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PANTERA

Pan European Technology Energy Research Approach

Work Package WP3 "The state of R&I, standardisation and regulation"

Deliverable D3.4

Initial report on key challenges and bottlenecks

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Section	Name	Resp. Partner	First Draft Due Date
1	Introduction	**UCD**	15.03.2022
2	Current state for the integration of citizens as active smart grid contributors	**FOSS/RSE**	01.03.2022
3	The enablers of citizens' engagement in energy citizens/communities	**UCD/IERC**	05.03.2022
4	Identification of key challenges, gaps, and bottlenecks in policies, regulations and standards, technical advancements, social behaviour, and financial support	**UCD/TUS**	10.03.2022
5	EU level and national challenges, gaps, and barriers to citizens' engagement in energy transition	**FOSS/UCD/IERC/RSE/IPE/TUS**	11.03.2022
6	Conclusion	**UCD**	20.03.2022

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Document Approval

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Abbreviations

Acronym	
CSA	Coordination and Support Action
DER	Distributed Energy Resources
DNO	Distribution Network Operator
DR	Demand Response
DSO	Distribution System Operator
DN	Distribution Network
EAC	Electricity Authority of Cyprus
EC	European Commission
EGD	European Green Deal
EIRIE	European Interconnection for Research Innovation and Entrepreneurship

EMS	Energy Management Systems
ENTSO-E	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute
EPBD	Energy Performance of Buildings Directive
ESCo	Energy Service Company
ESS	Energy Storage System
ETD	Energy Taxation Directive
ETIP-SNET	European Technology and Innovation Platform Smart Networks for Energy Transition
EU	European Union
EV	Electric Vehicle
ICT	Information and Communication Technology
IEA	International Energy Agency
IoT	Internet of Things
IRP	Integrated Research Program
LV	Low Voltage
LEM	Local Energy Market
MS	Member State
MV	Medium Voltage
NECP	National Energy and Climate Plan
PCC	Point of Common Coupling
NRA	National Regulating Authority
PV	Photovoltaics
R&D	Research and Development
RD	Regional Desk
R&I	Research and Innovation
REC	Renewable Energy Community
RES	Renewable Energy Sources
RESS	Renewable Electricity Support Scheme
RCS	Regulations, Codes and Standards
TSO	Transmission System Operator
TN	Transmission Network
WT	Working Team

Executive Summary

This report (Deliverable 3.4) is the initial report on key challenges and bottlenecks and describes the work carried out within task 3.4 of the PANTERA (PAN European Technology Energy Research Approach) as a part of the ongoing effort in Work Package 3 (WP3) of the project. WP3 has been aimed at determining the state of research and innovation, standardisation and regulation with special attention to the key activity "energy policy and barriers".

The success of the energy transition in Europe depends on the sustainable replacement of conventional generation with renewable production. The variability of renewable energy indicates the necessity of the integration of energy citizens, as the new sources of flexibility, into the energy systems. This deliverable focuses on the barriers to the successful and sustainable engagement of European citizens in the energy transition that root in the European and national regulations, codes, standards, policies, financial support schemes, and behavioural patterns of citizens. These barriers hinder the effective realization of efficiency measures, demand response, and energy management systems, as well as the efficient local energy markets as the enablers of citizens' engagement in the Member States. Many of the barriers that mattered in the past have been removed and new gaps are emerging as the energy transition progresses. The focus in this deliverable is on the contemporary challenges that still matter. Dealing with the identified barriers and gaps pave the way for the effective engagement of energy citizens in the energy transition by assuring service quality through developing effective standards, making effective policies, direct financial supports in the correct directions, and amending the behavioural patterns of citizens by improving their awareness and presenting the whole picture of the energy transition, and boosting their knowledge of the main targets of the energy transition.

This study identified that the low quality of renovation (mostly limited to cosmetic fixes), institutional and legal frameworks that slow down renovation, and the lack of building class-oriented standards delineating the minimum level of renovation, putting the energy efficiency measures into action. The implementation of domestic demand response is hindered by insufficient wholesale price variation, energy and a network tariff structure that does not support demand shift in time and switching to e-mobility and electrical heating, distribution system operator remuneration approach that incentivises non-wire solutions over demand response, ambiguous rights for direct control of citizen's loads, and regulation interaction barriers. Finally, the complexity of prosumers' remuneration, data confidentiality/transparency, technical responsibilities for aggregators that originally have not been technical organizations and fairness in allocating such responsibilities, and recognition of user characteristics for market-oriented demand response comprise a subset of the barriers to the efficient integration of citizens into the local energy markets. In addition, the outdated wholesale market mechanisms, separate power exchange and flexibility market, technical problems, lack of standardization on smart metering, inconsistency of market instruments for incentivizing renewables, distribution system operators' regulations motivating investment in only wired solutions, and long administrative procedures for the energy community projects are also hindering the efficient implementation of the local energy markets.

Thus a variety of entities and organizations are working together for meeting the EU's objectives and targets that are envisaged to provide a fair deal for households as energy citizens and ensure nobody is left behind in the energy transition of Europe.

Many research studies have presented new structures for the energy markets along with the regulations and standards that are redesigned for the integration of energy citizens and communities

in the energy systems. There are some pilot projects around the globe to showcase the participation of energy citizens in energy provision. However, there is a wide variety of challenges that have been hindering the sustainable and effective participation of energy citizens and communities. The gaps and barriers to the sustainable engagement of energy citizens in the energy transition are presented in this report. Technical solutions, regulation, standards and policy gaps related to smart grids, demand-side flexibility, storage and local energy systems to empower the energy citizen, at the EU and national levels will be pinpointed. A systematic approach has been adopted to discover key challenges to integrate consumers in the smart grid solutions, PAN European Energy Exchange System and make them energy active citizens.

A wide variety of barriers to the sustainable integration of energy citizens into the modern structures of the energy systems has been studied in the literature. Many of these barriers are no longer a concern (at least in the pioneer MSs) as some practical solutions have been proposed and even implemented in practice to deal with these barriers. What will be presented in Chapters 3 and 4 of this deliverable are the contemporary barriers and unsolved issues and challenges that still hinder the successful integration of energy citizens and communities.

This deliverable does not present the barriers related to technologies, as enabling technologies for achieving smart grid functionalities are one of the main focuses of the PANTERA project that will be analysed at length in other tasks of this project including D3.5 Roadmap to 2030.

Hence, this deliverable presents the current state of the integration of citizens as active smart grid contributors in Europe, European vision and definitions of the term for such integration, the role of collective self-consumption and citizens and renewable energy communities, as well as the standards and the best engineering practices in this regard.

The enablers of citizens' engagement in the energy transition are identified. The barriers to exploiting these enablers are also discussed. This deliverable aims at presenting the barriers to achieving effective use of demand response and energy efficiency options, the new structure of energy markets, and distributed energy resources, renewable resources, and energy storage systems. The barriers related to the maturity of the required technologies will be discussed in a future deliverable D3.5 Roadmap to 2030.

An important contribution of this deliverable is the identification of the main category of gaps and challenges including the challenges, gaps, and bottlenecks in policies, regulations, codes, and standards, technical advancements, behavioural patterns, and financial support and mechanisms. The barriers identified are mapped into these general categories of gaps and challenges to complete the study. The policy-related challenges are partially linked to Chapter 4 of a previous Deliverable D3.3 where the national policies of the Member States were apprised in comparison with the requirements of Clean Energy for all Europeans package.

This entails a process that we have set out in PANTERA for raising awareness and finding the methods of strengthening R&I in Europe and more specifically in the low activity countries for bridging these identified shortcomings and strengthening commitment and engagement.

1 Initial report on key challenges and bottlenecks

1.1 Purpose of the document

The successful energy transition of Europe is contingent upon the successful and sustainable replacement of conventional fossil-fuel generation with renewable production. Given the variability of renewable energy and the unavailability of conventional generation, new sources of flexibility are sought. Demand-side energy management has shown promise in fulfilling this requirement. The EU is being prepared to set an exceptional target for the participation of citizens and energy communities in the energy transition. A variety of entities and organizations are working together for meeting the EU's objectives and targets that are envisaged to provide a fair deal for households as energy citizens and ensure nobody is left behind in the energy transition of Europe. Nevertheless, the old policies, regulations, standards, and financial mechanisms do not support such a revolutionary transition from old structures of the energy systems in which the citizens could only take the consumer role, and even sometimes hinder the effective integration of energy-empowered citizens into the energy systems. As an example, the market design initiatives must put strong regulations in place to acknowledge, allow for and offer rights to households that want to participate in energy communities and ultimately in energy markets. The regulations and standards should also be amended to allow for such a transition and avoid technical issues when the citizens and energy communities take more active roles such as energy and ancillary service providers.

Many research studies have presented new structures for the energy markets along with the regulations and standards that are redesigned for the integration of energy citizens and communities in the energy systems. There are some pilot projects around the globe to showcase the participation of energy citizens in energy provision. However, there is a wide variety of challenges that have been hindering the sustainable and effective participation of energy citizens and communities. The gaps and barriers to the sustainable engagement of energy citizens in the energy transition are presented in this report. Technical solutions, regulation, standards and policy gaps related to smart grids, demand-side flexibility, storage and local energy systems to empower the energy citizen, at the EU and national levels will be pinpointed. A systematic approach has been adopted to discover key challenges to integrate consumers in the smart grid solutions, PAN European Energy Exchange System and make them energy active citizens.

1.2 Activity "Initial report on key challenges and bottlenecks"

A wide range of challenges hinders the successful integration of energy-enabled consumers, known as prosumers, and energy communities into the energy transition to achieve the required flexibility. The successful energy transition, therefore, depends on the identification of the important gaps and barriers to the sustainable integration of consumers and directing the global efforts to effectively bridge such gaps and remove those barriers. These barriers are rooted in policies, regulations, codes, standards, and technological challenges. However, it is hard, if not impossible, to begin from these categories of challenges and manage to achieve a thorough list of barriers simply by looking into the policies, regulations, standards, and financial mechanisms.

Alternatively, to accomplish this task, the PANTERA consortium has identified 4 enablers that facilitate the engagement of citizens in the energy transition:

1. Energy efficiency, and demand response
2. DERs (distributed generation, CHP, HP), RES (PV), and Energy storage systems (ESS)

3. Local energy markets
4. Technological advancements

In the second step, to achieve a comprehensive list of barriers, PANTERA identifies the barriers to the exploitation of these enablers separately and discusses how each of the identified barriers hinders the successful and sustainable integration of energy citizens and energy communities into the energy transition.

In the third step, four categories of gaps and challenges are identified.

1. Gaps in policies
2. Gaps in regulations, codes and standards
3. Gaps in social behaviour
4. Gaps in financial support and related mechanisms.

In the last step, the barriers identified in the second step are linked to one or more than one category of gaps. Using this approach, for each category of gaps, a comprehensive list of barriers are found. It makes it easy for the respective authorities and organizations in charge of dealing with a certain category of gaps to direct their efforts more effectively to remove the barriers and facilitate the integration of energy citizens into the energy systems.

1.3 Limitations of the document

A wide variety of barriers to the sustainable integration of energy citizens into the modern structures of the energy systems has been studied in the literature. Many of these barriers are no longer a concern (at least in the pioneer MSs) as some practical solutions have been proposed and even implemented in practice to deal with these barriers. What will be presented in Chapters 3 and 4 of this deliverable are the contemporary barriers and unsolved issues and challenges that still hinder the successful integration of energy citizens and communities.

This deliverable does not present the barriers related to technologies, as enabling technologies for achieving smart grid functionalities are one of the main focuses of the PANTERA project that will be analysed at length in other tasks of this project including D3.5 Roadmap to 2030.

1.4 Structure of the document and links to other project tasks

Chapter 2 presents the current state of the integration of citizens as active smart grid contributors in Europe, European vision and definitions of the term for such integration, the role of collective self-consumption and citizens and renewable energy communities, as well as the standards and the best engineering practices in this regard.

The enablers of citizens' engagement in the energy transition are identified in Chapter 3. The barriers to exploiting these enablers are also discussed in this chapter. This Chapter is aimed at presenting the barriers to achieving effective use of demand response and energy efficiency options, the new structure of energy markets, and distributed energy resources, renewable resources, and energy storage systems. The barriers related to the maturity of the required technologies will be discussed in D3.5 Roadmap to 2030.

Chapter 4 identifies the main category of gaps and challenges including the challenges, gaps, and bottlenecks in policies, regulations, codes, and standards, technical advancements, behavioural patterns, and financial support and mechanisms. The barriers identified in Chapter 3 are next mapped into these general categories of gaps and challenges to complete the study. In this chapter, the policy-related challenges are partially linked to Chapter 4 of Deliverable 3.3 where the national policies of the Member States were apprised in comparison with the requirements of Clean Energy for all Europeans package.

The analysis of the national (country-specific) barriers is discussed in Chapter 5. In this chapter, the current level of empowerment of energy citizens in the energy transition is also presented in short based on the finding of the PANTERA project in Deliverable 3.1. The main focus of this chapter is on national policy, regulation, behavioural, technical and financial challenges. Finally, Chapter 6 conclude this report with interesting discussions based on the results of this task.

2 Current state for the integration of citizens as active smart grid contributors

2.1 Empowering energy citizens: European vision (FOSS)

On the 11th of December, 2019, the new EU Commission, headed by Commission President Ursula von der Leyen, presented its vision for a 'European Green Deal' [1]. The European Green Deal aims to transform the EU into a modern, resource-efficient and competitive economy, ensuring:

- no net emissions of greenhouse gases by 2050
- economic growth decoupled from resource use
- *no person and no place left behind*

The last point highlights that the European Green Deal, as an overarching policy, impact Europe's transition to energy democracy and aims to empower the energy citizens e.g. through energy communities. Through the related document, the European Green sends a strong message on the need to ensure a **socially fair** and **inclusive energy transition**. Therefore, a strong potential is given to energy citizens for becoming active and empowered in Europe's clean energy transition.

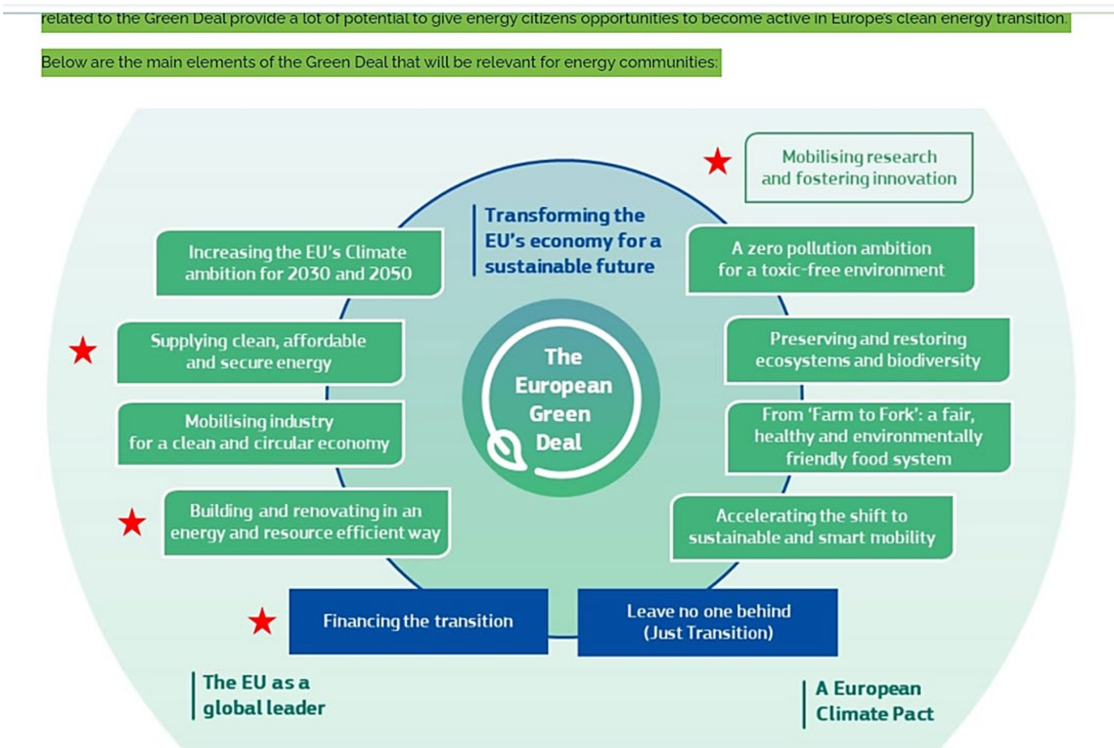

Figure 2.1The Green Deal in a nutshell (source: EC 2019)

Below are the main elements of the Green Deal that are relevant:

2.1.1 A Socially Fair Transition

A new **Social Climate Fund**[1] is proposed to provide dedicated funding to the Member States to help citizens finance investments in energy efficiency, new heating and cooling systems, and cleaner mobility. The Social Climate Fund would be financed by the EU budget, using an amount equivalent to 25% of the expected revenues of emissions trading for building and road transport fuels. With a proposal to draw on matching Member State funding, the Fund would mobilise €144.4 billion for a socially fair transition. The challenge is to make sure the benefits and opportunities that come with it are available to all, as quickly and as fairly as possible. These measures and investments need to principally benefit vulnerable households, micro-enterprises or transport users. Pending the impact of those investments on reducing costs and emissions, the Fund will also be able to finance temporary direct income support for vulnerable households.

2.1.2 Supplying clean, affordable and secure energy

It has to be mentioned that citizens' role in the energy transition has been highlighted before in the Clean Energy Package (which includes the recast Renewables Directive and legislation for a new electricity market design) where citizens were supported in investing and taking ownership in the energy transition – both individually and collectively through 'renewable energy communities' (RECs) and 'citizen energy communities' (CECs). Green Deal takes the establishment of energy communities for granted and commit to increasing climate ambition for 2030. It is highly likely then that through this stronger ambition, a greater need for citizens to help drive investments in clean energy technologies shall be foreseen as presented below.

2.1.3 Buildings renovation and addressing energy poverty

Buildings renovation is seen as a centrepiece of the Commission's Green Deal Strategy. This will include revisions to strengthen policies and legislation related to buildings, and new innovative EU financing schemes for renovations. Close attention will be paid to barriers to investing in energy efficiency improvements in rented and multi-owner buildings, as well as social housing. Energy communities are capable to tackle this important social issue and setting it as a primary objective.

Especially for tackling energy poverty, the European vision goes a step beyond:

European External Investment Plan [2] (EIP): The purpose of the European External Investment Plan is to provide an integrated and comprehensive structure to finance investments in Africa and the EU neighbourhood. The EIP is based on three pillars:

(i) The European Fund for Sustainable Development (EFSD) [3],
(ii) Technical assistance and
(iii) Improved investment climate and overall policy environment.

The European Commission singles out five areas of investment. One of these areas is dedicated to 'Sustainable Energy and Connectivity' – to attract investments in renewable energy, energy

[1] https://ec.europa.eu/clima/eu-action/european-green-deal/delivering-european-green-deal/social-climate-fund_el

efficiency and transport [4].

2.1.4 Sustainable Europe Investment Plan

According to the Commission, achieving the 2030 climate and energy targets will require additional investments of 260 billion euros per year by 2030. Indeed, citizens, small businesses and local authorities will need to contribute towards these investment needs. The Commission has communicated how it intends to facilitate and support such investment through its Sustainable Europe Investment Plan.

The funding mechanisms below are relevant to the citizens' empowerment:

- **State aid guidelines**

State aid for environmental protection and energy (EEAG) has been in force since 2014 with a revision in 2021 [5].

- **InvestEU and the EIB**

The InvestEU Fund aims to mobilise more than €372 billion of public and private investment through an EU budget guarantee of €26.2 billion that backs the investment of implementing partners such as the European Investment Bank (EIB) Group and other financial institutions[2].

- **Public Procurement**

EU Public Procurement legislation allows public authorities to use environmental and social criteria in tendering for products and services around energy. This can promote local collaboration between local authorities and citizens through schemes such as RECs or CECs.

2.1.5 Mobilising Research and Innovation

As part of the Green Deal, the Commission will provide at least 35% of the budget for Horizon Europe, which helps fund research and innovation related to energy transition and climate solutions. The Commission mentions that the research and innovation agenda should work across different sectors and disciplines, and involve local communities with initiatives that combine social elements.

2.2 The role of collective self-consumption and energy communities (FOSS)

The Clean Energy Package has introduced CSC at the EU level through the definitions of "jointly acting renewable self-consumers" (Directive on the promotion of the use of energy from renewable sources, art. 2.15 and 21 [6]) and "jointly acting active customers" (Directive on common rules for the internal electricity market, art. 2.8 and 15 [7]), but it is now up to the Member States to specify the terms of CSC in their jurisdictions.

In several EU Member States, framework legislation is being established that still needs to be detailed in the future. In particular, several MS have started to establish Renewables Energy Communities (REC) and CSC provisions within the same legislative proposals [8]. Linking the

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[2] https://europa.eu/investeu/about-investeu_el

implementation of the CSC to REC concepts seems reasonable as both aim for the self-supply of renewable energy putting the citizen in the centre.

Collective Self-consumption (CSC) is a framework that supports the energy transition in the electricity sector by facilitating the collective sharing of renewable electricity generation assets within a community of prosumers [9]. Collective self-consumption is based on the same principle, applied at the neighbourhood, district or local level where a local energy cooperative virtually and flexibly can be created as follows: each customer connected to the same low-voltage sub-station could easily join or leave the community having as main objective to consume their energy production. This, of course, involves RES e.g. photovoltaic systems of a certain power capable of producing sufficient or surplus electricity. Having said that, Collective self-consumption is one way to create a local community virtually and flexibly.

This is close to the web-of-cells concept rather than to micro-grid islands operating in a confined system, independently of the upper grid. The local community stays connected to the grid and injects any surplus production into it. Similarly, they are different from the projects aggregating load or generation like VPPs, as CSC rely on simultaneous consumption and generation in a confined area. A comparison of the CSC with other local energy initiatives are shown in the following schematic:

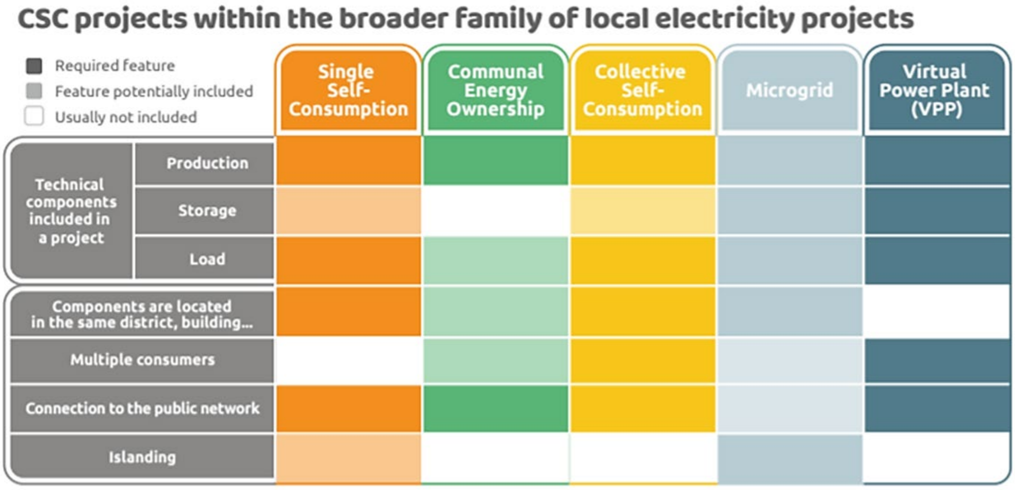

Figure 2.2 CSC positioning within the local energy initiatives [9]

The main targets and role of a CSC are in line with what is mentioned in the directives of CEC and REC of EU and can be summarized as follows:

- To **trade** energy within members of the community and the upper grid.
- To maximize **renewable energies** with naturally fluctuating prices when they become available.
- To better **balance the network**, as balancing producer-consumer injections into the network is complex to manage.
- To support the grid in their planning objectives.
- To **promote** the installation of **decentralised RES** systems and storage technologies.

There are three types of CSC projects:

- **Projects based on a single asset** collectively operated on a multi-tenancy building.

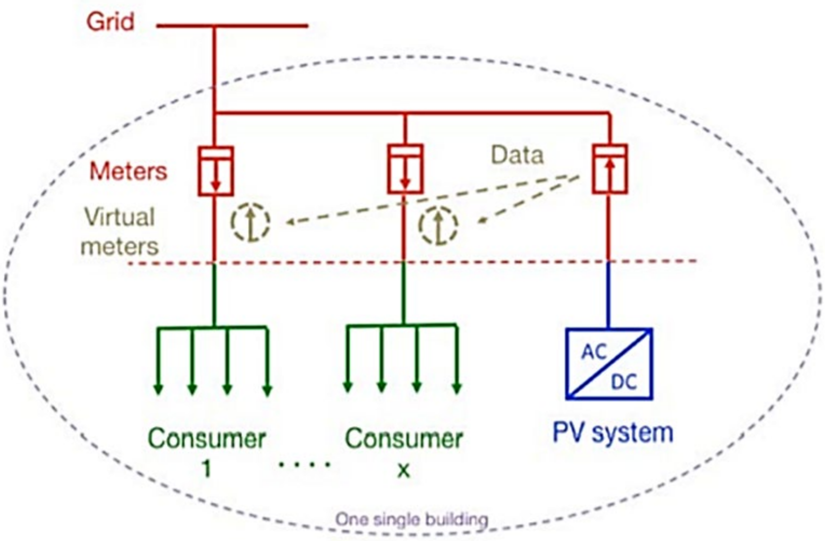

Figure 2.3 Collective self-consumption at building scale [10]

- **Shared distributed electricity generation assets:** several distributed generations, sometimes accompanied by storage, are distributed in different sites of a confined region. This model requires the use of the public network.

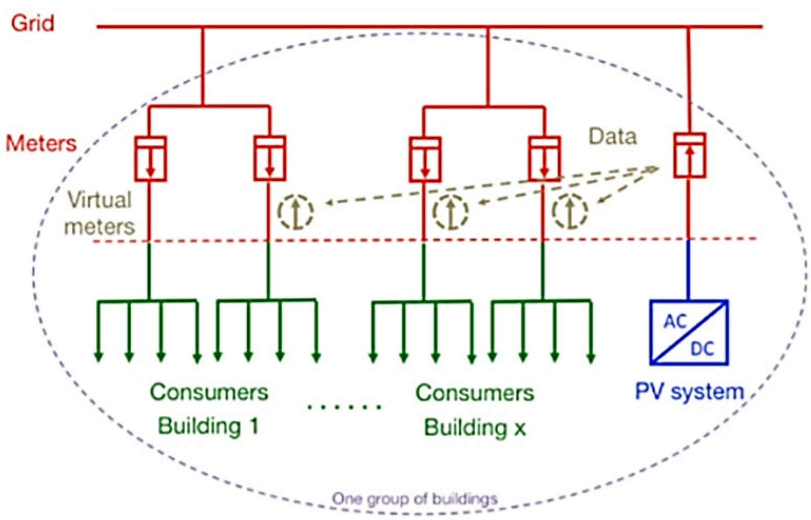

Figure 2.4 – Collective self-consumption at block scale [10]

- **Peer-to-peer trading on existing assets:** a software platform operator is set up to allow electricity trades between self-producers of a local community. The platform balances supply and demand and manages the financial flows.

As CSC is a rather new concept, certain technical and regulatory issues need to be considered for establishing such a scheme to be sustainable.

2.2.1 Technical requirements

Sharing local production collectively is only possible for consumers whose electrical installation is connected to the same low voltage sub-station. This limits the possibilities of creating energy cooperatives.

2.2.2 Legal and Regulatory requirements

CSC as other energy transition concepts is highly dependent on local energy regulation. The regulatory framework needs to recognize the ability of consumers to share energy. Then to share locally produced energy, local customers must use the public low voltage grid or be allowed to operate a private grid which is the less common case among states. For using a public grid, it will therefore be necessary to have a mediator such as an operator or retailer. Then usage tariffs as is already the case for a conventional electricity supply should be considered, but at a lower price, given that only a small portion of the grid has been used. The regulator will have to agree to allow special tariffs, as electricity prices are regulated by the regulatory authorities.

Also, collective consumer-producer customers must be represented by a legal entity (company, association, etc.) which will be the point of contact for the retailer or distribution network operator. At last but not least, uneven market conditions can be blocking points for the sustainability of CSC projects.

2.3 Standards and identified best practices (RSE)

Communication between devices is a key enabler for smart grids applications and, since different and heterogeneous actors and devices are interacting, interoperability is a prerequisite for the deployment of efficient solutions. Their deployment can reduce energy utilization of appliances by enhanced management strategies optimised at the system level. Standardized interfaces and a common architecture allowing consistent communication among all the different actors and devices are needed to ensure interoperability. Moreover, the adoption of proper standards is essential to allow seamless operation of devices from a different vendor and to foster the market uptake of innovative and smart solutions. In the following, we give a brief overview of relevant protocols and standards within the domain of the smart grid.

IEC 62746-10-1 (OpenADR 2.0b)

The Open Automated Demand Response (OpenADR) standard developed by North American research organisations and enterprises to allow demand response operations, in its 2.0b edition was approved by the IEC as an international standard for demand response. IEC 62746-10-1 specifies data and services models for demand response especially dedicated to distributed energy resources. The standards can be used to manage end-users resources (renewable energies, loads and storage), through signals provided by grid or market operators. The standards define two-way communication to allow information exchange between the different actors (electricity service providers, aggregators, end-users, etc.)

IEC 60364-8-2

Published in 2018 this standard is a section of the IEC 60364, known as Prosumers Electrical Installations (PEI), which incorporates energy efficiency measures, smart grid interfaces and requirements for consumption units as well as renewable sources of electricity and energy storage.

The standard considers three types of PEI:

- Individual Prosumers (for example a private house) that can either produce or consume electrical energy.
- Collective Prosumers (for example, a group of single private houses)
- Shared Prosumers (for example a group of individual houses sharing their supply with their neighbours. Each user may have installed renewable energy sources which can either his appliances or other uses).

For each type of PEI the following three modes of operation are considered:

- Direct feeding mode (user's appliances are fed by the energy coming from the main grid)
- Island mode (users have their generators and are not connected to the grid)
- Reverse feeding mode (the user's renewable energy sources inject energy into the grid)

The standard addresses different technical issues related to PEI ranging from safety issues (protection against electric shock, system earthing, protection against overcurrent and overvoltages, etc.) to the requirements concerning an interaction with the public networks, electric vehicle charging, and other topics.

CIM (Common information model IEC 61970 and IEC 61968)

The standards of the IEC 61970 series deals with the Application Program Interfaces (API) for Energy Management Systems (EMS). More in detail, the standards address both the integration of applications developed by different suppliers in the control centre environment and the exchange of information between the control centre and the external environment. It includes also specifications for transmission, distribution and generation systems that need to communicate in real-time with control centres. Instead, the IEC 61968 deals with information exchanges between electrical distribution systems supporting the coordinated deployment of innovative solutions.

IEC 61850

The IEC 61850 standard defines protocols for electronic devices communication at a substation level. Developed and maintained by the Technical Committee 57 of the IEC it provides also a reference architecture for power systems. It contains also an abstract data model that can be mapped to different communication protocols. Up to now, this mapping is available for the following protocols:

- MMS (Manufacturing Messaging Specification): widely used for communication between the electronics devices and SCADA systems
- GOOSE (Generic Object-Oriented Substation Events): to read the status of devices such as protections
- SMV (Sampled Measured Values): mainly used to communicate with voltage and current transformers.

These protocols provide a fast way to transmit data otherwise not reachable with the general-purpose internet protocols.

IEC 62056

IEC 62056 is a standard dedicated to electricity metering and the associated data exchange. It details a model for smart meters to facilitate its communication through interfaces. Generic building blocks are defined using object-oriented methods in the form of interface classes to model meters from simple up to very complex functionalities.

Besides specific standards, it is relevant to report a tool and a document that support engineers in choosing the most appropriate standard available for a specific application.

Solar Electric Power Alliance Catalogue of Standards

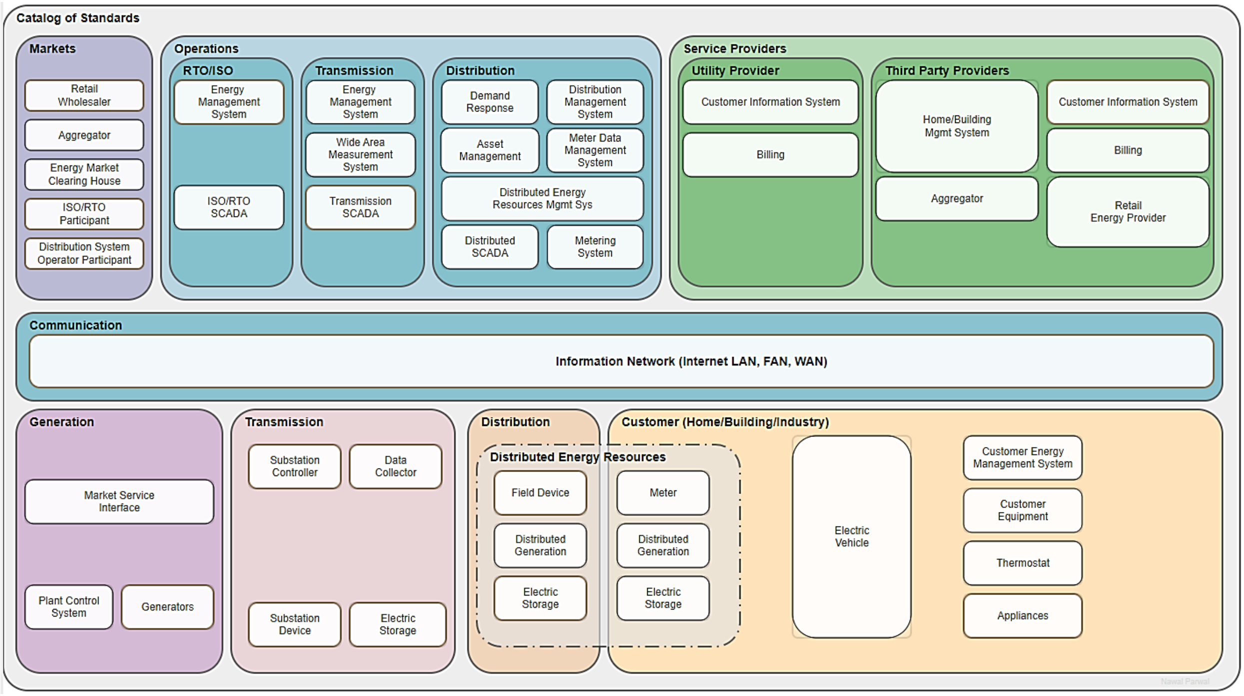

Figure 2.5 The Solar Electric Power Alliance provides Catalogue of Standards (available at http://gridstandardsmap.com)

The Solar Electric Power Alliance provides Catalogue of Standards[3] is a collection of standards relevant for the development and deployment of a modern secure smart grid. It represents a reference to the electric grid community supporting the selection of the most suitable standards among the many available. As can be seen from Figure 2.5 the catalogue covers a broad set of domains of the smart grids. Navigating the map, for each domain several standards are listed, however being the catalogue developed by an American body it gathers, apart from international standards such as the ones developed by IEC, mainly US standards developed by American bodies such as ANSI or IEEE. Nevertheless, the catalogue is a useful tool since gives a good overview.

IEC Smart grid standardization roadmap

The document IEC/TR 63097:2017 “Smart grid standardization roadmap” published by IEC provides

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[3] https://sepapower.org/knowledge/catalog-of-standards/

guidelines to select the most appropriate standard for different applications. Standards under development are considered too. This document is intended to be updated regularly, as a “living document”, to enable tracking all the novelties that occur in this field. Presently the IEC/TR 63097:2017 is dedicated to smart grids and the whole smart energy system (i.e. the interactions with other energies such as gas, and heat) has still to be addressed completely. The document aims also at creating a common set of guiding principles that can be referenced by end-users and integrators who are responsible for the specification, design, and implementation of smart grids.

The Platone EU project aimed to develop advanced management platforms to unlock grid flexibility and realize an open and non-discriminatory market has mapped in [11] several relevant international standards for the development and deployment of demonstrators to validate the devised smart grid solutions. Also, this document could support users in finding standards for specific applications.

2.3.1 Communication protocols for IoT applications

Besides the mentioned international standards that cover different aspects of interoperability, are available also other relevant communication protocols allowing communication between devices. In particular, we focus here on protocols for the Internet of Things (IoT) applications since they could strongly support the diffusion of smart solutions at the customer level.

Smart user appliances and IoT devices need suitable communication protocols since traditional communication standards (WiFi, Bluetooth and cellular network) often are not suitable for carrying out this task because they require a considerable amount of power. In the following are reported a list of the main communication protocols that suit requirements for IoT application.

LoRaWAN[4]

The LoRaWAN (Long Range Wide Area Network) is a proprietary *low-power* protocol. Thanks to its features, including the ability to connect sensors over a long range, with low energy consumption, LoRaWAN is ideal for applications in the field of the Internet of Things. The Lora Alliance foundation (a non-profit organisation involving different big companies) supports and fosters the spread of LoRaWAN on a global scale.

Z-Wave[5]

Z-wave, developed by a Danish company is aimed to make interoperable at the application layer devices assuring information exchange. Z-wave protocols allow each device to talk with the adjacent ones (either directly if they are in the communication range or indirectly) in a meshed network.

Zigbee[6]

Zigbee is a wireless communication standard based on the IEEE 802.15.4 specification, maintained by the Connectivity Standard Alliance. Using small digital antennas with low power consumption, it

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[4] https://lora-alliance.org

[5] www.z-wave.com

[6] https://csa-iot.org/

implements wireless personal area networks allowing smart applications.

Sigfox[7]

Sigfox provides a communications solution based on clouds systems aiming to drastically reduces energy consumption and costs of connected devices. It could be used for electricity meters, smartwatches and other appliances which need to be continuously on and transmit small amounts of data.

AMQP

Advanced Message Queuing Protocol (AMQP) is an open-source standard for asynchronous messaging by wire. The protocol is used in client/server messaging and in IoT device management. The messaging protocol is fast and features guaranteed delivery with acknowledgement of received messages.

MQTT

Message Queueing Telemetry Transport (MQTT) is a lightweight network protocol for messaging between devices. MQTT is designed for connections considering limited power and network bandwidth. In Italy, it is used for the second generation of smart meters. More in detail, MQTT is a many-to-many communication protocol for passing messages between multiple clients through a central broker.

CoAP

Constrained Application Protocol (CoAP) is a web transfer protocol used in the Internet of Things for application in constrained (in terms of bandwidth) conditions. It defines one-to-one communication (machine-to-machine).

XMPP

Extensible Messaging and Presence Protocol (XMPP) is an open communication protocol designed for instant messaging allowing the near-real-time exchange of structured data between two or more network entities. Exploited in different contexts it is also used for IoT applications.

In the following, we also mention other two relevant experiences/projects that lead to the development of protocols and reference architecture for smart applications.

Smart Appliances REFerence ontology (SAREF)

Based on the results of the Smart Appliances Project [12], the European Telecommunications Standard Institute (ETSI) standardized a machine-to-machine (M2M) architecture that describes in which way and how machines could interact with one another. This standard [13] addresses the consumer market of the home but also public buildings and offices, and the appliances used in these environments. The standard proposes a reference ontology, named Smart Appliances REFerence ontology (SAREF), designed to cover the needs relevant for energy efficiency. More in detail, it consists of a shared model of consensus that facilitates the matching of existing assets in the smart appliances domain, reducing the effort of translating from one asset to another. SAREF requires one set of mappings to each asset made easier by the fact that different assets share some recurring

[7] www.sigfox.com

core concepts.

FIWARE[8]

FIWARE was born from the public-private partnership future internet, aimed at increasing European competitiveness in the field of information and communication technology. FIWARE is now an independent foundation aiming to simplify the creation of smart applications. FIRWARE drives the definition and open-source implementation of standards that enable the development of portable and interoperable smart solutions avoiding vendor lock-in. The FIREWARE mission is to “building an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that ease the development of new Smart Applications in multiple sectors” and it is active in the following different fields: smart cities, smart energy, smart industry, and smart water.

8 https://www.fiware.org

3 The enablers of citizens' engagement in energy citizens/communities

3.1 Identifying enablers of citizens' engagement in energy transition (UCD)

This chapter aims to identify the barriers to the sustainable integration of energy citizens and communities into the energy systems. These barriers are rooted in policies, regulations, codes, standards, and technological challenges. It is hard, if not impossible, to begin from these categories of challenges and achieve a thorough list of barriers only by looking into the policies, regulations, standards, and financial mechanisms. Alternatively, in this Chapter, four enablers that facilitate the engagement of citizens in the energy transition, i.e., Energy efficiency and demand response, DEGs and ESSs, Local energy markets, and technological advancements are regarded as the start point. This chapter looks into the first three enablers in this list[9]. The remainder of this subsection is dedicated to identifying the barriers to the successful exploitation of these enablers.

3.2 Barriers to exploiting enablers of engaging energy citizens in energy transition (UCD)

In the remainder of this chapter, the barriers to exploiting each enabler of energy citizens that might hinder achieving the targets of the energy transition will be presented. To the benefit of clear analysis, for each enabler, the barriers are provided separately. In the next chapter, these barriers and gaps are traced back to financial, regulatory, policy-making, and social challenges.

3.2.1 End-use energy efficiency, and demand response (UCD)

3.2.1.1 Energy efficiency in domestic buildings

End-use building energy efficiency is linked to building policy and is also becoming more related to renewable energy policy and network policy as domestic buildings are increasingly integrated into the energy systems as not only end-users of energy but also the providers of a wide range of services such as energy provision, storage, and flexibility. For an energy citizen willing to be a part of the energy transition, it is important to put energy efficiency as the priority, before engaging in service provision. This demonstrates that it is of premium importance to ensure that energy management in citizens' buildings puts energy efficiency at the centre of new and revised building energy policies. As much as this means that citizens should not use more energy than necessary, the energy policies should ensure that building residents have a cosy and healthy life and workspaces. There is a relatively wide range of literature introducing the energy efficiency concepts in buildings, and more specifically, the barriers to putting the energy efficiency measures into action and how to overcome such barriers. A literature review in [14] presented the general barriers to the improvement of buildings energy efficiency. The industrial and academic reports that present an in-depth investigation to identify the detailed barriers are abundant. Reference [15], for instance, reviewed the barriers related to the awareness of all participants that hinder building energy efficiency. This

[9] Technological advancements is one of the focuses of the PANTERA project that was addressed to some extent in D3.1, i.e., "Report on current status and progress in R&I activities: Technology", and also will be covered in D3.5 Roadmap to 2030.

reference provides a detailed assessment of the complexities that building owners, funders, and constructors might face in assessing the opportunities, costs, and benefits of building energy efficiency projects. This paper also provides an approach to review what options are available and applicable. The relative costs and benefits of such actions have also been presented to enrich the study. Another study [16] focused on social behaviour and building renovation. This study identified the main barriers on technical, political, financial, and behavioural levels.

Building renovations can improve energy efficiency, directly and indirectly, reduce emissions, and immensely enhance human health. Many activities have been focused on building renovation for energy saving but the expected saving has not been realized. The associated workload is cumbersome: more than 97% of the buildings in the EU hold an energy rating below-A. According to the statistics, about 40% of the EU's energy supply is wasted in buildings, and about 36% of CO2 emissions are produced by buildings. The EU's building renovation rate is not reaching 1% per year. Increasing this rate should be regarded as a key priority to keep the EU on track for its energy transition and climate neutrality objective. The EU pushes towards renovations. The success of the European renovation wave will be measured not only by the quantity but also by the quality of these renovations. The European Commission considers renovations that result in more than 60% savings to be "deep renovations". Unfortunately, despite the climate crisis and the rise of energy prices, many renovations done are so far from reaching the 60% mark, let alone the 80% energy savings which are technologically feasible for most buildings. Analysis of the National Recovery and Resilience Plans (NRRPs) shows that most of the renovation investments planned under the Recovery Fund will deliver only 30% energy savings [17]. The remainder of this subsection lists the barriers to the sustainable enhancement of energy efficiency, including those that most hinder effective renovations.

1. The complexity of associated renovation and lack of skills in the supply chain of renovation works. This indicates the necessity of sharing the information and experience gained in accomplishing the successful renovation projects as good engineering practice at both EU and national levels.
2. Sometimes renovations are cosmetic fixes only. In this case, the citizens risk undermining climate policies at a time that we really cannot afford to. The lack of monitoring bodies that periodically control the building energy efficiency can be an important barrier in this regard. The citizens' awareness should be improved to implement the energy efficiency measures systematically.
3. Institutional and legal frameworks that do not allow for or slow down renovation projects. An example of such a barrier is the resistance of a group involved in urban decision-making against the renovation as they believe this may distort the buildings' view. This can be categorized as a policy conflict barrier.
4. Lack of access to finance while renovation costs are high in most European countries. Renovations are often resource-intensive, both in terms of financing and time. Sometimes, the energy performance is less valued than the required investment costs. Discrepancies between predicted and actual savings also reduce the citizens' trust in energy efficiency projects. Therefore, it is important to provide a clear picture of the cost and saving for citizens. Financial incentives are weak and external risks such as price volatility give rise to the lack of citizens' motives for enhancing the building energy efficiency.
5. Lack of standards delineating the minimum level of renovation in different classes of buildings that can guarantee compliance to the climate neutrality objectives. A 'deep renovation' standard in the Energy Performance of Buildings Directive (EPBD) is vital for more highly

energy-efficient renovations. The Commission is persistently following this to develop a 'deep renovation' standard that can be bolted onto the EPBD, which has been promised to be updated later this year. National standards need to be also updated to follow those presented by EC in EPBD. Currently, such national revisited standards do not exist in most European countries. An ongoing study, i.e., "Renovate2Recover" [18], is analysing the progress of such standardization in the member states.

In addition to the barriers to effective renovation projects that prevent energy efficiency from being improved throughout the continent, some other important obstacles should also be noted.

6. Split incentives, lack of communication between buyers and building constructors, and fragmented real estate market [15]. An example is different and sometimes opposing interests of constructors and final building buyers. For instance, the constructor may favour low cost to the efficiency of the equipment. The other example can be the incentive of contractors to oversize equipment. This is important to note that the building energy policies should be revisited to avoid such barriers.
7. Barriers related to citizens' behaviour such as the lack of shared objectives among citizens, and inertia, e.g., aversion to change and the conservatism in the construction and renovation industries.
8. Lack of information and knowledge regarding energy efficiency and sustainable products. These barriers used to cause a major gap in the past. Even today, they continue to be an important cause hindering the improvement of citizens' energy efficiency. The citizens' perception of High investments and long return time is an important ambiguity that should be clarified for end-users. Most citizens are also aware of the positive environmental impacts of putting energy efficiency measures in place. However, the mixed signals that they receive make it hard for them to discern between the impact of energy efficiency measures and other actions in this regard.

The abovementioned barriers to investment in building energy efficiency introduce broad gaps that can be examined in more detail by looking more closely at some types of barriers or certain sections of the building and construction industry. However, many of the important barriers that were provided in the literature have been mitigated by taking effective measures. One of the barriers that lost its importance is the lack of public awareness of the positive environmental effects of improving domestic building energy efficiency. The abovementioned barriers only include those that were reviewed in the literature and are still a real concern.

The target of domestic building energy efficiency measures is to reduce the overall consumption permanently. Nevertheless, in contrast to energy efficiency improvement demand response means an action that changes the consumption pattern over time and does not necessarily lead to an overall decrease in demand. Analysing the barriers to the effective implementation of demand response programs is the subject of the next subsection.

3.2.1.2 Residential demand response programs

Demand response programs pervade in the National Energy and Climate Plans of all member states as a key enabler of energy transition in Europe. DR programs are the most important building block of demand-side management from the perspective of the engagement of energy citizens in the energy transition. In the case of electricity, demand response means changing the pattern of the daily load. As an instance, demand response programs can help to reduce the peak of demand.

Reducing the peak of demand will in turn reduce the size of energy infrastructure (generation capacity, transmission and distribution networks, and storage facilities). Such demand-side management is also important for gas and heat, acknowledging that they now have cheaper storage options to meet demand. Smoothing the demand curve and using the existing network and in general, the available energy infrastructure more efficiently is crucial when we heed the growth of overall electricity demand due to the electrification of most urban activities including transportation (electric vehicles) and heating (heat pumps) for power systems. Well-designed demand response programs can delay and reduce the required network or capacity investment [19].

Other than DR, demand-side management includes the overall reduction of energy use that requires behavioural changes and energy efficiency technologies. The effects of demand reduction are very tangible for the consumers and policymakers, and it does not impose an additional burden on the grid. Therefore, even though it still needs the training to increase the awareness of consumers of such opportunities, it is being followed almost on a right track. On the other hand, DR entails changing consumers' electricity demand at different times or more accurately managing the demand profiles by the consumers based on grid requirements. Therefore, it is more complicated to implement, requires more effective policies to become ubiquitous, poses more challenges on the grid operation, and is harder to be fully explained to the residential consumers. Nevertheless, from the perspective of the energy transition, other than the other advantages of DR, it helps increase the penetration of renewable generations especially through energy communities or by energy citizens, and therefore, pave the way towards further decarbonization of the energy sector.

Residential customers can offer a significant amount of such demand-side flexibility. Exploiting the flexibility of residential demand has become more challenging and at the same time more advantageous as electric heating and transport are gaining popularity, and in turn, electricity demand is increasing. While there is undeniable evidence that some residential customers are ready to engage in at least some forms of DR programs, the research shows that the customers' engagement could be variable [20]. Investigating the consistency of customers in providing flexibility helps predict demand response potential, remove the barriers, and boost the consumers' participation in DR programs. Based on a systematic review of demand response trials in Europe, here the barriers and enablers to consumers' engagement are identified. By reviewing the reports of trial projects and best engineering practice across Europe, it becomes clear that the barriers of engaging the residential consumers can be rooted in either consumers' participation (being enrolled in DR programs), performance (delivering the service in a desired manner), and finally, the persistence of service provision over time [21]. These steps are summarized in Figure 3.1.

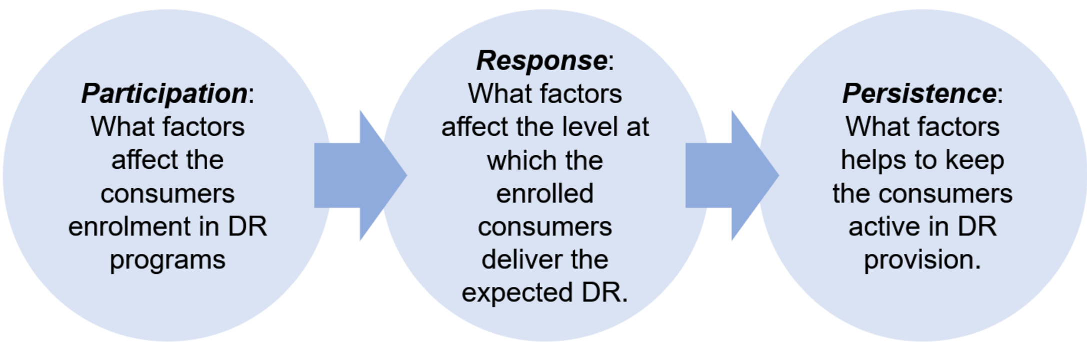

Figure 3.1 The steps of the engagement of consumers in demand response programs [21].

Recent research for policy-making has bolstered the key message that boosting the flexibility level of the distribution system is a key enabler in reducing the costs of integrating intermittent renewable energy sources [22]. While industrial and commercial customers currently contribute more to DR programs in most European countries and the UK [20], from a theoretical viewpoint, residential customers represent a larger source of flexibility with more effect on the decarbonization of energy systems [23]. For several reasons, the EU level and national policies have the greatest impact on user engagement in residential DR programs. Such policies could allow DR potential to be more accurately anticipated [20]. Policies may pave the way to reduce marketing costs to engage the consumers who are likely to offer their best performance. Such policies also protect consumers by informing them of if they are likely to benefit from participating in the provision of DR products and services.

Reference [24] classifies DR programs in price-based DR (including time of use (ToU) tariffs, real-time pricing (dynamic pricing scenario), and peak load pricing), and incentive-based DR programs (including direct load control, curtailable load, and demand-side bidding in the capacity market and ancillary services). Figure 3.2 presents such classification for residential DR programs. A residential building can participate in all price-based programs [25]. Smart meters and other advancements have made multi-tariff plans and dynamic pricing viable. In terms of incentive-based DR programs, the direct participation of individual buildings in the energy market is not viable. However, the participation of residential consumers can be aggregated and offered to the market. In direct load control programs as the next incentive-based program, the building owners hand over the control of certain equipment, e.g., freezers and beverage refrigerators, to the utility operator for additional remuneration. The associated slight alteration of the load is included in the uncertainties, as the decision-makers, i.e., the building owners, have no control over it. Curtailable loads are also the other service that can be offered by residential consumers for a certain portion of their load. The presented classification of DR programs can disclose some important barriers and bottlenecks of engaging the consumers in the DR program.

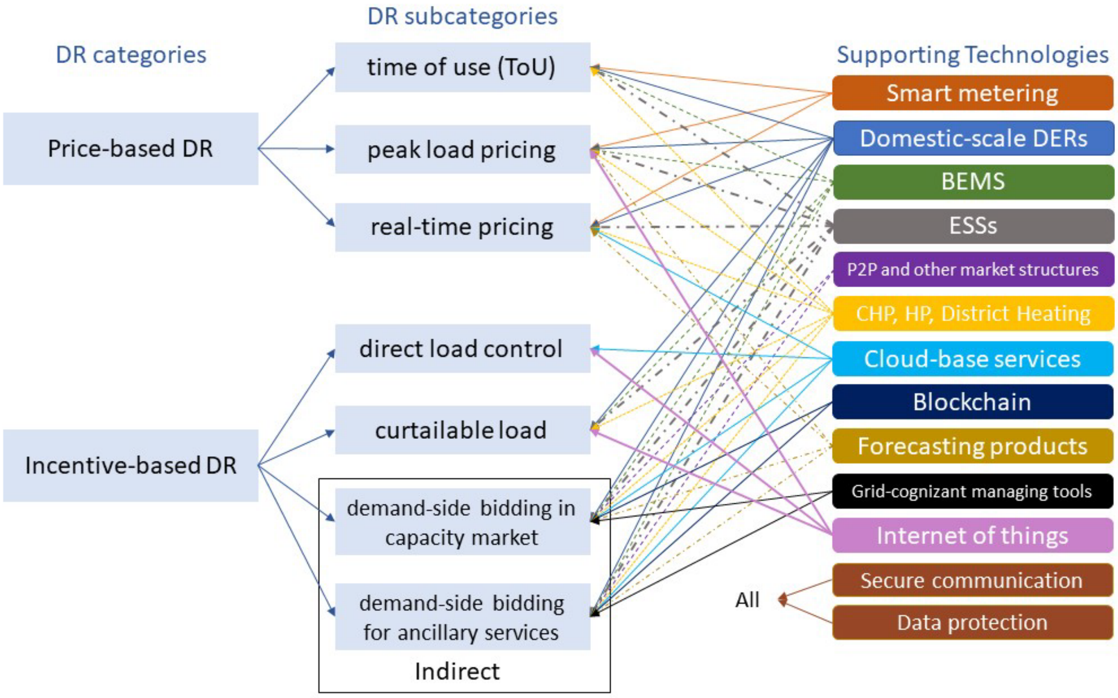

Figure 3.2 Classification of DR programs and supporting technologies.

Consumers' engagement in DR programs is more effective if other supporting technologies, e.g., energy storage systems, DERs, building energy management systems, smart meters, and the internet of things, are also adopted. Therefore, other than policy barriers in the promotion of consumers' engagement in DR programs, the immaturity of such technologies on a domestic scale may also hinder the response and especially, the persistence of the consumers' engagement in DR programs (see Figure 3.1). The technologies that support the successful implementation of each type of DR programs are also presented in Figure 3.2. Even though DR and generally demand-side management can be considered as a technology, its successful implementation is rooted in the readiness of many other technologies including but not limited to those introduced in Figure 3.2. This indicates that the immaturity of these technologies can be one of the important barriers in the enrolment, responsiveness, and persistence of energy citizens in DR programs. The barriers to the improvement of such technologies will be presented in detail in the upcoming sections of this deliverable.

Reviewing the academic publications, grey literature, i.e., related policies, and engineering reports, may also reveal more barriers to the successful implementation of DR programs. Reference [21] conducted a systematic literature review to find the key factors affecting the engagement of residential consumers in DR programs from the viewpoint of these consumers. A wide variety of motivations were identified for residential consumers to participate in DR programs. Among such motivations, monetary and environmental concerns were the most frequent motivations identified, while the monetary benefits were typically given the highest importance. This result was confirmed by [26]. In this regard, some consumers state that bill reduction is much more appealing than bonuses or other financial incentives. Therefore, as was expected, the enrolment rates in various sub-categories of DR programs are different mostly because of their effect on the bill reduction. As much as the importance level of the financial aspects seemed to be obvious, with the national and EU-level programs for improving the awareness of the citizens of environmental concerns in the energy sector, it was expected that the environmental concerns be of much more importance for the consumers than what found in the related research, e.g., [21]. One of the reasons is that most of the impacts of citizens' engagement in DR programs on pollution reduction and climate change are not obvious for the citizens. For example, because in most DR programs the total electricity use will not necessarily decrease [27], the citizens might not comprehend the potential environmental benefits of participating in DR. In this regard, one of the gaps is the lack of enough focus on promoting the effects of engaging with DR programs on the penetration level of renewable energy resources. Most of the citizens are not aware of such a potential, as the main focus of the programs provided for improving the awareness of the citizens has been on the detrimental effects that conventional energy generation might have. It should be declared for the citizens, how their participation in DR benefits the environment.

There is some evidence that after enrolling in DR programs, citizens continue to compare the potential monetary benefits against the effort, time, and loss of comfort when deciding whether to stay active or not. At this stage, it is very important to provide them with some tools that facilitate responding to dynamic pricing signals or make this challenge enjoyable for them for instance, by presenting this challenge as a game to children.

3.2.1.2.1 Trust issues

Many barriers that hinder the increasing enrolment in DR programs can be categorized as familiarity and trust issues. Mistrust can arise before or after enrolment. It is often linked to unfamiliar technology/technical issues. The second factor that gives rise to such mistrust is the lack of transparency around what DR entails. Finally, the mistrust might be started when the citizens cannot comprehend whom DR benefits. Clarity is perhaps the key to mitigation of the second and third issues. The level of citizens' trust can be enhanced by measures that improve clarity around DR in general. Such measures include providing information on DR from independent sources [21], communicating how different parties such as contributing citizens and energy provides benefit from DR [28] and notifying users of any direct load control actions taken [29]. However, the first issue (related to unfamiliar technology/technical issues) has persisted to be one of the most hindering challenges. The other substantial barrier is the possible lack of trust in the energy communities. To elaborate, engagement with forms of demand response that involve community action, such as peer-to-peer trading, may be affected if citizens do not trust the behaviour of other community members.

3.2.1.2.2 Perceived loss of control and risk

The risk might seem much clearer concerning the features of time-varying pricing or remuneration of DR. Technologies that enable responses to time-varying pricing, e.g., building energy management systems, may help to address the monetary risk associated with time-varying prices. However, such technologies themselves might be seen as a risk due to the loss of control of the citizens over their demands/tasks.

Higher price levels and less predictable pricing demonstrate higher risk for the citizens for engaging in the DR programs that entail time-varying pricing. Perceived risk or complexity can deter some consumers from enrolling in real-time pricing [21]. Participants in some trials of dynamic time-of-use pricing declared that they might willingly sign up again if the price changes were more predictable. Some citizens prefer smaller price change ratios for both increasing and decreasing scenarios, even though this might reduce their benefit. A price cap was required by some consumers, and others preferred engaging in ToU DR over critical peak pricing since the price ratios are much higher for the latter [21]. The key message throughout this discussion is that the risk (stemmed in unpredictability) associated with price variation is one of the barriers to the engagement of citizens in the respective DR programs. The BEMSs might help deal with this issue but more reliable forecasting is sought. Enrolment in price-based DR can be fostered by features of automation, e.g., through effective BEMSs that promote the users' perceptions of control. Such approaches include providing a choice about how and when automation takes place; specific agreements on allowed control including limited duration; adequate notification of control; the option to override, and more importantly, the DR practical models that can be fully comprehended by the consumers.

To elaborate on the abovementioned key enabler to promote the citizens' engagement in the DR program and to alleviate the risk and fear of losing control, it is of critical importance to the citizens to have an easy interaction with the automation system. It has been outlined in the literature and even put into action in the pilot project around the globe how the bidirectional communication between the retailer and consumers, based on smart grid technologies, makes it viable to provide the electricity price signals a few minutes in advance to the next consumption period and how the consumption of the next period can be communicated back to the retailer [25]. However, one of the most hindering issues in engaging the consumers in DR programs is the lack of DR practical models that can be fully comprehended by the consumers, given that they are usually no engineers. Parameters such as the minimum and maximum demand and future demand cannot be readily comprehended by the consumer. The load model needs to be able to categorize and prioritize the tasks as the components of loads. The consumer's preferences might vary among the tasks, and each task, from the point of view of DR, might belong to a certain category/subcategory that entails certain models. The BEMS should schedule a task in the periods that leads to the minimum cost for the task while satisfying the consumer's constraints and preferences. This is one of the important socio-technical barriers to the successful implementation of DR programs. In short, it indicates the lack of an understandable model that residential consumers can apply in their day-to-day energy consumption.

Unlike time-varying pricing that might seem risky from the viewpoint of citizens, incentive-based DR programs and the associated rebates for demand reduction/shift carry no financial risk for participants. However, mixed evidence on how such lower risk might influence the rate of enrolment of citizens has been identified in the literature. In a study presented in [30], the citizens declared they prefer incentive-based DR over time-varying pricing as a result of the higher risk of the former. However, as summarized in [26], in a series of trials in the US, little difference was observed in actual rates of enrolment in variable pricing and rebate-based DR. These trials identified that incentive-based DR results in less consistent responses, but higher retention rates compared to the incentive-based DR, e.g., critical peak pricing.

3.2.1.2.3 Complexity and effort:

The complexity and required effort for providing DR affect citizens' engagement. Considering demand shifting in general terms, some users expect changing demand patterns would be hard or undesirable due to inconvenience and effect on day-to-day routines [29]. However, others anticipate adjusting demand patterns to be simple. In some studies, the importance of how the effort citizens expect compares to the benefits they anticipate from involvement in DR programs [21]. The complexity and required effort of responding to time-varying pricing may be related to less predictable prices and other factors that should be predicted, e.g., the temperature. This highlighted the importance of the quality of forecasting products. In some countries, e.g., Ireland and other western European countries, the unpredictability of the weather might seem to be one of the substantial challenges in increasing the engagement of citizens in price-based DR programs. This might suggest for these countries, direct load control DR is a more suitable option. The forecasting technology needs to be evolved to facilitate engagement with more DR programs. Some trials of real-time pricing (see Figure 3.2 to see the categories of DR programs) reported very limited manual demand shifting since consumers found it difficult to change their use of appliances in line with continually changing price signals [21].

For a few consumers, even the routine responses to static ToU may seem too much effort by some users. However, in general, the ToU DR seems to be the most effortless DR from the viewpoint of most citizens. The results of a post-trial survey on the contributors of some trail projects reported in [31] showed that about 80% of contributors found dynamic ToU tariff too complex, 60% declared it was fairly easy to benefit monetarily from such rates, and 50% declared it was easy to avoid high rates. Note that in static ToU, in which, prices vary by time of day between fixed values and over fixed periods. These prices may vary over longer periods, e.g., by season. In contrast, in dynamic ToU, the prices vary between fixed levels, but the periods of different price levels are not fixed.

3.2.1.2.4 Need for installing new technologies

Automation or direct load control DR programs can mitigate the complexity and effort associated with responding to price variation. These enabling technologies may be associated with perceived ease of use, and some users who are away from home within the day may adopt them to increase their contribution in DR programs for extra remuneration. Nevertheless, using automation or accessing additional information provided by such technologies can itself lead to extra complexity and difficulty [32]. In the same way, the need to install new technologies may act as an important barrier to participation in automation and direct load control demand response. This might be attributable to the high cost of such technologies, the space required [33], and the disruption of services while installing the required equipment [27]. Not only for these types of DR programs, but the technology installation step is also an important obstacle in citizens' involvement in DR programs [33].

Other than the abovementioned barriers to the effective and sustainable engagement of citizens in demand response programs which are mostly related to citizens' behaviour and awareness, and policy gaps, the most cited barriers to engaging citizens in demand-response programs and exploiting the potential of residential buildings to reach the targets of energy transition include:

3.2.1.2.5 Insufficient wholesale price variation to compensate for the elastic demand of energy citizens

This can be categorized also as a market barrier. Besides, an important policy conflict is observed here as to make the other energy-dependent businesses more predictable, the policymakers often tend to keep the energy prices at a fixed level or within a predetermined limit. Price caps, over-procurement of conventional energy supply resources in energy and reserve markets, and other distortions to price formation and fluctuations related to the increasing share of intermittent renewables limit the business case for DR programs.

3.2.1.2.6 Energy and network tariff does not motivate to shift energy demand in time

Again, this barrier can be referred to as a market and regulatory barrier and at the same time policy confliction barrier. Energy and network tariffs that do not change enough for different periods are volumetric, capacity-based, or sometimes fixed making the energy citizens indifferent to the level and pattern of energy use. Such tariffs are not able to incentivize the citizens to engage in time-of-use demand response programs and keep them motivated to provide sustainable support even after they register in such programs. Further on this issue, according to [34], reforming tariff structures is a crucial factor in motivating the consumers to switch to electrified transport and e-mobility and the use of electrical heating, e.g., through heat pumps.

3.2.1.2.7 Distribution System Operators (DSO) remuneration approach

Distribution System Operators' (DSO) remuneration approach incentivizes much more or only for wire solutions and non-wire solutions such as the support provided from demand response are not well incentivized. This might be referred to as a regulatory barrier. Utility companies including both power and gas providers usually get paid based on the energy that they deliver. However, other than the revenue that they receive based on the energy volume distributed, they are also remunerated for invested assets, such are electricity networks, e.g., wires, poles, and transformers. Such a capital expenditures approach is common in remunerating utility companies to cover their investment costs. This, for sure, creates a bias against upgrading to smart grids [35] or investing in demand resources and demand-side management projects, instead of upgrading the electricity and gas network, i.e., non-wire solutions. Such conflict of interests is one of the important barriers to the sustainable engagement of the energy citizens in the energy transition. As the volume of demand support and the share of local energy providers in energy and other services increase, the resistance of the owners of network equipment and utility companies increases. Therefore, as this challenge is much more pronounced in future if the sustainable support from non-wire solutions is sought to achieve the targets of the energy transition, it is important to make policies that facilitate the gradual transition from such old models of remunerating the utilities to new models that promote the integration of energy citizens. From such a perspective, this challenge is not only regulation-related but also introduces an important policy barrier. In this regard, the readers are referred to chapter 4 of deliverable D3.3. In chapter x, where the challenges of new market designs are investigated, this point has been further discussed.

3.2.1.2.8 The necessity to give access to third-party actors to accumulate demand resources and introduce them to energy and flexibility markets

This can be another market and regulatory barrier. Also, as will be introduced later, there is an important gap in decision-making due to the low weight of the demand-side stakeholders in policymaking, which gives rise to this issue. The pooling of small residential demand involves aggregators that are free to employ domestic and other consumers and energy market access rules that enable these pooled resources to compete with supply-side resources. In recent years, other mechanisms have been proposed to obviate the need to give access to third parties. One of these mechanisms is energy communities. The other mechanism in this regard is P2P market designs.

However, such mechanisms also face their challenges, and further investigation needs to reach a final market and regulatory structure that solves these challenges.

3.2.1.2.9 The final list of challenges and barriers to sustainable engagement of energy citizens in demand response programs

The challenges that were listed for energy efficiency improvement should also be listed for the successful and sustainable engagement of energy citizens in demand response programs as without being able to optimize the use of energy in buildings, citizens do not have the potential to take part in demand-side support. Other than those challenges, many barriers are social barriers, e.g., lack of trust. Of course, among such barriers, most stemmed from the gaps in policies, e.g., the lack of trust can be (partially) mitigated by the policies that encourage clear communication with citizens. The other common barriers to demand response are mostly related to regulatory and specifically market barriers. To summarize the discussions provided in this section, the main barriers to the sustainable engagement of citizens in demand-side management programs are provided in this subsection.

1. Citizens' unfamiliarity and mistrust.

- Unfamiliar technology/technical terms
- Lack of transparency around what DR entails and whom DR benefits
- Mistrust in community-based mechanisms

2. Perceived loss of control and associated risk

- Long-term time-varying pricing may hinder enrollment
- Fear of loss of control of the citizens over their demands/tasks
- Unpredictable short-term prices that may deter citizens' persistence
- The prices should be predictable, but variable enough to guarantee the earning
- Lack of DR models that is understood by citizens and offer acceptable control

3. Complexity and effort

- Inconvenience and discomfort associated with demand shift
- Low reimbursement compared to the underlying decrease in comfort level
- Complexity and required effort of responding to time-varying prices
- Unpredictability of the weather in western European countries

4. Need to install new equipment and technologies

- High cost of such technologies
- Space required
- Disruption of services while installing the required equipment
- Lack of trust in additional technology
- Associated complexity of new technologies

5. Insufficient wholesale price variation discourage engagement in dynamic pricing DR

- Conflict with other conventional use cases that favour low variation in prices

6. Energy and network tariff structure does not support demand shift in time

- Lack of motivation to switch to e-mobility and the use of electrical heating

7. Distribution System Operators (DSO) remuneration approach

- Preferring wire solutions over non-wire solutions
- Lack of policies for the gradual transition from old DSO remunerating models

8. The necessity to give access to third-party actors

- Low weight of the demand-side stakeholders in policymaking

9. No definitions for rights for direct control of citizen's loads: Since different entities might make use of customers' load control for different purposes, it turns into a requirement to define certain rights and obligations which apply to the parties responsible for power balance.

From a higher-level point of view, most of these barriers are rooted in, policymaking gaps, e.g., the higher weight of the supply-side stakeholders in decision-making for policy development. Many of these barriers also stemmed from the supply chain barriers, e.g., energy markets have been designed from a supply-side perspective. The stakeholders on the supply side have no genuine incentive to support demand-side services. Further, they may even have inducements to hinder the successful implementation of demand response. As presented above using a few examples, some other barriers are originated from policy interaction barriers, an example of such barriers is conflicting objectives or priorities when making the supporting policies. These categories of gaps are added here to the list of barriers to sustainable engagement of energy citizens in the energy transition, bearing in mind that such gaps may also be the main cause of many other barriers to the other enablers that will be discussed in the upcoming sections of this chapter.

10. Policymaking gaps

- Higher weight of the supply-side stakeholders in decision-making

11. Supply chain barriers

- Old design of energy markets from a supply-side perspective

12. Policy interaction barriers

- Conflicting objectives or priorities when making the supporting policies

3.2.1.2.10 Lessons for policymakers

The related energy policies at EU and national levels concerning DR programs might target the following:

- Financial incentives: including time-varying prices, rebates, and payment for allowing direct control of the citizens' demand. Most studies suggest that adequate financial incentives and the predictable forms of DR support the citizens' engagement in DR programs.
- Promoting the enabling technologies such as direct load control, BEMSs, and automation. The policies should support the adoption of these technologies in a way that improves the citizens' trust and does not reduce perceived control. It might be possible to increase demand flexibility by making the policies that support the adoption of enabling technologies.
- Training the citizens and improving public awareness. In this regard, it is important to inform the citizens of DR programs, clearly introduce who benefits from DR programs, and improve

their awareness regarding the environmental impacts of DR programs. As this study reveals, most EU citizens are aware of the environmental effects of renewable production but not the effects of DR on improving the penetration level of renewable energy sources. Trust is encouraged by supplying transparent information about different parties that benefit from DR programs, and by providing the citizens with realistic expectations. It is important to form an organization that truthfully answers the questions raised by citizens and offers help when they face problems that escalate. Also, bill calculator tools guarantee help to inform and protect energy citizens.

3.2.2 Distributed energy resources (IERC)

This subsection mainly includes the barriers to exploiting the distributed energy generations (DEG) and energy storage systems (ESS) to help the integration of energy citizens into the energy transition. The market-related barriers that also hinders the applications of DERs' will be discussed in subsection 3.2.3.

3.2.2.1 DEG

Distributed energy generations are becoming increasingly competitive, and there is an increasing interest from energy citizens to take part in this energy transition. Thus, the effective integration of renewables and distributed generation resources at the citizens' premises is of high importance toward achieving a smooth and efficient transition.

DEG benefits citizens in different valuable ways. Solar PV/Thermal presents an attractive option in a sunny area where consumers can generate potential economic profits. The DEG can also benefit the utilities and the overall system. Depending on the status of the grid, the DEG can be used to locally supply electricity directly to customers and grid upgrade capital investment deferral. In some cases, the DEGs are one of the most valuable and affordable solutions to support load growth in some areas where adding new generation or grid infrastructure is too difficult, time-consuming or expensive. Distributed generation incentive programmes to encourage distributed generation in the form of rooftop solar photovoltaic technologies have been highly effective in many cases, and customers have embraced them in many countries.

Distributed generation incentive programmes are playing a potential role in DEG market uptake. Rooftop solar photovoltaic systems have been widely deployed at the citizen's level. The US Energy Information Administration (EIA) estimates that in 2019, 53.3 billion kWh were from small-scale or distributed PV systems [36].

New Infrastructure, customer engagement, regulation and new business models are the main enabling keys to deal with challenges and unlock the potential DEGs deployment opportunity at the end-user/citizen site. To enable a successful integration, both public and private sectors must contribute, and complimentary engage an ongoing effort in the coming years [36].

There is an ongoing effort toward analysing the barrier and bottlenecks that hinder the successful development of DEG in energy citizens. Literature is rich and relatively broad, including reports, publications and grey literature.

In [37], a review of DER grid integration challenges is presented. The authors identified five main technical challenges; 1) Lack of interoperability standards, 2) Lack of detailed DER modelling, 3) Increased control points and operation burden, 4) New protection scheme and configuration 5) New stability phenomena. The authors also provided an overview of the grid code and standards associated and the future of the role of the smart inverter to support a smooth energy transition.

In the Report to the European Commission [38], the authors analysed the barrier that affects the effective integration of DER for providing flexibility to the grid. Different technical, market, regulatory barriers have been identified. One of the main recommendations is to put more focus on the energy customers.

In the World Economic Forum report [39], the main trends affecting the power grid have been assessed; electrification, decentralisation and digitalisation. This report also identifies the critical actions for public and private sectors participants to effectively ensure a smooth, sustainable electricity system using grid edge technologies. An actionable framework of four key complementary principles has been identified toward unlocking potential opportunities and alleviating the main challenges for accelerating the transformation toward an environmentally sustainable electricity system. The four-identified principle are: 1) Redesign regulatory paradigm, 2) Deploying enabling infrastructure, 3) Redefining customer experience, 3) Embracing new business models.

Report [40] published by the International Energy Agency (IEA), it was argued that, in addition to grid digitalisation, all aspects of the power system need transformation for enabling valuable DERs integration into the energy system.

In reference [19], The authors have analysed regulatory, standards, and network codes and barriers that hinder the participation of energy citizens in the local energy market.

However, citizens are now in the heart of the energy transition, focusing on analysing the main barriers hindering effective DEG integration. Citizens have many peculiarities compared to the other energy sector stakeholders, and analysing the needs and potential engagement in the energy transition is more complicated than dealing with organisations, companies or institutions. The above analysis of state of the art shows that the main literature focuses on analysing DERs in a holistic approach. There is a lack of analysis of barriers and enabler factors of DEGs on the energy citizen level. In this regard, this report proposes an analysis of the main barriers, bottlenecks and the key enablers toward achieving a successful energy citizen integration of distributed energy generation. In the remainder of this report, a list of the main barriers is described. It is to be noted that some barriers are common for all DERs and also energy markets for the energy citizens and communities, hence those are mentioned in the next subsection 3.2.3.

3.2.2.1.1 Barriers

This subsection analyses the main barriers and bottlenecks hindering energy citizens. The identified barriers are classified under technical, cybersecurity, market, and regulatory categories. Further details of each category are discussed in the following sections.

1. Technical barriers

Many technical challenges hinder the DEG integration at the citizen level. They are almost related to grid code and stability and interoperability issues.

The DEG at the end-user premises is generally considered as a net constant power load [41]. The widespread of these systems in the LV network will require a better understanding of their dynamics and their ability to integrate smart inverter grid supporting functionalities.

It is to be noticed that with the increase of inverter-based grid-connected DEG, the short circuit current is becoming more sensitive. Due to the limited capability of the distributed inverter to provide short circuit current compared to the synchronous generator, the grid protection system needs more developed and sensitive relays and sensors to enable a secure grid operation [41][42]. Another challenge related to inverter-based grid-connected DEG is the harmonics caused by power electronics control and high switching dynamics. An unstable operation can occur at super-synchronous harmonics frequency. The root cause and the impact on the power grid are still unknown, requiring the design of consistent grid super-synchronous harmonics frequency stability analysis [37].

Along with the challenges mentioned above, the distribution network lines were initially designed to support unidirectional power flow; however, a high DEG citizen penetration can lead to bidirectional power flow. Thus some unstable operating conditions might occur.

Different norms and standards have been developed to cope with DER, DEG deployment, and grid integration. While the IEEE1547 [36] and IEC 61850 [36] form the primary documents for grid integration, specifying the required mandatory specifications for grid code and operation conditions and some details on flexibility and choices, other standards have been developed for enhanced integration. For instance, the IEEE 2030 and IEC 61850-7-420 [36] propose an enhanced framework for intelligent DER and DEG grid integration, defining realisation and interoperability functionalities for associated IoT and ICT technologies. The proliferation and diversity of the integration and connectivity models have led to the development of different industrial protocols. Service providers also might consider specific regional/ continental integration and connectivity measures. The co-implementation of the different developed protocols becomes very challenging, especially in terms of cost and cyber security issues. It is a vital R&D area, and despite the development of interconnection and interoperability standards, the market uptake of plug and play DEG-citizen oriented solutions requires a common standard [41][42][43].

2. Cybersecurity

The multiplicity of DEG citizen-based solutions and their communication points make the main power grid more vulnerable [42]. The authors in [44] claim that over 70% of DER devices contain vulnerabilities, insecure data transfer, operator-side data leakage, insufficient data breach response. Even with the implementation of local cyber security procedures and technologies, the diversity of communication gates and the heterogeneity of cyber security procedures can impact global system security. The coordination between the different cyber security protocols and the localisation of an eventual attack is still one of the primary concerns of grid operators.

3. Market

As the concept of energy citizens is relatedly new, the energy citizen market framework is not well established yet. Recently, transactive energy frameworks and several transactive control strategies are developed to enable citizens and local prosumer to actively exchange the produced energy locally and maximise their DEG social welfare. In the literature, this concept refers to the local energy markets (LEMs), where small-scale energy users who produce and consume energy can exchange this energy in a competitive market and improve the local energy balance of demand and supply.

In [45], the authors have analysed Re of Peer-to-Peer, Community Self-Consumption, and transactive local energy market models and have identified five research gaps that require further analysis: physical constraints integration into market mechanisms, holistic approach of market operation, market scalability and replicability, information security, and prosumer/end-user privacy

4. Regulatory

The energy system is facing a big and fast revolution. The energy citizen concept is relatively new in the ecosystem environment. The complete value chain here is still not well known. The conventional energy/electricity system regulatory structure was built around a well-known and static energy ecosystem where centralised generation assets ensure power delivery to the consumers via a unidirectional power flow in the grid. New players are integrating the value chain, and the role of traditional stakeholders is changing. Most of the upstream generation responsibilities (grid stability, security of supply etc.) will be delegated to the local generation. Market operators will have to deal with new entrants. Thus, the conventional regulatory structure is not adequate to support this transition.

3.2.2.2 ESS

ESS mainly focus on battery-based solutions. Battery energy storage systems are the most common storage system in the citizen premises. They use electrochemical technologies to store the energy. In 2019, a total of 960,000 systems was installed in Europe, representing 745 MWh energy capacity and a 57% year-on-year growth. It is expected that the market residential BESS market will continue to achieve a low growth rate from 2021 to 2024, leading to 1 million homes installation and around 7 GWh total capacity (compared to 270,000 systems and 2 GWh at the end of 2019) [46]. The ’100% Renewable Europe" conducted by LUT University and solarEurope showed that to achieve the 2050 renewable energy target in Europe, there would be a need for 1,600 GWh distributed BESS system integration [46]. The market distribution between the European countries is unbalanced. Only a few countries monopolise the market, 90% of the novel residential BESS, in 2019, have been installed in Germany, Italy, the UK, Austria, and Switzerland [46]. Germany is the main undisputed leader. In 2019, the country was responsible for two-thirds of market growth in Europe, 496 MW residential BESS capacity has been installed, presenting 63,000 new residential BESS systems. The annual market growth in Germany is 75% compared to 57% in Europe [46].

3.2.2.2.1 Barriers

As the ESS is a part of DERs and also a part of the energy market for energy communities, all the barriers as outlined in the DEG subsection and energy market are equally important for ESS. This section outlines some of the key barriers that need more attention and especially for the ESS solutions.

1. Techno-economic maturity

The techno-economic maturity of the ESS for energy citizens presents one of the main factors hindering the ESS deployment at the citizen premises. The BESS is one of the most mature ESS technologies in the market. The technical merits are well known and established; however, the economic viability deployment at the citizen side is still questionable. Most of the recently reviewed literature conclude that BESS is still not profitable under the actual market conditions.

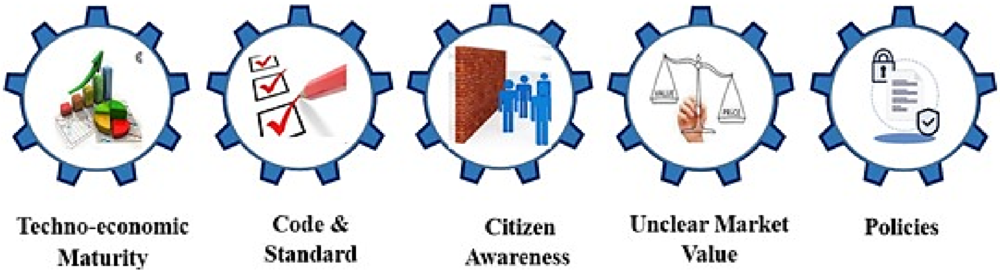

Figure 3.3 Barriers to citizen EES deployment

2. Code and standardisation

There is an ongoing effort on developing and upgrading grid code for enhancing DER grid integration and interoperability as IEEE1547 [47], IEEE 2030 [47], and IEC 61850-7-420 [48]. However, there is a lack of common and harmonised standards for deploying ESS plug and play solutions. Still, BESS is vulnerable among the other citizen-based ESS technology. The development of grid code and standards for DR and DEG has a direct on the BESS. The safety standard is well developed, and the BESS storage is widely integrated at the citizen premises.

3. Citizen awareness

There is a lack of public awareness on how ESS can provide individual economic benefits and community and environmental benefits. In [49], the authors performed a study to analyse comment barriers for citizen BESS deployment. 23% of respondents mentioned that BESS does not make financial/ economic sense, 26% claimed to lack knowledge about the storage, and 14% expressed concern about the BESS's durability. House renting present also one of the main barriers for ESS energy citizen empowerment. Citizens are less likely to invest in residential storage in case they are not household owners. In the study [49], 35% of respondents cited this barrier for not investing in household battery storage.

4. Unclear Market value

The role of ESS energy citizens in the whole energy transition is still unclear. Despite the huge potential that residential ESSs present, no clear market framework for residential storage is established yet. As a new approach, the aggregation concept offers a lot of opportunities for the citizen to maximise the value of their ESS in the wholesale and ancillary market. However, this is coordinated through a centralised strategy. The decentralised ESS citizen market framework is still established yet. Transactive energy and local energy market are still at their early stages, and the complete value of citizen ESS in the market space is still unlocked.

5. Policy

There is siloed thinking among policymakers on how to promote each ESS category independently of the other one. Furthermore, there is a gap between the residential heat sector decarbonisation policies and the energy citizen sectors. This has created some unbalanced ESS citizen-oriented markets that can set a complex cost competitiveness environment for some technologies. What is more, there exist some conflict and lack of harmonisation in policies design. In France, for example, the low retail electricity price (around 0.18 EUR/kWh) present a major barrier to the residential BESS business take-off.

3.2.3 Energy market structures, local market structure (UCD)

The EU is being prepared to set an exceptional standard by ratifying the role of citizens and communities in the energy transition. Nearly half of all EU citizens could be engaged in producing renewable energy by 2050. About 37% of this could be realized through the involvement of such citizens in citizen and renewable energy communities. Nevertheless, the market design initiatives must put strong regulations in place to acknowledge, allow for and offer rights to households that want to participate in energy communities and ultimately in energy markets. A variety of entities and organizations, e.g., local authority representatives, renewable energy cooperatives, NGOs, and members of the renewable energy industry, the Community Energy Coalition are working together for meeting the EU's Clean Energy for all Europeans package [50] that is envisaged to provide a fair deal for households as "energy citizens" and ensure nobody is left behind in the energy transition of Europe. As co-legislators, the European Council and European Parliament have been tasked with ensuring that all European citizens can harness this potential.

Essentially, the electricity market design should be coherent with other regulations in the Clean Energy Package that have already been decided by the European Parliament and the Council. Particularly, such regulations should not be inconsistent with provisions in the Renewable Energy Directive. Such provisions include: 1. definitions of RECs and self-consumers; 2. allowing for citizens' right to take part in the energy transition as an active customer or an energy community without losing their rights as consumers; 3. acknowledging the right to access all types of relevant markets without idiosyncrasy or disproportionate treatment; 4. considering a right to sell energy through suppliers and peer-to-peer energy sharing; and finally, 5. acknowledgement of the benefit that energy citizens and energy communities can bring to the energy system and remuneration of their contribution. The European Commission has acknowledged that revised policies [51] and structures for electricity markets are required to:

- Expedite the energy transition
- Better fit to current advancements
- Encourage prosumers rather than consumers
- Motivate the citizens to further participate in collective organization and electricity markets
- Put demand-side flexibility as one of the main priorities

The EU Electricity Directive and Renewable Energy Directive indicate the vision of the EU on the future structure of the energy system. For the future of energy communities in Europe, how these directives will be interpreted into national regulations matters the most. Both opponents and advocates of energy communities will be involved in discussions to impact national legislation to their advantage. Depending on the conclusion of such a process, a variety of roles and functionalities beyond energy efficiency improvement and saving and energy generation might become possible, feasible, and appealing for such communities. Local energy trading, for instance, through peer-to-peer trading or a community energy market if the related barriers are effectively dealt with. Pooling, and selling energy from renewable energy resources, demand response, and storage, as well as flexibility from the same sources and also controllable appliances, and perhaps combining this with the energy supplied by other energy communities, as an aggregator is the next activity that communities can take part in to increase their profit. The energy communities can also sell flexibility through a third party.

The analysis of the national (country-specific) barriers is discussed in Chapter 4. This subsection is aimed at presenting the market-related challenges that might hinder the energy transition in Europe. More specifically, in the following, various roles in the current and futuristic scenarios of electricity market structures in the EU are discussed. It has also been described which roles can be taken by energy communities and energy citizens. This subsection finally summarizes the barriers to the successful and sustainable introduction of demand-side products and services into electricity markets.

Many businesses and citizens are more and more installing their renewable energy resources. This transforms them from only customers to active customers, known also as prosumers, who consume energy and also provide power to the electricity network. On the other hand, since traditional flexibility sources are going offline due to environmental concerns and their impact on climate change, the flexibility must take new forms. In this regard, demand-side flexibility provision is essential for the EU to meet its sustainable energy targets. Active customers have the potential to provide the new form of flexibility that electricity networks need. The flexibility that they individually offer might be insignificant but when pooled or “aggregated” such flexibility could be sufficient to cater for a considerable amount of flexibility that a power system might need. Various market roles can be identified in some of the current electricity markets and those which are being designed for the near future. Such roles are outlined below, as defined in [52]. Unavailability of the individuals, groups, or organizations to take such roles, or ineffectiveness of the enabling measures that they might take with regards to the sustainable introduction of citizens’ products, i.e., energy and flexibility, defeat such a target.

- **Prosumer:** Consumes energy and produces energy and flexibility as end-users. An example of such prosumers is the citizens that have PV panels on their roofs enabling them to produce as well as consume energy.
- **Facilitator:** Facilitates implementation of DERs, RESs, RECs, CECs, and so on. In many energy communities, one of the reasons to establish such a community is to facilitate the uptake of RESs and other energy generators in their community by for example proving help with financing, awareness increasing, joint purchasing, and knowledge sharing. The facilitator can be such communities or some organizations that can provide help and support.
- **Producer:** Generates energy and feeds this energy into the electricity network. If renewable energy communities have considered investing in a collective generation project, such as a collective rooftop photovoltaic system or a wind park, they are taking the role of producer in the new market structure.
- **Energy Service Companies (ESCos):** Provides energy profile optimization tools and services. An example of such a provider is a company that offers cloud-based building energy

management systems. An energy community might also be able to provide technologies/management systems that optimize energy profiles in response to varying external signals, e.g., energy or flexibility prices.

- **Aggregator:** Pools and sells the flexibility that citizens and communities might be able to offer. An energy community itself can combine the flexibility of multiple households and together as a single 'package' introduce the collative flexibility to the energy market and perhaps directly sell this to another party that may want to buy flexibility. For prosumers to gain access to flexibility market and sustainability support the energy system, the role of the aggregator is gaining more importance. Aggregators pool enough flexibility from multiple flexibility suppliers (who can be energy citizens or energy communities) to provide a worthwhile amount of flexibility to flexibility users such as distribution system operators (DSOs), transmission system operators (TSOs), and balance responsible parties (BRPs).
The need for demand response aggregation and the aggregator role has been acknowledged and sought in the European Union's Clean Energy Package for all Europeans (CEP). This package also provides a series of directives to support the necessity of defining such a role in electricity markets. Specifically, in Directive 2019/944, Article 17 presents the new features of electricity market designs that deal with Demand response through aggregation. This Article requires all Member States to develop the necessary regulatory framework for (independent) aggregators and demand response to participate in energy and flexibility markets. In addition, Article 32 seeks to motivate the use of the flexibility provided by the aggregators in distribution networks. Article 32 also, encourages the Member States to develop the essential regulatory framework to allow the transmission and distribution system operators to deploy such flexibility to alleviate congestion (in terms of the adherence to both line power carrying limits and statutory voltage constraints) in their networks.
- **Supplier:** Buys and sells the surplus energy produced by citizens and communities. Heed that an aggregator or the community itself might also take the role of a supplier. In general, in case a collective generation project has been established by an energy community, and it decides to supply this energy to its members, other customers, or utility companies, the supplier role is being fulfilled.
- **DSO:** Effectively manages the distribution systems at low- and medium-voltage (LV and MV) levels. DSO is generally responsible for regional grid stability and adherence to the power quality standards. In the futuristic scenarios for energy markets, energy communities might be permitted to operate their LV distribution (micro) grid. In some modern structures for the electricity markets, it has been proposed to regard the DSOs as fully independent bodies and even remove their technical role. Another player, Distribution Network Operator (DNO) might take this role. The DNO provides technical support to the aggregators and those who might take the role of an aggregator [53]. In this scenario, the DNO is not in charge of ensuring power quality.
- **TSO:** Actively manages the high voltage (HV), i.e., transmission, grid. TSO is regarded as responsible for system balance and adhering to the security and power quality standards at the HV level. The physical extent of TSO's working field is most often large, its role is practically always beyond the capabilities of energy communities to fulfil. However, in the new setup of energy markets, TSOs are still attractive associates for aggregators/communities as they are in increasing need of new types of flexibility especially to replace the traditional flexibility providers. TSO-DSO coordination is also very important here.
- **BRP:** Manages and is responsible for the balance of demand and supply in its portfolio. This

party is responsible for and manages a very large portfolio. Thus, it is interesting for energy communities to collaborate with.

3.2.3.1 Discussion on the current and future roles in electricity markets

Although they might have their reasons to resist the new setups of electricity markets and the presence of the new players in this market, both industry bodies and regulators agree that demand flexibility should be an indispensable element of future sustainable energy systems and the aggregators are the main players that help to fulfil this. The CEP has already set the starting point for it. In the abovementioned list of the new or updated roles in energy markets, sometimes there are no clear borders between associated functionalities. As demand-side flexibility can be provided by households and communities, new chances arise for such parties to collectively take up new roles, e.g., aggregator and ESCo. An aggregator might also be a supplier, or most of the functionalities of aggregators and suppliers might be provided by energy communities in some instances. Regulators, system operators, market participants, and other parties in the current energy landscape all have different viewpoints on flexibility, and therefore approaches to procure the required levels of flexibility. However, a very transparent and integrated flexibility market requires more coordination of the abovementioned roles as well as clear market mechanisms. The important challenge in this regard might be that it is still not clear how this will work in practice.

An example of the realization of incentive-based and price-based DR are schematically presented in Figure 3.3 and Figure 3.4, respectively, through demonstrating the money, flexibility, and information flow among the abovementioned roles. Sometimes, there are no clear boundaries between associated functionalities. As demand-side flexibility can be provided by households and communities, new chances arise for such parties to collectively take up new roles, e.g., aggregator and ESCo. Figure 3.5 presents a widely discussed structure for LEMs [25] in the presence of CECs. However, in practice, there might be a variety of structures for money, information and flexibility flow among the participants of these markets.

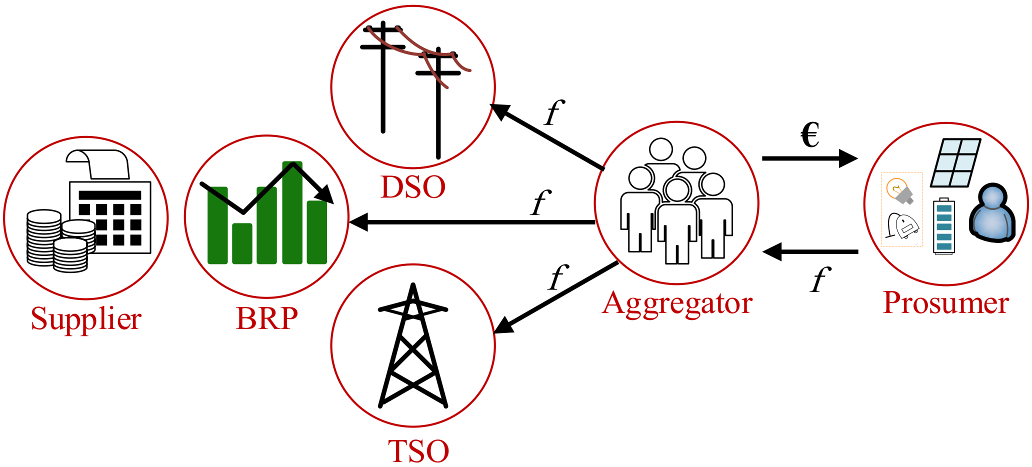

Figure 3.4 Flexibility provision of energy citizens in incentive-based DR and the remuneration of prosumers. In this figure, "f" indicates flexibility provision.

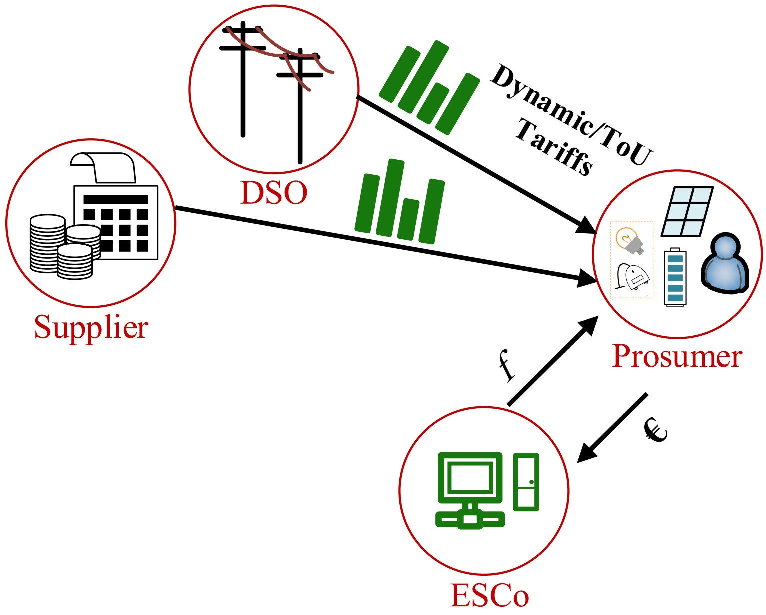

Figure 3.5 Information and money flow among the participants of LEMs in price-based DR.

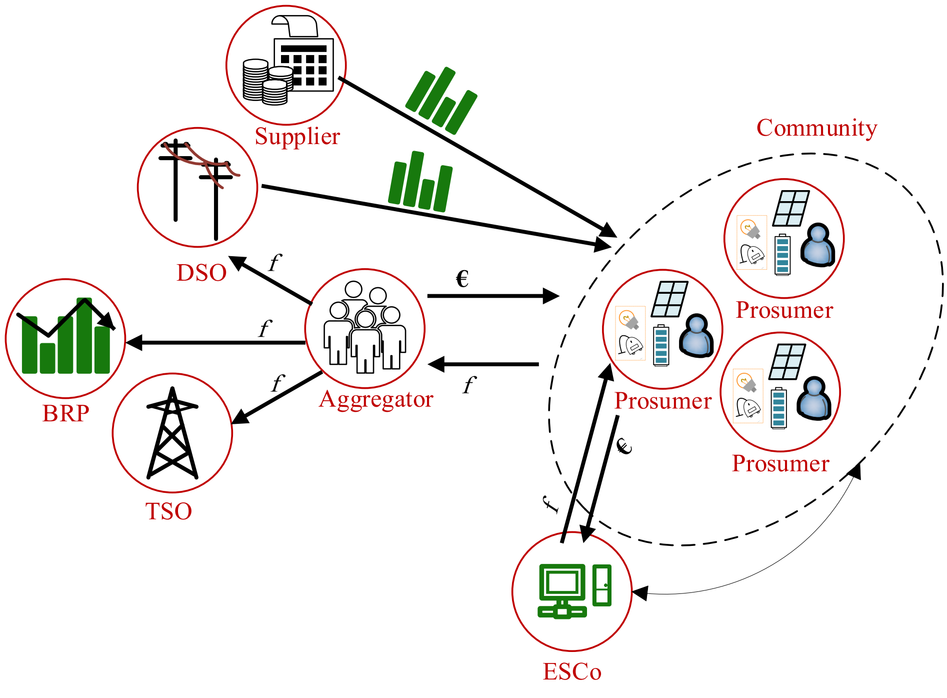

Figure 3.6 A widely discussed structure for LEMs and the roles of various participants.

There is a relatively wide range of organizations and companies involved in the current and future structure of energy markets. Most importantly, they can play multiple various roles. However, according to the regulations, currently, some roles are not allowed to be taken by one organization. An example of this is that the role of DSO and supplier cannot be both played by a single organization. In the future, energy citizens and energy communities can take the roles that they could not adopt before. This stipulates opportunities to contribute to new activities that pave the way towards achieving their economic, environmental, and social targets. Examples of such activities are as follows.

- **Prosumer role:** To install renewable power production capacity, e.g. solar panels, at both household and community levels.
- **Producer role:** To collectively develop energy generation projects, e.g., collective solar farms, solar roofs, wind projects) and sell the produced energy to a third party, i.e., a supplier.
- **Aggregator role:** To actively collect, aggregate, and next sell the flexibility provided by renewable energy resources, households' controllable appliances, and also, storage at distribution or transmission level. An energy community that takes this role, as an aggregator, might also bundle this with the flexibility provided by other sources, e.g., other communities.
- **ESCo role:** To enable citizens to respond to dynamic prices, time of use prices, and incentives to maximize their monetary benefits.
- **Supplier role:** To buy energy from energy citizens and community and sell it back to community members, other citizens, and/or sell it in an appropriate energy market. In the latter case, the community needs to be a licensed energy supplier.

The abovementioned roles, described in [54], reflect the current electricity markets and almost show the pathway that has been discussed in the past years for these markets. An important market design challenge that affects the sustainable integration of citizens in energy transition, is that even today it seems that change is on the way. This means it is possible that new roles emerge or that the roles listed above are changed. All these changes are not happening in response to new national and EU policies. The industry is striving to get its share from the available opportunity to make a profit. The energy sector has always been interesting for investment. Following the urgent need for effective transition of energy markets and the increasing push for the engagement of new flexibility providers, new investors and companies with new specialities are getting interested in investing in the new structure of energy and flexibility provision in power systems. An instance of such companies is electric energy storage companies.

As provided in the current prospect of CEP, when energy communities grow and become well-established, they can increase the number of roles that they may play in the energy system. This often requires growth in size, monetary resources, expertise, skills, and the list of adopted technologies, e.g., controllable appliances and storage systems, to be able to offer flexibility. Not that the presence of a new sort of investment in the energy sector can necessarily be seen as a challenge, the abovementioned point might distort the whole prospect. Some giant enterprises have started developing business models to step in to take the place of the available organizations that have been playing the available roles in electricity networks listed in this subsection. An example of such companies is Tesla (TSLA). They are launching a new “Energy Plan” to offer low electricity rates for citizens [55]. They plan to provide energy to households by rooftop photovoltaic systems and Powerwall VPP technology. In turn, it is sought that the households hand over the control of these resources to Tesla. In this way, they are targeting both energy and flexibility markets.

Of course, as explained above, this is not the first instance that a single entity wishes to play multiple roles (in this case all abovementioned roles except for DSO, TSO, and BRP), but if the future of the electricity market mix is headed to this destination, many business plans need to be revisited. Which roles an energy community is able and willing to take over the next years depends on economic changes over time and the actions of the possible new players, as well as the community's goals, abilities and also on policies that state the requirements for and possibilities to play and combine different roles. These all introduce new sources of uncertainties that can be categorized in the list of barriers to energy communities as one of the enablers of citizens in the energy transition. From the perspective of this subsection, however, this uncertain future not only affects citizens' choices but also the required design of future energy markets and related policies.

3.2.3.2 Barriers to updating the market design

PANTERA consortium has identified the barriers to implementing a market structure that needs to be removed to achieve the sustainable integration of energy citizens into the energy systems to achieve the targets of the energy transitions. These barriers are listed below.

1. Interactions and conflicts between functionalities of the roles as a barrier: In the implementation of the role of aggregator flexibility is separated from the underlying energy supply. The responsibility for the activation of flexibility is the role of aggregator while supplying the energy has been left aside for suppliers. Heed that separating flexibility from energy provision is not easy since activation of flexibility support causes a deviation in the normal pattern of energy consumption/generation of prosumers. It, therefore, affects the amount of consumed/produced energy. As a result, the BRP which takes the responsibility for the balance of demand and supply, and the supplier that provides energy are both affected. Active consumers should be free to offer their flexibility support to any party they might have in mind. Nevertheless, in practice, how to organize the electricity market to realize this, while also procuring the needs of other parties, is not yet clear. Thanks to solid work by researchers, industry, and regulators, good progress has been made. Some challenges of integrating demand-side flexibility into energy markets have been identified, and some important steps have been taken to mitigate such challenges. As a result of the effort put into identifying the challenges, it has been clarified that no single solution will be appropriate for the various market structure that might be found across Europe, in terms of employing flexibility aggregation. Each country/market structure may require special modification in the good engineering practice that might be effective in a certain project.

In USEF (a solid foundation for smart energy futures), the foundation's Aggregator Workstream set up to further define the functionalities of the aggregator role in integrating demand-side flexibility into all relevant markets and products [51], a wide range of complexities should be first addressed before the aggregators can achieve their functionalities. As outlined in the results of USEF Workstream the Barriers to the functionality of aggregators, i.e., the complexities that should be dealt with to make the aggregator role functional are as follows.

2. Measurement, validation, and baseline methodology: In remuneration of demand-side flexibility, a baseline is the value of demand/generation of flexibility providers before they change it based on the aggregator's request. A baseline methodology is required to quantify the performance of flexibility service providers towards the customers of the flexibility. According to the roles introduced at the beginning of this subsection, these customers include the TSO, BRP, or DSOs. How to define appropriate baseline methodologies, roles, and responsibilities in this regard has been a question. On the other hand, there should be some frameworks for ensuring accurate and dependable data. It should be clear how to measure or calculate flexibility.
3. Remuneration of joint price-based and incentive-based demand response: It is important to find a method to effectively separate the share of price-based and incentive-based demand response when a consumer/energy community changes its demand/generation. In many cases, a flexibility resource may be subject to both price-based and incentive-based demand

response programs. In this situation, to remunerate the service providers, the impacts of the two forms should be separated unambiguously.

4. Data confidentiality vs transparency: A balance between transparency and confidentiality is hard to find. For efficient demand response, each participant in the new structure of the energy market needs some information from others. An example of this is aggregators who need demand, demand reduction capability, and demand reduction data to be able to accurately forecast the demand response and also for billing purposes. Nevertheless, some of this information might be commercially sensitive. Finding a balance between transparency and confidentiality is critical for deciding what information can be shared and also, when and at what aggregation level this information is useful and can be passed to the respective bodies.
5. Data security: As discussed above, local energy markets involve dynamic gathering and transferring significant amounts of data. Much of such data is of a sensitive and confidential nature. Secure data handling and protection from various cyber security threats in this context are the main concerns. The respective challenges should be dealt with by ensuring a clear definition of responsibilities and updating the data exchange systems of local energy markets.

Other than the abovementioned challenges to (partially) deal with which, there have been some approaches proposed in the academic literature and industry reports [51], there are many barriers that have stemmed from the transition from the old structure of electricity market to the ones that are being put into action, and the associated new roles that have been introduced to assure the required functionalities. For most of these barriers, there have not been any effective remedies proposed even in the recent academic literature. Most of the propounded approaches are based on oversimplified assumptions. A concise list of such barriers is provided in this subsection.

6. Technical responsibilities for nontechnical organizations: According to the CEP, demand response aggregators are supposed to conflate the capabilities of a large group of householders in a DR pool and join in, as a single participant, in the electricity market. To this end, aggregators need to ponder the operational constraints of the local LV grids, including the voltage statutory limits. Otherwise, the power quality might be jeopardized. Neglecting the technical limitations demand response potential might be overestimated. This could lead to instability of the market and power systems, as the aggregators are not able to alter their demand/production when called on to. Reference [56] presented a method to deal with such an issue. This method coordinates the actions of the aggregators with DSO operations for a secure and efficient scheduling and real-time operation of demand response in residential feeders. This method assumes there is another role as the Distribution Network Operator (DNO) with the functionality of providing the results of state estimation and a set of sensitivity coefficients, using which the operational limits can be modeled. In practice, however, such an assumption does not hold. To elaborate on the sides of this issue, heed that the ultimate goal concerning aggregation role is for the mature energy communities to take on the associated functionality. On the other hand, if the aggregators benefit from demand-side flexibility, they should handle the power quality issues. The problem is that they do not have the technical knowledge and the required data. This is classified as a conflict barrier, as the DSOs do not willingly help the aggregators if they are not receiving monetary benefits. A proper mechanism should be developed for DSO and aggregator to support each other. Regulatory policies need to be amended to remove the conflict and facilitate the adherence of aggregators' action to power quality standards in distribution feeders.
7. Technical limitations and fairness: Reference [57] assumes only one aggregator is in charge

of pooling the demand-side resources in the LV feeder. In practice, however, many energy communities that can play the role of an aggregator might be available along with other aggregators. It is not clear which aggregators should share the task of solving the possible power quality issues and to what extent. In other words, there is no agreement on who is in charge of assuring the adherence to the statutory standards among the aggregators in an LV grid. Both issues, i.e., ambiguities around how the aggregators should deal with technical difficulties, and who is responsible for handling power quality issues, also go beyond the aggregation role and should be regarded as challenges that suppliers might also face. Both issues are originated from the fact that suppliers and aggregators (the role of which might also be played by energy communities) financially benefit from the aggregation of energy generations and flexibility supports. Hence, as long as the issue is related to their activities, they should handle such issues. The regulations should be changed and new policies should be developed to coordinate the actions of aggregators/suppliers and DSOs.

8. Recognition of user characteristics for market-oriented DR: Even though price-based demand response programs, e.g., critical peak pricing, dynamic pricing, and time of use pricing (for which the challenges and barriers were reviewed in subsection 3.2.1.2), have been implemented for many years across the globe, market-oriented demand response is still taking its early steps. Considering citizens’ intended tasks, their purposes, and also electrical safety, demand-side aggregators have no right to regulate user loads, e.g., by forcing the power-producing users to change their production patterns. On the other hand, the ambiguity in the citizens’ manual load alteration might lead to the deviation of the amount of increase/decrease in the production or consumption from the level that has been promised by aggregators. For aggregators, this can be interpreted as the (partial) loss of revenue. A more significant and practical issue is that citizens are not aware of their actual demand response capacity. The limited data on citizens’ demand response also puts the aggregators far away from the true recognition of citizens' DR characteristics. This leads to flawed decision-making by aggregators.
9. No DNO role is allowed for energy communities: In the current European electricity market structures, only industrial or commercial consumers can get exemptions concerning the operation of “closed distribution systems”. Domestic consumers and energy communities are not allowed to get such an exemption. In the future structure of the European energy markets, communities may be permitted to operate their distribution network (optional). Article 16 of the electricity directive should set the regulations to provide energy communities with a solid set of rights, involving an equal playing field and a right to build, keep, operate, and manage distribution networks or micro-grids or coordinately manage public distribution systems as well as ‘community networks’ (known as closed distribution systems, or microgrids). This right should not be discretionary. For this provision to be meaningful it must be mandatory. On the other hand, the Parliament’s proposal to ensure compliance with national concession rules needs to be supported. However, Member States should revisit such rules to ensure that energy communities can join in concession tenders on an equal footing with other available market participants.
10. Legal issues related to the new specially designed grid for energy communities: Local energy systems might require new distribution infrastructure, e.g., to connect the consumers for collative consumption. Such grids might be expanded to private properties which do not necessarily belong to community members or to publicly owned lands. This gives rise to legal issues that must be anticipated in policies [58]. Further, on this subject, it can create conflicts of interest, when the new grid intersects available distribution network rights-of-way, which

perhaps is owned by DSOs, or they hold it under a long-term lease.

11. Supplier license for sharing energy: Energy sharing within communities is very difficult to organize considering the current hindering legislation. One reason is that each party that supplies energy is obliged to have a supplier license. It is sought that in the futuristic scenarios for energy markets, energy sharing can be accomplished within a community.
12. Taxation barriers: The taxation of electricity plays an important role in achieving the climate and energy targets. The rules set under the Directive 2003/96/EC, i.e., Energy Taxation Directive (ETD) aim at ensuring the proper implementation of the Internal Markets. However, since 2003, the climate and energy policies have been changed radically and ETD is no longer in line with EU policies. More importantly, the ETD is no longer ensuring the proper functioning of the internal markets. Changing the ETD is a part of the European Green Deal (EGD) and the "Fit for 55" legislative package. The ETD was evaluated in 2019 [51]. The Council concluded that energy taxation plays an important role in steering successful energy transition [57], and invited the Commission to revisit the ETD. The current ETD however, hinders the effective energy transition, raises a series of issues linked to its disconnection from climate and energy objectives, and its shortcomings regarding the functioning of the internal market. For instance, in Finland, owners of electric storage systems pay taxes for the charging electricity. This not only does not motivate sustainable engagement in the energy transition but also leads to double taxation, as consumed electricity from storage is equally taxed [58]. In addition, there are some aspects of the ETD that lack clarity and lead to legal uncertainty, e.g., the definition of taxable products and uses that are out of the scope of the ETD. Such ambiguity along with the disconnection of the taxation Directive from the energy and climate targets widely hinder the formation and sustainable service of energy communities.
13. Outdated wholesale market mechanisms: A market clearing mechanism should be fair to aggregators, large renewable producers, and conventional producers, encourage flexibility providers, avoid spillage or renewable energy as long as it reduces consumers' payment, and does not cause technical issues. The available cost minimization wholesale market structures should also be revisited to achieve these targets. The other requirement that the wholesale electricity market should meet is the necessity of coordinated energy and flexibility markets. This is further explained in subsection 3.2.4.5.
14. Separate Power Exchange and Flexibility Market: In the continuous effort to achieve the targets of the energy transition, the variable energy sources are becoming more prevalent. The relevance of co-optimization of energy and ancillary services, e.g., flexibility reserve, pervades the electricity market structures in Europe. In the US, the integration of transmission constraints in energy markets was underpinned by the advent of electricity restructuring and later led to the integration of ancillary services in the market. However, restructuring in most European countries does not co-optimize energy and reserve and other services. The European power systems are divided into energy markets, mostly cleared by Power Exchanges (PX), and transmission and reserves services, mostly provided by Transmission System Operators (TSOs). In some member states, energy, transmission, and services are partially coordinated but not co-optimized. In EU-wide electricity market designs propounded in many European smart grid projects, the need for co-optimization has been recognized. A new EU-wide agent called "European Market Coupling Operator" deals with the transmission but not with ancillary services.

The growing reliance on renewable energy generation and the services provided by the energy communities and citizens provides the reasons for revisiting the role of co-optimization of energy and services. The impact of the lack of such co-optimization should be investigated in European electricity markets. From the engineering point of view, co-optimization reduces costs. In economic terms, it might lead to arbitrages between energy and reserves due to the strategic bidding of market participants for profit maximization. Therefore, to achieve such co-optimization there may exist institutional obstacles. Also, energy and ancillary markets obey different rules in different member states and are not subject to EU-wide regulations.

15. The pressure of traditional market players: This is another challenge that can be categorized in both economic and regulatory challenges. Innovative DER- and customer-centric business projects put pressure on conventional market participants, such as centralized generation companies and operators, to change their business plans and models until they finally reach new market equilibrium. Increased self-generation and share of local energy markets can threaten the ability of DSOs to invest in network expansion and maintenance if their income is reduced from network assets. This leads to increased electricity prices and network costs for citizens who do not engage in energy provision. It is also important to note that the local markets also need the distribution grid for delivering locally generated energy to the consumers. Traditional energy market players are also likely to resist the increased share of local markets as they may fear losing their position in the market. Although new opportunities will arise for these important and experienced market players to offer new types of services, at the early stages of the energy transition, they may resist it.

Some other challenges mostly stemmed from the complexity of control or the lack of effective management strategy. Such technical challenges are detrimental to upgrading the structure of energy markets. Many challenges in this regard are subject to academic and industrial research.

16. Unavailability of network codes and effective standards for switching between grid-connected and island modes: Such switching entails a complex sequence of actions and requires special care about frequency and voltage control, due to the imbalances of generation and loads [58].
17. Managing instantaneous active/reactive power balances between upstream and downstream networks: is problematic under various voltage profiles. TSO-DSO coordination needs to be revisited to cope with power and frequency control requirements since a significant extent of the generation in the downstream comes from intermittent sources.

Other than the abovementioned challenges and barriers, which hinder the effective and sustainable upgrade in energy market design in almost all European countries, some barriers are no longer a real concern to the high spending/active countries in the energy transition but are still hindering in some other countries.

18. Unavailability of Smart meters and lack of standardization on smart metering: Smart meters are the other key components to the operation of and to market flexibility management. Luckily, smart meter rollout is getting momentum in most Member States. The penetration of smart electricity meters has passed the 50% mark in 2020 owing to expanded investments in grid digitalization by utilities in Europe. In 2020, about 150 million smart electricity meters were installed with the bloc recording a 49% penetration rate. However, firstly, such meters have not been yet installed for many other households. On the other hand, there is a need to unify and tighten standardization in metering schemes. Smart meters are the most important devices that will enable the transformation of the grid and the utilization of important functionalities that all involved parties might be able to provide, in a scenario in which the

citizens have the most special role. Administration of the aspects linked to the data available from such smart meters should be better studied. An example is a need for the analysis of the data that should be availed to citizens to enable them to manage their demand based on the signal of the market price. The need for standardization of the data to be exchanged among the agents, or the plans for taking actions with regards to the access and protection of such data are the issues that should be tackled before causing escalating problems. More context on the plans for successful implementation of the smart meter systems, as well as the benefits such meters bring for citizens, was provided in the USmartConsumer project [59].

19. Regulation barriers hindering the effective operation of RESs and ESSs: In some Member States, some other regulatory barriers hinder the development of local energy markets. Most of these barriers are stemmed from blocking the effective operation of DERs, RESs, and ESSs that was discussed in the previous subsections. For instance, in some Member States, it is not legal to blend energy generation with storage in the customer premises. In some other states, it has not been viewed in the regulations to feed the citizens' generated electricity to the grid. These challenges hinder the energy transition and are detrimental to both sustainable adoption of RESs and ESSs and upgrade of market design that expedites the energy transition.
20. The regulators often do not permit microgrid islanding: Typically to avoid voltage stability problems and other challenges regarding the safe operation of microgrids (due to the small size of the grid) and distribution systems (due to bi-directional power flows) the islanding mode of operation is prohibited for microgrids [60]. To face this, the policymakers and other decision-makers need to push regulatory bodies to accelerate compliance with bi-directionality requirements, at the point of common coupling (PCC), where many technologies should be adopted to assure, voltage and frequency stabilities as well as protection coordination. These technologies range from fault current limiters to new methods that have been recently proposed for dynamic stability based on the inverters of RESs. Many of the required changes in the regulations have been presented in [60] as the early actions that should be taken.
21. Even though the energy communities can contribute to reactive power provision as an ancillary service (for voltage management), an effective active voltage control based on the roles that renewable and citizen energy communities can play is not proposed or planned in the policies of these Member states. This role should be noted in the regulations, standards, and network codes of the Member States.
22. Inconsistency of market instruments for incentivizing renewables and the need for further investment in these technologies: Regulations constantly change significantly concerning prosumer feed-in tariffs and the models that decide the level of such tariffs. Such regulations also vary among the Member States. Even though this gives rise to uncertainty of the business model from the perspective of citizens, it is understandable when analyzing the problem from the viewpoints of incentivizing the citizens for the adoption of such technologies and the need for such energy production. What is not rational, however, is that in some Member States, the feed-in tariffs/premiums are not considered for citizens and energy communities, while the renewable share in their energy markets is way lower than the amount provided in CEP. Except for such inconsistency, in some Member States, there are no customer remuneration schemes for surplus electricity generation. In other cases, it is not possible based on the local regulations to export electricity produced by energy communities to the grid, which keeps these communities away from minimum revenues for market

participation. In such situations, eliminating the chance of receiving extra remuneration through such premiums for self-consumption and the unavailability of an effective mechanism to adjust feed-in tariffs/premiums demotivate citizens. In less active countries, the operation of local energy markets entails well-determined and harmonized regulations geared towards permitting citizens to trade surplus electricity with grid operators or other customers [58].

23. DSOs regulations motivating investment in wired solutions and conventional production not in demand response and renewable production projects: It was discussed that the economic regulations of DSOs usually lead to their tendency towards employing the products of conventional generation companies since they are remunerated for providing the required assets that make it viable to deliver the power to end-users. As a side effect, such regulations also incentivize infrastructure expansion investments over RESs and demand response. Such legislative frameworks differ considerably across the Member States and also globally and will affect the development of efficient local energy markets to make the energy transition possible.
24. Long administrative procedures and delays for small-scale rural DERs: In some Member States there are no (or no expediting) regulations for connection of small-scale renewable generation in rural zones. This is likely to lead to a long administrative process and delay. There should be some mechanisms for obtaining the approvals for starting such a project. An example of such absent regulations is that it is not clear who pays for connecting the small-scale resources to the distribution grid. Another example is the ambiguity around the entities that are responsible for potentially required grid reinforcements [61]. Along with the already unclear policy settings around this subject, such an uncertainty introduces additional risks for shareholders. This accumulated risk negatively affects cost-benefit analyses and reduces the number of potential prosumers in the future of energy systems in the Member States.

4 Identification of key challenges, gaps, and bottlenecks in policies, regulations and standards, social behaviour, and financial support

4.1 Introduction to categories of barriers (UCD)

The barriers to exploiting each enabler of citizens' engagement in the energy transition that was reviewed in Section 3 cover a wide range of scopes and areas. In this section, these barriers are traced back to their roots in a set of sections, i.e., policies, regulations and standards, social behaviour, and financial support. Relating the barriers to the gaps and bottlenecks in these sections makes it easier to structure the analysis of the identified barriers and gaps.

The categories of gaps and bottlenecks presented in this subsection are not exclusive. As explained later, in practice, a certain barrier can be related to several categories of gaps and bottlenecks [14].

The next subsections briefly introduce the categories of barriers, gaps, and bottlenecks in this study. Subsections 4.1 to 4.6 describe in detail the gaps that exist in these categories.

4.1.1 Policy gaps

Gaps may be intrinsic to a certain policy design, mainly set off by politicians, or generally lie in the political structure. As an example, a policy might limit the extent of options or cause a bias in decision-making if the eligibility criteria encourage certain options.

Another crucial factor in this regard that may hinder the effective integration of energy citizens in the European energy transition is the conflict of policies. Most policy areas are strictly interconnected. However, in reality, decision-makers often look only at their policy field. In some cases, this can lead to conflict. In this regard, a familiar example is the risk of conflict between the policies designed for achieving the energy transition and energy security objectives. This might happen as the policymakers in charge of ensuring the secure operation of the energy systems may think demand response and other demand-side resources are not reliable enough.

The other possible gaps in energy policies that might hinder the successful integration of energy citizens in the energy transition might be attributable to the weak connection between policymakers and energy active citizens. Supply-side participants are usually more centralized or have a well-established and enduring connection with policymakers. Demand-side participants, on the other hand, are more diverse. They are not always well acknowledged in consultation or decision-making procedures. This may cause an imbalance between supporting policies on the demand side and the supply side in the decision-making process. Such a gap may also be identified as a social and behavioural gap [14]. The ensuing bias in favour of supply-side investments might also be categorized as a financial gap. This example shows that sometimes a gap can be categorized into different sections. However, as this gap can be (partially) filled by effective policies to form specialized working groups at both the demand side and the policy-making side, here, this is referred to as a policy issue.

This category of gaps is inclusive and almost all the barriers to successful and sustainable engagement of citizens in the energy transition have a root in policies and decision-making. Many factors affect the extent to which a government might impact the energy economy, especially in its new setting. These factors include but are not limited to energy tariffs, grant aid, tax and incentive policies, import restrictions and the associated impact on quality, legal bases, laws passed to restrict pollution, deregulation and competition regulations, government changes and persistence of new governments, state involvement in trade and agreements, e-commerce and citizens' protection, and for the member states the impact of EU level targets on national targets.

4.1.2 Financial gaps

These gaps are of the most important gaps in the successful and withstanding integration of energy citizens and can point to either lack of financial support available or slow investment returns when implementing energy community projects. Lack of subsidies to support the continuation of citizens' involvement or financial emphasis on opposing priorities that do not support the implementation of energy community projects are the most important financial gaps. Other gaps might, for example, exist due to the absence of financial support that helps highlight and promote the positive effects of energy community projects at the societal level. The other important factor in the analysis of financial gaps includes the cost of renewables, access to finance, and access to funding.

4.1.3 Gaps in regulations, standards and network codes

Regulatory gaps refer to the barriers in the energy system operational routines, or network control and management barriers. Such gaps might exist for example when current regulations impede the choice of demand-side resources as an alternative to supply-side resources. The other example in this regard is when current regulations do not deny the ability of demand-side resources but create a bias in favour of supply-side resources. An example of such a situation is a building energy code that might prefer renewable energy supply over end-use energy efficiency improvement. Other important points in regulations include planning lead time, integrated planning regulations, access to resources, grid access, ownership models, and local benefit frameworks.

Many regulatory gaps may be stemmed from political decisions and therefore, might be linked to policy gaps. In this case, the main issue is that the role of demand-side resources has not been considered properly when making the policies and subsequently when designing the regulation. In this fashion, such gaps are also linked to the lack of knowledge or expertise.

4.1.4 Social gaps

These gaps are of the most important gaps in the successful and withstanding integration of energy citizens and can point to either lack of financial support available or slow investment returns when implementing energy community projects. Lack of subsidies to support the continuation of citizens' involvement or financial emphasis on opposing priorities that do not support the implementation of energy community projects are the most important financial gaps. Other gaps might, for example, exist due to the absence of financial support that helps highlight and promote the positive effects of energy community projects at the societal level. The other important factor in the analysis of financial gaps includes the cost of renewables, access to finance, and access to funding.

Cultural habits (also referred to as past practice and users' behavioural preferences) are also of the most important bottlenecks of the successful engagement of citizens and also in the persistence of citizens in delivering the related services even when the services are well remunerated. This category also covers the habits of professionals that might limit the options of citizens for enrolment in demand-side activities. An example of such gaps is the limited citizens' options due to installers suggesting only options to which they are used.

Lack of awareness about energy efficiency and energy transition options limits the range of options that citizens might consider. Bad consultation on how energy community projects may benefit citizens and what they are, can cause it not to be considered in the decision-making of citizens.

The other important range of gaps in this category is related to the lack of information on how some of these projects benefit the environment. For instance, most citizens in Europe are aware of the positive effects of renewable generation on pollution reduction but they have some vague ideas on how demand response flexibility services allow for higher penetration of renewable energy resources, and hence, benefits the environment indirectly. Such gaps are also related to policy gaps, as they can be bridged by programs that boost citizens' knowledge regarding a wider range of activities that they can take part in. Another example of the gaps, which are behavioural and policy-related at the same time, is the trust issues of citizens towards the energy and flexibility provision services. This can also be resolved by clear signals on who benefits from such services. The next subsections provide an in-depth discussion and introduce the range of gaps in the abovementioned categories.

4.2 Possible gaps in EU level and national policies, policy conflicts and lack of effective policies (UCD)

The “Clean Energy for all Europeans” package facilitates the major transition of the European energy landscape towards citizens’ empowerment, Local Energy Markets, and Energy Communities. The Member States should transpose the new directives into national laws within their NECPs (see Chapter 4 of D3.3 [62]). Chapter 4 of D3.3 reviewed and elaborated on the treatment of empowered energy citizens and ECs in the NECPs of below-average spending Member States. The barriers to the development of LEMs, Citizens’ ECs (CECs) were analysed. The focus was on the limitations of the policies reported in the NECPs of the Member States that hinder the engagement of energy citizens in energy markets. The NECPs should contain a minimum level of sufficient information and should follow this template to be compared against each other. Chapter 4 of D3.3 covered the shortcomings of the policies presented in the national NECPs in comparison to the suggestions of the “Clean Energy for all Europeans” package. The sustainable engagement of empowered citizens and energy communities might also be hindered by a range of barriers that have not been directly cited in the template suggested by the “Clean Energy for all Europeans” package. The sustainable engagement is shaped through revisiting and amending the Electricity Directive, the Renewables Directive, and also the country-specific NECPs. These documents set the guidelines for market participation.

The main takeaway from this discussion is that other than the shortcomings of the country-specific NECPs compared to the proposed “Clean Energy for all Europeans” package and European directives (see Chapter 4 of D3.3), there are some other barriers to the successful integration of energy citizens into the European energy system. In this subsection, the shortcomings and challenges of the first group are first summarized in subsection 4.2.1 based on the findings of Deliverable 3.3 of the PANTERA project. For an at-length discussion in this regard, please see Chapter 4 of D3.3. In the next step, a list of other challenges and barriers that the PANTERA consortium has found in the policies that set the guidelines for integrating the citizens and energy communities into the modern structures of energy systems is presented in subsection 4.2.2. The approach for providing the list of the challenges of the second group is as follows. In Chapter 3 of this deliverable, the barriers to the successful exploitation of three main enablers of energy citizens in the energy markets were presented. These enablers include "energy efficiency and demand response", "domestic-scale distributed energy resources and energy storage systems" which also include residential renewable energy sources and combined heat and power production units, and "the local energy markets" in which the citizens are able to trade energy as well as ancillary services including flexibility services. Among the lists of challenges and barriers which were separately identified for these enablers, in subsection 4.2.2, the barriers arising from the lack of effective policies are filtered and presented.

4.2.1 Gaps and barriers identified by comparing the NECPs and the proposed templates recommended by the Clean Energy package and European Directives (linked to chapter 4 of D3.3)

From the assessments of Chapter 4 of D3.3, there is a very scant understanding among the Member States regarding the roles in the markets. This becomes more obvious when considering that most NECPs are not accompanied by concrete policies and effective measures. Even when for some Member States there are some policies and measures in NECPs in relation to the roles of citizens, communities, and local markets, the details are not provided and the policies tend to be vague or incomplete in scope. Chapter 4 of D3.3 compiled the relevant information included by each of the 16 below-average spending Member States on these roles. On the whole, while some countries are planning to develop strategies and policies to enable renewable energy communities, no measures or targets have been presented for energy efficiency and market integration. Other criteria and dimensions, such as targets/objectives, consumer-oriented policies, and integration of energy citizens into the energy markets did not receive as much attention. An ongoing challenge arises from the lack of unified definitions for most of the terms and concepts that are related to the engagement of empowered citizens in the energy transition. This hinders the standardization and implementation of sound engineering practices for the Member States.

The template provided for the NECPs of Member States explicitly refers to renewable energy communities, while only referring to consumer participation and self-generation, but not the communities. It was proposed in Chapter 4 of D3.3 that new dimensions should be added to cover the integration of the communities in the local energy markets.

The policies provided by the Member States regarding energy communities simply state that these sections are not applicable or are ignored completely in most of the abovementioned sections. Many countries, especially below-average spending Member States failed to include policies and measures for renewable energy communities. In their NECPs, they only mentioned that they intend to implement such policies in the future. Only a few countries explicitly provide some targets. Chapter 4 of D3.3 shows the summary of the assessment of NECPs for 16 low-spending Member States as well as more complete country-specific reports for these countries. There is a notable gap in the coverage of energy communities in the NECPs of these 16 Member States. From the perspective of this chapter, in most of these NECPs (except for the NECPs of Ireland, Italy, and Portugal) the citizens' energy communities are never directly mentioned in the section related to policies and measures regarding market integration.

In Chapter 3 of this deliverable, the ability of these communities to provide the necessary security in the energy system with a high share of renewables is an important function of these communities.

Among the 16 Member States analysed in Chapter 4 of D3.3, only Hungary and Bulgaria to a limited extent linked energy communities to national policies regarding security provision.

4.2.1.1 Summary of gaps and barriers in below-average spending Member States' policies reported in their NECPs compared to the provided templates:

1. The results of Chapter 4 of D3.3 suggest that the level of awareness among policymakers in these Member States is moderate and sometimes acceptable, but there is not adequate planning.
2. Another challenge facing empowered energy citizens is the lack of a supportive local government and/or local energy markets.
3. Some of these Member States demonstrate weak commitment and should look to the other Member States as examples. They should show stronger compliance with the "Clean Energy for all Europeans" package and the related Directives.
4. The policies presented in most of the NECPs do not distinguish between the dimensions presented for the better engagement of energy citizens and energy communities. They simply fail to discern between individual dimensions.
5. Among different aspects and roles that should be considered in the NECPs, renewable energy communities and self-consumption overshadow the others. There are other roles that the empowered energy citizens can take, e.g., in the energy communities, flexibility demand response, energy efficiency, activities related to the improvement of consumers' awareness, etc.
6. One other barrier that can be seen in the policies of most of these states is the lack of an effective mechanism for adjusting the tariffs for different renewable technologies. Financial incentives are of paramount importance to solving the barriers related to the resistance of consumers to change and transition. However, these policies should not distort the market competitive structure. Therefore, the Member States should provide an effective tariff mechanism with a plan to gradually move from a supportive tariff plan, e.g., fed-in-premium, to a competitive tariff mechanism, as the respective renewable technologies are becoming more mature and economically more viable. For each renewable energy technology, individual plans should be provided.
7. Overlooking some of the critical roles that energy citizens and energy communities can play in the energy transition. Among these overlooked roles, power quality and mitigating technical issues are of particular relevance. These roles do not appear to be outlined in the template.
8. The study of Chapter 4 of D3.3 also found that in almost none of the below-average spending member states, there are no targets directly related to the engagement of empowered energy citizens in energy markets and energy transition or local energy markets.
9. The lack of clarity in the application of consistent terminology across the NECPs provided by the Member States is another challenge that makes it hard to follow the best practices.

It is recommended that the roles presented in subsection 3.2.3 are introduced in the template provided for the NECPs. This helps to achieve consistent terminology in the NECPs. Also, by considering all these roles in the local energy market structure, the policies that will be made covers different functionalities and dimensions.

An at length discussion on the barriers and challenges that stem from the uncovered parts and sections of the template provided for NECPs has been provided in Chapter 4 of D3.3. As mentioned earlier, in the remainder of this subsection, the policy challenges and gaps which are not related to the shortcomings of NECPs are provided (in subsection 4.2.2).

4.2.2 Policy related gaps and challenges among those challenges introduced in Chapter 3 of the present deliverable

Based on the studies conducted in Chapter 3 of this deliverable, this subsection provides a list of barriers to the sustainable engagement of energy citizens and energy communities in the energy transition. Among the challenges introduced in Chapter 3 that hinder the exploitation of the enablers of citizens' engagement, those which are related to a gap in policies are filtered and presented in this subsection. Table 4.1 presents these challenges. As already mentioned in subsection 4.1, each barrier to the successful exploitation of each enabler might stem from a challenge in more than one category of challenges. For instance in Table 4.1, one of the barriers is that "renovations are cosmetic fixes only". It introduces both a policy and a regulation and standard challenges. Therefore, this barrier is included in the tables for this subsection in subsection 4.1.3 when the challenges related to the regulations, standards, and network codes are presented.

Table 4.1 Summary of the gaps in policies that may hinder the sustainable engagement of energy citizens (also see the gaps in subsection 4.2.1.1)

Enablers	Barriers to exploitation of enabler	Related gaps in policies
End-use energy efficiency (subsection 3.2.1.1)	Complexity of associated renovation and lack of skills in the supply chain	Necessity of policies that allows for sharing the experience of successful renovations (good practices).
	Institutional and legal frameworks that slow down renovation projects.	The conflict between the policies made by the authorities involved in urban decision-making and those concerned with the energy transition.
	Sometimes renovations are cosmetic fixes only	Lack of policies that pave the way for introducing the monitoring bodies and increasing the citizens' awareness.
Demand Response (subsection 3.2.1.2)	Higher weight of the supply-side stakeholders in decision-making	Necessity of including demand-side stakeholders in decision-making.
	Conflicting objectives or priorities when making the supporting policies	There are some conflicting objectives in the process of policymaking. An example of such an objective is reducing the energy price and price variations, and increasing the level of sustainable engagement of citizens in ToU and dynamic pricing demand response programs. It is necessary to identify such objectives and solve the conflict first by treating these objectives separately based on the targeted groups, and if impossible, by prioritizing these objectives from a wide range of perspectives.
	It is not clear for the citizens who benefit from demand response programs. The real financial benefit of citizens from participating in DR programs should be provided to avoid unrealistic expectations that reduce the persistence of citizens (see Figure 3.1).	The policies should be formed around this matter to help citizens discern between their benefits, environmental benefits, and energy system benefits of their participation in demand response programs. This is one of the main steps to regaining clarity and missing trust. Trust is restored by supplying transparent information about different parties that benefit from DR programs, and

		by providing the citizens with realistic expectations.
	The lack of public awareness of the positive impacts of citizens' participation in demand response programs on the improvement of the penetration level of renewable energy sources.	As this study reveals, most EU citizens are aware of the environmental effects of renewable production but not the effects of DR on improving the penetration level of renewable energy sources. Reforming policies may help to improve citizens' awareness from this perspective.
	Necessity to give access to third-party actors to accumulate demand resources and introduce them to energy and flexibility markets.	Low weight of the demand-side stakeholders in policymaking to promote the aggregator role for energy community.
DEGs and ESSs (subsection 3.2.2)	New technology deployment	Policymakers should align new technologies with novel codes and regulations to co-implement while considering policy objectives. The rapid change and involvement of these technologies require a continuing education and training scheme for highly technical workers and engineers to support the implementation, management, protection and maintenance of these systems.
	Lack of citizen engagement and communities interaction	The policies should focus on promoting education and citizen engagement. Policymakers should consider all consumer categories and leave no one behind as Disadvantages communities
	Appropriate market design	A competitive market framework should be established for independent citizens and aggregators that should also integrate conflict resolution mechanisms.
	Siloed thinking among policymakers on how to promote each ESS category independently of the other one.	Policymakers should adopt a long-term view on citizen empowerment while taking into account the whole systems approach, enabling a cost-effective and smooth energy transition. Strategies should be implemented as part of a clear, integrated energy policy to avoid any conflicting measures and help realise higher benefits.
	Conflict and lack of harmonisation in policies design.	Policymakers should define potential interests and future trends within the different citizen categories. Moreover, an overarching approach should be adopted to unlock the full value of ESS at the citizen premises.
	ESS forefront cost is still high.	The necessity of establishing a robust legislative framework, as well as efficient support mechanisms. Aligning citizens' interests with total system costs cut down is of high importance while designing policies.

Local energy markets (subsection 3.2.3)	Interactions and conflicts between functionalities of the roles as a barrier	The necessity of considering these roles in the policymaking process. This helps to achieve consistent terminology in the NECPs. Also, by considering all these roles in the local energy market structure, the policies that will be made cover different functionalities and dimensions.
	No distribution network operation role is allowed for energy communities.	Currently, only industrial/commercial consumers can get exemptions with regard to the operation of “closed distribution systems”. Energy communities are not allowed to get such an exemption. Policies should be made to make arrangements for communities to be permitted to operate their distribution network. Article 16 of the electricity directive should set the regulations required. In order to connect consumers for collective consumption, local energy systems may require a new distribution infrastructure. Such grids might be expanded to private properties which do not necessarily belong to community members or to publicly owned lands.
	Taxation barriers	Under Directive 2003/96/EC, i.e., Energy Taxation Directive, the correct implementation of the Internal Market should be ensured. However, since 2003, the climate and energy policies have been changed radically and the Energy Taxation Directive is no longer in line with EU policies. More importantly, the Energy Taxation Directive is no longer ensuring the proper functioning of the internal markets. Taxation plays a direct role in supporting the energy transition by sending the right price signals and providing the right incentives for sustainable consumption and production.
	Pressure of traditional market players	- Low weight of the demand-side stakeholders in policymaking - Innovative customer-centric business projects put pressure on conventional market participants, such as centralized generation companies and operators. It is necessary to make policies to change the business plan of conventional participants gradually until all market participants finally reach new market equilibrium.
	The lack of standardization on smart metering	Smart meters are the most essential devices that will enable the transformation of the grid. Smart metering is one of the main focuses of the NECP template. The administration of the data available from these smart meters should, however, be clarified. To facilitate the standardization of smart meter data sharing, new policies need to be made. The need for standardization of the data to be exchanged among the agents, or the plans for taking actions with

		regards to the access and protection of such data are the issues that should be tackled to prevent escalating problems.
	Reactive power support as an ancillary service	While the respective regulations and network codes need to be updated to deal with this barrier, this barrier is also related to policy. This possible role of renewable energy communities might have financial benefits for communities as an extra incentive. It should be included in the related policies.
	Current regulations motivating investment in wired solutions and conventional production not in DR and renewable energy community production projects.	DSOs usually lean towards employing conventional generation since they are remunerated for providing the necessary assets that make it viable to deliver the power to end-users. This incentivizes infrastructure expansion investments over demand response and energy communities. This trend affects the development of efficient local energy markets necessary for the energy transition. Effective policies may be required to solve the problem since regulatory bodies might resist the required change.
	Long administrative procedures and delays for small-scale projects to connect rural distributed energy sources	In some Member States, regulations for connecting small-scale generations in rural zones are restrictive. This leads to long administrative processes and delays. Examples: it is not clear who pays for connecting the resources to the grid. Ambiguity around the entities that are responsible for potentially required grid reinforcements. Along with the already unclear policy settings around this subject, such uncertainty introduces additional risks for shareholders. This accumulated risk negatively affects the cost-benefit analyses of citizens and reduces the number of potential prosumers.

4.3 Possible gaps and bottlenecks in related regulations and standards (UCD)

The barriers to exploiting each enabler of citizens' engagement in the energy transition that was reviewed in Section 2 cover a wide range of scopes and areas. As already mentioned, PANTERA tracks back these barriers to their roots in a set of sections. Relating the barriers to the gaps and bottlenecks in these sections makes it easier to draw rational conclusions.

Based on the results of the studies presented in Chapter 3 of this deliverable, this subsection presents a list of barriers in the related regulations, standards, and distribution grid codes to the sustainable engagement of energy citizens and energy communities in the energy transition. It is important to bear in mind that these barriers may affect the citizens' engagement in all steps including "participation", "response", and "persistence", according to Figure 3.1. Each barrier to the exploitation of a certain enabler in Chapter 3 roots in a challenge/gap in one or more than one of the areas of challenges introduced in the present chapter. Among the challenges introduced in Chapter 3, those related to a gap in regulations and standards are filtered and presented in this subsection. Table 4.2 presents these challenges. Each barrier to the exploitation of each enabler might stem from gaps in more than one category of challenges. Therefore, the categories of gaps and bottlenecks are not exclusive, and in practice, a certain barrier can be related to several areas. For instance, many regulatory gaps may be stemmed from political decisions and therefore, might be linked to policy gaps. In this case, the main issue is that the role of demand-side resources has not been considered properly when making the policies and subsequently when designing the regulation. In this fashion, such gaps are also linked to the lack of knowledge or expertise.

Generally, Regulatory, code, and standardization gaps refer to the barriers in the energy system operational routines, or network control and management barriers. Such gaps might exist for example when current regulations impede the choice of demand-side resources as an alternative to supply-side resources. The other example in this regard is when current regulations do not deny the ability of demand-side resources but create a bias in favour of supply-side resources. An example of such a situation is a building energy code that might prefer renewable energy supply over end-use energy efficiency improvement. Other important points in regulations include planning lead time, integrated planning regulations, access to resources, grid access, ownership models, and local benefit frameworks.

Table 4.2 Summary of the gaps in regulations and standards that may hinder the sustainable engagement of energy citizens in the energy transition

Enablers	Barriers to exploitation of enabler	Related gaps in policies
End-use energy efficiency (subsection 3.2.1.1)	Low-quality renovation	Sometimes renovations are cosmetic fixes only. The lack of monitoring bodies that enforce building energy efficiency certification can be an important barrier in this regard.
	Lack of standards delineating the minimum level of renovation in different classes of buildings.	A “deep renovation” standard in the Energy Performance of Buildings Directive (EPBD) is vital for more high-efficiency renovations. The Commission’s “deep renovation” standard can be bolted onto the EPBD, which is promised to be updated later this year. National standards also need to be updated according to the EC EPBD. Currently, such national revisited standards do not exist in most European countries. An ongoing study, i.e., “Renovate2Recover” [20], is analysing the progress of such standardization in the Member States. It is crucial to follow the related standards to achieve the renovation targets of the EC presented in subsection 3.2.1.1.
	Institutional and legal frameworks that slow down renovation projects.	The respective regulations and standards should be amended to ease the renovation projects. An example is the resistance of groups involved in urban decision-making, as they believe this may distort the buildings’ view which on a higher level can be interpreted as a policy conflict barrier. The

		related regulations should next be updated to expedite the renovation process.
Demand Response (subsection 3.2.1.2)	Lack of motivation to switch to e-mobility and the use of electrical heating	Energy and network tariff structures do not support demand shift in time
	Systems operators prefer wire solutions over non-wire solutions	DSOs' remuneration approach. At a higher level, this barrier also stems from the lack of policies for the gradual transition from the old remunerating models of the system operators.
	Ambiguous or no definitions for rights for direct control of citizen's loads	Since different entities might make use of customers' load control for different purposes, there is a need to define certain rights and obligations in the respective regulations and distribution network codes that apply to the parties responsible for power balance.
	Regulation interaction barriers	The conflict between price variability to motivate price-based (ToU and dynamic pricing) demand response programs and the need to stabilize the prices and make them predictable for other applications.
DEGs and ESSs (subsection 3.2.2)	The co-implementation of the different developed protocols becomes very challenging	Grid codes design should consider today's energy citizen and grid infrastructure and anticipate the future requirements and eventual operation conditions.
	Lack of information about the distribution network and its hosting capacity.	A valuable public access map for hosting capacity and grid requirements should be available.
	Stakeholders coordination new technologies integration	The architecture of the distribution grid has to evolve to support the new community microgrid concept. And this requires potential support and coordination between the DSO, utility suppliers and citizens The existing grid code and standard must be augmented to suit energy citizen empowerment. Tailored grid code can facilitate the use of new technologies, ease integration, and avoid any complexities on the citizen premises. The design should reduce additional construction costs and complexity toward populating these technologies into the market.
	Building code and architecture	Classic building architecture approaches are not adopted to the energy citizen transition. Regulations and codes should define novel building approaches while considering ESSs integration in the citizen premises and how to optimise the added value from different types of citizen ESSs in this case.

	Uncertainty and complexity of the ESS	The uncertainty and complexity of some ESS technologies are hindering representing these systems in the energy system models. There is also a gap in assessing the full life-cycle cost and a lack of systems modelling and analysis. Promoting demonstration and R&D is critical to show the viability of advanced citizen ESSs and pave the way for the non-delayed market uptake of the next technology generations.
Local energy markets (subsection 3.2.3)	Complexity of measurement, validation, and baseline methodology for flexibility provision to the local energy markets.	In the remuneration of demand-side flexibility, a baseline is the value of demand/generation of flexibility providers before they change it based on the market/aggregator's request. A baseline methodology is required to quantify the performance of flexibility service providers. How to define appropriate baseline methodologies, roles, and responsibilities is an open question. Regulations are needed for ensuring accurate and dependable data. It should be clear how to measure or calculate the flexibility provided.
	The challenge of data confidentiality vs. transparency	It is difficult to find a balance between transparency and confidentiality. For efficient demand response, each participant needs some information supplied by the other parties, e.g., aggregators need demand, demand reduction capability, and demand reduction data to be able to accurately forecast the demand response, as well as for billing purposes. This information might be commercially sensitive, or the empowered citizens might not want to share this data. Regulations and standards must introduce a balance between transparency and confidentiality, as well as the level that which this information is useful and can be passed to the respective bodies.
	Technical responsibilities for nontechnical organizations	Aggregators need to consider the operational constraints of the local LV grids, including the voltage statutory limits. This is to conflate the capabilities of a large group of households in a DR pool. Neglecting the technical limitations, DR potential might be overestimated. To solve this issue, maintaining power quality might not be considered as a task to be assigned to aggregators. However, aggregators benefit from demand-side flexibility, so they should handle power quality issues. The problem is that they do not have the technical knowledge and the required data. The network operators do not willingly help the aggregators if they are not receiving monetary benefits. Regulations need to be amended to remove this conflict.
	Complexity of the recognition of user	Even though price-based DR programs

	characteristics for market-oriented demand response.	have been implemented for many years in pilot projects or on a broader scale, market-oriented DR is still taking its early steps. The ambiguity in the citizens' manual load alteration might lead to the deviation of the amount of increase/decrease in the production or consumption from the level that has been promised by aggregators. For aggregators, this can be interpreted as a risk of loss of revenue. The limited data on citizens' demand response also puts the aggregators far away from the true recognition of citizens' DR characteristics. This leads to flawed decision-making by aggregators.
	No distribution network operation role is allowed for energy communities	Only industrial/commercial consumers can get exemptions regarding the operation of "closed distribution systems". Energy communities are not allowed to get such an exemption. Article 16 of the Electricity Directive should set the regulations to provide energy communities with a solid set of rights, involving an equal playing field and a right to build, keep, operate, and manage distribution networks or micro-grids or coordinately manage public distribution systems as well as community networks. On the other hand, the Parliament's proposal to ensure compliance with national concession rules needs to be supported. Also, the Member States should revisit the related regulations.
	Outdated wholesale market mechanisms	A market-clearing mechanism should be fair to aggregators, large renewable producers, and conventional producers, encourage flexibility providers, avoid spillage of renewable energy if it reduces consumers' payment, and does not cause technical issues.
	Separate Power Exchange and Flexibility Market	RESs are becoming prevalent. The relevance of co-optimization of energy and ancillary services pervades the electricity market structures in Europe. Restructuring in most European countries does not co-optimize energy and reserve and other services. A new EU-wide agent called "European Market Coupling Operator" deals with the transmission but not yet with ancillary services. The growing reliance on RESs and the services provided by the energy communities are the reasons for revisiting the role of co-optimization of energy and services in the regulations of the Member States. In addition, energy and ancillary markets obey different rules in different Member States.
	Unavailability of network codes and effective standards for switching between grid-connected and island	Such switchings entail a complex sequence of actions and require special care about frequency and voltage control, due to the

	modes	imbalances of generation and loads [26]. This necessitates the development of effective and clear standards and distribution network codes.
	Managing instantaneous active/reactive power balances between upstream and downstream networks	This is problematic under various voltage profiles [33]. TSO-DSO coordination needs to be revisited to cope with power and frequency control requirements since a significant extent of the generation in downstream comes from intermittent sources. No effective coordination scheme exists in the European distribution network codes.
	Unavailability of Smart meters and lack of standardization on smart metering	Smart meters are the key components of citizens' engagement. Luckily, smart meter rollout is getting momentum in most Member States. In some Member States, these meters have not yet been installed for many other households. Most importantly, there is a need to unify and tighten standardization in metering schemes. In order to achieve the target of the Clean Energy package, national efforts are needed. Administration of the aspects linked to the data available from such smart meters should be better studied. The need for standardization of the data to be exchanged among the agents, or the plans for taking actions with regards to the access and protection of such data are the issues that should be tackled in advance of escalating problems.
	Regulation barriers hindering the effective operation of RESs and ESSs	In some Member States, regulatory barriers hinder the development of local markets. Most of these barriers stem from blocking the effective operation of DERs, RESs, and ESSs that was discussed. For instance, it is not legal to blend energy generation with storage in the customer premises in some Member States. Several other states do not allow citizens to feed their generated electricity into the grid.
	The regulators often do not permit microgrid islanding	Typically, to avoid technical challenges related to the safe operation of microgrids, the islanding mode of operation is usually prohibited for microgrids [61]. The regulatory bodies should be pushed to accelerate compliance with bi-directionality requirements. Many technologies should be adopted to assure voltage and frequency stability as well as protection coordination. These technologies range from fault current limiters to new methods that have been recently proposed for dynamic stability. Many required changes in the regulations have been presented in [63].
	Inconsistency of market instruments for incentivizing renewables and the need	Regulations constantly change concerning prosumer feed-in tariffs. Such regulations

	for further investment in these technologies	also vary among the Member States. Even though this gives rise to uncertainty of the business models from the perspective of citizens, it is understandable when analysing the problem from the viewpoints of incentivizing the citizens for the adoption of such technologies and the need for such energy production. What is not rational is that in some States, the feed-in tariffs/premiums are not considered for citizens and energy communities, while the renewable share in their energy markets is way lower than the amount provided in the Clean Energy Package.
	Regulations of DSOs motivating investment in wired solutions and conventional production	The remuneration schemes of DSOs usually lead to their tendency towards employing conventional generation technologies since DSOs are remunerated for providing the required assets, e.g., distribution networks that make it viable to deliver the power to end-users. These regulations also incentivize infrastructure expansion investments in energy communities. Such legislative frameworks differ considerably across the Member States.
	Long administrative procedures can be an important barrier in getting the rights and incentives to install DERs.	Usually, different types and sizes of DERs are subjected to different authorization requirements and the process can last for a number of years. In some Member States, there are no expediting regulations for the connection of rural small-scale renewable generation. There should be some mechanisms for obtaining the approvals for starting such a project. Along with the already unclear policy settings around this subject, such uncertainty introduces additional risks for shareholders.

4.4 **Possible gaps and bottlenecks in social behaviour (UCD)**

The energy transition is a matter of change in policies, regulations, standards, financial support, and public behaviour that requires the involvement of policymakers, regulatory bodies, stakeholders, and laypeople (with different views and interests). In terms of social behaviour, this support should extend beyond public acceptance, which is a rather passive attitude. More importantly, it should include social factors such as "willingness to participate in the energy transition" and "willingness to use renewable energy sources". Additionally, it has to do with citizens' persistence in providing the grid with the services it requires. However, moving from just "awareness" and "acceptance" to real "action" and "persistence" is a complicated process that requires an understanding of a variety of social factors. While scientific research has been focused on technical and economic factors of the energy transition, the volume of scientific publications by social scientists involved in energy research is rising. The focus of this subsection is on how people are making choices and which factors are influencing their choices when they consider involvement in the energy transition. Studies based on societal sciences and behavioural economics demonstrate that people prefer to contribute to the energy transition. The results of this subsection are based on a large-scale literature review that deeply looks into the feedback received from citizens in a wide range of Member States.

In broad terms, the social and behavioural barriers to the sustainable engagement of citizens in the energy transition can be presented as follows:

1- While the results show a high level of awareness about the need for climate change mitigation across the Member States, the level of details about the projects or the energy transition processes is limited.
2- According to the results, the economic considerations including the concerns about energy prices and socio-economic impacts of the energy transition overshadow the other concerns such as environmental protection.
3- Many other factors, such as maintenance, renovation, and additional structures needed to implement the required technologies intimidate citizens that would rather have a quiet and easy life.
4- The limited possibility to participate in the decision-making process harms willingness to support the energy transition which as mentioned earlier goes beyond just social acceptance.

The remainder of this subsection is dedicated to presenting the details of the social and behavioural barriers to the successful integration of empowered energy citizens into the futuristic structures of energy systems. General barriers to the engagement of citizens were identified in Chapter 3. As mentioned before, each barrier to the exploitation of a certain enabler in Chapter 3 roots in a challenge/gap in one or more than one of the areas of challenges introduced in Chapter 4. Similar to subsections 4.2 and 4.3, in this subsection, firstly, based on the results of the studies presented in Chapter 3 of this deliverable, a list of social barriers is presented. Such barriers may hinder the citizens' engagement in all steps including "participation", "response", and "persistence", (Figure 3.1). Table 4.3 presents these barriers, delineates the respective enablers, and relates the barriers to the related gaps in social behaviour. As previously mentioned, each barrier to the exploitation of each enabler might stem from gaps in more than one category of challenges. For instance, a barrier might be rooted in both a social gap and a policy gap.

Table 4.3 Summary of the gaps in social behaviour that may hinder the sustainable engagement of energy citizens in the energy transition

Enablers	Barriers to exploitation of enabler	Related gaps in policies
End-use energy efficiency (subsection 3.2.1.1)	Lack of shared objectives among citizens	Citizens are aware of the positive impact of their contributions. They have also been provided with the required information regarding the financial benefits that such a contribution brings to them. However, until they do not realize the significance of energy communities they won't take part in such activities that lead to a sustainable engagement in the energy transition in the directions shown by the policymakers.
	Inertia of citizens	Aversion to change and the conservatism in the construction and renovation
	Lack of information and knowledge regarding energy efficiency and sustainable products.	These barriers caused a major gap in the past and continue to be an important cause hindering the improvement of energy efficiency. The perception of high

		investments and long return time is an important ambiguity that should be clarified for end-users. Most citizens are also aware of the positive environmental impacts of putting energy efficiency measures in place. However, the mixed signals that they receive make it hard for them to distinguish various impacts of energy efficiency measures.
Demand Response (subsection 3.2.1.2)	Familiarity/trust-related issues in citizens' individual contributions	Mistrust can arise before or after citizens' enrolment in DR. Such mistrust is often linked to: 1- Unfamiliar technology/technical issues. 2- Lack of transparency around what DR. 3- Lack of awareness of the parties who benefit from DR programs. The level of citizens' trust can be enhanced by measures that improve clarity around DR in general. Such measures include providing information on DR from independent sources, communicating how different parties such as contributing citizens and energy provides benefit from DR and notifying users of any direct load control projects (best practices). The first issue (unfamiliar technology/technical issues) has persisted to be one of the most hindering challenges.
	Possible lack of trust within energy communities.	Engagement in different forms of demand response that involve community actions, e.g., peer-to-peer trading, may be affected if citizens do not trust the behaviour of other community members.
	Perceived loss of control and risk	The risk might seem much clearer concerning the features of time-varying pricing and remuneration of DR. Technologies that enable responses to time-varying pricing, e.g., building energy management systems, may help to address the monetary risk associated with time-varying prices. However, such technologies themselves might be seen as a risk due to the loss of control of the citizens over their demands/tasks. Awareness should be enhanced around these technologies.
	Complexity and associated effort	The perceived complexity and required effort for providing DR affect citizens' engagement. Considering demand shifting in general terms, some users expect changing demand patterns would be hard or undesirable due to inconvenience and effect on day-to-day routines [29]. Others anticipate adjusting demand patterns to be simple. In some studies, the importance of how the effort citizens expect compares to the benefits they anticipate from involvement in DR programs [21]. The complexity and required effort of responding to time-varying pricing may be related to

		less predictable prices and other factors that should be predicted, e.g., the temperature. This highlighted the importance of the quality of forecasting products. To deal with this, it is important to provide the citizens with a realistic picture of long term effects of participating in DR.
	Resistance against implementing and installing new technologies and loss of comfort	Additional complexity and in some cases required installation space. This barriers also links to the regulations that does not permit property expansion. In small European residential properties, this affect the citizens' willingness to contribute in the energy transition.
DEGs and ESSs (subsection 3.2.2)	Economic concern	Citizens might have concerns about the economic viability of DEG and a lack of understanding of revenue schemes and potential subsidies, and this can impact their willingness to contribute to the energy transition.
	Resistance against LEM participation and aggregation	The potential value of DEG could not be unlocked if citizens resist LEM and do not will to aggregate their DEG resources.
	No clear idea about the full value of ESS	ESS energy citizen benefits, support mechanisms, should be effectively communicated across all stakeholders. Different media types should be involved to mobilise all citizen categories to enable a cost-effective and successful energy transition.
	Home ownership	Home renting present also one of the main barriers for ESS energy citizen empowerment. Citizens are less likely to invest in residential storage in case they are not household owners.
Local energy markets (subsection 3.2.3)	Data confidentiality vs. transparency	Being related also to a regulatory challenge (see Table 4.2), this barrier also links to a societal concern. Other than the required improvement in the related regulations, public awareness should be increased around this matter.
	Economic concerns	In some Member States, people are asked to pay more as their electricity is supplied by renewable. Increased energy prices might be translated into societal resistance. It might be a real concern, given that somebody needs to pay for the flexibility that should be provided to deal with the variability of RESs. The negative effect of the energy transition on employment (due to the elimination of a part of the conventional electricity business) might also stimulate societal resistance [64].

	Complexities related to various roles (see subsection 3.2.3) that citizens and energy communities should take. No unified definition.	The roles that citizens should take in the futuristic structure of the energy systems might seem to be even hard to explain to a person who is familiar with the concept. It is necessary to find a way to increase public awareness of these roles.
	Limited possibility for citizens to participate in policymaking.	A survey reported in [64] analysed the public view on the adoption of DERs and RESs to participate in the energy transition. In the countries where the level of awareness was higher, Some of the most frequent answers were: "I cannot change anything anyway," or "My voice will not be heard", signifying the importance of the active participation of citizens in decisionmaking.
	Ownership in energy communities	From a behavioural point of view, this might be deemed as a risk for contributing in the energy transition through the energy communities.

4.5 **Possible gaps and bottlenecks in financial support (TUS)**

Energy efficiency improvement requires reconstructions which are commonly both cost and time-demanding. Also due to the need for finding a temporary replacement during the building renovations additional cost and discomfort could arise for the citizens. Furthermore, the uncertainty if the predicted energy savings will be met might complicate the decision if the financial support scheme used will or will not offer an economically (and environmentally) viable solution.

The energy transition of Europe is highly dependent on the successful and effective Demand Response implementation. A literature survey based on [21], [65], [20], [27], [28], [30], and [19] shows that the lack of a proper and adequate financial support scheme appears to be one of the main bottlenecks and hindering factors which are preventing the massive DR spread among the energy citizens and communities. The experience gained from the national and EU programs shows that the environmental concerns are relatively weakly influencing citizens, thus leaving the pollution reduction and climate change hardly measurable and understandable for the citizens. As indicated by the majority of the research done the strongest motivation which allows DR remains the monetary benefit that is leading the consumers (and prosumers) in their decisions and actions.

Various financial support schemes for DR, pilot and test case results have been reported in [21], [65], and [20]. Taking into account the main results and outcomes it could be noted that there is no single strategy that is working properly for all but at the same time finding a common clear and understandable financial support solution for DR is critical. The different EU countries imply DR financial support strategies in a different way and to a different degree. It has to be noted that although some countries offer some DR financial support options their added value might remain weakly appreciated by the citizens for example because the investment for additional equipment, agent-based controls, works, applications and time spent from the citizens for DR participation could be difficultly evaluated and compared with the potential (monetary) benefit in case of implementing this investment and being involved in DR.

Table 4.4 Summary of the gaps in financial support that may hinder the sustainable engagement of energy citizens in the energy transition

Enablers	Barriers to exploitation of enabler	Related gaps in financial support
End-use energy efficiency (subsection 3.2.1.1)	Lack of information for energy efficiency financial support schemes and the	Citizens are not aware of the options for financial support and do not see much value to research them.
	Large minimal investment boundaries	The majority of financial support schemes require significant amount of paper work and needs participation of larger installer companies which hold the licences needed. This appears to be financially inefficient at small scale and makes the financial support schemes hardly applicable for small scale projects.
	Lack of clearly measurable information on what is the value originating from the energy efficiency financial support schemes, what are the savings, what are the risks and what are the potential financial (and the monetarized nonfinancial) benefits.	These barriers are hindering the improvement of energy efficiency. Due to the mix of financial and technical complexity the added value from energy efficiency improvement remains hardly understandable. Due to the long lifetime of the investment, relatively long pay back periods arise. These are commonly discouraging for the typical end users who feel comfortable with short pay back periods which are typical in their practice.
Demand Response (subsection 3.2.1.2)	Familiarity/trust-related issues in citizens' individual contributions	Mistrust can arise before or after citizens' enrolment in DR. Such mistrust is often linked to: 1- Unfamiliar technology/technical issues. 2-Lack of transparency around what DR. 3-Lack of awareness of the parties who benefit from DR programs. The level of citizens' trust can be enhanced by measures that improve clarity around DR in general. Such measures include providing information on DR from independent sources, communicating how different parties such as contributing citizens and energy provides benefit from DR and notifying users of any direct load control projects (best practices). The first issue (unfamiliar technology/technical issues) has persisted to be one of the most hindering challenges.
	Possible lack of trust within energy communities.	Engagement in different forms of demand response that involve community actions, e.g., peer-to-peer trading, may be affected if citizens do not trust the behaviour of other community members.
	Perceived loss of control and risk	The risk might seem much clearer concerning the features of time-varying pricing and remuneration of DR. Technologies that enable responses to time-varying pricing, e.g., building energy management systems, may help to address the monetary risk associated with time-

		varying prices. However, such technologies themselves might be seen as a risk due to the loss of control of the citizens over their demands/tasks. Awareness should be enhanced around these technologies.
	Complexity in evaluating the investments, financial support schemes, risks and potential benefits	The economical and technical complexity to understand the monetarized costs and benefits for providing DR limits the citizens' involvement.

5 EU level and national challenges, gaps, and barriers to citizens' engagement in the energy transition

5.1 Current level of empowerment of energy citizens in energy transition (FOSS)

The updated R&I roadmap 2030 of ETIPSNET is more focused on the integrated energy system approach and translates the needed requirements into 12 high-level functional specifications for the European energy system of 2030, called hereafter FUNCTIONALITIES (Table 5-1), and defines dedicated maturity levels for each of them. To turn this FUNCTIONALITIES into reality by 2030, 6 Research Areas (shown in Table 5-2) are identified and described, complemented by 120 research and demonstration activities, referred to as tasks in this ETIP SNET R&I Implementation Plan 2021-2024. ETIPSNET is linking these areas with the R&I path in future (2030+) to achieve the decarbonisation of the integrated energy system in 2050. The first research area as seen in the Table is focusing on Citizen and prosumer information, empowerment and engagement taking on board the importance of having the citizen in the centre of the energy transition.

Table 5-1 The functionalities of ETIP-SNET

Building blocks (ETIP SNET Vision 2050)	FUNCTIONALITY (Full name)	Short FUNCTIONALITY
The efficient organisation of energy systems	F1 Cooperation between system operators	F1 Cooperation
	F2 Cross-sector integration	F2 Cross-Sector
	F3 Integrating the subsidiarity principle - The customer at the centre, at the heart of the integrated energy system	F3 Subsidiarity
Markets as key enablers of the energy transition	F4 Pan-European wholesale markets	F4 Wholesale
	F5 Integrating local markets (enabling citizen involvement)	F5 Retail
Digitalisation enables new services for Integrated Energy Systems	F6 Integrating digitalisation services (including data privacy, cybersecurity)	F6 Digitalisation
Infrastructure for Integrated Energy Systems as key enablers of the energy transition	F7 Upgraded electricity networks, integrated components and systems	F7 Electricity Systems and Networks
	F8 Energy System Business (incl. models, regulatory)	F8 Business
	F9 Simulation tools for electricity and energy systems (SW)	F9 Simulation
Efficient energy use	F10 Integrating flexibility in generation, demand, conversion and storage technologies	F10 Flexibility
	F11 Efficient heating and cooling for buildings and industries in view of system integration of flexibilities	F11 Heating & Cooling
	F12 Efficient carbon-neutral liquid fuels & electricity for transport in view of system integration of flexibilities	F12 Transport

Table 5-2 ETIP SNET R&I Research Areas as defined in roadmap 2030

RA (No)	Research Area (RA)	RA Explanation
1	CONSUMER, PROSUMER and CITIZEN ENERGY COMMUNITY	Citizen and prosumer information, empowerment and engagement
2	SYSTEM ECONOMICS	Business models, market design and market-governance
3	DIGITALISATION	"Communication and data handling for the digitalisation of energy systems functionalities (including Data, Cyber and System security)
4	PLANNING – HOLISTIC ARCHITECTURES and ASSETS	Energy system architectures, design and planning; technology solutions, asset management, maintenance; System Stability and resilience.
5	FLEXIBILITY ENABLERS and SYSTEM FLEXIBILITY	Adapting all energy components to provide flexibility to the system (Flexibility in Demand, Generation, Storage & Energy Conversion, Network, Transport)
6	SYSTEM OPERATION	System supervision, monitoring, control, reliability, resilience and automation (State estimation and supervision, short-term, medium and long-term control), and control room operators' skills enforcement

Although citizen empowerment is related primarily to policy measures and political wiliness, technical solutions through R&I priorities that are related to energy markets, energy communities etc. are of high relevance. This means that the level of empowerment can be seen as directly connected to the level of maturity of certain technologies and systems. For example, the advancement of technologies and capabilities such as demand response, smart metering or Usage information to consumers can be quantified measures/indexes of citizen empowerment.

In the classification of the technologies as having been presented in PANTERA D3.1[10], several technologies and systems are linked to citizens and can be seen below.

Table 5-3 PANTERA proposed Technologies and Systems for Integrated Energy System

Technologies and Systems in support of the Functionalities			
No.	**Group of technologies**	**Technologies**	**Description**
1	**Integrated Grid**	Flexible ac transmission systems (FACTS)	Controllable power electronic equipment that will support the Transmission smart grid operations

[10] https://pantera-platform.eu/wp-content/uploads/2020/07/D3.1-Report-on-current-status-and-progress-in-RI-activities-Technology.pdf

2		Models, Tools, Systems for the operation analysis, control and the development of the integrated grid including cost elements	Advanced models, tools, systems for the operation analysis, control, state estimation and the development of the integrated grid (TYNDP etc) including cost elements
3		HVDC	High Voltage Direct Current overhead and underground grid.
4		Forecasting (RES)	Advanced forecasting tools (RES) will allow a low estimation error and provide accurate feedback for the actors that need these types of services. E.g. aggregators, operators, RES owners, ESP, the market operator etc.
5		Asset management	The methodology, procedures, devices and software allow the efficient management of assets of the integrated grid.
6		Outage management, fault finding and associated equipment (including protection)	The methodology, procedures, devices and software allow the efficient management of outages including fault finding of the integrated grid.
7		Equipment and apparatus of the integrated grid	All the primary equipment (rated at the rated voltage of the system) and apparatus constituting the integrated grid including Power guards and limiters.
8		Equipment, sensing, monitoring, measuring for analysis, solutions and control	Equipment, sensing, monitoring, measuring for analysis, solutions and control including procedures and software that make observable the integrated grid. These include the devices and the procedures that allow PMUs, PDCs and GPS to be efficient tools of the smart grid paradigm
9		Advance distributed load control	Software or hardware devices or procedures that allow advanced distributed control of distributed assets of the grids including different types of DERs and load
10		Feeder auto-restoration / self-healing	Advanced procedures and systems that facilitate the feeder auto-restoration thus implementing the self-healing of the interconnected system
11		Smart metering infrastructure	All the procedures and systems that are related to smart meters as devices and complete bi-directional communication link between metering data management systems and end-users.
12	**Customers and market**	Distributed flexibility, load management & control and demand response including	All procedures, controls and devices that facilitate distributed flexibility, load management including explicit demand

		end devices, communication infrastructure and systems	response and system
13		Smart appliances	Smart appliances that allow customer market participation and smart load control.
14		Building control, automation and energy management systems	All procedures, controls and devices that secure smart building automation including home energy management, active control, monitoring and market participation
15		Electric vehicles	Electric vehicles are vehicles based on battery or fuel cell resources for transport needs.
16		Energy communities	Its primary purpose is to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates. May engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;
17		Lighting	Any apparatus emitting light and related systems.
18		Electricity market	All elements of the electricity market including platforms that enable wholesale, retail, real time pricing / spot, flexibility, aggregated and peer to peer trading including ancillary services, etc.
19		Storage Electric	In the electricity system, apparatus capable of deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy.;
20		Thermal Storage	The main parts and all auxiliary components that form a ready to integrate device capable of storing thermal energy for use at a later stage.
21		Power to gas	The main parts and all auxiliary components that form a ready to integrate device from technologies that uses electrical power to produce a gaseous fuel for storing or use otherwise.
22	**Storage**	Pumped storage	The main parts and all auxiliary components that form a ready to integrate system to operate as a Pumped-storage system which is

			the process of storing energy by using two vertically separated water reservoirs. Water is pumped from the lower reservoir up into a holding reservoir. Pumped storage facilities store excess energy as the gravitational potential energy of water.
23		Other Storage	The main parts and all auxiliary components that form a ready to integrate device capable of storing energy other than the above systems.
24		Flexible generation	The main parts and all auxiliary components that form a ready to integrate device
25		Solar including PV & CSP	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from PV or CSP technologies.
26		Wind	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from wind technologies.
27		Hydropower	The main parts and all auxiliary components that form a ready to integrate system capable of generating electricity from flowing hydro.
28		Hydrogen & sustainable gases	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electricity from hydrogen and other sustainable gases.
29	**Generation**	Other generation	The main parts and all auxiliary components that form a ready to integrate systems capable of generating electrical energy other than the above.
30	**Digitalization, Communication and Data**	Communication networks including devices and systems for signals and data connectivity and solutions	Any combination of equipment and systems forming a communications network as a group of nodes interconnected by links that are used to exchange messages between the nodes. The links may use a variety of technologies based on the methodologies of circuit switching, message switching, or packet switching, to pass messages and signals including Local Area Networks, Home Area Networks and web-based solutions and cloud services for smart grid operations
31		Digital Twins	Any combination of equipment and systems forming Digital twins that are virtual replicas of physical devices that can be used to run simulations before actual devices are built and

			deployed.
32		Artificial intelligence	Any combination of equipment and systems forming Artificial intelligence that simulates human intelligence in machines that are programmed to think like humans and mimic their actions.
33		Data and cyber security including repositories	Any combination of equipment and systems offering Cyber security for defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks, including generated data from the interconnected system with related repositories other than that related to the MDMS (Meter and Data Management System).

On a step further, the R&I status per country as per the methodology provided under D3.1 and analysis conducted under D3.3 can give a good indication of the current level of citizen empowerment in the different EU countries. For example, in Ireland case, as already presented projects related to energy communities should get more important as a low number of such activities were identified.

Of course, these findings that are linked with national R&I status should be examined carefully along with the policy measures and the NECP ambitions of each country so that one can reach safe conclusions. In the next sections, the policy framework for empowerment shall be examined whereas the R&I evaluation shall be presented under future D3.5

5.2 National policy, regulation, social behaviour, technical and financial barriers

5.2.1 Ireland (UCD)

In 2018, the Irish Government approved the high-level design of the Renewable Electricity Support Scheme (RESS), including a community energy provision [66]. Within the RESS, community projects are introduced which receive special privileges for renewable generation. The design aims to facilitate energy communities, which are viewed as a key function of the recast Renewable Energy Directive of the EU Clean Energy Package and are a component of the Programme for Government and the Climate Action Plan 2021. Ireland's RES-E target is for at least 70% renewable electricity by 2030.

The RESS provides pathways and supports for communities to participate in renewable energy projects. The community enabling framework in the RESS aims to provide end-to-end support to create a community energy sector in Ireland. Community-led projects can apply for RESS if they meet certain criteria. The project size must be between 0.5 and 5 MW. The project must be fully owned by a renewable energy community (REC) whose primary purpose is community benefit (environmental, economic or social) rather than financial profit. There are several legal forms the REC can take; however, the crucial characteristic is that the REC must be based on the open and voluntary participation of natural persons based on the local domicile (within proximity to the RESS project).

The community-led projects have to:

Be part of a “Sustainable Energy Community” (SEC), a concept that exists in Ireland for several years. However SECs are broader, regional initiatives, while community-led projects are more specific, local projects. The Declaration of community project must identify the SEC to which the project is correlated and the relationship between the applicant and the SEC. According to the current regulations, the majority ownership (51%) must be a Renewable Energy Community having community benefits such as environmental, economic, and social benefits as a primary purpose rather than financial profit. This reduces the willingness of citizens to contribute to such projects and hence, hinders the energy transition from this perspective.

Support under RESS is allocated by way of auctions. RESS auctions are delivered by the Department of Environment, Climate and Communications (DECC) with the support of the Commission for the Regulation of Utilities (CRU) and EirGrid, the Transmission System Operator (TSO). RESS uses a competitive auction process to determine which generators receive support. For projects that are successful in the RESS 1 Auction, this support typically applies for approximately 15 years. Seven community projects were successful in RESS 1, the first such auction in 2020. 3.4 MW of onshore wind, and 20.95 MW of solar power [67].

Ireland also adopted a new grid connection policy, i.e., Electricity Connection Policy (ECP) in 2020 assisting community-led renewable energy projects to get a connection to the grid offer on a preferred basis. ECP was designed to reduce the implementation barriers. The Irish ECP’s principal objective is to allow those projects which are ready for implementation to have an opportunity to connect to the network. However, a wide variety of technical problems are yet to be dealt with through effective network codes and standards (see subsection 4.3).

In addition to technical requirements, RESS projects must establish a community benefit fund to support the wider economic, environmental, social, and cultural well-being of the local community where the project is located. The contribution is €2 per Megawatt hour of generation of the RESS Project. The objective is to benefit the local community and incentivise investment in local renewable energy, energy efficiency measures and climate action initiatives in the locality.

Shareholders or members of a renewable energy community need to be located (in the case of SMEs or local authorities) or resident (in the case of natural persons) in the proximity of an ECP project.

There are some initial considerations that citizens' energy communities could encapsulate one or more RECs. Therefore, a CEC would have a wider geographical scope, but could also fulfil the purpose of connecting several RECs which are not in close proximity to one another. Several preliminary considerations were recently outlined in a public consultation for the development of RECs and CECs and participation by active consumers in the energy systems [68].

No framework has been defined in Ireland for collective self-consumption in multi-tenant buildings exists yet as 97% of residential buildings are single dwellings[11].

5.2.2 Italy (RSE)

In Italy, after the adoption of the European directive 2012/27/EU in 2014, started the process to improve the measurement systems installed at end users’ premises to allow the exploitation of

[11] https://www.cso.ie/en/releasesandpublications/ep/p-cp1hii/cp1hii/hs/

production and consumption data. The Italian Electrotechnical Committee (CEI), the Italian body in charge of the standardisation of the electricity sector, published in 2017 the reference standard for the communication technology “Chain 2” that provides the end-user with the opportunity to have knowledge and awareness of their electricity consumption in real-time in an open way.

The communication channel is allowed by the second generation of smart meters that are presently being deployed and represents a fundamental element in the management of a "smart home", in fact, they allow market operators to provide to the user new services. The “chain 2” channel is one of the main innovations of the second generation of smart meters as it makes available, through a user device (external to the meter), data measured by the meter such as: consumption and energy production data, reports relating to interruptions in the electricity service or the exceeding of power limits. Chain 2, providing information in near real-time on the consumption of an energy user, can support the spread of value-added services, such as the management of customized tariffs, peak shaving and demand response (i.e. the possibility of modulating the level of active power withdrawn from the electricity grid according to the trend in demand and supply of energy). This will also allow the possibility for end-users to provide flexibility services to the electric grid by participating, through aggregators, in electricity markets.

Before proceeding with the activation of the Chain 2 channel, it was conducted a campaign of performance monitoring that lasted one and a half year in real conditions[12]. The results of the monitoring activity confirmed the quality of the service levels of the channel and therefore the reliability of the technology allowing to proceed with the real deployment.

The availability of consumption data, a notice of detachment and exceeding of thresholds in real-time will pave the way for new application solutions in the field of energy efficiency and true integration between home automation systems and the electricity meter of the distribution company.

It’s important to note that the communication “channel 2” is additive to the usual connection between the meter and central system (the so-called "Chain 1") which was already part of the first generation of smart meters. “chain 2” is implemented through PLC communication in the band C as defined by CENELEC and, as reported before, allows the communication of the meter with the user device through which different service can be provided.

This is a relevant step in fostering customers’ engagement towards the actual deployment of the possibility to providing distributed flexibility services. However, this is not the only enabler needed to make customers active. In this view, to complete the needed set of solutions it is important to note that they are under development standards and architectural solutions to enhance the user participation and provision of services to the grid. It is under discussion, within the relevant national technical committees, how the aggregators should interact with user devices and the technical rules for the home private electric vehicle charging points. However, this is not to be seen as a barrier, but as an opportunity for the future, since these are new solutions that need to be discussed by the relevant bodies before a real market uptake can happen. It is, however, important to point out that, due to the complexity of the field, several committees are involved in the discussion; a lack of coordination should be avoided, otherwise the standardisation process slows down, resulting in a relevant barrier, as already highlighted.

Finally, it is important to report that are under definition (within CEI) the specification for the controllers that will be implemented in the domestic charging devices for electric vehicles (wall

[12] https://www.arera.it/it/eventi/190522.htm

boxes). These will be able to communicate with smart meters through "chain 2" allowing smart charging solutions.

5.2.3 Greece (FOSS)

Greece was one of the countries to release related legislation on energy communities soon enough. The law 4513/2018 established a new type of cooperative, the "energy community" whose main characteristics such as the open and voluntary membership, the democratic governance and the requirement of proximity were aligned with the EU definitions. It has to be mentioned that good interpretation on issues such as energy poverty, special care to municipalities and local communities have also been taken on board. As an example, the activities that such a community can undertake include the ones defined under the EU directive but also energy innovation, energy poverty reduction and promoting energy sustainability. But these issues as were broad enough, created space so that energy communities were developed by private investors rather empowered citizens.

Regarding the main points of citizens' empowerment, the following qualities are discussed:

- **Open and voluntary membership**: it is open to natural persons as well as legal persons governed by private and public law. The only local authorities that can participate are municipalities or their enterprises
- **Requirement of proximity:** at least 51% of the members must be related to the place of the headquarters of the energy community. This encourages also collective self-consumption.
- **Democratic governance and effective control:** The law defined the minimum number of members that can take part in a community. This number is strongly related to the legal status of the participants with targeted empowerment of natural persons and municipalities.
- **Primary purpose**: The purpose is defined as environmental, economic or social community benefits provision for its shareholders or members or for the local areas where the community operates. There are 2 types of ECs profitable and non-profitable.

To sum up, Regulation in Greece supports the empowerment of citizens but needs to take on board further EU interpretations through a transposition process. Also, some regulation issues need to be further investigated e.g. although that collective self-consumption via virtual net metering is allowed by community members, they need to have the same electricity supplier.

Regarding energy efficiency, according to Greece's NECP, the objective is to improve energy efficiency in final energy consumption by at least 38% concerning the foreseen evolution of final energy consumption by 2030. Towards this objective, the "Save Energy at Home II" Programme was launched to empower citizens to take energy efficiency measures for their first home. The programme provided incentives for energy-saving interventions in the residential buildings. The programme was funded by the European Regional Development Fund (ERDF) and national resources. The provided incentives are in the form of a grant (direct support) or/and a loan with an interest rate subsidy.

5.2.4 Bulgaria (TUS)

As considered in the EU Renewable Energy Directive [6] the renewable energy communities (RECs) are gaining high importance for the decarbonization of the European power and energy system.

Expected to be a financially efficient way of decentralizing the Electrical power system RECs found good acceptance in some EU countries such as Germany, Denmark and also developing well in some other countries such as Croatia, Greece, Italy et. al.

The RECs represent a promising business model which gave expectations for successful implementation also in Bulgaria [69]. However, RECs concepts remain in a very early stage of development in Bulgaria still remaining without any official legislative definition and legal framework. Although no RECs and no financial support schemes are presently known in Bulgaria some similar pilot initiatives such as community-owned PV rooftop installations and municipal renewable energy sources could be noted. The RECs concepts remain widely unknown to the citizens and where present the information about RECs covers foreign sources and practices which is not always adequate for the local specificities in Bulgaria.

Being the country with the lowest gross disposable income of households in the EU, the smallest average and minimum wages, the highest income inequality rates, the lowest Human Development Index and Social Progress Index figures and the largest percentage of people living below the poverty line [70] Bulgaria remains economically far away from the western countries.

The absence of a legislative framework supporting RECs and the lack of measures for the development of RECs in Bulgaria's National Energy and Climate Plan (NECP) represent a major barrier.

Other factors which gradually hinder RECs implementation are the administrative barriers, with large amounts of paperwork, complex and time-consuming procedures and processes [70]. The administrative processes necessary for installing small-scale renewable electricity generators are hardly understandable to the common citizen. The building and connection process in Bulgaria also takes much more time consuming than in the advanced European countries requiring approximately 20–25 weeks and 170 h to install a single RE system [71].

5.2.5 Malta (FOSS)

As Malta is a geographical island whose electricity system has only one exclusive electricity market, it is not foreseen that renewable energy communities will develop in the short term. The specific nature of Malta's electricity system is fully recognized in Directive (EU) 2019/944 on common rules for the internal market for electricity in which Malta is granted derogations on third-party access, choice of supplier, and provisions related to unbundling [72].

5.2.6 Cyprus (FOSS)

The transposition process of the legislation under energy clean package is progressing in Cyprus delivering in the first phase the amended electricity law that was published on the 7th of October 2021. This important Law includes the definitions of CECs and RECs as have been identified in the EU directives and have been translated untacked from the European document. This means that there is a reference to qualities such as open and voluntary membership, autonomy and requirement of proximity for the RECs. Members of a REC can be natural persons, SMEs or local authorities, including municipalities. For CECs there is a reference to open and voluntary membership and members can be natural persons, local authorities, including municipalities, or small businesses. The enabling framework for both entities shall be enabled by the Regulatory Authority of Energy of Cyprus.

In parallel, a draft Law on the Promotion and Encouragement of the Use of Renewable Energy Sources has been open to a public consultation process. The draft Law also includes the definition of RECs and the transposition process is estimated to be complete within 2022.

The Third Energy Package has progressed well but still not fully implemented in Cyprus. The reason behind this is that only one state-owned company, the Electricity Authority of Cyprus (EAC), generates and supplies electricity within this island country. Therefore, there is no wholesale market and there are no cross-border links at present. Liberalisation of the Cyprus electricity market began under the provisions of the First Electricity Directive and the Second Electricity Directive since 2009, including all "non-domestic" consumers being able to select their supplier according to what is in their best interest [73]. Nevertheless, EAC remains the dominant producer of electricity and the owner of both the electricity transmission and distribution assets in Cyprus. The opening of the electricity market to all customers has been delayed and should be implemented towards the end of year 2022. These market conditions hinder the further formulation of innovative LEM structures that would empower citizens' participation, e.g., through citizen energy communities. The same stands for aggregators' schemes and explicit demand response programs that depend upon the participation of consumers and are not viable under no market conditions.

On the other side, EAC has committed to supporting the integration of RES plants (solar) in the power generation system through schemes for net-metering and self-generation for all consumers. Support scheme "Solar Energy for All" for on-the-site production and consumption of RES for their own use provides:

(a) The installation of net-metering photovoltaic systems with a capacity of up to 10 kWp connected to the grid for all consumers (residential and non-residential). Net metering will be converter to net-billing after 2023, and

(b) The self-generation systems with capacity up to 10 MWp for commercial and industrial consumers.

There was a debate during the public consultation regarding the self-consumption fee, which is something that needs to be examined in more detail, considering the study contacted from JRC, under the administrative arrangement of SRSS/C2017/077 that the existing framework for network charges must change, moving towards a usage-based capacity charging system [74].

Renewables up until now are entitled to dispatch priority. The current call, however, as well as future ones, will require prospective RES generators to operate through the market rules similar to any other generator. This, together with the non-interconnection status of Cyprus, highlights the importance of the storage installations for the island case of Cyprus. At the time being, no regulations exist regarding storage. It should be mentioned, however, that behind-the-meter storage could be profitable for end-consumers under a net-billing plan and in case time-of-use electricity tariffs are adopted in the future.

To sum up, the main barriers for citizens' empowerment are related to the structure and the size of the electricity market in Cyprus, coupled with no active market rules in place till today.

5.2.7 **Latvia (IPE)**

5.2.7.1 Smart metering

In Latvia, the DSO, Sadales tīkls AS, is legally entitled to define deployment targets and conditions for smart electricity; for gas meters, it is the Latvian DSO GASO AS. The DSO is in charge of meter ownership and installation as well as metering data collection and storage. The DSO is also metering data protection officer (Art. 37 GDPR) and in charge of metering data transmission to third parties. All investments in smart metering deployment are financed through network tariffs. The defined target is 100% smart meters nation-wide in 2022. Meters are installed for all connections in selected secondary substations, with no differentiation between households or SME connections.

Available services: historical consumption, dynamic tariffs, smart meter to integrate prosumers in the market.

It appears that in Latvia, the approach to directly deliver smart metering benefits to the final customer has not been particularly pursued in the deployment programme. Moreover, there is no apparent research regarding customer concerns or expectations for the rollout, nor any material by the National Regulatory Authority (NRA) that is publicly available. One of the key lessons learnt by the Latvian is that the smart meter project has decreased the operational costs (OPEX) for the network [75].

5.2.7.2 Energy communities in Latvian policy

Energy communities are not directly addressed in Latvian policy. National Development Plan 2021-2027 published in 2020 [76] aims at providing «access to innovative and efficient energy solutions achieving greater self-sufficiency and distributed generation» as well as supports «civic micro-projects for involving households in RES deployment and housing renovation». Latvia's Sustainable Development Strategy 2030 published in 2010 [77] supports distributed RES and microgeneration in the private sector.

However, one of the most important activities listed in the National Energy and Climate plan for Latvia until 2030 [78] directly encourages the introduction of renewable energy communities in Latvia: "The goal is to promote economically justified energy self-generating, self-consuming and renewable energy communities and promote the creation of legal regulation and support mechanisms for energy cooperatives in Latvia". The National Energy and Climate Plan (NECP) also proposes the establishment of a Renewable Energy Promotion and Energy Efficiency Improvement Fund.

The definitions of energy communities will be provided by amendments to the Law on Energy and the Electricity Market Law [79]. At the moment the final Draft Amendments are not yet approved by the government and need to be submitted to the Parliament.

As for prosumers, the number of prosumers remains very low in Latvia mainly because the solar sector is not yet sufficiently developed. There is a will to support the self-generation of electricity in Latvia, but there is no coherent support scheme for this action plan. Latvia is considering a plan for financial instruments or loans for solar electricity generation and storage, but it is not yet applicable [80].

5.2.7.3 Experience

RES community movement in Latvia is in the early development stage. At the moment there are few initiatives – both by municipalities and by individual citizens – that include features of energy communities or RES projects, like solar collectors and biomass boilers for renovated houses in

Sigulda, Valmiera and Marupe.

According to Co2munnity project's[13] findings [81] the following measures could accelerate community development in Latvia:

- Facilitate energy communities through regulations
    - Incorporate community definitions and general provisions in Energy Law & Electricity Market Law
    - Strengthen flat owner associations and synergies with renovation projects
    - Ensure participation of public/local authorities in community RES projects
    - Adjust the net metering system to include community organizations, or come up with alternative models
    - Balance costs and benefits with other players, as well as adopt rules among the community members
- Diversify funding
    - Fit community RES under Cohesion policy objectives «A smarter Europe» & «A greener, low-carbon Europe» in the programming period 2021-2027
    - Include communities in the Rural Development Programme, LEADER
    - Establish a new state foundation for RES and EE projects & ETS funding
    - Address community projects in European Investment Bank's and commercial lending criteria, and sustainable finance planning
    - Adjust support schemes (equal conditions with commercial actors) & specific tax exemptions
- Ensure engagement, coordination and access to information
    - Establish a single contact point for administrative procedures (including know-how assistance & info hub about existing initiatives)
    - Launch information campaigns authored by the government that demonstrate public support for energy citizens and community projects
    - Publish energy monitoring and carbon footprint data
    - Enhance participation through neighbourhood associations and green NGOs
    - Support research & cooperation with universities for innovation
- Create energy community development plans
    - Focus on energy communities in implementing the NECP2030 – new decarbonisation targets upon its revision in 2023
    - Advance spatial planning & Sustainable Energy and Climate Action Plans
    - Activate the role of distribution system operators based on shared benefits
    - Wind energy projects – aim for social acceptance, explore community ownership and draft guidelines for commercial projects

5.2.8 Lithuania (IPE)

5.2.8.1 Smart metering

The organisation, coordination and implementation of the state policy in the energy sector are managed by the Ministry of Energy. In accordance with Paragraph 6 of Article 21 of the Law on Energy, the Ministry of Energy approves the development plans for smart grid and smart metering, or so-called intelligent energy accounting systems, and sets requirements for these networks and

[13] https://co2mmunity.eu/

respective systems. In Lithuania, the DSO is responsible for meter ownership and installation, metering data collection and storage as well as metering data transmission to third parties. The DSO also has the responsibility of the metering data protection officer (Art. 37 GDPR).

The DSO in Lithuania is planning to apply for support from available European Union funds to finance the smart metering programme along with the distribution tariffs paid by the customers. Deployment of smart meters is actually planned from 2020 to 2023.

Available services: bill forecasting, historical consumption.

In Lithuania, there has been an elaborated approach to smart metering benefits for the final customer with pre- and after-interviews made in conjunction with a smart metering pilot. The majority of the respondents considered the advantage of basic smart metering that eliminates the need to take manual meter readings. Also, about half of the respondents indicated the advantages of being able to pay bills automatically and tracking online electricity consumption [82].

5.2.8.2 Energy communities in Lithuanian policy

Lithuania targets a share of 2% of total electricity consumers (1.6 million) to become prosumers by 2020, 30% by 2030 and 50% by 2050. At the end of 2020, Lithuania had 8 473 prosumers with an installed capacity of 80.5 MW, a significant increase from 2015 when it had 63 prosumers with 0.5 MW capacity. This is still below the targeted level for 2020. By 2024, a total of 696 MW of installed capacity is envisaged under the prosumer scheme for small-scale renewable energy facilities [83].

Net-metering is in place for electricity production from solar and wind. Net-metering was introduced in 2015, but the design has been reinforced over the years. Net-metering can be used for solar PV and wind installations up to 500 kW by any legal or personal entity: by private households, commercial units, communities [83].

In Lithuania, the description of an energy community and the principles of its operation are defined by law. In 2020 Seimas - the Lithuanian Parliament - has approved draft laws prepared by the Ministry of Energy which will allow residents to cooperate and establish renewable energy communities[14]. The amendments to the Law on Energy from Renewable Sources envisage that renewable energy communities will be able to manage and develop power plants using renewable resources for energy production – to produce, consume and accumulate energy in their storage facilities and sell the energy produced. These communities can be owned by individuals along with small- and medium-sized enterprises or local authorities, such as municipalities or elderships. However, natural persons will have to hold at least 51 per cent of the votes at the general meeting of shareholders.

Lithuania is the first country in the world to launch an online platform to buy or rent a remote solar panel (https://www.eurodad.org/sustainable_infrastructure_casestudies). It is possible to construct PV power stations in one part of the country and consume its electricity in another; only the electricity transmission will be charged. Individuals can buy or lease part of a big PV facility (for instance 1 000 kW), thereby providing multi-apartment buildings with access to solar power.

The Seimas also approved amendments to the law that will create more favourable conditions for

[14] https://enmin.lrv.lt/en/news/lithuania-to-allow-renewable-energy-communities-more-opportunities-for-businesses-to-use-green-electricity

residents to purchase remote solar power plants. Conditions have been simplified for prosumers who have purchased a power plant from a solar farm – the solar power plant will be considered movable property, so the purchase and sale agreement for the power plant part will not have to be drawn up as a notarised transaction. In addition, prosumers who have chosen an independent electricity supplier are able to be compensated for the electricity produced and not consumed during the accumulation period at the price agreed with the supplier or set by the National Energy Regulatory Council.

Furthermore, Lithuania promotes the deployment of small-scale renewable energy installations owned by private energy consumers and renewable energy communities by different means [83]:

- The government invests the revenues received from the statistical transfers to Luxembourg in tenders for decentralised energy production facilities during 2020. Around EUR 7 million are allocated to renewable energy communities, farmers, and small and medium-sized enterprises for small-scale renewable projects. The support funds up to 45% of the investment costs for solar power plants (up to 500 kW) and wind power plants (up to 3 MW).
- It also allocates EU funding to the prosumer scheme.
- The prosumer scheme is also facilitated by lower preconditions for development and production permits, a reduced cost for connecting to the networks, a general opening to enterprises, easing of the capacity limitation requirements, modification of financial incentives for solar installations, elimination of control accounting and inclusion of the investments needed for the integration of prosumers in the distribution system operator's investment plan.

5.2.8.3 Experience

According to Co2munnity project[15], the most important issue in the development of energy communities in Lithuania is hindered by the definition of community energy: as part of the law, it is required to establish a legal commercial entity, i.e. a non-profit public organization. That means, the profit must go to the benefit of the shareholders, but no financial gain is possible for the investors. So, while all shareholders in the community invested their own money, the profit can solely be reinvested in the development of the solar park or other ways to improve the wellbeing of the entire community. This is the reason why the model is not business-friendly.

5.2.9 Estonia (IPE)

5.2.9.1 Smart metering

In Estonia, the Government is legally entitled to define deployment targets and conditions for smart electricity and gas meters. Those provisions will mostly apply to the DSOs that are the parties in charge of meter ownership, installation and data collection, as well as in-home display ownership and installation. Metering data is also collected to a Central Data Hub where meter readings are stored and if requested transmitted to third parties. The Central Data Hub also fulfils the duties of metering data protection officer. The smart metering programme is financed through the network charges paid by the end customer. According to the Electricity Market Act, all smart meters were installed by the 1st of January 2017 and the deployment was mandatory for all customers.

Available services: relatively to other consumers, bill forecasting, unusual usage alert, historical

[15] https://co2mmunity.eu/

consumption, dynamic tariffs, flexibility provision, energy sharing.

A number of lessons learned by the Estonian NRA regarding smart metering deployment is shared below [82].

- Smart meters are more convenient for end-users since they do not have to inform the DSO about their meter readings.
- They are also convenient for DSOs since they have a better overview of hourly consumption in the network, which enables better network planning.
- Moreover, DSOs, can have, thanks to smart meters, a better overview of their network losses (as confirmed in the Estonian distribution network: from 5,7% losses recorded in 2012, down to 4,1% in 2017).
- In addition, DSOs can easily detect with the help of smart meters illegal electricity consumption (theft).
- Finally, smart metering supports the implementation of demand response.

5.2.9.2 Energy communities in Estonian policy

The Estonian Government has transposed the Citizen Energy Community definition into its Electricity legislation. It uses the term ‘energy community’. It foresees a very open concept of forming energy communities, essentially allowing anyone to participate. Furthermore, any legal form that is capable of being used by an energy community is eligible to become one. There is little to no elaboration of the criteria contained in the Electricity Directive, notably effective control. Furthermore, no regulatory authority is appointed to oversee the registration of energy communities and compliance with the EU criteria. As such, there is a large risk of corporate capture and abuse of the concept [84].

As for prosumers, Estonian NECP does not include specific objectives for prosumer development, but it clearly identifies prosumers as an objective of the Estonian energy policy. Self-consumption is possible in Estonia and self-consumers may access support under certain conditions [85].

Energy communities are promoted by municipalities, i.e. Tartu city energy and climate plan [86] and Tallinn [87] city energy and climate plan aim to support the establishment and promotion of energy communities.

5.2.9.3 Experience

Initial attempts to establish energy cooperatives took place in 2015 and 2016 when the Energy Cooperatives Mentor Programme was implemented by the Estonian Development Fund. It was funded by ERDF and supports Estonian start-ups and their development through workshops, peer-to-peer learning, and mentorship programmes. The programme included 10 CE projects.

5.2.9.4 Demand response in the Baltic States

Considering the Baltic region’s specific set up within unified power system (Russian energy system) and that the wind and solar energy penetration for the Baltics is still below Western Europe, it follows that the pressure to integrate demand response in the energy markets are comparatively lower in the Baltics than in the rest of Europe. However, this situation will change after the upcoming desynchronization as demand response could play a key role in the provision of holding reserve and deliver the significant cost-saving potential for the Baltic system [88]. Demand response is available at the wholesale level in the Nordic market, which provides great flexibility. TSOs in the Baltic region have worked together to harmonise demand response across the region. In June 2020, an independent aggregator was appointed for demand response [83].

6 Conclusion

The success of the energy transition in Europe depends on the sustainable replacement of conventional generation with renewable production. The variability of renewable energy indicates the necessity of the integration of energy citizens, as the new sources of flexibility, into the energy systems. This deliverable focuses on the barriers to the successful and sustainable engagement of European citizens in the energy transition that root in the European and national regulations, codes, standards, policies, financial support schemes, and behavioural patterns of citizens. These barriers hinder the effective realization of efficiency measures, demand response, and energy management systems, as well as the efficient local energy markets as the enablers of citizens' engagement in the Member States. Many of the barriers that mattered in the past have been removed and new gaps are emerging as the energy transition progresses. The focus in this deliverable was on the contemporary challenges that still matter. Dealing with the identified barriers and gaps pave the way for the effective engagement of energy citizens in the energy transition by assuring service quality through developing effective standards, making effective policies, direct financial supports in the correct directions, and amending the behavioural patterns of citizens by improving their awareness and presenting the whole picture of the energy transition, and boosting their knowledge of the main targets of the energy transition.

This study identified that the low quality of renovation (mostly limited to cosmetic fixes), institutional and legal frameworks that slow down renovation, and the lack of building class-oriented standards delineating the minimum level of renovation, putting the energy efficiency measures into action. The implementation of domestic demand response is hindered by insufficient wholesale price variation, energy and a network tariff structure that does not support demand shift in time and switching to e-mobility and electrical heating, distribution system operator remuneration approach that incentivises non-wire solutions over demand response, ambiguous rights for direct control of citizen's loads, and regulation interaction barriers. Finally, the complexity of prosumers' remuneration, data confidentiality/transparency, technical responsibilities for aggregators that originally have not been technical organizations and fairness in allocating such responsibilities, and recognition of user characteristics for market-oriented demand response comprise a subset of the barriers to the efficient integration of citizens into the local energy markets. In addition, the outdated wholesale market mechanisms, separate power exchange and flexibility market, technical problems, lack of standardization on smart metering, inconsistency of market instruments for incentivizing renewables, distribution system operators' regulations motivating investment in only wired solutions, and long administrative procedures for the energy community projects are also hindering the efficient implementation of the local energy markets.

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