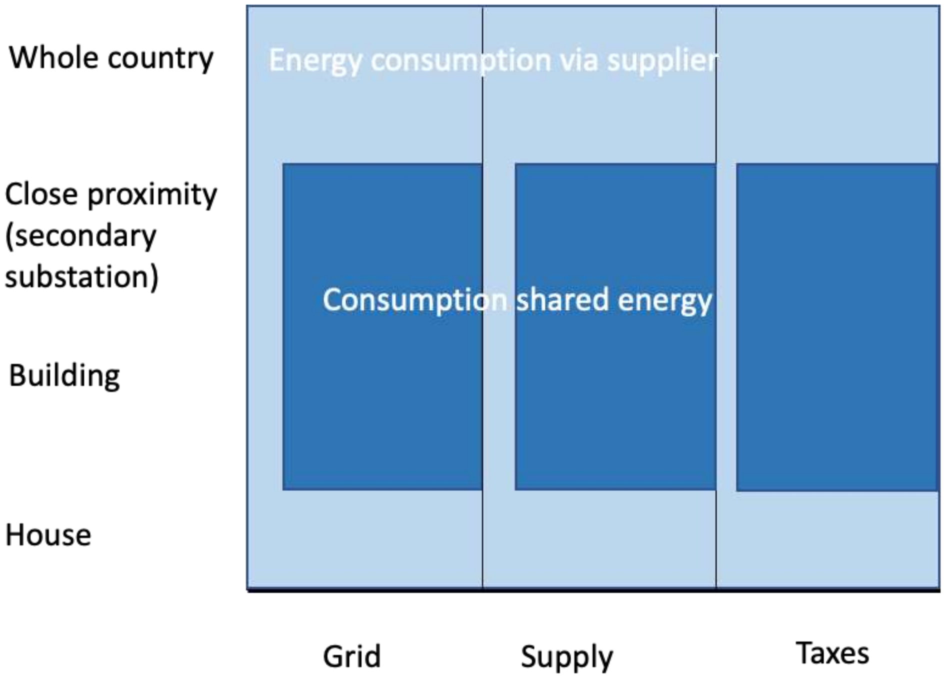
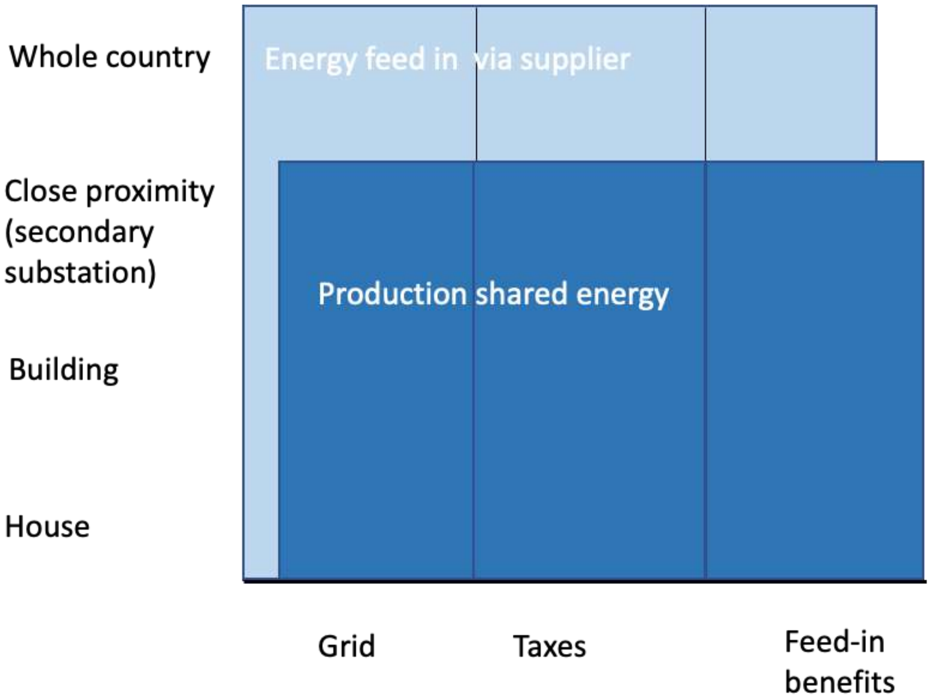


Figure 14 Example of energy bill effect mapping for the prosumer that consumes shared energy in Italy



8.2.2 Contract

For JARSCs, the *energy sharing group representative* can be the legal representative of the building or the producer that manages the generating units in the configuration. For RECs, the contact person is the REC itself, as it is already a legal entity.

8.2.3 Validation

The energy sharing representative must submit an application to GSE, which checks that all requirements are met and, if so, concludes a contract.

8.2.4 Calculation

Metering requirements: Digital meters are a requirement, but they are already available for over 95% of low voltage delivery points in Italy.

Sharing keys: The allocation of shared energy and of the cash-back on the energy shared among participants is included in private agreements between the participants in the configuration arrangements and their legal representative. As such, it is not known to retailers, DSOs, or other parties. There is an ongoing discussion on whether the sharing keys should be made available to retailers for billing purposes.

8.2.5 Administration

There is no supply-sharing administration integration so energy sharing is administrated in a dedicated process. The advantages are that the responsibilities of for balancing and collection of network charges of the Energy Supplier are not affected and the bill from the Energy Supplier to the consumer stays the same. Consumers belonging to a sharing configuration fully retain their rights as final consumers. Each consumer is able to choose their own supplier and to opt-in and opt-out of the collective scheme with no restrictions.

8.2.6 Settlement

Each member of the collective scheme pays the traditional electricity bill for electricity withdrawn from the public grid and then receives monthly cash-backs for the *shared electricity*. These cash-backs are computed by *Gestore dei Servizi Energetici* (GSE – national public agency in charge of managing renewable-related incentives). To perform this task, GSE has access to the national data centre collecting consumption data for all consumers and has access to metered data of renewable power production sites. In Italy, the metering activity is regulated and placed under the responsibility of the DSOs.

GSE pays the cash-back to the contact person, who is responsible for the allocation of the cash-back to the participants in the sharing configuration. The allocation of the cash-back among participants is made according to a private agreement. Therefore, no entity outside the JARSC or the REC needs to know the sharing keys.

Table 8 Overview of settlement types and their application

Settlement type	Does it apply?
Settlement of the reductions of grid charges and taxes	Yes, there is a monthly cash-back for the network tariff reduction.
Compensation of stakeholders on which the energy sharing has an impact on their revenues or responsibilities.	No, there is no impact since energy sharing is taken care of in a dedicated administrative process.
Paying fees to the energy sharing facilitator(s).	No.
Financial settlement between the energy sharing group members	Yes. The cash-back of grid charges is settled with the energy sharing group representative. This party has to divide this benefit among the members of the community.

There is very little impact on the retailer because they still charge each consuming member of the sharing agreement (for sourcing costs and network tariffs and taxes) according to their individual, hourly electricity consumption (as derived from consumption data as measured by the smart meter at each consumer location and validated by the national data centre managed by the DSOs).

8.2.7 The cost of energy sharing facilitation

Costs for metering for DSOs remain unchanged. The national data platform costs are considered part of generic investment in the digitalisation of market processes. There is also a plan to include the producers' metering data in the same data centre. Currently, these metering costs are socialised. The costs for the activities of the GSE (which also include verification of requirements for members of the sharing configuration) are also socialised.

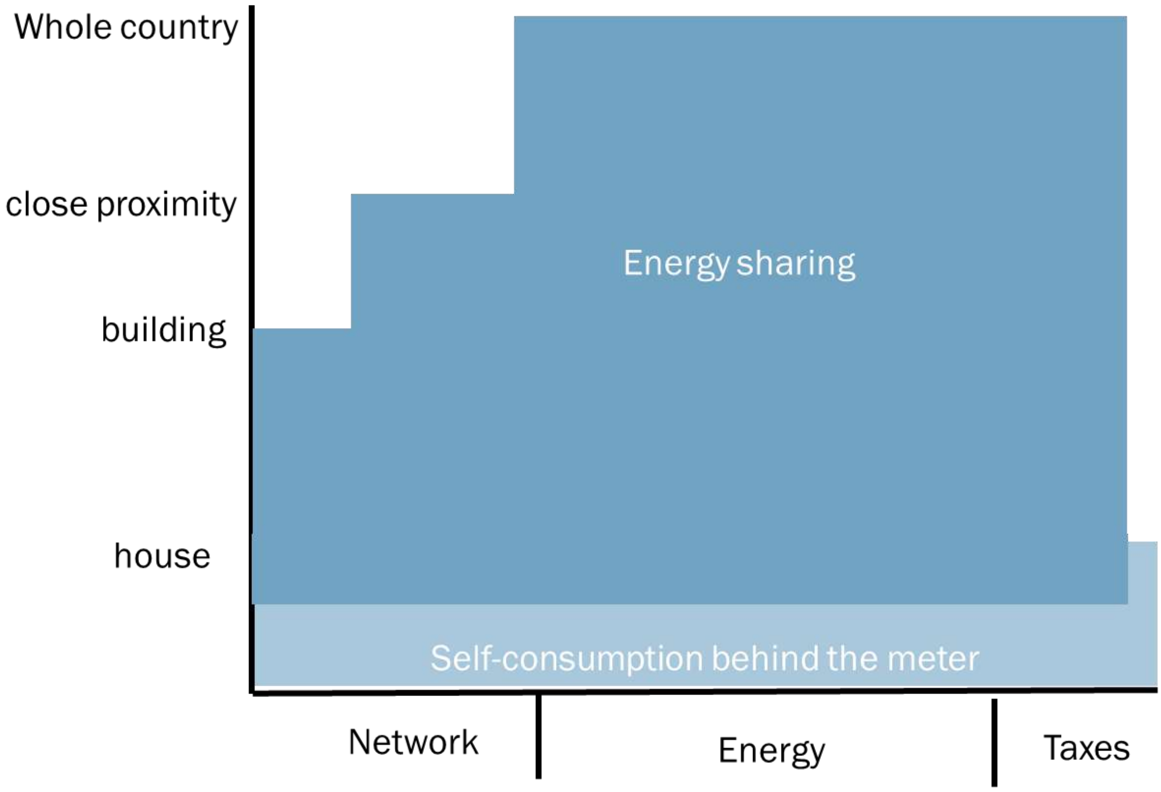
8.3 Other countries

In this section, we mention some interesting aspects of the energy sharing implementations in other Member States. In general, we see that in many countries, the DSO is the facilitator, but, for example, in Portugal, the role of the energy sharing group representative and Energy Supplier is larger than in Luxembourg.

8.3.1 Energy bill effect

In Luxembourg and Portugal, it is possible to join multiple sharing groups that are active on different levels in the grid and to share energy in these sharing groups at the same time (see Figure 15).

Figure 15 Example visualisation of energy bill effect, where the benefits on the network element differ based on the locational distance



8.3.2 Contract

In France, a contract needs to be established between the DSO and the legal entity, which identifies the different participants and determines the sharing scheme between the involved consumers

8.3.3 Validation

In France, the sharing group representative is responsible for the validation checks such as location.

8.3.4 Calculation

Fixed proportional sharing keys are an option in most Member States, but not necessarily the most popular option. For example, in Portugal, pro-rata sharing keys - determined based on the consumption measured - are more popular than these fixed proportional sharing keys.

Another interesting type of calculation method is one that takes into account multiple layers of sharing groups. This makes sense if it is permitted to join multiple sharing groups and if there are incentives that make sharing in a certain group more preferable than in other groups. For example, this is the case in Luxembourg and Portugal (pilot): sharing more locally has more benefits. This adds additional complexity to the optimisation, and DSOs like to offer this service as well.

8.3.5 Administration

In Portugal, the data platform and communication processes that are in place for energy supply are also used for energy sharing. In Slovenia, the national data hub is used for all processes including interaction with the consumer. This makes it easier to move towards a closer sharing-supply integration.

8.3.6 Compensation

In Portugal, there is impact on the balancing but since costs are socialised this not a large issue at the moment.

8.3.7 The cost of energy sharing facilitation

Based on the interviews conducted for this study, we estimate that, for a typical DSO implementation, supporting all steps in the process to an acceptable level will cost 1-5 million euros. Costs of organising the metering and administration processes in a data hub are not taken into account here, since those are not primarily made to facilitate energy sharing. The same is the case for the cost of the roll-out of smart meters.

9 Conclusions about energy sharing and the implementation of energy sharing in EU Member States

We understand energy sharing as an opportunity for consumers to participate in renewable energy projects as non-professional producers. Together with other consumers that also own, rent and lease these renewable energy installations, they can form an *energy sharing group*. This group can reduce the energy bills of its members by sharing energy, i.e. by administratively attributing produced electricity to each other.

The commercial way to attribute electricity produced by renewable energy installations to consumers is via energy traders and suppliers. The energy bill of consumers covers costs and profits related to these actors. The responsibilities and costs that come with energy trading and supply are a barrier for non-professional and small parties. It would not lead to a reduction of their energy bill, if they took over all responsibilities and costs of professional traders and suppliers.

Energy sharing requires new administration processes to attribute the electricity produced by renewable installations to consumers in a (cost-)effective way. Implementing such an administration process requires a regulatory framework for energy sharing. Such a framework should support consumers, e.g. citizens participating in renewable energy projects, in reducing their energy bills without jeopardising the functioning of the energy market and the protection of energy consumers.

The design of such a framework entails questions and answers that are outlined in this concluding chapter. The aim of this exploratory study is to point out open questions regarding energy sharing implementations in EU Member States, provide suggestions how to approach and implement energy sharing, but without claiming to provide full answers to all questions.

9.1 Conclusions about energy sharing

There is a lot of discussion going on about what energy sharing is and what its effect should be. Below, we share our thought on this.

9.1.1 What is the goal of energy sharing?

The main goal of energy sharing is to give all consumers access to renewable assets, meaning they have the ability to participate in renewable energy projects through ownership, rent or lease, and benefit from this position (see Section 1.4).

By sharing energy, consumers can contribute more to the green transition. Sharing energy will lead to new investments in renewable energy production, but can also lead to new investments in assets providing flexibility to the energy system (see Section 1.3).

9.1.2 When do you have the right to share energy?

Having collective control over the production installation, either through ownership, rent or lease, is a core requirement of energy sharing. Energy can be shared among the consumers that have shared control over a renewable energy installation or a set of such installations.

A second requirement is that energy can only be shared by non-professional producers. Energy sharing is described in the articles on energy communities (both the *citizen energy community* and the *renewable energy community*)[23] and jointly acting renewable self-consumers[24]. Energy sharing is, therefore, typically aimed at household customers. Not only natural persons, but also local authorities or small enterprises can be part of an energy community. They can also have effective control within the energy community, as long as this is not their primary commercial or professional activity. Drawing on the definition of the energy community in both EU directives, it would be possible that, for example, a local shop or municipality, as members of an energy community, could participate in sharing energy. Member States have to define the requirements for participants of energy communities, and this includes defining when the production of renewable energy should be seen as a professional activity of a commercial/industrial consumer.

Third, Member States should also define what it means to have control of the installation. The situation of a group of consumers that is renting an installation from a professional organisation and sharing this energy with each other could be very similar to the situation where this professional organisation is supplying this energy to these consumers. This can lead to alternative supply models with less responsibilities, e.g. a professional organisation that updates the renting prices every month based on the expected energy market prices. Member States can introduce production capacity limitation in case of third party facilitation and/or can exclude large enterprises from energy sharing to limit the risk of the emerge of such unwanted supply models.

9.1.3 Should energy be shared locally?

We see that Member States limit energy sharing to a certain distance between the locations of production and consumption or add additional benefits for the locally shared energy.

Stimulating the local sharing of energy can boost the development of renewable energy projects in the proximity of people and companies that benefit from it, which could be a way to increase the acceptance of renewable energy installations. However, in areas with less space for renewable energy installations, and so high social impact of such projects, this could cause unnecessarily resistance.

Furthermore, sharing locally has additional benefits for the energy system, since it adds an incentive for consumers to match consumption with local production. This can potentially decrease voltage overloads in local networks and can reduce congestion, however self-consumption is not a guarantee for a positive effect on congestion reduction: e.g. it is even possible that flexibility resources such as batteries will be used for self-consumption and are as such not available to help solve congestion on transmission system level

We think that energy sharing can be done everywhere in a country as long as it contributes to the goals of empowering consumers to take part in renewable energy projects so that they can reduce their energy bills. Since energy sharing is mentioned in the EU directives 2019/944 and 2018/2001 in the context of limiting the locational spread of energy communities, this can also be used to define the scope of energy sharing within these communities.

9.1.4 What is the advantage of energy sharing for consumers?

For consumers, the advantage of sharing is that they can reduce their energy bill, because they can directly consume renewable energy from installations they have (shared) control of by owning, renting or leasing. The benefits can be found in various elements of the energy bill. The costs of procurement of energy can be reduced, but the benefit can also be found in reduced grid charges and taxes (see Section 2.1).

[23] Articles 1 (11) and 16 of EU Directive 2019/944 and articles 1 (16) and 22 of EU Directive 2018/2001
[24] Article 21 of EU Directive 2018/2001

As mentioned above, it makes sometimes sense to stimulate energy to be shared locally. This stimulation can be implemented as a reduction of grid charges, but there is a risk that it constitutes a breach of the non-discriminating principle: parties that cannot share energy but can show that they use mainly locally produced energy may also have the right to benefit from the grid tariff reduction. Other principles such as cost-reflectivity that apply to grid charges and taxes should also be taken into account.

9.1.5 How to reduce energy poverty?

Having control over renewable energy installations via leasing or renting (from non-profit investors) instead of only owning is a requirement to make energy sharing accessible for consumers suffering from energy poverty. Local authorities can provide financial support to energy poor and vulnerable households to help pay rent/lease fees or invest in renewable energy installations. They can also share excess production as a priority to vulnerable and poor households.

Furthermore, energy sharing should be easy and ideally not require much extra effort from consumers.

9.2 Conclusions about the implementation of energy sharing

Many Member States are currently designing or redesigning their regulatory framework for energy sharing. There are many choices to be made. This study intends to inspire and provide guidance on how to implement energy sharing. However, it is not possible to establish a uniform all-inclusive recommendation for a regulation that accounts for all the different designs, needs and structures of the energy markets and their consumers in the different Member States. Nevertheless, we describe the most important take-aways below.

9.2.1 What needs to be in place for energy sharing?

We have identified that energy sharing facilitation requires the implementation of:

- Agreements between energy sharing group members on how to share.
- Validation of the sharing agreements.
- Calculation of the results of energy sharing.
- Administration of the results of energy sharing.
- Settlement of the financial effects of energy sharing including compensation of stakeholders such as the Energy Supplier.

9.2.2 Where should energy sharing arrangements be registered?

In this study, we introduce four places where the administration of energy sharing can take place (see Section 5.1). Every option has its own pros and cons.

The greatest impact on the consumer's energy bill can be realised by integrating energy sharing in the business processes of energy supply. The drawback of such an integration is that these options require the Energy Suppliers to cooperate (voluntarily or forced by regulation). Therefore, it is not surprising that most Member States nowadays choose options with no or minimal integration of sharing in energy supply.

9.2.3 When should energy sharing arrangements be registered?

Energy sharing is implemented in Member State as a settlement-only process, meaning that energy sharing does not require to provide any prognoses like for energy supply. The most important time element to meet is to be aligned with the timeline for the energy bill process of the Energy Supplier. When energy sharing is integrated as a subtype of energy supply, planning processes may also be needed.

9.2.4 What are the requirements for measuring?

Energy sharing requires separate registers for production and consumption, at least for every Imbalance Settlement Period. Smart meters and the metering installations typically used at a renewable energy production site provide this.

9.2.5 How is energy divided between the members of a sharing group?

The most implemented static proportional sharing keys offer a simple way to attribute a certain part of the production of an installation to the consumers that control that installation. The drawback of this type of sharing key is that it can lead to attributed production not matching the consumption. Putting a cap on the attributed production so that it will not be higher than the consumption at that moment happens often, and, in addition, it is possible in some Member States to share the energy not attributed to a consumer among the other members of the community.

9.2.6 Who should facilitate energy sharing?

This report shows that facilitation can be done by one or multiple parties as long as roles and responsibilities are described well. For example, DSOs, Energy Suppliers and energy sharing group representatives play a role, but most facilitation tasks could be at each of these parties in principle.

The advantage of a central and regulated party, such as the DSO as main facilitator, is that the number of negotiations about the division of tasks and responsibilities decreases.

The role of DSOs in facilitating energy sharing is not limited to metering, but is essential for connecting renewable power production sites to the network and allowing flows of shared energy on public networks. EU Directive 2018/2001 (Article 22(4)) specifies that "the relevant distribution system operator cooperates with renewable energy communities to facilitate energy transfers within renewable energy communities".

A situation where the energy sharing groups or Energy Suppliers are the main facilitators and responsible themselves may work in competitive energy service markets. Here, central data hubs can be great enablers. If the Energy Supplier plays a crucial role, there is a risk that consumer rights are limited, for example, the right to switch Energy Supplier.

9.2.7 Who steers the innovation?

1) DSOs having a large role in facilitation of energy sharing can boost the accessibility and attractiveness of energy sharing.
2) Research on how to extent the HRM model so that it supports energy sharing and even multi-supplier models can reduce implementation issues and will lead to harmonization of energy sharing processes in Member States.
3) Regulation that implements the EU directives but also takes into account the foreseen implementations in new or existing processes- also on the longer term- can boost innovation.
4) Energy sharing may be beneficial to the system at times. These benefits should be remunerated through explicit or implicit demand response measures. This includes but is not limited to networks tariffs.

Open sourcing facilitation software can play a role in speeding up the innovation. DSOs and energy sharing groups should not reinvent the wheel.

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