IElectrix

Current regulation in target countries and regulatory barriers identified for the implementation of the use case

Deliverable D4.4

Version 1.0

27/04/2021

Short description

This deliverable identifies the key regulatory issues that may act as a barrier to the deployment of the IELECTRIX project solutions. Moreover, a comparative review and analysis of existing regulation in the demo countries (Austria, Germany, Hungary and India) and the replication countries (France, Sweden and Greece) are presented. Lastly, a preliminary identification of potential regulatory barriers for the project use cases in the countries mentioned above is given.

Associated document(s) & annexe(s)

- Appendix A - Regulatory questionnaire

Revision History

Version	Date	Nature	Author/Company
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V0.2	18/02/2021	ToC revised after comments from E.DIS	R. Cossent/Comillas
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Accessibility

☒ Public ☐ Consortium + European Commission

Responsibility

Author(s)/Contributor(s)		Reviewer(s)		Other Information		
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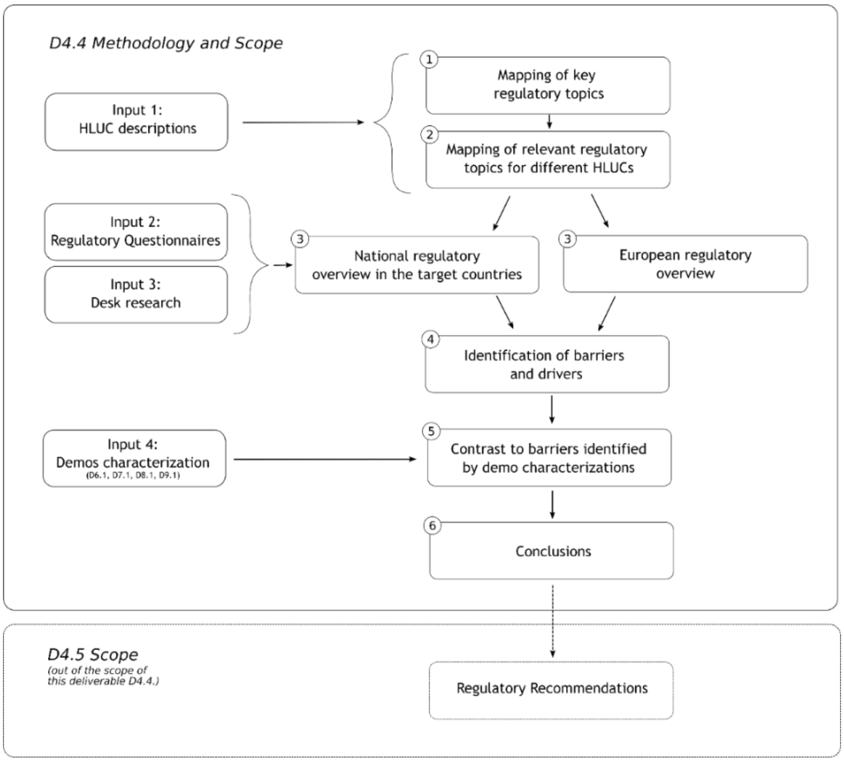
EXECUTIVE SUMMARY

This deliverable aims to identify key regulatory issues that may act as a barrier to the deployment of the project solutions for local communities. Thus, the report reviews and analyses existing regulation in the demo countries (Austria, Germany, Hungary and India) and the replication countries (France, Sweden and Greece), collectively referred to as target countries. Moreover, the latest developments and discussions on the implementation of the EU Clean Energy Package (CEP) are assessed.

Considering the high-level use cases (HLUCs) being demonstrated in the IElectrix project, key regulatory topics are identified. The assessment of the situation of these regulatory topics is twofold. On the one hand, the CEP is analysed in order to determine which topics are covered by the EU legislative package and how clear the directives are for implementation in the Member States (MS). As the analysis shows, several topics are left open for further definitions by the CEP to be done at the MS level. On the other hand, the national regulatory framework is analysed, and regulatory barriers are identified as a result of this analysis. In order to collect the required information, regulatory questionnaires were answered by partners in the target countries. Finally, the list of potential regulatory barriers is compared with the barriers already identified by each demonstration in their respective "demo characterisation" deliverables (D6.1-D9.1).



Overview of the methodology used in D4.4

The analysis of regulatory characteristics in the seven target countries has led to the identification of 13 main barriers for the deployment of IElectrix solutions. For each regulatory topic, one or more potential regulatory barriers were found. These barriers could limit the potential for the implementation and replicability of IElectrix solutions.

Nevertheless, not all barriers are verified in every analysed country. In addition, not all barriers are equally crucial for every HLUC being developed in IElectrix.

One may notice that the transposition of the CEP is expected to bridge several of the barriers identified. However, the complete transposition also depends on the capability of NRAs to reach a conclusion with regards to open topics in a timely and efficient way. The delay in transposing and implementing the directive from the CEP also creates regulatory uncertainty, which is a barrier in itself, as identified by the demonstration activities in IElectrix. Regulatory sandboxes and large scale pilot projects can aid NRAs in this process. However, this too has been identified as a missing aspect in several national regulatory frameworks.

The analysis of regulation in the seven target countries also led to the discovery of a few drivers for the implementation of IElectrix HLUCs. These drivers are not analysed in this deliverable, but they will inform regulatory recommendations to be provided in the IElectrix deliverable D4.5.

Regulatory barriers (ID and description)		AT-1	AT-2	DE-1	HU-1	HU-2	IN-1	IN-2	IN-3
1	CAPEX-Bias in incentive regulation	●	●	●	●	●	●	●	
2	No binding investment plans approved or published	●	●	●	●	●	●	●	●
3	Limitations to use of BESS by DSOs	●		●	●				
4	Lack of local flexibility procurement mechanisms	●	●	●	●	●	●	●	●
5	Lack of sandbox regulation and experience with large innovation programmes	●	●	●	●	●	●	●	●
6	Limited smart meter deployment		●			●		●	
7	Deep connection charges as a barrier for small DG	●	●	●	●	●	●	●	
8	Inexistence of flexible network options	●	●	●	●	●	●	●	
9	Existence of net-metering schemes	●		●	●		●		
10	Not developed liberalised retail markets and presence of regulated tariffs		●					●	
11	High share of regulated costs in the electricity bill		●	●	●		●	●	
12	Uncertainty on LEC definitions, especially on topics that are left open to MSs by the CEP	●	●	●			●	●	
13	Collective self-generation is still incipient	●	●	●			●	●	

Table 1: Regulatory barriers relevant to the different HLUCs in IElectrix

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1. Introduction and Project background

1.1. Context of the IElectrix project

IElectrix started in response to the growing need for creating innovative technical solutions and business models that facilitate the implementation of Local Energy Communities[1] (LECs) and the integration of distributed Renewable Energy Sources (RESs).

IElectrix contributes to the European ambition by adopting a consumer-centred approach and increasing its involvement, particularly through LECs. This project is also a way to accelerate the integration of RESs into the distribution networks and the decarbonisation of the energy system. In this context, Distribution System Operators (DSOs) play an important role by ensuring the connection of RESs within the grid and facilitating the energy transition.

To reach such goals, the IElectrix project brings forward innovative technical solutions:

- Mobile storage systems and smart substations
- Implementation of demand-side management schemes
- Low voltage (LV) grid digitalisation

The project brings together 15 European partners and 1 Indian partner in order to experiment, through 5 demonstrators, the technical and economic relevance of LECs in different regulatory and ecosystem contexts.

Two demonstrators are located in Hungary, one in Austria, one in Germany and one in India:

- The Austrian demonstration pilot is currently creating a new energy community in the Güssing District, where RES investments have already been made.
- The German demonstration pilot is carried out in a region with a high amount of RES already integrated into the grid. Within the demonstration, a mobile storage system is used in order to postpone costly network reinforcements and vice versa to integrate more distributed energy resources (DERs) in a faster way.
- The Hungarian demonstration pilots address issues that are located at an early stage of renewable deployment in two distinct regions.
- The Indian demonstration pilot anticipates a large number of photovoltaic panels (PVs), which will be connected at the low voltage level in the coming years following recent governmental plans.

[1] The EU regulation defines energy communities under two different concepts, namely Citizen Energy Community (CEC) and Renewable Energy Community (REC). The “Local Energy Community” concept, defined in the IElectrix Grant Agreement, is used throughout this report in reference to energy communities in general terms, including both CEC and REC. The differences between the two EU concepts are highlighted in Chapter 4.

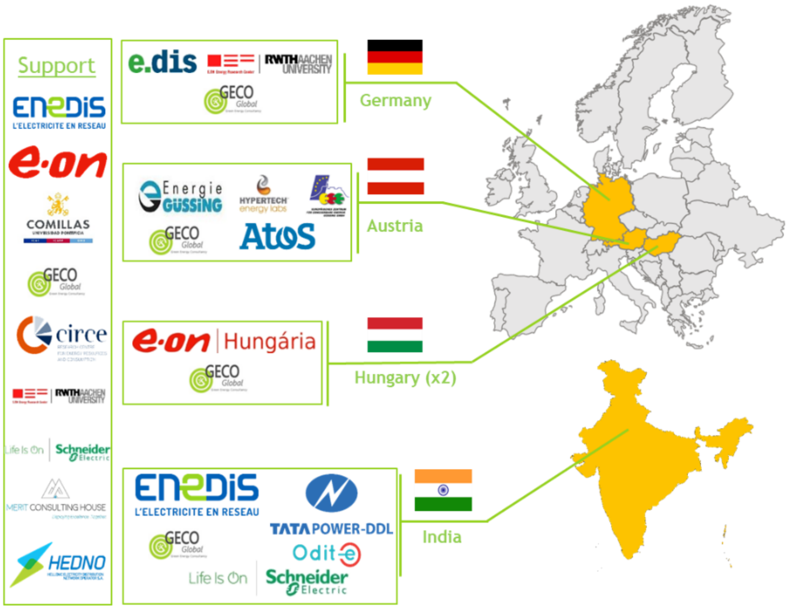

Figure 1: IElectrix Demo map

1.2. Scope and objectives of the document

The main aim of this deliverable is to identify key regulatory issues that may act as a barrier to the deployment of the project solutions for local communities. Thus, the report will review and analyse existing regulation in the demo countries (Austria, Germany, Hungary and India) as well as the replication countries (France, Sweden and Greece), collectively referred to as target countries. Moreover, the latest developments and discussions on the implementation of the European Union's (EU) Clean Energy Package will be assessed.

1.3. Methodology

In order to achieve the objectives proposed for this deliverable, the following methodology is applied. Firstly, the key regulatory topics to be analysed are identified. For this purpose, the description of High-Level Use Cases (HLUCs) of IElectrix serves as a baseline. Based on their objective and scope, key regulatory topics can be identified and mapped to the different HLUCs. Secondly, the analysis of regulatory conditions for these regulatory topics is carried out. In this step of the research, two parallel approaches are adopted. On the one hand, this report maps and explores the provisions brought by the Clean Energy Package for the EU target countries. On the other hand, the current national regulatory frameworks are analysed, and key regulatory aspects described for all seven target countries.

As a first input for the country description, a questionnaire was circulated among the IElectrix partner. The questionnaire was answered by DSOs of the seven target countries. In total, seven questionnaires were completed, one per target country in IElectrix. The questionnaire was composed of 80 questions organised by regulatory topics (questionnaire included in Appendix A). Nine groups of questions were defined, specifically DSO economic regulation, Pilot projects and regulatory sandboxes, grid access and connection, new toles of DSOs, smart metering, retail tariffs, self-generation, and energy communities. The survey included both multiple choice and open questions. As a secondary source of information, additional desk research is used to complement the information received in the questionnaires. These additional sources of information include results from previous H2020 projects, as well as reports and publications from National Regulatory Authorities (NRAs), DSOs, EU institutions and academia[2].

From the analysis of the regulation in the target countries, barriers are identified and described. The identified barriers are also contrasted with barriers identified in the demo characterisation tasks of IElectrix, considering that each demonstration Work Package of IElectrix already conducted a regulatory barrier identification exercise.

The final list of regulatory barriers and conclusions produced in this deliverable D4.4 will serve as the basis for the elaboration of regulatory recommendation in IElectrix, to be presented in deliverable D4.5.

Figure 2 illustrates the methodology and scope followed in this deliverable.

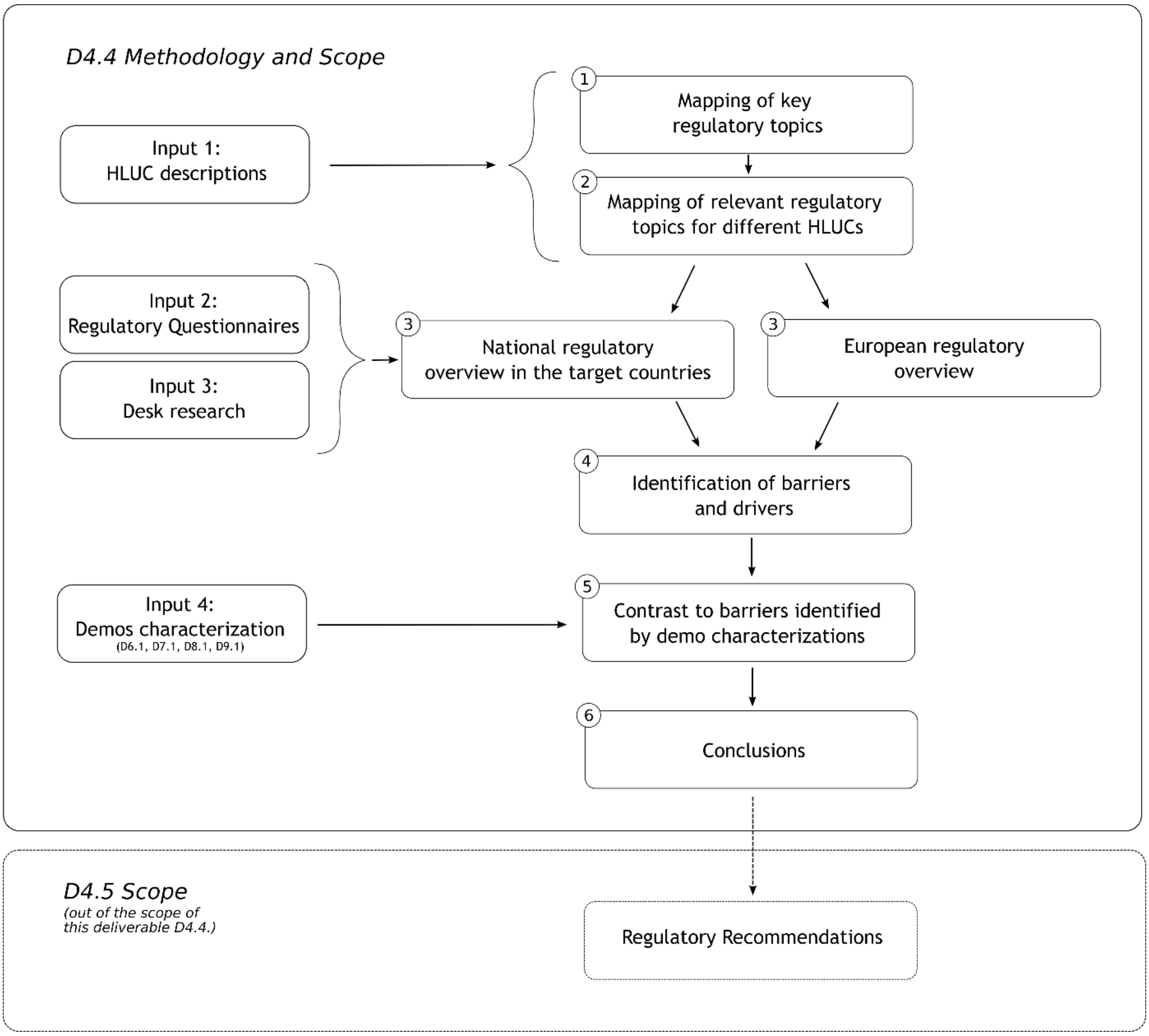

Figure 2: Methodology and scope in D4.4

[2] All unreferenced information in this report is taken from the questionnaire answers. Information obtained from desk research is referenced otherwise.

1.4. Structure of the report

After this introductory chapter, the remainder of this report is structured as follow. Chapter 2 maps the relevant regulatory topics for the development and replication of IElectrix solutions. These regulatory topics are also mapped with respect to the relevant HLUCs. Chapter 3 provides an overview of the European and Indian power sectors. Chapter 4 provides a mapping and assessment of the Clean Energy Package on topics that are relevant for the IElectrix project. Chapter 5 conducts an assessment of the current national regulation on the topics previously identified. This assessment is carried out for the seven target countries in IElectrix. Chapter 6 identifies potential regulatory barriers based on national regulatory conditions observed previously and contrast them to the ones identified by demo work packages. Chapter 7 concludes.

1.5. Acknowledgements

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Without your contributions and support, this report would not have been possible. Please note that any misinterpretation or error remains the sole responsibility of the authors.

1.6. Notations, abbreviations and acronyms

The table below provides an overview of the notations, abbreviations and acronyms used in the document.

Acronym	Meaning
ACER	European Union Agency for the Cooperation of Energy Regulators
AT	Austria
BESS	Battery Energy Storage System
BUC	Business Use Case
CAPEX	Capital Expenditures
CEC	Citizen Energy Community
CEER	Council of European Energy Regulators
CEP	Clean Energy Package
CHP	Combined Heat and Power
DE	Germany
DER	Distributed Energy Resource
DG	Distributed Generation
DISCOM	Distribution Company [India]
DLC	Direct Load Control
DoA	Description of Action
DR	Demand Response
DSO	Distribution System Operator [EU]
ENTSO-e	European Network of Transmission System Operators for Electricity
EU	European Union

EV	Electric Vehicle
FiT	Feed-in-Tariff
HEDNO	Hellenic Electricity Distribution Network Operator
HLUC	High-Level Use Case
HU	Hungary
ICT	Information and Communications Technology
IN	India
IPP	Independent Power Producer
LEC	Local Energy Community
LV	Low Voltage
MS	Member State
MV	Medium Voltage
NRA	National Regulatory Authority
OPEX	Operational Expenditures
PPA	Power Purchase Agreement
PV	Photovoltaic (solar)
RAB	Regulatory Asset Base
REC	Renewable Energy Community
RES	Renewable Energy Sources
RPI	Retail Price Index
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SERC	State Electricity Regulatory Commission
SINTEG	German Smart Energy Showcases
TOTEX	Total Expenditure
ToU	Time-of-Use
TSO	Transmission System Operator
UoS	Use of System
VAT	Value-Added Tax
WACC	Weighted Average Cost of Capital

1.7. References

IElectrix documents:

[REF DoA] IElectrix Description of Action

[REF D2.2] Assessment of the national implementation of new key-related European regulatory requirements and use case detailed definitions and interoperability specifications of joint activities in the Demonstrators

[REF D6.1] Design of solutions – Austrian Demonstration

[REF D7.1] Design of solutions – German Demonstration

[REF D8.1] Design of solutions - Hungarian demonstration

[REF D9.1] Design of solutions – Indian demonstration

Legal documents:

Directive (EU) 2018/844 - Energy Performance in Buildings Directive

Directive (EU) 2018/2001 - Renewable Energy Directive (RES-Directive)

Directive (EU) 2018/2002 - Energy Efficiency Directive

Regulation (EU) 2018/1999 - Governance of the Energy Union Regulation

Regulation (EU) 2019/943 - Electricity Regulation (E-Regulation)

Directive (EU) 2019/944 - Electricity Directive (E-Directive)

Regulation (EU) 2019/941 - Risk Preparedness Regulation

Regulation (EU) 2019/942 - ACER Regulation

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2. Mapping of relevant regulatory topics for the implementation of the different use cases

This section analyses the IElectrix project use cases, particularly the HLUCs or business use cases (BUCs), in order to identify the key regulatory topics relevant to the IElectrix project. Furthermore, these topics and mapped against the aforementioned HLUCs, serving as the basis for the subsequent preliminary identification of drivers and barriers posed by regulation to the realisation of the IElectrix goals.

The IElectrix project will demonstrate its concepts in four different countries, namely Austria (AT), Germany (DE), Hungary (HU), India (IN), in which different HLUCs will be tested. Although different HLUCs are tested in different countries, they all aim the demonstrating correlated concepts, namely the energy optimisation within LECs, the use of battery energy storage systems (BESSs) to support grid operation and RES integration, and the participation of demand response, having the DSO as a facilitator for these objectives. **Erreur ! Source du renvoi introuvable.** below summarises the nine HLUCs defined in the project, as described in the IElectrix Deliverable D2.1.

Country	HLUC Code	HLUC Description
IN	IN-1	Maximise the quantity of local consumption of RES
IN	IN-2	Boost the consumption of local energy with an adapted energy community Demand Response of consumers
IN	IN-3	Improve the resilience of the local energy system thanks to the islanding capability of the microgrid in case of an outage occurring within the area
AT	AT-1	Maximise the quantity of local consumption of RES generation thanks to Forecasting and scheduling of DER within the Integrated Local Energy System
AT	AT-2	Personalised, human-centric and contract-safeguarding participation in explicit demand response programmes, on the basis of context-aware flexibility profiles
AT	AT-3[3]	Improve the resilience of the local energy system, thanks to the distributed voltage control in case of an outage occurring on the overlaying grid
DE	DE-1	Evaluation of business case and benefits of integrating mobile battery systems into networks that would otherwise require reinforcement
HU	HU-1	Evaluation of business case and benefits of integrating mobile battery systems into networks that would otherwise require reinforcement
HU	HU-2	Evaluation of the possible flexibility within the network, the operation of the current Direct Load Control (DLC) system and the implications on customer behaviours and the potential benefits of more sophisticated load control

Table 2: Overall description of HLUCs in IElectrix. Source: IElectrix D2.1.

The development and deployment of the nine HLUCs are dependent not only on the development of technical solutions – described in four Technical Uses Cases – but also on the regulatory conditions and incentives in the different countries. Different regulatory topics will impact each HLUC differently.

[3] This HLUC is not considered in this regulatory analysis. The reason for this is that, even though it is listed among the use cases to be demonstrated in Austria, this use case is not elaborated in D2.1 nor listed among the business cases to be tested in D6.1. Hence, the regulatory analysis will focus on the necessary conditions for the implementation of the business cases identified by the Austrian demo (i.e. HLUCs AT-1 and AT2).

On the one hand, regulation on DSOs will impact the possibility and the incentives of solutions such as the optimisation of local consumption and use of BESSs as a means to reduce network reinforcements (e.g. AT-1, DE-1, and HU-1). More specifically, three regulatory topics can be identified as the most relevant for these HLUCs, namely (i) the economic regulation for DSOs, (ii) the incentives for innovation and pilot projects, and (iii) the upcoming regulatory definitions on the new roles of DSOs (e.g. BESS ownership by DSOs).

On the other hand, distributed energy resources are also impacted by the regulatory framework in place. The development of LECs, the participation of consumers in demand response (DR) programs and installation of local RES (e.g. as in IN-2, AT-2, for instance) can be affected by the regulation concerning network access and connection, retail tariff design and self-generation rules and LEC rules.

- DSO Economic Regulation

The DSO revenue regulation is expected to impact nearly all HLUCs, as it sets the incentives for DSOs in relation to operational expenditures (OPEX) and capital expenditures (CAPEX), as well as the remuneration of DSOs. The regulatory incentives on expenditures will determine if DSOs have the motivation to use the LEC as a means to reduce network reinforcement at the expense of increasing OPEX. On top of the incentives on OPEX and CAPEX, it is common for regulation to set specific incentives for the improvement of continuity of supply and the reduction of losses. In the case of the former, the main HLUC affected would be IN-3, as the islanding capability of microgrids is used specifically for increased resilience. In the case of the latter, several HLUCs are influenced, namely AT-1, DE-1, HU-1 and 2, and IN-1 and 2. In these use cases, the optimisation of local generation-consumption, including the use of BESS, could potentially reduce losses in the distribution grid. For example, load levelling enabled by BESS can reduce peaks utilisations of the network and, therefore, losses, considering the relationship of power losses with the related squared current (Alzahrani, Alharthi, and Khalid 2020). Moreover, additional incentives may exist for additional purposes other than losses and continuity of supply. Such incentives, if they exist, will be analysed on a case-by-case basis. Finally, the existence of network expansion investment plans is also important, as they may allow for DSOs and regulators to find opportunities to consider the use of local flexibility instead of reinforcing the grid, as proposed in DE-1.

- Incentives for innovation

The deployment of innovative solutions is often associated with economic risks and concepts that are challenging to comprehensively validate and assess in the context of the regulatory framework in place. Therefore, DSOs (and other actors) should have appropriate incentives for facilitating innovation initiatives. This can be translated into economic incentives for the development of pilot projects and for the recognition of costs associated with pilot projects. Additionally, DSOs could be granted an exception to certain regulatory conditions, limited both temporally and geographically, allowing the DSOs to test technical and market-based solutions that are currently not allowed by regulation. These exceptions are commonly known as “regulatory sandboxes”. Given the innovative solutions proposed in IElectrix, it is safe to say that this regulatory topic impacts all HLUCs in all countries.

- New roles of DSOs

With the deployment of smart grids, new roles are expected to be performed by DSOs in relation to data management, system operation, and market facilitation. In the context of IElectrix, two of the new roles of DSOs are selected to be analysed, namely the **use of flexibility from DERs** and **storage operations and ownership** by DSOs. With regards to the use of flexibility from DER for grid management purposes, all HLUCs are impacted by this regulatory topic. The rules on storage ownership will define in which cases the DSO is allowed to own and operated storage systems such as batteries. This definition is important as batteries can play an important role in grid management, but BESS administrators/owners can also act as market participants providing different services.

Therefore, these definitions should be relevant for all HLUCs that make use of BESSs in IElectrix, namely AT-1, DE-1, HU-1 and IN-1.

- Network access and connection

Not only DSOs are impacted by the regulatory framework in place, but also consumers, prosumers, and LECs. The rules on access and connection to the grid will have an effect on all HLUCs to a greater or lesser extent. The regulation on connection charges, allocation of grid capacity, connection requirements and firmness of access will give important signals for potential RES deployments, making them more or less economically viable. Considering that nearly all HULCs consider the use and integration of DERs, it is important to verify if barriers to their deployment exist.

- Smart metering

The deployment of smart meters enables several benefits to the system, such as higher observability of the grid by the DSOs, the reduction of operation costs (e.g. remote switching) and the availability of important data for consumers. Moreover, smart meters are almost a requirement for the design of effective demand response programs, as they provide the necessary granularity of consumption/generation data. Therefore, the solutions proposed by HLUCs testing demand response programs[4]., such as AT-2, HU-2 and IN-2, are impacted by the level of deployment, as well as the functionalities of smart meters. In addition, it is also important to consider how the data gathered by smart meters is managed and accessed by consumers and authorised third parties.

- Retail tariff regulation

The design of retail tariffs, together with the network connection and access cost, is also relevant in incentivising consumers and DER owners to participate in demand response (DR) programs or to provide flexibility in organised markets. In countries in which the retail activity is liberalised, it is important to evaluate which costs other than energy and network-related costs are borne by consumers. If such costs are too high, they could potentially dilute eventual incentives from DR programs, weakening the economic incentive. Also, the way these components are charged also matter (e.g. charges in energy terms or fixed payments). In the case of countries without liberalised retail or countries that have an "opt-out" default tariff, it is necessary to analyse if the design of such tariffs is compatible with the solutions proposed in the IElectrix project.

- Self-generation and self-consumption

The capacity to install RESs, to use it for self-consumption or to inject the remaining energy into the grid is fundamental for the development of LECs. Therefore, it is important for self-generation not only to be authorised but also to be fostered by appropriate regulatory signals, as the existence of self-generation taxes or limitations to grid access may hinder the deployment of local RESs. The analysis on barriers for self-generation should consider both individual self-generation as well as collective self-generation, as the latter is an important step towards the formation of LECs.

[4] For effective DR programs, not only smart meters are necessary, but also "smart devices", sensors and energy management systems for monitoring and controlling of flexible loads and DG. However, the deployment of smart meters is often a regulatory matter, while the adoption of smart devices and management systems is associated to commercial activities and business models. Therefore, in this deliverable we limit the analysis to the rollout of smart meters only.

■ Local Energy Communities (CECs, RECs)

The last regulatory topic considered is the rules for LECs. As the development of LECs is still in progress, the legal definitions and implementations in the different countries have to be considered, also in light of the European definitions of Renewable Energy Communities (RECs) and Citizen Energy Communities (CECs) defined by the Clean Energy Package. The scope of the LEC's activities, as well as the permitting process and requirements, will determine if barriers for an eventual deployment of IElectrix's solutions exist, specifically for HLUCs AT-1, AT-2, DE-1, IN-1 and IN-2, where LECs will play a central role.

		Business use cases							
		Austria		Germany	Hungary		India		
		AT-1	AT-2	DE-1	HU-1	HU-2	IN-1	IN-2	IN-3
DSO Economic Regulation	DSO remuneration and investments	X	X	X	X	X	X	X	
	Incentives to improve continuity of supply								X
	Incentives to reduce losses	X		X	X		X	X	
	Other regulatory incentives for DSOs	X	X	X	X	X	X	X	X
Innovation and pilots	DSO incentives for pilots/innovation	X	X	X	X	X	X	X	X
	Regulatory sandboxes: permitting and conditions	X	X	X	X	X	X	X	X
Network access and connection	Connection charges	X	X	X	X	X	X	X	
	Determination and allocation of grid capacity	X	X	X	X	X	X	X	
	Connection requirements	X	X	X	X	X	X	X	
	Firmness of access capacity	X	X	X	X	X	X	X	
New roles of DSOs	DSO procurement and use of services from DER	X	X	X	X	X	X	X	X
	Storage ownership	X		X	X		X		
Smart metering	Smart meter deployment and functionalities		X			X		X	
Retail tariff regulation	Design of regulated tariffs		X	X	X		X	X	
	Default/last resort tariffs		X					X	
Self-generation	Individual self-generation schemes	X	X	X			X	X	
	Collective/shared self-generation schemes	X	X	X			X	X	
Local Energy Communities (CECs, RECs)	Legal implementation	X	X	X			X	X	
	Scope of LEC activities	X	X	X			X	X	
	Permitting and requirements	X	X	X			X	X	

Table 3: Mapping regulatory topics to HLUCs.

3. Overview of the regulatory frameworks: comparison between EU regulation and India

The IElectrix project is demonstrating innovative solutions not only in the EU Member States (MSs) but also in India. These two power systems are different in terms of regulation, operation, market design and generation mix. Therefore, to better understand potential barriers for the solutions proposed in the IElectrix project in India, it is necessary to consider the current regulatory framework and market conditions. This chapter aims at providing a very brief overview of the Indian and the European power systems, highlighting the important differences, especially in the context of the IElectrix HLUCs.

3.1. Indian power system[5]

The Indian power system is among the largest in the world, together with the EU, China, Russia and the United States. India is the largest national synchronous grid in the world and a country that generates the equivalent of 55% (1,532 TWh in 2018 - (IEA 2020)) of the electricity generated in the whole European Union (2,806 TWh in 2018 - (Eurostat 2020)). Networks and generation capacity have been increasing in order to provide electricity access to its population. Until very recently, electricity access was a significant problem in India, as only 50% of the population had access in the year 1994 and 75% in the year 2009 (World Bank 2021). In March of 2019, the Government of India announced that 100% of the electrification of households had been achieved. 75% of the Indian electricity is generated by coal power plants. Wind and solar have been expanding their participation in the generation mix. Nevertheless, despite the growth in demand and the effort to ensure universal electricity access, the generation investment in new capacity grew faster than the load, leading to idle capacity and financial stress to generation companies.

The power sector in India started being liberalised in the 1990s, culminating in the Electricity Act of 2003, which restructured the sector in the way it is currently. The Electricity (Amendment) Act 2018 is pending adoption in parliament, which will introduce further changes towards more liberalised markets.

As of today, the power system is mostly unbundled between generation, transmission and distribution. The distribution companies (DISCOMs) are also responsible for the retailing activity, and therefore, this activity is not open for competition. The generation, on the other hand, is open to competition. Large power plants are not required licensing, and the network should be open for access. Two power exchanges exist in India; however, most of the power trade (90%) is made through long-term power purchase agreements (PPAs). Generation companies enter in these PPAs with the DISCOMs, leaving a limited opportunity for spot trading. In recent years, another modality of generation type has increased, namely the independent power producers (IPPs). The IPPs, also known as captive producers, are owned by consumers, mostly industrial loads. Around 18% of the grid-connected capacity is composed of captive producers, accounting for around 70% of India's industrial power demand. This modality is a means for industrial consumers to achieve a cheaper and more reliable supply of electricity. In India, security of supply is still an issue, and industrial tariffs charged by DISCOM's tariffs are high, considering the high cross-subsidies forcing industrial and commercial consumers to pay higher tariffs to cover for the shortfall in revenues of domestic and agricultural consumers. These shortfalls are partially due to the need to recover high losses (on average 20%, and up to 40% in some states).

On the retail side, consumers pay tariffs defined by the State Electricity Regulatory Commissions. The tariffs are defined per voltage level and are based on the cost of the supply of electricity. For consumers with suitable meters, a Time-of-Use (ToU) is in place. Nevertheless, the deployment of smart meters is still limited.

[5] The information used in the section was largely obtained from the India 2020 Energy Policy Report from the IEA. In the absence of references in this section 3.1, (IEA 2020) is the source of the information. Otherwise, the respective reference is provided.

3.2. The Electricity Sector in the EU

3.2.1. EU energy regulation

The EU is currently composed of 27 MSs, each one of them with its own national regulatory frameworks and policies on energy and electricity specifically. Nevertheless, an EU supranational set of regulations also exist in order to harmonise topics relevant for the development of the common objective of the Union. Among those objectives is the creation of a common market to eliminate trade barriers between MSs, which dates back to the founding Treaty of Rome in 1957 (Meeus and Reif 2020). Building on top of this foundation stone, energy, too, should be part of the single internal market, as stated by the European Council in 1986: "'greater integration, free from barriers to trade, of the internal energy market with a view to improving the security of supply, reducing costs and improving economic competitiveness". Therefore, building a single European electricity market was and still is one of the cornerstones of energy policies in Europe. More recently, another EU goal started to steer the regulation of the power sector in the EU, namely the need for decarbonisation in the continent. This need translated into different measures such as the creation of the EU Emissions Trading System in 2005, and specific energy-related targets, such as the initial "20-20-20 target" from 2007: by 2020, three targets should be met in the EU, namely (i) reducing greenhouse gas emissions in the EU by at least 20% below 1990 levels; (ii) increasing the share of energy consumption from renewable sources to 20%; and (iii) improving energy efficiency in order to reduce the use of primary energy by 20% compared to forecast levels (Amanatidis 2020).

These targets, such as building an internal electricity market and decarbonising the power sector, are political guidelines for the Union, and as such, are defined in treaties and political declarations, the most recent being the EU Green Deal, which updates the decarbonisation targets and aims at achieving a 55% reduction of EU's greenhouse gas emissions by 2030. The implementation of these targets, however, is defined in additional EU legislative packages. In the energy sector, the "EU energy packages" are known for defining, more specifically, the rules that should apply to all EU MSs.

The first EU energy legislative package was introduced in 1996, coinciding with the liberalisation processes taking place in most EU countries. The so-called "First Energy Package" established the foundations for the internal electricity market. The subsequent Second and Third Packages further reinforced the rules for the internal electricity markets, legislating on matters such as cross-border exchanges, creation of pan-European sectorial institutions such as the European Network of Transmission System Operators for Electricity (ENTSO-e) and the European Union Agency for the Cooperation of Energy Regulators (ACER), besides defining key principles in the EU power sector such as the need for unbundling between activities. Finally, in 2019 the Fourth and latest energy package was published, known in the sector as the Clean Energy Package for all European (or simple Clean Energy Package [CEP]). The latter, besides reinforcing rules for the functioning of the internal electricity market, also legislates in topics with aims to decarbonise the electricity sector and to empower consumers. These topics are discussed in detail in the next chapter, with a focus on those with implications for the development and eventual exploitation of the IElectrix solutions.

Figure 3 illustrates the evolution of the four energy packages in the EU. It is worth mentioning that these packages are composed of different legal acts, often several of them in a single legislative package. These legal acts are either completely new or amendments to previous acts (recasts). It is also worth noticing that the most relevant legal acts come in two forms, namely Directives and Regulation. The latter is a binding legislative act, and it must be applied in all EU MSs without the need to be transposed into national law. The former is an act that sets out goals that have to be achieved in all EU countries. However, it is up to each individual MSs to transpose these goals to national legislation together with the definition on how to achieve such goals (EU 2016).

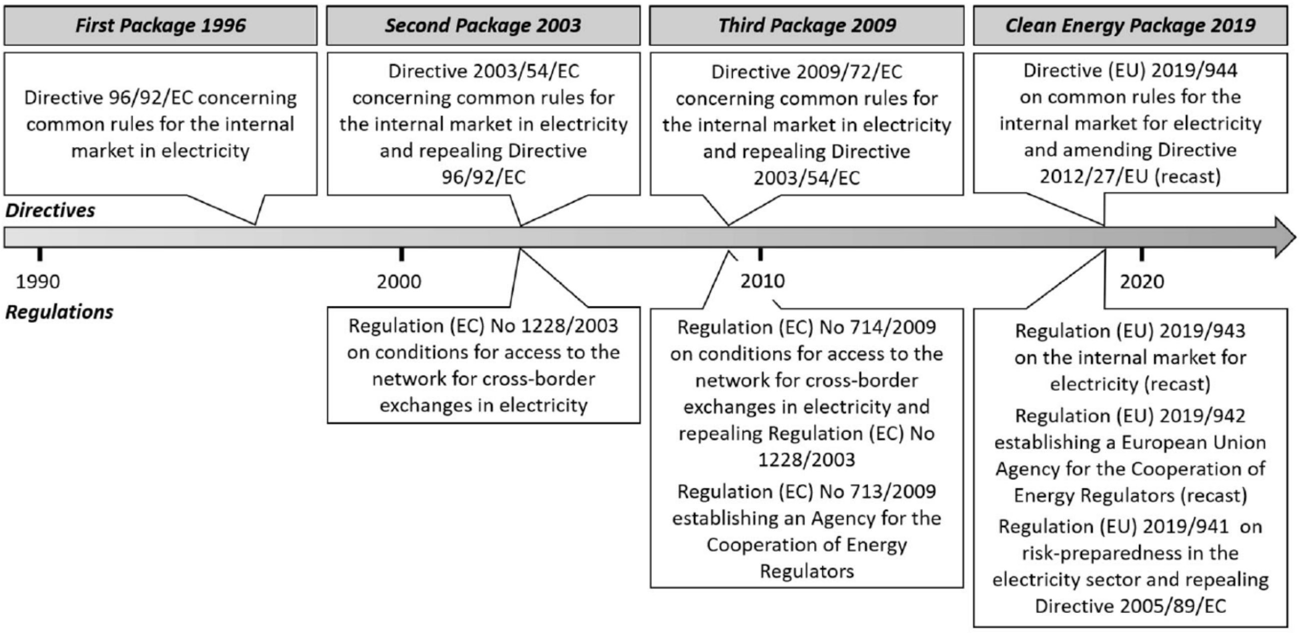

Figure 3: The main steps in the evolution of European electricity markets. Source: (Meeus and Reif 2020)

Below the political declarations and the energy packages, an even more detailed set of rules may exist, namely the Network Codes and Guidelines (or simple "network codes"). In their first generation, the network codes were published between 2015 and 2017 and were divided into three groups:

(i) Markets codes: rules and guidelines on capacity allocation, congestion management and balancing markets
(ii) Connection network codes: rules on grid connection for generators, demand and high-voltage direct current connections
(iii) Operation codes: rules on transmission system operation and electricity emergency and restoration

3.2.2. European power system organisation and markets

In a nutshell, the power systems in Europe are characterised by a liberalised wholesale market, as well as a liberalised retail market. The transmission and distribution companies (TSOs and DSOs, respectively) are regulated activities and are required to fulfil unbundling requirements if they are part of a company group that also operates in generation or retailing[6]. The system operation is performed by the TSO who, in addition to planning and operating the transmission network, is generally responsible for operating ancillary service and controlling cross-border power flows.

Following the implementations of previous energy packages in the EU, it is safe to say that wholesale electricity markets are mostly harmonised among MSs, and some of them are well integrated across the Union. In the long term, several forward markets exist, taking place from years to weeks ahead of delivery. On the day preceding the energy delivery (also referred to as D-1) , a spot market takes place. The wholesale markets are organised by the Nominated Electricity Market Operators. In Europe, several biding zones were defined, within which the price is expected to be the same. Considering that the day-ahead market does not fully consider the network, redispatch markets are necessary after the day-ahead wholesale markets. Close to delivery, balancing markets are used to

[6] Exceptions exist, such as for small DSOs (less than 100.000 clients).

ensure the security of supply by continuous balancing of power demand and supply. At any point in time, the production of electricity must be equal to consumption in order to maintain frequency stability, the reason why balancing products are also defined as frequency control products (van der Veen and Hakvoort 2016). Figure 3 shows a general overview of the energy market sequence in the EU.

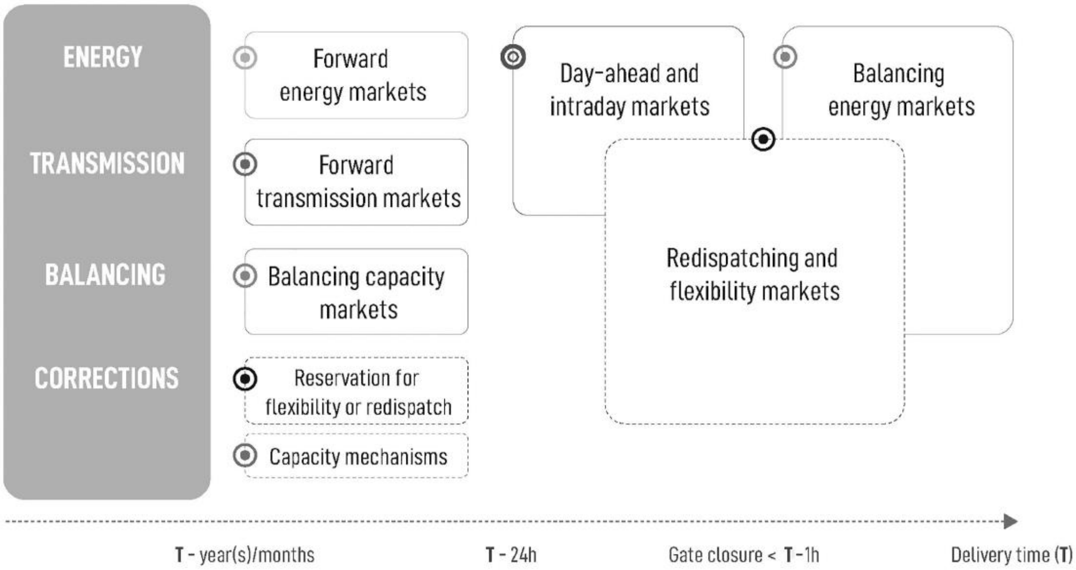

Figure 4: Sequence of Electricity Markets in Europe. Source: (Meeus 2020)

Box 1: Comparison between DISCOMs in India and DSOs in the EU

DISCOMs in India and DSOs in Europe are both in charge of planning, operating and maintaining the distribution grid. However, important differences exist between the two. In India, DISCOMs are also responsible for retail activities. They buy electricity through long-term PPAs and sell it to end-users. The high level of non-payments from the retail activity and the high level of losses at the distribution activity has led DISCOMs to significant financial stress in recent years (IEA 2020). In order to improve the financial health of DISCOMs, the central government has elaborated a restructuring plan for the DISCOMs' debts and mandated the installation of smart meters, separation of agriculture and power generation feeders, and metering of transformers, aiming at cutting down losses to an average of 15% (IEA 2020). The unbundling of retail and distribution is expected, as proposed by the Electricity (Amendment) Act 2018, however not completed yet (IEA 2020).

The DSOs in Europe are, in general, legally and functionally unbundled from retail activities. The MSs may decide if this requirement is applicable to DSOs serving less than 100,000 customers. The high-level tasks and guiding principles for DSOs in the EU are set in the European legislation. However, the DSO landscape in Europe is very diverse. Some countries have only one DSO, like Greece, for example, while others have hundreds of DSOs, such as Germany (approximately 880) (CEER 2021). Countries with a large number of DSOs are usually characterised by a reduced number of DSOs supplying the majority of the energy demand and a large number of small DSOs supplying a minor share of the total demand. Moreover, it is not uncommon to observe a two-level DSO in Europe. In Germany, for example, many DSOs are not connected to the transmission grid but to the upper voltage level grids of other DSOs (REF-E, Mercados, and Indra 2015). In Sweden, the distribution grid is divided by Regional

DSOs and Local DSOs (Wallnerström et al. 2016). As discussed in the following sections of the deliverable, DSO roles in Europe are changing as new EU regulation is adopted. In the near future, DSOs are expected to move from reactive grid planners and operators to active system managers. That means that DSOs will have new roles to perform, such as the procurement of local ancillary services aiming at deferring network investments.

4. The Clean Energy Package for All Europeans and the IELECTRIX project

The CEP, published in the Official Journal of the EU between June 2018 and June 2019, is the most recent and significant piece of European regulation concerning the energy sector. Together with the adoption of the Network Codes and Guidelines, these two packages are expected to have an important influence on the national regulations, contributing towards the achievement of key European goals, such as the single electricity market and the decarbonisation targets assumed by the EU. The importance of these goals, as well as specific targets, have been recently reinforced and extended by the publication of the European Green Deal, a political initiative that sets even more ambitious targets for decarbonisation in the continent, moving from 40% to 55% the cuts in greenhouse emissions by 2030 (European Commission 2019). Fostering renewable distributed energy resources, storage systems and increasing the efficiency of the networks, as fostered by the CEP and currently being tested in the IElectrix project, are an integral part of the set of strategies necessary to reach the European energy vision.

Therefore, this section presents an assessment of the regulatory topics included in the CEP that are relevant for the deployment of IElectrix HLUCs. The objective of this assessment is twofold. Firstly, it aims at identifying the relevant topics regarding the solutions proposed in the project. Secondly, it is important to understand how clear or specific the CEP is in each of the regulatory topics. For some topics, the CEP is precise in its orientations and clearly states the measures MSs should adopt. For others, the general directions are provided, but the implementation is not completely defined. This can happen either because the CEP does not advocate for one single solution or because the topic is still not fully mature or depends on the country context.

4.1. CEP Mapping – Relevant documents and topics

The CEP is a major European regulatory package on energy that will guide energy regulation in Europe for the following decades. In legal terms, this package is distributed across nine different legal acts. Most of these documents are amendments or recasts from previous legal acts already introduced by previous important regulatory packages (e.g. the Third Package). As shown in **Erreur ! Source du renvoi introuvable.**, the most relevant documents in the context of the IElectrix project are the Electricity Directive, the Electricity Regulation, and the Renewable Energy Directive.

Legal Act	Official Journal Publication	Relevance in the context of IElectrix
Energy Performance in Buildings Directive	Directive (EU) 2018/844	Very low
Renewable Energy Directive (RES-Directive)	Directive (EU) 2018/2001	High
Energy Efficiency Directive	Directive (EU) 2018/2002	Low
Governance of the Energy Union Regulation	Regulation (EU) 2018/1999	Low
Electricity Regulation (E-Regulation)	Regulation (EU) 2019/943	High
Electricity Directive (E-Directive)	Directive (EU) 2019/944	High
Risk Preparedness Regulation	Regulation (EU) 2019/941	Very low
ACER Regulation	Regulation (EU) 2019/942	Very low

Table 4: CEP legal acts and their relevance in the context of IElectrix

After an analysis of the above-mentioned legal acts, several topics were identified as being critical for the solutions proposed in the IElectrix project. These topics can be divided according to the main actor they are addressed to. On one hand, the consumer is at the centre of the CEP, as well as initiatives promoted by consumers – e.g. self-consumption, self-generation, renewable self-generation, and energy communities. On the other hand, the regulation concerning DSOs is also addressed in the CEP. Among those, topics such as the use of local flexibility by DSOs, storage operation and ownership are particularly important for the deployment of IElectrix solutions.

Erreur ! Source du renvoi introuvable. summarises the main relevant topics covered by the CEP that are relevant for the IElectrix project, as well as a reference of the most important legal acts for each topic. The remainder of this subsection will discuss each of the regulatory topics, the main ideas brought by the CEP, and how they impact each BUC.

<table>
<tr><th>Actor</th><th>Topic</th><th>Sub-Topic</th><th>Main Legal Act(s)</th></tr>
<tr><td rowspan="4">DSOs</td><td rowspan="2">Core activities of DSOs</td><td>Network Expansion Planning</td><td>Electricity Directive</td></tr>
<tr><td>Network Operation: Use of Flexibility</td><td>Electricity Directive</td></tr>
<tr><td rowspan="2">New Roles of DSOs</td><td>Storage facilities ownership</td><td>Electricity Directive</td></tr>
<tr><td>Smart-meter deployment</td><td>Electricity Directive</td></tr>
<tr><td rowspan="3">Consumer / Flexibility Providers</td><td rowspan="2">Consumers</td><td>Self-consumption
(Active consumer consuming self-generated electricity)</td><td>Electricity Directive,
Renewables Directive</td></tr>
<tr><td>Energy/Flexibility provision
(Active consumer injecting electricity upstream the meter)</td><td>Electricity Directive,
Renewables Directive</td></tr>
<tr><td>New agents</td><td>Energy Communities</td><td>Electricity Directive [CEC], Renewables Directive [REC]</td></tr>
</table>

Table 5: Relevant topics addressed in the CEP for the IElectrix project

4.2. DSO regulation

■ Core Activities for DSOs

The CEP brings several definitions for DSOs that are relevant for the IElectrix project. One of the topics discussed in detail by the CEP is network planning by DSOs. Article 32 of the E-Directive establishes that DSOs should produce development plans that go through public consultation, are approved by NRAs and are made public. The objective of the network expansion plans is twofold. Firstly, that potential flexibility providers should have access to network information, so they can install DERs where it will be most needed. Secondly, DSOs should actively consider potential investment deferrals at the network expansion planning.

Several are the provisions for DSOs to not only be able to procure and use local flexibility but also to be incentivised to do so. The traditional incentive regulation in the EU, characterised by the "RPI-X" approach[7], provides a clear incentive for OPEX reduction while usually incentivising the increment in CAPEX, as this component is the remunerated one by the weighted average cost of capital (WACC). This setting, as it is, provides little incentive for the use of local flexibility. Acknowledging this fact, the CEP states that "Member States shall provide the necessary regulatory framework to allow and provide incentives to distribution system operators to procure flexibility services, including congestion management in their areas, in order to improve efficiencies in the operation and development of the distribution system."[8] Moreover, "distribution system operators shall be adequately remunerated for the procurement of such services to allow them to recover at least their reasonable corresponding costs".

The E-Directive highlights that this procurement should allow for DER participation and that it should be done "with transparent, non-discriminatory and market-based procedures unless the regulatory authorities have established that the procurement of such services is not economically efficient or that such procurement would lead to severe market distortions or to higher congestion.". Therefore, it is important to note that the CEP does not provide clear incentive mechanism options, but rather that the need for incentives to be defined by the MSs. The second important conclusion is that the procurement of local flexibility should be done only when and where it proves to be more efficient than the business-as-usual operation.

New roles for DSOs

The CEP also defines conditions for the new roles of DSOs. Three main definitions can be highlighted, namely regarding the ownership and operation of electric vehicle (EV) charging stations, the ownership and operation of storage facilities and data management responsibilities. In the context of the IElectrix project, the definitions of the ownership and operation of storage facilities are the most relevant ones, and therefore the ones analysed in this section.

The energy storage systems should not, in principle, be owned or operated by DSOs. The Recital 62 of the E-Directive argues that energy storage services should be market-based and competitive, and for that reason, DSOs should not operate these assets. However, exceptions exist, as defined in Article 36 of the E-Directive. Regulators can authorise DSOs to own/operate storage systems "where they are fully integrated network components", or when public tenders are not successful in attracting investments and storage systems are necessary. By "fully integrated network components", the CEP "means network components that are integrated in the transmission or distribution system, including storage facilities, and that are used for the sole purpose of ensuring a secure and reliable operation of the transmission or distribution system, and not for balancing or congestion management" (E-Directive, Article 2(51)).

The private investment in storage systems should prevail according to the CEP. Nevertheless, when there is no interest by investors, DSOs could own and operate such storage facilities. In this case, a periodic revision of market and interest conditions would be performed at regular intervals of at least every five years. Once the assessment shows that the external investment interest exists, DSOs should phase out the specific storage activity within 18 months and being able to receive compensation in order to recover the residual value of the investment.

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[7] The RPI-X approach is the most common for of incentive regulation. Under this scheme, the maximum revenue or price that a company can charge is set for a longer period known as "regulatory period" (e.g. from 3 to 6 years). For every year in the regulatory period, the revenue/price is updated according to Retail Price Index (RPI) minus a factor X. Therefore, the company has an incentive to reduce costs below the X factor defined by regulation (Pérez-Arriaga 2014).

[8] Electricity Directive, Article 32

It is important to say that "regulatory authority may draw up guidelines or procurement clauses to help distribution system operators ensure a fair tendering procedure" (Article 36(2)). Such guidelines are important so that DSOs can promote the investment in storage systems and also to properly evaluate when such interest does not exist and when they could install storage systems.

- Consumer / Flexibility Providers

The CEP is designed as a consumer-centric package, as Article 3 of the E-Directive calls for competitive, consumer-centred, flexible and non-discriminatory electricity markets. Therefore, several are the provisions with regards to new roles and opportunities for consumers and related stakeholders. It is important to notice that the concept of consumer includes not only the final consumer, who purchases electricity for own use but also the "active consumer", which is

> *"a final customer, or a group of jointly acting final customers, who consumes or stores electricity generated within its premises located within confined boundaries or, where permitted by a MS, within other premises, or who sells self-generated electricity or participates in flexibility or energy efficiency schemes, provided that those activities do not constitute its primary commercial or professional activity" (E-Directive, Article 2, Item 8).*

In the context of IElectrix, the active consumer is a Distributed Generation (DG) owner or a DR provider, or a storage system owner/operator, or simply referred to as DER.

We divide the consumer-related topics into two groups. Firstly, we analyse the topics directly related to consumers and DER. These topics include self-consumption, flexibility provision, smart metering, data access and dynamic pricing. Secondly, we look at definitions for the aggregator, with special attention to the independent aggregator, a new agent that will act as an enabler for flexibility provision, as well as how balancing market rules may be adapted.

- Self-consumption: Active consumer using electricity behind the meter

An important distinction must be made between the concepts of self-generation and self-consumption. Self-generation is understood as the generation made by a DG owner for the purpose of self-consumption or for selling as flexibility. Therefore, self-consumption can be defined as the part of self-consumption dedicated to internal consumption behind the meter.

The CEP addresses mainly self-generation as a whole. Nevertheless, it also recognises the importance of self-consumption, and acknowledges that "legal and commercial barriers exist, including, for example, disproportionate fees for internally consumed electricity, obligations to feed self-generated electricity to the energy system", and that "*such obstacles, which prevent consumers from self-generating electricity and from consuming, storing or selling self-generated electricity to the market, should be removed while it should be ensured that such consumers contribute adequately to system costs*" (E-Directive, Recital 42). In this context, the E-Directive, in its Article 49(1z), states that it is a duty of regulators to "*monitoring the removal of unjustified obstacles to and restrictions on the development of consumption of self-generated electricity*". With regard to network tariffs for self-consumption, the E-Regulation, in Article 18(2), states that "network charges shall not discriminate either positively or negatively against energy storage or aggregation and shall not create disincentives for self-generation, self-consumption or for participation in demand response."

Finally, one last aspect about self-consumption should be mentioned. The CEP makes a distinction between the "self-consumption" and the "renewables self-consumption", established in the RES-Directive. For the latter, in addition to the general objectives set by the CEP in terms of fostering DER, one aspect should be taken into account. The RES-Directive also defines the concept of the "jointly acting renewables self-consumers", meaning consumers of the same residential building that jointly own/operate DG. For these consumers, the RES-Directive states that "*MSs should* *therefore generally not apply charges to electricity produced and consumed within the same premises by renewables self-consumers*". However, exceptions exist. In case the renewable self-consumers benefit from support schemes, charges over self-consumption could be charged under a series of conditions.

- Energy/Flexibility provision: Active consumer injecting electricity upstream the meter

Enabling self-generators and demand response to participate in energy markets is at the centre of the CEP. The Recital 49 of the E-Directive clearly states that "all customer groups (industrial, commercial and households) should have access to the electricity markets to trade their flexibility and self-generated electricity." Moreover, it concludes by saying that "products should be defined on all electricity markets, including ancillary services and capacity markets, so as to encourage the participation of demand response". Therefore, fostering self-generation and demand response, or in other words, fostering DER flexibility provision, is at the core of the CEP.

Article 15 of the E-Directive lists a series of rights and requirements for DERs. On the rights side, DER should be able to participate in energy markets, directly or through aggregation, benefit from flexibility or energy efficiency schemes, and delegate their energy management. As requirements, they should be subject to cost-reflective, transparent and non-discriminatory network charges and should be financially responsible for their imbalances. The same article also states that DERs should not be "subject to disproportionate or discriminatory technical requirements, administrative requirements, procedures and charges, and to network charges that are not cost-reflective".

Although the CEP aims at securing important rights for DER, at least one regulatory challenge can be identified when it is stated that DER should be "*financially responsible for the imbalances they cause in the electricity system; to that extent they shall be balance responsible parties or shall delegate their balancing responsibility*". It is not clear, however, how self-generator or demand response can be responsible for imbalances, as most of the DER units do not have individual scheduling. This problem, also known in the literature as the baseline problem, is not clearly addressed by the CEP.

One topic on self-generation, conversely, is clearly defined by the CEP, namely the phase-out of net-metering schemes. After 2024, no schemes that do not account separately for the electricity fed into the grid and the electricity consumed from the grid should be granted, and a consumer under net-metering should be able to change the scheme. This is an important definition that affects IElectrix target countries, as discussed in the following sections.

- Energy Communities

The concept of energy communities is explored extensively in the CEP. Energy communities are defined in two forms, namely as Citizen Energy Communities and as Renewable Energy Communities. The CEC is defined and regulated on the E-Directive, while the REC in the Renewables Directive.

Article 2(11) of the e-Directive defines the CEC as a legal entity defined by three characteristics:

(i) Based one voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises;
(ii) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and
(iii) 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.

Furthermore, the CEP also clarifies objectives and possibilities for energy communities in recitals 43 to 47 of the e-Directive. It is worth mentioning that the decision making of CECs should not involve the participation of member/shareholders involved in the large-scale commercial activity, neither for members that develop their main economic activity in the energy sector (recital 44). Additionally, recital 47 clarifies that MSs could allow CECs to become DSOs, either a regular DSO or a "closed distribution system operator".

Article 16 of the E-Directive provides the remaining guidelines for the regulation of CECs. Firstly, article 16(1) mandates MSs to establish an enabling regulatory framework for CECs. Among the requirements are the open and voluntary character of the CEC, the possibility for member or shareholders of the CEC to leave it, the fact that members of the CEC do not lose their rights or obligations as consumers (households or active consumers) and that CECs should be subject to transparent and non-discriminatory procedures. Nevertheless, the same article also states network charges should be cost-reflective, ensuring that CECs "contribute in an adequate and balanced way to the overall cost-sharing of the system". Also, "subject to fair compensation as assessed by the regulatory authority, relevant DSOs cooperate with citizen energy communities to facilitate electricity transfers within citizen energy communities".

Furthermore, article 16(3) also defines what CECs should be able to perform, including the access to all electricity markets and the possibility of sharing the production of units within the CEC. With regards to consumption and self-generation, CECs are treated like active customers and should be financially responsible for imbalances.

The concept of the REC appears in the RES-Directive, and it is defined in Article 2(16). With respect to the CEC, the definition of the REC differs as the latter should be "effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity". Therefore, the REC can generally be seen as a specific type of CEC (Roberts, Frieden, and d'Herbemont 2019). The REC is, in essence, a CEC with stricter participation rules, governance and geographic limitation, and a broader rule for effective control, as illustrated in Figure 5.

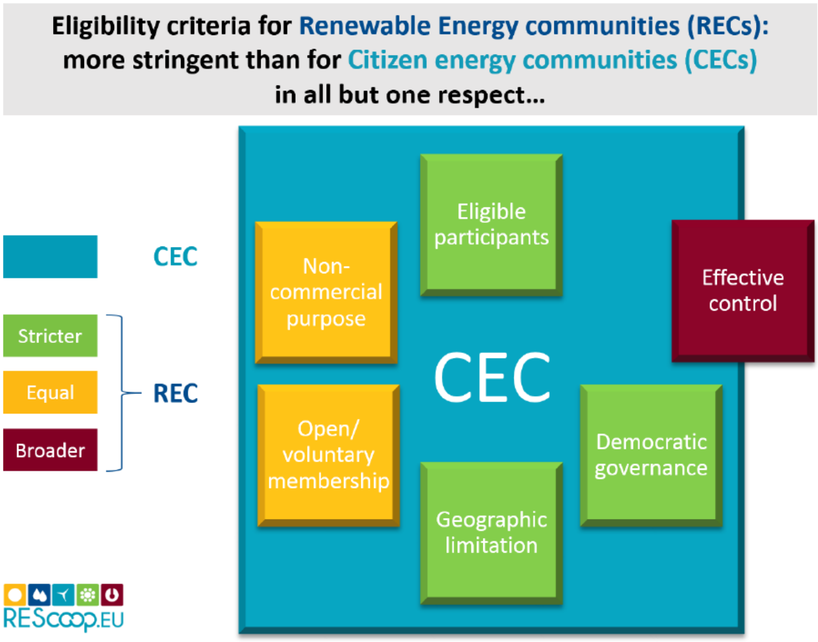


Figure 5: Comparing eligibility criteria of RECs and CECs. Source: (Roberts et al. 2019)

According to the Article 22 of the RES-Directive, RECs should be able to produce, consume, store and sell renewable energy, including through PPAs. As with CECs, MSs should also design a framework that enables the development of REC, with the difference that this framework should be reported in the progress of the national energy and climate plans. Moreover, not only RECs should be able to access eventual support schemes, but they should also be taken into account by MSs when designing them.

Actor	Sub-Topic	What does the CEP say?	How clear is its implementation?
DSO	Network Planning	- DSOs should produce development plans that go through public consultation, are approved by NRAs and are made public, so grid users have the necessary information to decide on new grid connections. - DSOs should demonstrate the expected usage of flexibility and the respective deferred investment. - DSOs should have the proper economic incentives to procure flexibility.	Partially clear: The CEP is precise on the requirements for planning consultation and publication. However, it doesn't provide important details on how the NRA evaluates and approves the development plan and how binding these plans are.
	Network Operation: Use of Flexibility	- DSOs should have the means to procure flexibility (incentives and cost recovery) - DSOs should design non-discriminatory, transparent, and market-based mechanisms for flexibility procurement. The flexibility products ought to be standardised at the national level.	Unclear: The CEP does not clarify which could be the market-based mechanisms could be used or how flexibility products could be standardised. These definitions are left to MSs.
	Storage facilities	- DSOs should not be allowed to own and operate storage systems (with exceptions)	Clear: The CEP is clear in its general approach, but the exceptions could lead to different interpretations.
Consumer/ Flexibility Providers	Self-consumption (Active consumer using electricity behind the meter)	- Active consumers should be able to store and consume self-generated electricity without barriers. - Nevertheless, charges can be applicable in the case of renewable self-consumption that benefits from support schemes.	Clear: Active consumers should be able to store and consume self-generated electricity without disproportionate fees and should not be obliged to feed self-generated electricity to the grid
	Energy/Flexibility provision (Active consumer injecting electricity upstream the meter)	- Active consumers, demand response, and aggregated active consumers should be able to participate in all electricity markets, including ancillary services and capacity markets.	Partially clear: It is unclear how to adapt products and services in order to enable the integration of active consumers. Although the CEP is unclear in some aspects, some answers may come

			from the Network Codes. E.g., balancing capacity should be procured separately (upward and downward). This enables demand response participation.
	Energy Communities	- Both CECs and RECs are to be allowed and fostered by MSs. - An enabling framework has to be designed and implemented by MSs for both CECs and RECs. Mandatory principles and further possibilities are defined in the CEP. - MSs can allow CECs to become DSOs.	Partially clear: Key definitions are provided, but given the complexity of the topic, much is left to MSs.

Table 6: CEP assessment

5. Assessment of regulatory conditions in the target countries

In this chapter, an analysis is made of the existing regulation in the target countries defined in the IElectrix Description of Action (DoA), namely the four demo countries (Germany, Austria, Hungary and India) and the three replication countries (France, Greece, Sweden). The objective of this analysis is to provide an overview of how relevant regulatory topics are treated by national regulatory frameworks in the different target countries. The description, analysis and comparison are made on a high level, trying to identify key features in regulation that could be enablers or barriers for the IElectrix solutions. Following the overview presented in this chapter, specific barriers are identified and discussed in the next Chapter 6.

5.1. Organization of the regulatory assessment

The overview and comparison between countries are organized by the main stakeholder being targeted by the regulatory topics being discussed. Therefore, considering the regulatory topics identified in Chapter 2, three main stakeholders are identified, namely the DSO, the end-user, and the self-producer and/or energy community.

The following analysis is a qualitative one. Quantitative aspects fall out of the scope of this IElectrix deliverable D4.4.

5.2. DSOs

5.2.1. DSO Economic Regulation

Power distribution is a regulated network monopoly within a given geographical area. Therefore, the revenues of DSOs are determined or supervised by NRAs and policymakers. The economic regulation of electricity distribution companies defines how the allowed levels (i.e. those passed through to the network tariffs) of network investments, other CAPEX, and OPEX are determined and recovered by DSOs. In addition to revenue regulation, distribution regulation has increasingly included additional incentive mechanisms related to the performance of DSOs in areas such as energy losses or quality of service.

From the perspective of the IElectrix project, several components of the economic regulation framework could have an impact on the incentives for DSOs to implement the solutions proposed in the project. Firstly, the type of economic regulation must be considered. International experience has shown that incentive regulation (typically characterized by the "RPI-X" approach) provides stronger incentives for DSOs to improve the efficiency in the management of the network. Secondly, the way the incentive regulation is set also matters. Incentive regulation is traditionally set either over the OPEX alone (letting the CAPEX be a pass-through component) or over the total expenditure (TOTEX). Historically, the former setting was firstly adopted, providing the signal to DSOs to build a strong network (investments were incentivised, as they are the ones actually remunerated) and providing an incentive to reduce inefficiencies in the management of the companies. However, in the perspective of high penetration of DERs and the possibility of such resources providing flexibility as a means to avoid reinforcement, this CAPEX-biased type of regulation ends up providing an incentive in the opposite direction. Considering that the main objectives for the use of BESSs and promotion of LECs are to increase the resilience of the grid and possibly avoid reinforcements, a TOTEX oriented incentive regulation could provide the best incentive. Even in the case that a BESS is owned by the DSO, the CAPEX of this investment should be lower than the reinforcements of the lines necessary to achieve the same objectives as BESSs would (e.g. solve voltage problems, increase hosting capacity). On top of that, DSOs would also benefit from lower maintenance costs and extended lifetime of assets.

In addition to the CAPEX/OPEX treatment, economic regulation may also include additional components to the DSO's revenue formula in order to provide target-specific incentives. A widely used example is the incentive to reduce losses. This can be done by including a bonus (or penalty) to the remuneration by obliging the DSO to buy their own losses. Additional, quality of supply can be incentivised, also by providing bonus/penalties based on pre-established indicators (e.g. System Average Interruption Frequency Index [SAIFI], System Average Interruption Duration Index [SAIDI]). These two incentives would also provide a signal in line with the solutions proposed in IElectrix.

Finally, it is also important to consider if DSOs have to submit network expansion plans, if they are made public and if they influence the remuneration of DSOs. The network expansion plans can serve potential local flexibility providers by informing them where flexibility is most needed. It can also serve DSOs and regulators by identifying reinforcements that could be deferred by the use of local flexibility. Moreover, their expansion plans can offer an intermediate step in the overall incentive regulation scheme by having a CAPEX-oriented regulation in which allowed CAPEX is based on the investment plans that include the use of flexibility.

AUSTRIA: In Austria, a price cap incentive regulation is in place. Currently in the 4th regulatory period (five-year periods), Austria treats OPEX and CAPEX separately, with efficiency targets (X-factor) applied to the former. However, before every regulatory period, in order to establish the efficiency factor, a TOTEX benchmarking is carried out. Regarding the incentives to reduce losses, the Austrian DSOs have to buy their losses in markets or through PPAs. This means that the losses will be part of the TOTEX, to which the efficiency targets will be calculated. On the continuity of supply, Austria does not have a financial incentive, but minimum standards are mandated by law. DSOs do not submit investment plans.

GERMANY: Among the IElectrix countries, Germany is known for a large number of DSOs, approximately 880. The DSOs are submitted to an incentive regulation scheme with a revenue cap. Germany is currently in its 3rd regulatory period after moving from a cost-plus regulation to the incentive regulation in 2009, and each regulatory period lasts for five years. For the first two regulatory periods, Germany adopted a TOTEX revenue cap approach with a yearly efficiency X-factor. However, for the 3rd regulatory period, starting in 2019, a reform of the incentive regulation was made. Now, efficiency targets are applied only to “generally controllable costs”, while CAPEX can be considered a pass-through component. In order to adjust the revenue cap before the start of a new regulatory period, benchmarking techniques are used. Also, for a very efficient DSO, a bonus can be introduced, being distributed equally over the regulatory period. Also, a bonus/malus for quality of supply exists.

DSOs have to report their investment plans to the NRA on-demand only. The NRA will approve these plans based on the relation between planned costs and (i) age of assets, (ii) annual depreciation, and (iii) quality of supply.

FRANCE: In France, a hybrid regulatory scheme applies. On the one hand, CAPEX related to the network infrastructure is treated under a cost-of-service scheme, while other types of CAPEX and OPEX is treated under an incentive regulation scheme. For the network CAPEX, a bonus-malus incentive based on the unit cost is applied. However, a new mechanism to balance local flexibility OPEX cost with CAPEX savings is already in place, although not used yet. On energy losses, a bonus-malus incentive exists, and in addition, DSOs have to buy their losses. With regards to continuity of supply, both SAIDI and SAIFI are subject to bonus-malus incentives financial incentives. Currently, no investment plans are required.

GREECE: The regulatory framework in Greece is currently set as a cost-of-service scheme, but a new incentive regulation with a 4-year regulatory period will start (2021 to 2024). Within the new regulation, CAPEX and OPEX are regulated separately. According to the recent law (NRA’s decision) on the methodology of DSO’s revenue calculation, there are also separate incentive mechanisms in order to increase the efficiency of controlled OPEX and perform projects of major importance. A premium WACC is provided for these projects of major importance, including those that contribute to the facilitation of an increase in DER penetration and smart grid implementation. With regards to energy losses, no incentive is planned for the first regulatory period. However, a bonus-malus incentive is expected at the second regulatory period (starting in 2025). Similarly, there will be no incentives for continuity of supply in the first regulatory period. It is not defined yet if they will be implemented in the second regulatory period. Investment plans are required and approved by the Greek NRA.

HUNGARY: In Hungary, incentive regulation and a 4-year regulatory period are in place. The CAPEX and OPEX are treated separately, the latter being subject to an RPI-X correction during the regulatory period. The energy losses are subject to a penalty only incentive, while the continuity of supply is subject to a bonus-malus incentive. Three indicators are monitored on a 3-year moving average, namely unplanned SAIFI, SAIDI, and energy not supplied. There is no obligation to submit investment plans in Hungary.

SWEDEN: The Swedish economic regulation for DSOs is set as an incentive regulation with a revenue cap in a 4-year regulatory period. The CAPEX and OPEX are calculated separately. OPEX is based on the company's own historical cost and with an efficiency target. Efficiency targets are based on national benchmarking, using Data Envelopment Analysis simulations. On the CAPEX side, the calculation is based on the standard cost for all assets, and this gives incentives to invest at a lower cost than the standard cost. In Sweden, the DSOs are responsible for buying the losses, and a symmetric bonus-malus for continuity of supply indexes exists (SAIDI, SAIFI and LV energy not served, both planned and unplanned). Investment plans are submitted by the DSO as a prognosis only.

INDIA: In India, a cost-of-service regulation is in place for DISCOMs. This regulation, however, is determined by the State Electricity Regulatory Commissions (SERC) and therefore is not nationally harmonized. The OPEX is controlled by the SERC ex-post, while CAPEX has to be approved beforehand by means of the submission of investment plans to the regulator. The investment plans are evaluated and, if approved, are referenced to a standard unit-cost regulatory reference. If the tendering process leads to a higher cost than suggested by the regulatory reference, additional approval is necessary. The losses are part of the energy purchased by the DISCOM – which also performs the retailing activity. Therefore, a financial incentive exists for the reduction of both commercial and technical losses. Quality of supply in India is still an issue, and, as mentioned above, the regulation varies from state to state. In general, continuity of supply indexes are measured, but no specific financial incentives exist. In case of shortages, DISCOMs have to comply with pre-established reconnection times. Failing to comply with those could result in compensations to customers. In extreme cases of poor continuity of supply, the regulatory authorities could revoke the DICOM's license.

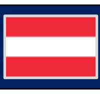
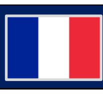
Regulatory Aspects							
Type of regulatory regime	Incentive Regulation	Incentive regulation	Hybrid: network CAPEX under cost of service, rest on incentive regulation	Transitioning from cost-of-service to incentive regulation	Incentive regulation	Incentive regulation	Cost-of-service
Treatment of CAPEX/OPEX	Separately	TOTEX	Separately	Separately	Separately	Separately	CAPEX subject to previous approval
Incentives for Energy losses	DSOs have to buy losses	Bonus-malus	Bonus-malus	None so far. Expected in the second regulatory period	Penalty only	DSOs have to buy losses	DSOs have to buy losses
Incentives for continuity of supply	Bonus-malus	Bonus-malus	Bonus-malus	None so far	Bonus-malus	Bonus-malus	No specific financial incentive. Penalty may apply.
Submission of investment plans	Not required	Required on demand by the NRA	Not required	Required and approved by the NRA	Not required	Submitted only as an estimation	Required and approved by the NRA

Table 7: Key characteristics of DSO economic regulation in the target countries

5.2.2. New roles of DSOs

The distribution side of power systems is going through significant changes due to the deployment of smart meters and grids on the one hand and the adoption of different DER technologies, including intermittent RESs, on the other hand. This change is being characterised by the three 'Ds', namely decarbonisation, digitalisation, and decentralisation (Silvestre 2018). In this context, new roles will have to be performed by new or incumbent agents. The DSOs, too, will have to assume new roles. Considering the analysis of the CEP presented in chapter 4, the main new roles for DSOs can be listed as (i) the roles on metering data management, (ii) the ownership and operation of EV charging stations and (iii) the ownership and operation of storage systems and (iv) the procurement of services by DSOs from DER. In the context of the IElectrix project, we focus on the last two.

As described in chapter 4, the CEP indicates that storage systems should only be owned by DSOs under certain conditions. The limitation over DSOs owning and/or operating storage systems is due to the fact that BESSs may be used in flexibility provision under competitive schemes. In a public consultation, the Council of European Energy Regulators (CEER 2014) describes a framework for the allocation of new activities to DSOs. It states that new activities that are could be open for competition, but that are special justifications for the DSO to carry the activity, could be allowed for the DSO under certain conditions, as illustrated in situation "III", in Figure 6. This seems to be the case for storage ownership and operation by DSOs, which are limited by the CEP to a limited number of scenarios.

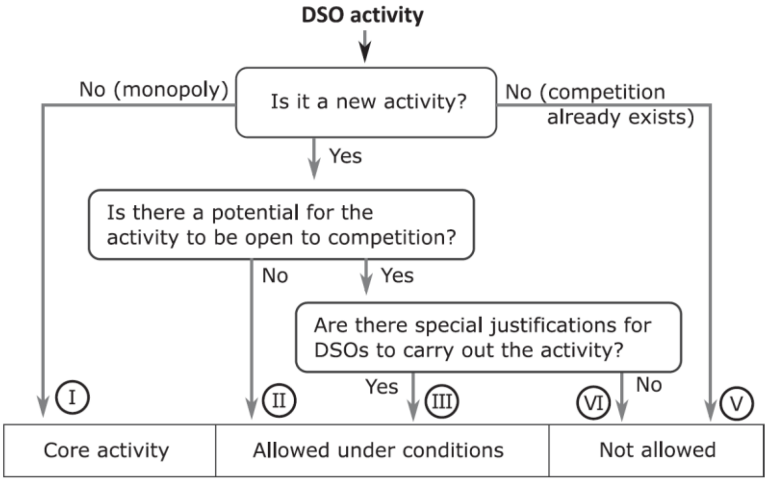


Figure 6: Logical framework for DSO Activities. Source: (CEER 2014)

The use of services provided by DERs is, however, an important new role for DSOs as a tool in the transition from the "fit-and-forget" approach toward an active system management (Ruester et al. 2014). The deployment of smart meters and grids have allowed DSOs to have higher observability of the network, together with more efficient control and maintenance processes. The installation of DG and the rise of other types of DERs (e.g. EVs, BESSs) too is leading to changes in the distribution grid management. On the one hand, these resources impose a challenge for DSOs, as the hosting capacity may soon become limited to accommodate the new DERs, as observed by the Hungarian demonstration (REF D8.1). On the other hand, however, opportunities for DSOs may arise from the local flexibility of DERs. The use of this flexibility (not only active power flexibility but also other services such as reactive power for voltage control) may enable DSOs to improve hosting capacity and possibly defer or avoid reinforcement.

5.2.3. Flexibility procurement by DSOs

AUSTRIA: No specific mechanism by which DERs can provide services to DSOs. However, customers connected to the distribution grid have to comply with requirements for voltage control.

GERMANY: Several pilot projects are testing local flexibility markets in Germany. Most of these projects are supported by a large-scale government-funded research program called "SINTEG". This program also grants DSOs with regulatory exceptions.

FRANCE: Since 2015, the French Energy Law allows the utilisation of flexibility for the optimisation of distribution systems (Gonzalez, Petit, and Perez 2019). However, the process for the definition of how tenders for flexibility will work is still ongoing. In 2018, a consultation process was started by the French DSO Enedis, being finalized in 2019. Flexibility will be procured for defined periods called availability windows and with certain technical requirements (minimum duration, number of activations, response time).

GREECE: No market mechanisms exist for the procurement of services by the DSOs in Greece. Any DER have to comply with mandatory requirements regarding voltage limits, for instance, and the DSO has the possibility of curtailing/limit DG in emergency cases.

HUNGARY: So far, no framework for flexibility procurement is in place. Nevertheless, the legislative process started in order to set a framework. Eventually, details will be defined in the Hungarian distribution code.

Sweden: The DSOs can have bilateral agreements with DERs for load reduction and increase of DG production (Lind and Chaves Ávila 2019). Nevertheless, there is no specific regulation defining the characteristics of these bilateral agreements, being the DSOs responsible for setting their functioning. In Sweden, at least one DSO already uses flexibility from DER through bilateral agreements, duo to the regulatory context of the TSO-DSO relationship in Sweden. The DSO have a fixed power capacity contracted with the upstream system operator called subscription level. If the power withdrawn at the interface is higher than the subscription level, the DSO is subject to a penalty. Therefore, there is a natural incentive for DSOs to procure flexibility, as long as the cost of flexibility procurement is lower than the penalty for surpassing the subscription level.

India: As of today, no scheme for DERs to provide flexibility or other services to DISCOMs exist. Distributed PV is expected to grow in the coming year, helped by the government programs such as a feed-in-tariff support scheme for the substitution of agricultural diesel pumps by PV pumps. “This may not, however, allow DISCOMS to use these pumps for system flexibility”, according to IEA (2020:214).

5.2.4. Storage ownership and operation by DSOs

Austria: There are no specific rules for storage systems. The national grid codes state that storage devices are to be regarded as generating units in terms of their effect on the distribution network, and therefore rules for storage apply equally to generation units. Therefore, in principle, DSOs should not own or operate these assets unless they are required for grid operation (e.g. emergency supply or batteries in substations for uninterruptible power supply). This rule, however, applies to large DSOs (>100.000 customers), following the European regulation on unbundling. A legislative proposal is ongoing to allow DSOs to have storage for use in sector coupling projects (REF D2.1).

Germany: Similarly, the regulation on DSO-operated BESS is currently not defined at the national regulatory framework (REF D2.1). Therefore, as of today, DSOs could not own or operate BESSs. Future national regulation is expected to reflect the definitions from the CEP.

France: Storage systems are treated as consumers and generators, with both rules applying. With regards to the DSO possibility of owning or operating storage systems, DSOs cannot own or operate a storage system directly, except if the market is not able to offer the service required. Nevertheless, such a situation has not happened yet.

Greece: DSOs are only allowed to own or operate BESSs if there is not proven business interest on the field and only after NRA’s approval.

Hungary: The ownership, development, management or operation of BESSs by DSOs is regulated in §33 of Act LXXXVI of 2007 on Electric Energy. For the purpose of optimizing the distribution system operation, an electricity storage facility can be part of the distribution system based on minimum costs compared to conventional grid reinforcement. As mentioned in the IElectrix deliverable D2.11, after the adoption of the E-Directive, additional conditions will be added, such as prohibiting DSOs from using BESSs in congestion management and limited the installed capacity to 0.5 MW.

Sweden: the topic is currently not comprehensively regulated, but DSOs can own and operate BESSs for the purpose of supporting power quality and or losses in the grid. It cannot be operated, however, for islanding purposes, as this is considered an unregulated service.

India: Currently, there is no regulatory framework for BESSs in India (CERC 2017). The national regulatory authority acknowledges in its position paper that storage systems could be used both for commercial purposes and to give support to the grid and system. In such a case, “it is expected that a range of regulatory modes should be employed for addressing regulatory requirements of storage facilities” (CERC 2017:32). However, although this may indicate the future regulatory treatment for BESSs, currently, no definition exists.

Regulatory Aspects							
DSO storage ownership and operation	No specific regulation. In principle, DSOs should not own/operate BESSs	No specific regulation. In principle, DSOs should not own/operate BESSs	No specific regulation. DSOs should not own/operate BESSs, except in case of lack of commercial interest	Only in case of lack of commercial interest	DSOs can own/operate BESSs if used for the optimization of the grid. The CEP is expected to bring additional conditions	In principle, DSOs could own/operate BESSs for supporting power quality and or losses. The matter is not comprehensively regulated.	Currently, there is no regulatory framework for BESSs in India
DSO procurement of local services from DER	No specific mechanism in place.	No specific mechanism in place. Several pilots are testing concepts	The legislation already allows for flexibility tendering. The process for concluding the tendering process is ongoing	No specific mechanism in place.	No specific mechanism in place.	DSOs are allowed to have bilateral contracts with DERs. This modality of procurement is already used due to "subscription limits" between system operators.	No specific mechanism in place.

Table 8: New roles for DSOs in the target countries

5.2.5. Incentives for innovation

The implementation of local flexibility mechanisms implies an innovative way of planning and operating the network that also leads to new organizational models and cost structure for the DSOs. NRAs do not have complete evidence about how these innovations are going to impact the power system or the electricity market, and DSOs are not sure about the technical and economical strategy to follow.

Recently, some countries began the creation of "safe spaces" or "sandboxes". This is the selection of an "area" within a system or market in which a different regulation could apply for a certain period. This allows for testing new services and products that are not yet stipulated or permitted under the existing regulation.

Generally, regulators follow an "evidence-based" path, meaning they propose and introduce new pieces of regulation based on evaluations and results of already made projects. This way of proceeding based on pilot projects and/or experiences in other countries provides stability and confidence. But, what to do when there is no or little evidence, as in the case of local flexibility mechanisms? The regulator may need to create an environment where it is possible to get evidence from the implementation of new ideas and projects, but without affecting end-users or the complete system or market.

Regulatory sandboxes are used to promote entrepreneurship and innovation not only in power systems but within segments of the economy that may have restrictive regulation while keeping comprehensive consumer protection and regulatory oversight in place. The objective is to promote innovation, and so far, there is evidence of successful results (Wechsler, Perlman, and Gurung 2018). There are concerns as well to pay attention to, like when companies take riskier decisions or also when economic privileges are given to specific firms without extending those same privileges to others, that could ultimately harm consumers (Knight and Mitchell 2020).

There is not a generally accepted definition of the term "regulatory sandbox". However, Zetzsche, Buckley, Barberis, & Arner (2017) define these sandboxes as an environment where companies can test their innovations with real customers, with fewer regulatory constraints, less risk of execution, and permanent guidance of regulatory bodies. A sandbox can be understood as the selection of a group of clients to whom an exception to the regulations in force for a certain period will be applied, where new services and/or products will be developed that are not yet available, regulated, or supervised by current regulations, determining how feasible they can be in a real system or market.

The electricity sector is highly regulated since it has a series of market failures such as the existence of natural monopolies (network business), externalities, and asymmetric information, among other aspects. In some activities and areas of the sector, regulation can delay the adoption of innovative technologies.

Therefore, there is a need for a dynamic regulatory environment that responds to and satisfies the new needs of distribution network managers and users, providing the safest possible environment for innovators and investors. Technological innovation is an inherently high risk, which is why, to foster innovation, it is important to have a safe environment where the developer and the regulator can work together to assess the benefits of new technologies and services before they are implemented. Regulatory sandboxes are an example of this approach and a valuable learning experience, both to better understand the constraints imposed by existing regulation and to identify possible corrective measures that facilitate innovation.

AUSTRIA: as part of the Austrian Energy Research Initiative, a funding program called Energie.Frei.Raum is now in preparation for experimental areas/sandboxes for system implementation of new realisation concepts and business models. It is a promotion program that is planned to be established as a preparatory phase for a possible introduction of an experimentation clause to give companies the possibility to test the systemic implementation of new technologies and market models for system integration of renewable energy sources, storage, and energy efficiency technologies.

There are no regulatory sandboxes in Austria now. However, within the framework of the Austrian Climate and Energy Strategy (#mission2030), several flagship projects, including —Energy Research Initiative, have been established. The Strategy was drafted in connection with Austria´s engagement in the global initiative Mission Innovation.

GERMANY: Although not formally referred to as a sandbox, the German Smart Energy Showcases (SINTEG) funding program allows experimentation with new technologies, procedures, and business models, while providing regulatory exemptions. The projects in this program operate under a special regulatory ordinance with “experimental options” that exempt the participant from certain regulations.

DSO regulation allows a temporary extra remuneration for the projects in the experimentation period. It is debatable if this experience is a sandbox. Strictly speaking, most are refunds of fees paid for participation in the exhibition projects, almost all of them related to flexibility.

Germany has mostly carried out large-scale projects in conjunction with DSOs. Rather than using sandboxes for particular initiatives, Germany focused on creating the conditions for a special type of innovation to take place (flexibility mechanisms for modernisation of networks). DSOs and companies were in charge of looking for the best flexibility mechanisms. Other types of initiatives that can also be adopted through a sandbox, for example, tariff changes, were not considered.

Although a sandbox is not made for financial purposes, the funding incentive of SINTEG to develop projects is a big boost. SINTEG shows that if a sandbox is created with a predefined objective and with government funds, it could obtain results in a shorter time and with greater security.

FRANCE: The law of November 8, 2019, on Energy and Climate, has introduced a regulatory experimentation system (sandbox) in the energy sector. This system allows the Energy Regulation Commission and the administrative authority to authorize experiments temporarily deviating from the legal framework. The normative experimentation system allows testing innovations whose generalisation would require changes in the applicable regulatory and legislative framework.

The experimentation system allows the implementation of innovations temporarily under certain conditions. Exceptions cannot be granted for a period exceeding 4 years. They can only be renewed once, under the same conditions.

The conditions in which the experiments are carried out are framed in the deliberation (approval) of the Energy Regulation Commission that grants exceptions to the current legal framework. These temporary exceptions are part of a framework that enables the deployment of innovative experiments but also ensures the safety and quality of operation of networks and facilities. Project owners should provide regular feedback on experimentation.

Currently, some projects are using the sandbox mechanism. Also, there is an OPEX financial amount determined each year by the French NRA for R&D, innovation and pilot projects. If the DSO spends less, the tariff will decrease; if the DSO spends more, the tariff doesn't move.

GREECE: The Hellenic Electricity Distribution Network Code introduces the concept of Funded Research and Innovation Projects, as projects that can contribute to the advancements in the operator's know-how in the field of grid planning, constructions, operation and maintenance, and the activity of distribution, in general, facilitating the increase in OPEX and CAPEX efficiency in the long term.

These projects can be completely or partially funded through the required revenue of the Hellenic Electricity Distribution Network Operator (HEDNO), upon NRA's approval. For this to happen, the operator should submit to the NRA documentation regarding the project details and the expected benefits of the proposed developed and implemented technologies.

However, this mechanism has not been activated yet, and no additional details on its implementation have been published. It may be activated in the new Regulatory Period.

HUNGARY: For the current DSO regulation, the activated value of smart grid elements is considered by 110% value in Regulatory Asset Base (RAB).

There is not yet specific regulation for regulatory sandboxes. For some ongoing innovative projects where a need for sandboxes has come up, the proposal of a sandbox is included by the tenders. It is expected that those sandbox proposals will be evaluated by the NRA.

It is planned to have a sandbox regulation, but this topic did not form part of the CEP implementing proposal submitted to the Parliament. However, since the implementing act sets only a minimum framework of the new market design, it is considered possible to allow sandboxes for new market players and innovative projects to gather experience and develop potential regulatory proposals. The detail of such regulation is not known yet.

SWEDEN: There are no specific regulatory mechanisms for the DSO's innovations like regulatory sandboxes, funded pilot projects, or something similar for testing innovative solutions.

In the current regulation, Information and Communication Technologies (ICT) CAPEX is handled as actual costs with a depreciation time of 12 years. OPEX costs can be recovered in the next regulatory 4-year period except for the efficiency factor of about 1%/year.

Funding can be supplied by state organizations as the Energy Agency of about 25-33% of the costs.

INDIA: About specific regulatory mechanisms to encourage DSOs to test innovative solutions or fund pilot projects, the Regulator approves Innovative Projects on a case-to-case basis based upon the Detailed Project Report submitted to the Regulator.

Currently, regulatory Sandboxes are not used. A sandbox is categorized under Innovation projects which are evaluated and approved by the Regulator.

Erreur ! Source du renvoi introuvable. shows the innovative legislation for DSOs related to incentives for grid innovations.

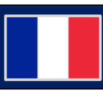
Regulatory Aspects							
Regulatory Sandbox Legislation	NO	NO	YES	NO	NO	NO	NO
Other incentives for DSOs Innovations	Yes. As part of the Austrian Energy Research Initiative: Energie Frei Raum	Yes. The SINTEG funding program	Also, there is an OPEX financial amount for R&D, innovation, and pilot projects	Yes. The Distribution Code introduces the concept of Funded Research and Innovation Projects	Yes. For DSO regulation, the value of smart grid elements is considered by 110% value in RAB.	Yes. Different treatment of CAPEX and OPEX of ICT investments	Yes. The Regulator approves Innovative Projects on a case-to-case basis
Innovative projects experience	Not documented to date	Yes. mostly large-scale projects in conjunction with DSOs	Currently running	Not documented to date	Not documented to date	Not documented to date	Not documented to date

Table 9: Incentive for innovation in the target countries

5.3. End-users

5.3.1. Network access and connection

Network access and connection describes the whole process from applying for accessing to the grid over getting connected to operating. For connecting to the electricity grid, DG end-users may face different types of connection charges to pay for the reinforcement triggered by their connection. Shallow connection charges shift the financial burden of network reinforcement from the user seeking connection to all grid users via Use of System (UoS) charges. Paying the full magnitude of reinforcement might be significant for small projects. However, a deep connection charging approach provides a strong locational signal and an incentive to efficiently use the existing hosting capacity.

This available capacity is generally calculated based on the operational parameters of the distribution system. The exact methodology varies from country to country. The available hosting capacity might be allocated preferably to renewable generators to further support the decarbonisation of the electricity sector. The voltage level of connection for a DG customer might vary according to the size of the user in order to assure a safe operation of the power system. Depending on national regulation, small LV users might even be connected as a one-phase connection. While this is more generally the case for demand, there might be exceptions for DG. Once the connection is carried out, the standard IEC50160 regulates the operation of the power system. However, national regulation might add further criteria.

The regulation of access to the distribution system can be used as an additional provider of flexibility by employing non-firm access. This allows the DSO to regulate the injection of a generator into the grid. Traditionally, this measure is reserved for situations in which grid stability is endangered and needs to be maintained. In these cases, generators would receive financial compensation for the energy they could not inject into the grid. However, including the non-firm access modality in the contract with the DSO allows the DSO to plan the curtailment of the new generator in a limited number of situations and avoid costly network reinforcement. The benefits for the customer translate into a shorter connection time due to the avoided reinforcement work. Connection costs to be paid by the generator are also reduced in the case of deep connection charges.

Finally, another relevant aspect of the network connection process for DG adoption is the availability of information regarding hosting capacity. Having this information in a public and updated way helps not only the DER applicant but may also benefit the DSO, avoiding duplicated connection requests and speeding the connection process.

In this section, the design of the access and connection process is described for each of the countries participating in the questionnaire.

AUSTRIA: In Austria, DG is required to pay for grid reinforcement, but not for the cost of the connection itself. The regulator sets the deep part of connection charges and publishes them in the system charges ordinance. DG is not required to pay UoS charges, although network losses and ancillary services are charged above 5 MW. RES generators are given priority at a capacity assignation. For the connection, voltage levels are assigned according to capacity. LV connections are commonly three-phase connections with a maximum asymmetry of 3.68 kVA. The operating voltage limits are defined according to IEC50160.

GERMANY: In Germany, the DSO must not charge the DG customer nor for the connection neither for the use of the system when injecting energy. DSOs are obliged to offer a connection to DG and carry out the corresponding reinforcement, which is why available capacity is not published. Capacity is calculated based on network calculations considering simultaneity factors and the metering of electrical parameters at the substations. The hosting capacity is allocated according to the first-come-first-served mechanism with priority to RESs. DSOs do not have to publish information on hosting capacity, only connection requirements. Hosting capacity is processed after the application for connection is submitted. In Germany, DSOs may opt into a curtailment scheme that allows them to curtail up to 3% of annual generated electricity. Users receive financial compensation for the curtailment they experience (Furusawa, Brunekreeft, and Hattori 2019).

FRANCE: In France, the general generator connection charging approach is deep, with the exception of shallow charges for DG below 5 MW. The charges are calculated by the DSO according to the methodology set by the ministry and approved by the NRA. A set of flat rates for non-critical situations is published by the DSO. DG is not charged any UoS charges but required to pay for contract management, metering and reactive power. However, the implementation of DG UoS charges is currently under consideration of the French NRA. Available network hosting capacity is calculated according to criteria set by the regulator and published every quarter in the form of a traffic light system for LV and medium voltage (MV) customers. This capacity is assigned with a first-come-first-served approach. For the connection, the size of the customer is used to decide both the voltage level and the phases in the case of LV connections. Operating limits are set according to IEC50160 and used as a planning criterion. The limits are monitored in case of customer complaints. Temporary non-firm access is possible in case of network reinforcement requirements. However, a more permanent introduction is currently being considered by the regulator.

GREECE: In Greece, DG is required to pay for network reinforcement. The connection charges are determined by the DSO according to a methodology approved by the regulator. The publication of connection charges is currently at the implementation stage. Currently, DG is not required to pay UoS charges, although it is under consideration for future change. The DSO is the responsible entity for the determination of available hosting capacity. This calculation considers parameters such as the voltage, thermal limits of the lines and short-circuit current. The information on available hosting capacity is published at HV/MV substation level in the form of coloured maps or tables and updated daily in the interconnected system. In the non-interconnected island systems, this frequency is reduced to every two weeks. Limits of the size of customers per voltage level are applied for the connection. LV connections might be one- or three-phase, although DG connections are required to be carried out three-phase. Operating limits are the same as in IEC50160 and can be monitored at major LV and MV customers. The rest of LV customers might request temporary monitoring in case of complaints. There is no flexible connection option for DG, and RESs are entitled to compensation payments in the case of curtailment due to network restrictions. However, solar generation must not be an object to curtailment.

Hungary: In Hungary, connection charges vary upon different sizes of customers. In general, deep connection charges are applied. However, existing customers may install small DG plants at the capacity already contracted without any additional fee. Other small DG plants are entitled to a connection charges reduction. The connection fees are calculated by the DSO according to a methodology set by the regulator. Although the methodology is public, the exact connection fee is an object to an individual study. UoS charges apply to the energy required by generators of any size, not for injecting electric energy into the grid. These charges are designed as a flat tariff and include energy and a capacity term. Available hosting capacity is determined by the DSO and published in the form of a coloured map which is updated monthly. No capacity limits are employed for the connection at the different voltage levels. LV connections might be one-phase or three-phase according to user size. Operating voltage limits are generally the same as in IEC50160 and monitored at HV/MV substation level. Currently, there is no option for non-firm access, but it is expected to be implemented soon.

Sweden: In Sweden, DG customers are required to pay deep connection charges. The charges are calculated by the DSO, but the customer might complain to the regulator in case of conflict. Small connections below 63A are charged according to a standard model established by the regulator. This approach depends on the length of the cable for the connection and is made public. For larger connections, there is joint planning. DG costumers below 80A pay UoS charges based on energy, while larger users pay UoS charges based on capacity. Available hosting capacity is calculated according to criteria set by the DSO. This capacity is allocated according to the first-come-first-served approach. The DSO does not publish the hosting capacity in advance. Estimated costs for connection are calculated on demand. For the connection, there are no limits of size per voltage level and LV connections are carried out as three-phase. The operating voltage limits are defined according to national power regulation, which sets similar thresholds as IEC50160. DG customers may opt for non-firm access if an agreement is included in the contract with the DSO. This option is available for all users. All details such as curtailment procedures are set in the contract with the DSO.

India: In India, available network hosting capacity is determined according to criteria set by the regulator. If the required capacity is higher than 20% of the distribution transformer level capacity, a detailed connection study is required. Smaller installations are allowed to connect directly. The distribution transformer capacities are published by the DSOs and updated within seven working days. Available hosting capacity is allocated with the first-come-first-served approach. For the voltage level of connection, users are categorised according to size. LV connection is carried out as single-phase for users of up to 10 kW and three-phase for bigger units. Operating voltage limits are lower than in IEC50160, namely ±6% below 630V and +6% to -9% at higher voltages. The limits are amplified to +10% to -12.5% at the highest voltage level (66 kV). These ranges are used as planning criteria and monitored at the transformer station level.

Regulatory Aspects							
Connection charges	Deep for network provision and shallow for network admission	Shallow	Deep, Shallow for DG < 5 MW	Deep	Deep, Shallow for DG with the size of contracted demand capacity, Shallowish for small RES plants	Deep	
UoS charges for DG	No, but network losses and ancillary services are charged for DG > 5 MW	No	No	No	Only for the energy consumption, not for injection	< 80A: Energy UoS > 80A: Capacity UoS	
Capacity allocation	RES priority	RES priority	First-come-first-served		First-come-first-served	First-come-first-served	First-come-first-served
Availability of information on hosting capacity		No information published in advance	An online system is available for consultation of hosting capacity and connection cost. Updated every quarter.	Information available at the HV/MV substation. Updated daily (bi-weekly for non-interconnected island)	Published in the form of a coloured map. Updated monthly.	No information published in advance	Distribution transformer capacities published. Updated weekly.
Operating voltage limits	As in IEC50160		As in IEC50160	As in IEC50160	Yes, with slight variations depending on the voltage level	National power regulation (similar to IEC50160)	Yes, at HV/MV substation level
Option of non-firm access for DG		Yes, up to 3% curtailment	Yes, temporarily until reinforcement is carried out	No	No	Yes, if the user and DSO agree in a bilateral contract	

Table 10: DG network access and connection in the target countries

5.3.2. Smart metering

Smart metering is a crucial enabler for demand flexibility and well-functioning retail electricity markets. Accordingly, it is a central technology within many of the IElectrix functionalities. For instance, smart meters will act as enablers of properly functioning LECs, will allow for BESSs to be used efficiently and may allow for DERs to provide service to DSOs. European directives place a strong emphasis on the need for deploying this infrastructure. However, different countries may opt for different smart metering deployment and data management models. In this section, the status of the roll-out process and the characteristics of the smart meters are explored.

Austria: Smart metering is mandatory and regulated by a directive of the ministry. The directive foresees that grid operators (DSOs are responsible for metering) must show a project plan for the rollout of smart meters of 80% of metering points by 2020 and 95% of the metering points by the end of 2022. The actual status of the roll out by the end of 2018 was 15,4% (European Commission. Directorate General for Energy. et al. 2021a). In Austria, the smart meter is owned by the DSO. Consumers pay a fee for metering, and the remaining cost is recovered by the network tariffs.

Germany: Of the total 50 million metering points in Germany, there was no considerable amount of smart meters installed by the end of 2018 (European Commission. Directorate General for Energy. et al. 2021c). Large rollout (>80% of metering points) is expected between 2026 and 2030. In Germany, either the DSO or a 3rd party meter operator is the owner and responsible for the smart meter.

France: Smart metering implementation is mandatory for all customers due to French law. A specific regulation has been published by the French NRA. The DSOs are responsible for the deployment. With more than 28 million smart meters, 80% of the rollout has been completed. Full deployment is expected by 2022. The DSO is the owner of the smart meter. Consumers pay a fee for metering.

Greece: According to the Ministerial Decision GG B 297/13.2.2013, HEDNO is obliged by legislation to have 80% of consumers in a remote-metering system by the end of 2020. However, current implementation timelines indicate that this would not be possible. Consequently, a new timeline is being considered for new legislation. HEDNO is planning the deployment of smart meters for the digitisation of the distribution network, and more specifically, the procurement and nationwide installation of 7.5 million smart meters to all low voltage customers of the electricity distribution network, as well as the integration of all low voltage customers at a remote-metering centre with a capacity of 8.0 million metering points. The project is expected to be completed over a six-year horizon by 2026. HEDNO is responsible for the smart metering rollouts' deployment. The percentage of rolled-out smart meters up to now is 3.2% of the total 7.5 million metering points.

Hungary: Hungary is a lagging country in terms of smart meter rollout within the EU (European Commission. Directorate General for Energy. et al. 2021e). So far, deployment has been limited, and a detailed plan on the rollout timeline and functionalities is yet to be finished. In Hungary, the DSO is the owner of the meter, and costs are included in the RAB. In order to accelerate the process, DSOs have an incentive to deploy smart meters: recognition of 110% of the cost in the RAB. The consumers pay a metering fee, but this regulation is under review.

Sweden: The country was one of the pioneers in the adoption of smart meters in the EU. By the year 2009, the first deployment of smart meters was completed. However, considering that by the first deployment, there was a lack of specifications in terms of functionalities, DSOs adopted different approaches, leading to the deployment of meters with limited time resolution (maximum hourly measurement) and functionalities (European Commission. Directorate General for Energy. et al. 2021f). Sweden is now undergoing a second deployment of smart meters, capable of 15-minute readings. This second deployment is expected to be completed by 2024.

India: There are no official reports accounting for the current number of smart meters installed in India (Chawla, Kowalska-Pyzalska, and Skowrońska-Szmer 2020). Estimates range from 500 thousand (Chawla et al. 2020) to 1.4 million installed by 2020 (Jones 2020). Nevertheless, a comprehensive plan for deployment has already been produced. In 2015, the National Smart Grid Mission was created by the government of India in order to promote the deployment of smart meters. A plan to substitute 250 million conventional meters with smart meters in a period of three years has been established (IEA 2020). The DISCOM is the owner of the infrastructure, and it is included in the RABs. The consumers pay a one-time cost for the meter and its related services at the time of applying a new connection.

Regulatory Aspects							
Smart meter rollout	15.4% by 2018	Limited rollout. Large rollout (80%) expected between 2026 and 2030.	80% currently. Completion expected by 2022.	Limited rollout (3.2% currently). Large rollout expected by 2026.	Limited rollout. National rollout plan still pending.	First rollout completed by 2009, but with limited functionality. Completion of the second rollout expected by 2024.	Limited rollout. However, an ambitious national plan was already developed for a large rollout in the 3 coming years.

Table 11: Smart meter rollout in the target countries

5.3.3. Retail market conditions and tariff regulation

The price signals seen by consumers are a key variable affecting demand behaviour, including their level of engagement, actual flexibility provision, or investment decision in grid-edge technologies (PV, storage, heat pumps). Oftentimes, market prices or network tariffs are seen in isolation from the rest of the cost components that are included in the retail tariff paid by end-users. However, this is a myopic view. In order to accurately assess the behaviour of end-users, it is necessary to consider the breakdown of costs in the retail prices/tariffs as well as the structure of these price signals.

When referring to retail prices or tariffs, it is worth noticing that, at least in the EU, having a liberalised functioning retail market is a key objective in the European view of the power sector. In a context of a liberalised retail market, the well-functioning of such markets is key to provide appropriate short-term signals for the consumer in terms of demand response and long terms signals such as DG and BESS installation. In many cases, however, regulated tariffs exist. In the European case, such tariffs can be reserved to vulnerable consumers or, if available to all consumers, can be an "opt-out" solution for consumers unwilling to look for a supplier. Although regulated tariffs are usually more limited in providing consumers with different price signals, they too can be designed in a way that incentivizes customers. One example is the ToU regulated tariff, which is implemented in Spain.

On top of understanding how electricity prices are formed in retailing, it is also important to understand what is included in the price paid by consumers. Retail tariffs can be broken down into i) regulated charges needed to recover the costs of non-competitive activities (transmission, distribution, system operation), ii) policy costs (capacity mechanisms, regulator costs, RES subsidies, other), iii) the cost of producing the electricity, iv) the cost of supply, and v) taxes. Having higher policy costs and taxes may dilute potential benefits from dynamic electricity and network prices. Finally, the way retail tariffs are charged (e.g. energy, capacity or both) also affects the overall set of incentives for consumers.

AUSTRIA: The retail markets in Austria is a well-functioning market. No regulated tariffs remain, as most consumers have liberalized retail contracts. Last resort tariffs are only in place in exceptional cases. In total, 59 suppliers[9] are available to households (European Commission. Directorate General for Energy. et al. 2021a). Switching is considered low, with 4.2% annually. Currently, 35% do not remain with the incumbent electricity supplier. The

[9] In the capital of the country.

energy component in the electricity bill accounts for 34% of the total. Network tariffs are not time differentiated. The ToU tariffs can only be applied to the energy component.

GERMANY: The German retail market is also well developed. In total, 168 suppliers[10] are available, and a high switching of 10% is observed annually (European Commission. Directorate General for Energy. et al. 2021c). Regulated tariffs are not common. Just in case a customer has not concluded a market-based contract with any supplier at the time of electricity consumption or an existing supply contract is extinguished, the last resource tariff will be automatically applied.

FRANCE: The presence of regulated tariffs in the French market is still high. Residential consumers and small businesses can opt for the regulated tariffs, which tend to be more attractive than most offers by liberalized suppliers (European Commission. Directorate General for Energy. et al. 2021b). The French market is also fairly concentrated. Although 28 suppliers are available[11], the largest share of contracts remains with two traditional companies EDF and Engie. The energy component as a share of the end-user price is 35.5% of the electricity bill.

GREECE: In Greece, a fully liberalised retail market is in place since 2013, and currently regulated tariffs are exceptional (e.g. vulnerable consumers). In total, 24 suppliers are available, an annually switching rate of 4.5% is observed (European Commission. Directorate General for Energy. et al. 2021d). The energy component of the final electricity bills totals 58%. Although a fully liberalised market, a recent study points out the complexity of the Greek market and the advantages for incumbent retailers as a potential limiting factor for the well-functioning of the retail market (European Commission. Directorate General for Energy. et al. 2021d).

HUNGARY: Electricity are regulated for households in Hungary, which are set by the government by decree (European Commission. Directorate General for Energy. et al. 2021e). A liberalized market exists for businesses and large consumers (e.g. industries).

SWEDEN: The retail markets in Sweden is a well-functioning market. No regulated tariffs remain, as most consumers have liberalized retail contracts. Last resort tariffs are only in place in exceptional cases. In total, 91 suppliers[12] are available to households (European Commission. Directorate General for Energy. et al. 2021f). Switching of 11% is observed annually. The energy component in the electricity bill accounts for 33% of the total. Billing is done separately for energy and for energy costs unless the retailer is part of the same group as the DSO.

INDIA: Only large consumers are able to access liberalized retail offers in India (IEA 2020). Small consumers are supplied by DISCOMs. Tariffs for retail supply and sale of electricity (both retail and wholesale) are determined by the SERCs, while the Ministry set a tariff policy (guideline for SERCs). Tariffs are divided by the voltage level and capacity of consumers. Consumers that already have smart meters should be charge with a ToU and two-part tariff. Consumers that have their meters substituted by smart ones should also have their tariffs adapted to the new requirements. Retail tariffs in India are considered high when compared to other countries considering the purchasing power parity and highly different between states (IEA 2020).

Figure 7 presents a breakdown of the final electricity price paid by a hypothetical consumer with a standard incumbent offer in each EU capital by the end of 2019. One may notice that in Greece, the energy components account for more than half of the electricity bill, while in Germany it represents only a quarter. In Germany, 21% of the electricity bill corresponds to supports to RES, while in Hungary, this component is not included in the electricity bill, most probably being paid by the taxpayer. Taxes (apart from the Value-Added Tax [VAT]) are also high in Germany, Sweden, and Greece compared to the other target countries.

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[10] In the capital of the country.
[11] In the capital of the country.
[12] In the capital of the country.

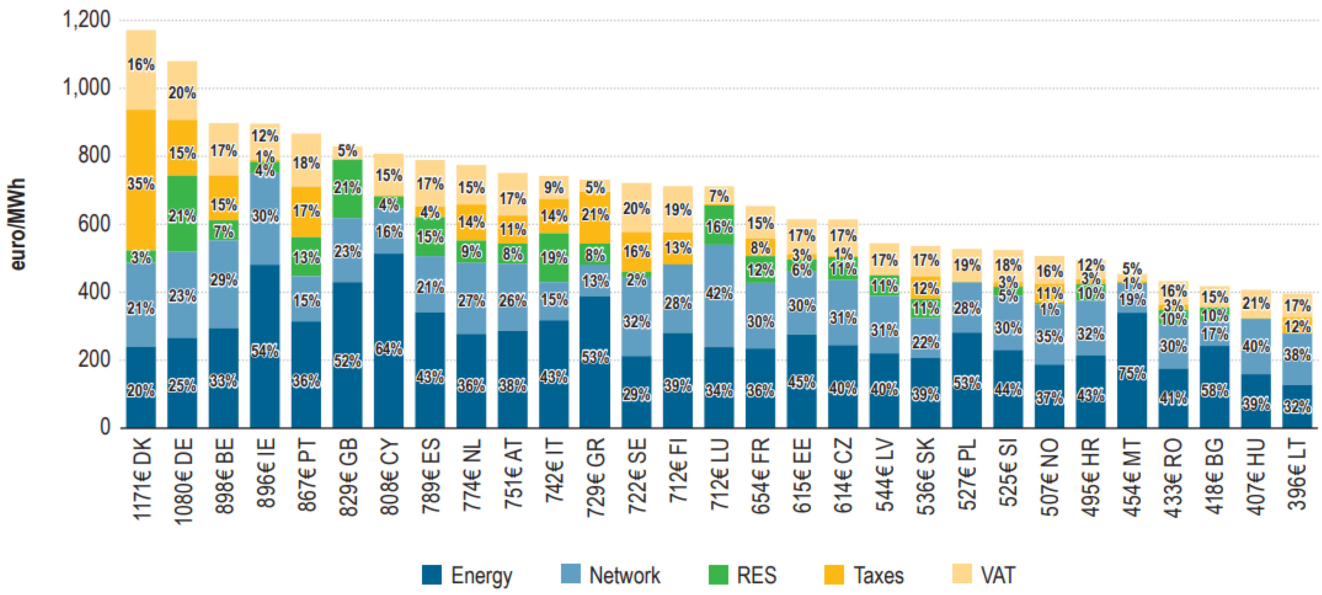


Figure 7: Breakdown of incumbents' standard electricity offers for households in capital cities – November/December 2019 (%). Source: (ACER and CEER 2020)

Apart from the components included in the electricity tariff, another important aspect is how this tariff is charged to consumers. When designing electricity tariffs, regulator or policymakers have three primary options to choose from: (i) charge based on the energy consumed (€/kWh), (ii) charge based on the installed capacity (€/kW), or charge a fixed amount per customer (€/month). Traditionally, energy-based tariff has been the preferred choice in Europe, including for the remuneration of the distribution grid (CEER 2020). Nevertheless, different tariff components call for different charging method in order to be cost-reflective. The energy consumed, for instance, is usually charged in energy terms. The network, however, could be charged both in energy and capacity/fixed, as an important part of the network cost is fixed. On top of that, network tariffs could also be time differentiated and eventually dynamic, aiming at reaching cost-reflectiveness. The RES support scheme is in principle a policy cost and is not directly correlated to the energy consumed by the customer.

Figure 8 presents a breakdown of the different charging components in the electricity bill in different European countries, including the six EU target countries. The weights shown are with regards to a typical household consumer (REF-E et al. 2015).

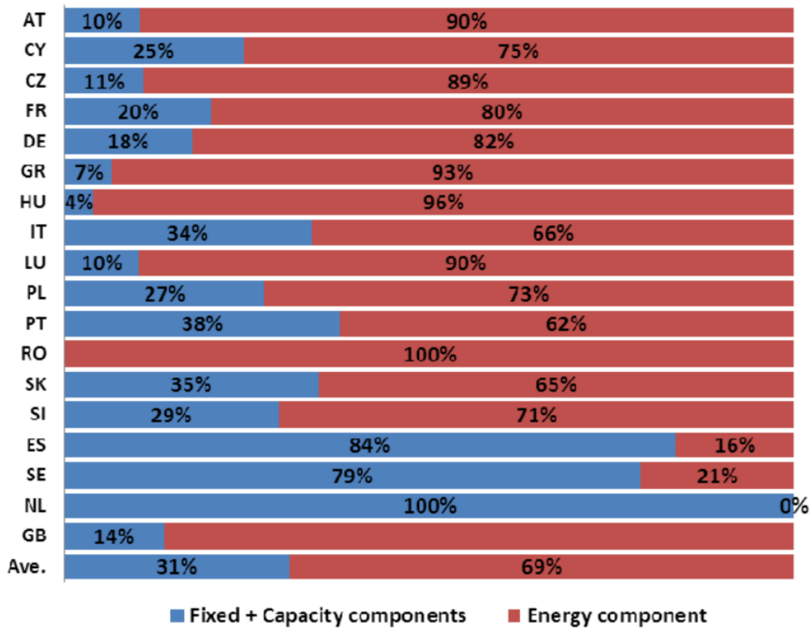


Figure 8: Breakdown of electricity bill by charging component for a household. Source: (REF-E et al. 2015)

Erreur ! Source du renvoi introuvable. presents a summary of the key regulatory features of retail markets and tariff design in the seven target countries of IElectrix.

Regulatory Aspects							
Functioning of liberalised retail markets	Well-functioning market	Well-functioning market	Presence of regulated tariffs in the French market is still high	Retail is liberalised, but barriers such as complexity and advantages to incumbents exit	Electricity tariffs are regulated for households	Well-functioning market	Electricity is regulated for households
Are there regulated tariffs?	No	No	Yes	No	Yes	No	Yes
Electricity bill breakdown (in %)	VAT: 17 Taxes: 11 RES: 8 Grid: 21 Ener.: 38	VAT: 20 Taxes: 15 RES: 21 Grid: 23 Ener.: 25	VAT: 15 Taxes: 8 RES: 12 Grid: 30 Ener.: 36	VAT: 5 Taxes: 21 RES: 8 Grid: 13 Ener.: 53	VAT: 21 Taxes: 0 RES: 0 Grid: 40 Ener.: 39	VAT: 20 Taxes: 16 RES: 2 Grid: 32 Ener.: 29	-
Tariff components	Mostly energy (>90%)	Balanced	Balanced	Mostly energy (>90%)	Mostly energy (>90%)	Mostly fixed or capacity (79%)	-

Table 12: Retail tariffs

5.4. Self-producers and energy communities

5.4.1. Self-generation

The CEP defines the concepts of self-generation and self-consumption as possibilities for the active consumer. Self-generation is defined as generation made by an active customer. In other words, the generation from DG associated with a consumer. Alternatively, the generation of a "prosumer". Self-consumption is the part of the self-generation used for internal consumption of the active customer. The possibility for the implementation of individual self-generation, specifically, is the first step in fostering LECs, as collective self-generation is an important part of the LEC concept.

AUSTRIA: In Austria, self-consumption is allowed, and net metering applied. In principle, no direct support for self-consumption applies (e.g. no feed-in-tariff). Self-consumption is mainly profitable due to price difference, as the energy taken from the grid is charged with regulated costs that account for approximately two-thirds of the total cost for consumers. Prosumers may be charged with a part of these regulated costs, the so-called "electricity duty", at approximately 1,5 cent/kWh. Nevertheless, this charge is only applicable to prosumers whose consumed and produced electricity are higher than 5 MWh/year or 25 MWh/year in the case of renewable energy (E-Control 2018). Although this approach may be foster the adoption of DG by consumers, the net-metering approach may be considered not as efficient.

GERMANY: The PV installation in Germany is notably one of the largest in Europe, with more than 1.5 million PV systems installed and a nominal capacity of 41 GW. There is no net-metering in Germany, and small PV installation (less than 10 kWp) are exempted from most taxes and levies, including grid charges. Surplus is remunerated with a guaranteed feed-in-tariff (FiT) (Fett et al. 2019).

FRANCE: About 80.000 customers in France also have self-generation. They can sell surpluses if they want, and no net metering scheme is allowed. Every customer is eligible for self-generation. When installing it, both consumption and generation grid requirements are applied. If the active customer is not equipped with a smart meter yet, two electro-mechanical meters are needed, one for consumption and another one for generation. Feed-in tariffs and net-billing for PV apply in France. The value for the FiT varies according to the size of the PV.

GREECE: Self-generation in Greece is allowed since 2015 in the form of net-metering and virtual net-metering. Energy surpluses are not remunerated financially. Instead, if there is an energy surplus on one billing period, this is transferred to the next billing period. Net-metering is applied on a three-year basis. Consumers eligible for self-generation are (i) individuals or legal entities that are owners of the installation location or (ii) are renting in and have the consent of the owner of the installation location. Especially for virtual net-metering, legal persons governed by public or private law that provide public-interest services registered farmers and Energy Communities that own or possess license to use the installation location. If the feeder needs to be upgraded to accommodate increased consumption, this needs to happen before the connection is made. Limitations in terms of capacity exist, depending on the location (interconnected mainland vs non-interconnected islands) and voltage level, as well as levies paid by the active consumers. Finally, a bidirectional meter is required, plus individual meters for each DG installed by the active consumer.

HUNGARY: Self-generation and self-consumption are allowed in Hungary. In the case of household-sized DG with an installed capacity equal to or less than 50kVA, a net metering scheme is applied. The net-metering can be settled on a monthly, semi-annual or annual basis. As for the metering, active consumers with DG will have to have smart meters installed by 2023. There are no specific requirements for the connection to the grid and no additional costs or levies to prosumers.

SWEDEN: Self-consumption in Sweden is allowed, and prosumers are able to sell excess electricity to suppliers. According to Sweco and Osloeconomics (2019), approximately 50% of retailers in Sweden offer to buy the energy surplus from distributed generation. Besides benefiting from the energy sold, prosumers may also benefit from a support scheme in the form of tax reduction. For small DG connected at the location as the consumption unit, a tax reduction of 60 öre/kWh is given in the income tax. This benefit is valid for both households and small businesses. Additionally, storage can also receive support to cover up to 60% of the installation cost if connected to self-production of energy. Other support schemes may also be applicable to self-consumption, such as support on PV installation cost and energy certificates from renewable production (Sweco and Oslo Economics 2019). Grid tariffs over DG are, in general, exempt for small units.

INDIA: Self-generation with net-metering is permitted in Delhi. Customers with installed solar plants are balanced on an annual based on the excess generation supplied to the DISCOM's network. However, a recent change in the net-metering rules is limiting the scheme to rooftop PVs up to 10 kW. Bigger installations will be subject to "gross metering", meaning that they will be remunerated for the energy injected in the grid by a fixed amount (ETEnergyworld 2021).

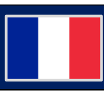
Regulatory Aspects							
Is individual self-generation allowed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is net-metering allowed?	Yes	No	No	Yes	Yes	No	Yes (only to small DG)
Which period?		NA	NA	Three-year basis	Monthly, semi-annual or annual basis	NA	Annually
If net-metering is not in place, which is the compensation scheme?	NA	Fixed FiT	Fixed FiT (according to size)	NA	NA	Free to sell to supplier	NA

Table 13: Self-generation rules in the target countries

5.4.2. Local Energy Communities (CECs, RECs)

As described in chapter 4, the CEP recently introduced the concept of "Energy communities" for residential consumers into the EU body of law. Two types of energy communities are defined: Citizen Energy Communities (CECs) (Directive 944/2019) and Renewable Energy Communities (RECs) (Directive 2018/2001). Nonetheless, the EU Directives leave some room for MSs to transpose these figures into national law concerning topics such as what activities these communities may carry out, economic arrangements, administrative requirements, etc.

AUSTRIA: LEC is still not regulated in Austria. The transposition of the e-Directive and the RES regulation is currently ongoing. The initial proposal submitted for approval at the Austrian parliament foresees:

- Enable the shared use of electrical energy across the entire market area and across concession areas of different system operators;
- Support open and voluntary participation and no restriction of the final customers free choice of suppliers;

- Provide regulations for measurement and billing;
- Permit the ownership and operation of distribution systems.

- Enable the sharing of energy from RES in the electricity sector, while maintaining the proximity criterion by the connection of consumption and generation via the same medium or low voltage distribution network (transformer station);

- Promote open and voluntary participation and no restriction of the participants' free choice of suppliers;

- Provide the possibility of promoting generation plants through investment grants.

These features, however, are still undergoing the legislative approval process and may change before official publication, providing only an indication of the expected legislation at the time of writing.

As for collective self-generation, national regulation was amended in 2017 to allow for PV electricity to be shared among residents of the same building or apartment blocks (Fechner 2019).

GERMANY: As described in the IElectrix deliverable D2.1, provisions regarding CEC already exist but are limited to the onshore wind only. The CECs shall consist of minimum 10 natural persons and shall be effectively controlled by natural persons having the majority of voting rights where no single persons shall hold more than 10% of the total voting rights of the community. Such CECs are allowed to build and operate up to 6 onshore wind turbines with a total installed capacity of 18 MW under specific conditions, providing them significant benefits in public tendering procedures (D2.1, pg. 39). The transposition and definitions of LEC from the CEP into German legislation has not been carried out at the time of writing.

FRANCE: France, too, is undergoing the process of transposing the CEP directive, which has not been completed at the time of writing. With regards to collective self-consumption, it is allowed and is currently running in 37 sites for 500 LV customers with a power of less than 3 MW. In urban areas, the distance between participants should be less than 2 km. The prosumers decide the rules for sharing collective energy. They can set flat or dynamic rates. The French DSO Enedis calculates the sharing between participants with this rule.

GREECE: Energy Communities are defined in the Greek Law 4513/2018 as cooperatives that perform activities exclusively in the energy sector. The Law defines the purpose and activities of LECs, specifies the framework for their establishment and operation and offers economic and administrative motives to LECs. The Law does not distinguish between Citizen LECs and Renewable LECs. The Law sets the following conditions for the establishment of LECs:

- Members can be individuals, local authorities (Municipalities, Regions) or any other legal entities

- More than 50% of the members shall be 'associated' with the place where the LEC has its registered offices

- LECs are generally non-profit. In case they consist of more than 15 members, the majority of whom are individuals, they may be profit-driven.

- Each member, independently of the shares that may possess, has only one vote to the General Assembly.

An LEC can use the scheme of 'Virtual Net Metering' to virtually share energy among members. According to this scheme, the energy produced by a RES or combined heat-power plant (CHP) owned by the LEC is used to offset multiple energy bills of the members of LEC (or non-members, provided they are vulnerable consumers or suffer from energy poverty).

HUNGARY: As described in the IElectrix deliverable D2.1, the transposition of the CEP directive is still ongoing at the time of writing, and currently, only individual self-generation is regulated.

SWEDEN: The transposition of the CEP directive is still ongoing at the time of writing. The existing regulation only considers collective self-generation for apartments inside the same building. In order to profit from self-generation, apartment buildings share one electricity contract with the DSO and that the electricity cost-sharing among apartments is done internally by the housing company/society (Lindahl, Rosell, and Westerberg 2019).

INDIA: As described in the IElectrix deliverable D2.1, currently, there are no specific provisions on the establishment and operation of energy communities. However, governmental actions are being taken to foster the development of an LEC legislation. The energy communities are seen as an important tool for rural electrification and reduction of losses.

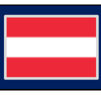
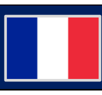
Regulatory Aspects							
Is collective self-generation allowed?	Yes, but limited	Yes	Yes	Yes	No	Yes, but limited	No
What are the characteristics of collective self-generation?	Allowed for PV in residential multifamily buildings	Limited to onshore wind. Min. of 10 people, and up to 6 turbines/18 MW in total	Either consumers located at the same building (up to MV), or consumers at LV within 2km	Considered a cooperative, in the context of LEC definition. Energy communities can benefit from the "virtual net-metering" scheme	NA	Only for consumers within the same building	NA
Are LEC regulated?	No	No	No	Yes	No	No	No

Table 14: Energy communities in the target countries

6. Identification of regulatory barriers

The regulatory overview provided in the previous Chapter 5 allows for the identification of critical barriers for the implementation of the HLUCs proposed in the IElectrix project. In what follows, these barriers are identified based on the regulatory framework observed in two or more target countries. This identification of regulatory barriers does not aim at assessing challenges for the demonstration implementation per se, but tries to anticipate overarching barriers for the future replication and large-scale deployment of IElectrix's HLUCs. For an analysis of the regulatory conditions for the current implementation of demonstrations, the reader is referred to the IElectrix deliverable D2.11 on the "final assessment of the national implementation of key European regulations in the demonstration countries", as well as the "Design of Solutions" deliverables of the Austrian, German, Hungarian, and Indian demonstrations (D6.1, D7.1, D8.1, and D9.1, respectively).

6.1. Identification of regulatory barriers from the target country analysis

- DSO Economic Regulation

Among the seven countries analysed, most of them have implemented incentive-regulation schemes in order to incentivized DSOs to become more efficient over time. A few countries have a cost-of-service scheme or are transitioning from cost-of-service to incentive regulation. The latter scheme tends to provide more incentives to DSOs to promote innovative solutions such as the ones proposed in IElectrix. However, the vast majority of target countries treat CAPEX and OPEX differently within their incentive regulation schemes. This means that DSOs have a strong incentive to reduce OPEX but little or no incentive to reduce CAPEX. Considering that DSOs are remunerated based on their RAB, the typical "RPI-X" actually incentivizes DSOs to increase CAPEX. This could be a barrier to the replication of certain HLUCs, such as DE-1 and HU-1.

Barrier No. 1: CAPEX-Bias in incentive regulation CAPEX-bias in incentive regulation scheme weakens the incentive for DSOs to look for more efficient alternatives to grid reinforcements, such as the use of local flexibility resources.

Apart from the general incentive regulation scheme, most DSOs in the target countries have additional specific incentives to reduce losses and to improve continuity of supply. In the context of IElectrix, these regulatory features are positive, as several HLUCs propose solutions that would contribute to the improvement of performance in these indicators (e.g. IN-1, IN-3, AT-3).

Driver No. 1: Incentives for loss reduction and improvement of continuity of supply Specific incentives for the reduction of losses and improvement of continuity of supply are beneficial for the exploitation of IElectrix solutions, as several HLUCs contributed to the improvement of these aspects.

Most of the seven countries analysed do not have to submit investment plans or submitted investment plans, only an estimation and DSOs do not have a strict requirement to follow them. In fact, the two countries in which investment plans are approved by regulators are those with cost-of-service regulation. The ones with incentive regulation still do not require the DSO to submit network plans for approval or to publish them.

Barrier No. 2: No binding investment plans approved or published

Network investment plans could be an important tool for potential flexibility providers in order to verify where flexibility is most needed. Moreover, DSOs and regulators may benefit from using investment plans to identify which network reinforcements could be deferred considering the use of local flexibility.

New Roles for DSOs

In line with the provisions of the CEP, most EU target countries limit the ownership of the BESS by DSOs. The transposition of the CEP directive is still ongoing and should limit the ownership and operation of batteries by DSOs to very specific situations such as lack of commercial interest by third parties. This is clearly a barrier to the replication of HLUCs DE-1 and HU-1. However, the legislative process of transposition may also offer the possibility for MSs to define which would be the conditions to which BESS could be considered a fully integrated network component of the distribution grid.

Barrier No. 3: Limitations to use of BESS by DSOs

Recent EU regulation limits the possibilities for DSOs to own and operate BESS. MSs and regulators may allow DSOs to own and operate storage systems if they are considered fully integrated networks components or when no commercial interest exists in their deployment. Regulators should monitor the commercial interest every five years.

With regards to the use of local flexibility by DSOs, most target countries lack regulatory mechanisms that not only allow but that can also foster the procurement of local services by DSOs. Together with the CAPEX-bias barrier abovementioned, this constitutes another barrier for HLUCs that foresee the use of local services by DSOs. Moreover, a functioning local flexibility mechanism can provide additional incentives for customers to install DERs such as DG and BESSs, which in turn could increase the potential benefits for the forming of local energy communities.

Barrier No. 4: Lack of local flexibility procurement mechanisms

The lack of regulatory definition on the possibilities for the procurement of local services by DSOs reduces the possibilities for both DSOs procuring local services and for flexibility providers to offer them.

Incentives for Innovation

When investing in innovative solutions, DSOs incur a higher financial risk. In addition, certain solutions may not be allowed by the current regulation. Therefore, incentives and regulatory exceptions can play an important role in speeding the research and innovation process, helping not only DSOs and research institutions but also providing regulators with practical case studies that can inform future regulation. Within regulatory exceptions, target countries do not have the option for sandboxes to be requested by DSOs and third parties. In addition to that, target countries also lack experience in large-scale innovation projects.

Barrier No. 5: Lack of sandbox regulation and experience with large innovation programmes

The CEP is not exhaustive for every topic, especially in the case of the e-Directive. Several definitions are left to be defined at the MS level. In such cases, large research and innovation programmes, including sandboxes, could serve to inform regulators and policymakers on the different regulatory alternatives, providing results that consider the local context.

As a possible driver, several target countries provide different financial incentives to innovation. These incentives come in several different forms, namely research funds, provision of innovation costs in the OPEX, increase RAB value for smart grids and differentiated treatment for CAPEX and OPEX related to ICT.

Driver No. 2: Financial incentives for innovation.

Financial incentives for DSOs to invest in innovative solutions are important as they reduce the risk for the DSO inherent in this type of investment.

- Smart metering

The deployment of smart meters in most target countries is still limited. With the exceptions of France and Sweden, the other target countries have not reached a large rollout (>80%), and some countries still miss a national rollout plan.

Barrier No. 6: Lack of smart meter deployment

Smart meters are the backbone of several innovations and business models at the distribution grid. For several use cases, they are necessary equipment (e.g. enabling dynamic tariffs). For other use cases, they may be not essential but are an important facilitator when put in place (e.g. fostering DG).

- Network access and connection

Among the target countries, different network access and connection rules are applied. Connection charge rules are mostly shallow for small DG. However, Greece and Sweden apply deep connections charges. Deep connection charges are useful in providing a strong locational incentive for new investments, but at the same time, can be an important barrier, especially for small DG.

Barrier No. 7: Deep connection charges are a barrier for small DG

Active consumers, especially the ones installing small-sized DG, may be disincentivised by deep connection charges.

Besides the type of connection charge, the need for firm network access for all DG connection requests may also be a barrier for DG deployment. Although having the certainty regarding capacity connection is beneficial for active consumers, always requiring it prior to the connection of new DG may lead to important connection delays and the lack of future needs for flexibility procurement by the DSO.

Barrier No. 8: Inexistence of flexible network options

The inexistence of flexible network options may lead to expansive reinforcement needs. Moreover, DG installation may be delayed by the need for prior reinforcements.

One possible driver for DG could be the interaction of connection charges and flexible network connection agreements. In Sweden, it is observed that a deep connection charge is in place, but an option of non-firm access for DG also exists. In this context, the DG adopter could choose between paying for the reinforcement and possibly waiting for the connection or entering into a non-firm access contract. In this context, locational network signals are also preserved. The benefits of this interaction would depend on the specific design of both connection charges and non-firm access contracts and will be explored in the IElectrix deliverable D4.5 on regulatory recommendations.

- Self-generation rules

All seven countries analysed allow for active consumers to install DG and to inject the exceeding energy into the grid. However, four of the seven countries allow net-metering to balance self-generation. The net-metering scheme can provide a strong incentive for the adoption of DG units, but it also disincentivises other consumption behaviours and DER types. The most important one, in the context of IElectrix, is the adoption of BESS. The net-metering scheme effectively transforms the network grid into a storage system for the active consumer that can consume at peak hours and inject electricity when prices are lower. For this reason, the CEP already mandates countries to phase out net-metering schemes.

Barrier No. 9: Existence of net-metering schemes

Net-metering schemes may be an effective solution to foster the deployment of certain types of DG. However, they reach this result at the expense of under remunerated network costs by active consumers and the disincentive to other types of DER, in particular the BESS.

- Retail markets and prices for end-customers

The situation in the seven target countries with regards to retail markets is mixed. Some countries have developed well-functioning liberalised retail markets and have phased out the regulated tariffs, limiting the “last resort” tariffs to exceptional cases (e.g. vulnerable consumers). However, some countries still opt for a completely regulated tariff, while others have both liberalised and regulated tariffs in parallel. In the case of the latter, it is common for the regulated tariff to offer lower prices, which ends up reducing the attractiveness of the liberalized market for household consumers.

Barrier No. 10: Not developed liberalised retail markets and high presence of regulated tariffs

Liberalised retail offers may help to foster consumer awareness and DER deployment, which can later translate into the formation of LEC.

Another characteristic that varies among the analysed countries is the composition of the typical electricity bill. While some countries do not include RES support schemes and taxes other than the VAT in the bill (e.g. HU), others heavily charge consumers on those components (e.g. DE). The effect of having higher charges of RES policy costs and taxes is that eventual price-signals will be diluted, reducing the attractiveness of flexibility provision or BESS adoption.

Barrier No. 11: High share of regulated costs in the electricity bill

High shares of regulated costs (e.g. RES support schemes and taxes) reduce potential incentives for demand response and DER installation as price signals are weakened.

- Energy Communities

The concept of LEC is still new, and the majority of target countries reported that regulatory schemes for LEC are not in place yet. Additionally, most countries reported that legislation is expected to transpose the CEP directive, but at this point, no information exists on the decision that will be taken by the MSs on topics that the CEP leaves open (e.g. LEC acting as DSOs).

The concept of collective self-generation is already a reality in several countries, but not in a harmonized way and with limitations. Austria and Sweden, for instance, only allow self-generation for residents of the same building, while Germany limits self-generation towards onshore wind turbines.

It is worth mentioning that policymaker at the MSs should aim at not only allowing the formation of LEC but also providing the conditions for this to happen. Historically, the transposition of EU directives into national legislation has led to long periods in which regulation allows for a particular use case to take place, but the necessary conditions are not provided. One example is the possibility for demand response to participate in balancing markets. MSs transposed this possibility into national laws, but market conditions made it prohibitive for it to happen during a certain period (e.g. large minimum bids, need for symmetric bidding). With the LEC definition, there is a risk for the same to happen.

Barrier No. 12: Uncertainty on LEC definitions, especially on topics that are left open to MSs by the CEP

The definition of the LEC concept is still incipient. The CEP only provides broad definitions that should be finetuned by the MSs. However, no timeline exists for this definition of the concept, and a risk exists that the LEC is allowed in the MSs, but lack the additional necessary conditions leads to a period in which LECs are not viable in practice.

Barrier No. 13: Collective self-generation is still incipient

Collective self-generation can play an important role in LECs. Allowing collective self-generation is an important step toward fostering the formation of LECs. However, the schemes in place are still limited.

Summary of regulatory barriers

The analysis of regulatory characteristics in the seven target countries had led to the identification of 13 main barriers for the deployment of IElectrix solutions. For each regulatory topic, one or two potential regulatory barriers were found. These barriers could limit the potential for the implementation and replicability of IElectrix solutions. Nevertheless, the identified barriers are not verified in every analysed country and are not equally important for every HLUC being developed in IElectrix. For this reason, Table 15 presents a summary of regulatory barriers identified and the importance in each target country, and Table 15: Regulatory barriers in the different target countries presents the correspondence between regulatory barriers and HLUCs, based on the mapping done in Chapter 2. One may also notice that the analysis of the seven target countries also led to the discovery of a few drivers for the implementation of IElectrix HLUCs. These drivers are not analysed in this deliverable, but they should inform regulatory recommendations to be delivered in the IElectrix deliverable D4.5.

Regulatory barriers (ID and description)								
1	CAPEX-Bias in incentive regulation	●		●	●	●	●	●
2	No binding investment plans approved or published	●	●	●		●	●	
3	Limitations to use of BESS by DSOs	●	●	●	●		●	
4	Lack of local flexibility procurement mechanisms	●	●		●	●		●
5	Lack of sandbox regulation and experience with large innovation programmes	●	●		●	●	●	
6	Limited smart meter deployment	●	●		●	●		●
7	Deep connection charges as a barrier for small DG	●			●		●	
8	Inexistence of flexible network options			●	●			
9	Existence of net-metering schemes	●			●	●		●
10	Not developed liberalized retail markets and presence of regulated tariffs			●	●	●		●
11	High share of regulated costs in the electricity bill		●		●			

12	Uncertainty on LEC definitions, especially on topics that are left open to MSs by the CEP	●	●	●		●	●	●
13	Collective self-generation is still incipient	●	●			●	●	●

Table 15: Regulatory barriers in the different target countries

Regulatory barriers (ID and description)		AT-1	AT-2	DE-1	HU-1	HU-2	IN-1	IN-2	IN-3
1	CAPEX-Bias in incentive regulation	●	●	●	●	●	●	●	
2	No binding investment plans approved or published	●	●	●	●	●	●	●	●
3	Limitations to use of BESS by DSOs	●		●	●				
4	Lack of local flexibility procurement mechanisms	●	●	●	●	●	●	●	●
5	Lack of sandbox regulation and experience with large innovation programmes	●	●	●	●	●	●	●	●
6	Limited smart meter deployment		●			●		●	
7	Deep connection charges as a barrier for small DG	●	●	●	●	●	●	●	
8	Inexistence of flexible network options	●	●	●	●	●	●	●	
9	Existence of net-metering schemes	●		●	●		●		
10	Not developed liberalized retail markets and presence of regulated tariffs		●					●	
11	High share of regulated costs in the electricity bill		●	●	●		●	●	
12	Uncertainty on LEC definitions, especially on topics that are left open to MSs by the CEP	●	●	●			●	●	
13	Collective self-generation is still incipient	●	●	●			●	●	

Table 16: Regulatory barriers for the different HLUCs in IElectrix

6.2. Identification of regulatory barriers from the demo characterisation

Apart from the regulatory barriers identified based on the analysis of regulatory characteristics in the seven target countries, each demonstration also conducted an exercise in identifying regulatory barriers that could be relevant for the implementation of IElectrix solutions in the respective countries. These regulatory barriers, together with technical, social-economic and legal barriers, are reported in the “Design of Solutions” deliverables, namely D6.1 (Austria), D7.1 (Germany), D8.1 (Hungary) and D9.1 (India).

Erreur ! Source du renvoi introuvable. presents a consolidated view of all barriers identified as “regulatory” or “legal” that are related to the regulatory topics covered in this deliverable. This table also contains a column that identifies if the barrier identified by the demonstration characterisation was also identified in this regulatory analysis, showing the ID number of the regulatory barrier in accordance with Table 15 and Table 15: Regulatory barriers in the different target countries.

The comparison between the regulatory barriers identified by the demonstration partners and the ones from the analysis above leads to the following main conclusions:

- More than half of the barriers identified by the demonstration partners are related to the ones identified in this deliverable D4.4 in some form.
- Several demonstrations mentioned the constant change in regulatory definitions as an important barrier. This barrier was not explicitly identified in the analysis contained in this report, as the methodology followed looked at regulation in a static way. However, the analysis of the EU-wide regulatory framework presented here, which will also be taken as the key boundary conditions when proposing recommendations in successive stages of the project, aims to ensure that the proposals are consistent with a long-term perspective.
- Some barriers identified by partners are with regards to costs and quantitative economic results. Considering that this regulatory analysis is only quantitative, such barriers were not explicitly addressed. However, they should be taken into account for future studies within the project, especially the scalability and replicability analysis and the cost-benefit analysis performed under Task 4.1 and Task 3.2, respectively.
- Lastly, the remaining legal barriers referred by demos correspond to standardization, importing rules or taxation aspects that fall beyond the scope of this report, which focuses on power system regulation.

Demo.	Regulatory barrier	Technology	Related to barrier ID
	Minimal requirement not clearly defined yet	BESS	3
	Change in cost definition	BESS	
	Continuously improving / changing regulatory environment	DR	
	System optimisation too slow	DR	
	Undefined incentives for participation in the energy market	DR	10, 9
	Connection delay	Local Energy System	8
	Customer engagement (lack of)	Local Energy System	
	Change in cost definition	Local Energy System	
	Not meeting defined CO2 goals	Local Energy System	
	Lack of investment in projects at Local Energy System level	Local Energy System	5
	Costs for curtailment and grid expansion are comparatively low	BESS	
	System of network tariffs does not adequately reflect the actual network load	BESS	11

	Uncertainty regarding the ownership of BESS by DSOs	BESS	3
	Uncertainty regarding BESS requirements and classification	BESS	3
	Uncertainty regarding the ownership of BESS by DSOs	BESS	3
	Battery requirements may change in the future	BESS	3
	Delays in implementation to ensure the procurement of secure equipment	BESS	7,8
	Changes in the regulatory environment may result in a more challenging planning and optimisation conditions for DSOs	DLC	
	Uncertainty regarding the LEC definitions	LEC	11
	Lack of customer awareness	DR	
	Inadequate electricity tariff structure	DR	10, 11
	Lack of incentive to invest in smart demand response devices	DR	5,6
	Lack of Demand Side Management international standards	DR	
	Lack of incentive to invest in smart grid technologies	Smart Grid Technology	5,6
	Lack of smart grid international standards	Smart Grid Technology	
	Continuously improving / changing regulatory involvement	Smart Grid Technology	
	High level of customs barriers for importing foreign equipment	Smart Grid Technology	
	No clear legal and regulatory framework for the operation of storage systems and the services they can offer, the rules for connecting to the network	Smart Network Asset	3
	DSO's role in energy storage	Smart Network Asset	2
	Role of energy storage in the future	Smart Network Asset	3
	Connection delay	Smart Network Asset	8
	Long lead time of procurement	Smart Network Asset	8

Table 17: Regulatory barriers identified by the IElectrix demonstrations and correlation to previously identified barriers

6.3. From regulatory barriers to recommendations on how to overcome them

The analysis of the current regulatory conditions in the target countries, together with the analysis of the recent changes in European regulation, allowed for the identification on the most outstanding regulatory challenges to be faced by future large-scale replications of the IElectrix's solutions. This identification could also be confirmed by the parallel and individual identification of regulatory barriers in the demo countries, which also informed this regulatory task in IElectrix of other barriers not identified by the static overview presented in Chapter 5 (e.g. constant changes in regulation – regulatory uncertainty). Therefore, the next required step in this research is to provide recommendations on how to overcome the identified barriers, allowing for the replication and exploitation of the HLUCs proposed in the project.

The deliverable D4.5[13] will provide a detailed analysis of the identified barriers and provide recommendations. Nevertheless, considering the barriers identified in this deliverable D4.4, a few guidelines and expected recommendations can already be identified:

- Several regulatory barriers present in the national regulatory frameworks are expected to be lifted by the adoption of the recent EU regulation, especially the transposition of the CEP into national regulation.

[13] Upcoming. To be published by October of 2022.

However, as shown in Chapter 4, the CEP is not exhaustive in the directives for every regulatory topic. In fact, several relevant topics for the IElectrix project are partially left open, so decisions are taken at the MS level. Therefore, national stakeholders such as regulators, policymakers, system operators, and end-users should agree on the way forward to bring the European vision into effective national implementation.

As the transposition of past EU regulatory packages has shown, this discovery and agreement process can be lengthy, and therefore MS should be proactive in order to reduce the period in which new solutions and business models are unable to foster due to the lack of regulatory definition. In this context, research and innovation actions (e.g. incentives for innovation and sandboxes) can serve as valuable **discovery tools** for regulators and policymakers in this discovery process, together with public consultations for the engagement of stakeholders.

- In order to overcome the barriers identified, not only solutions and business models have to be allowed by regulation, but also a **complete framework** must be in place in order to foster their development. Past experience has also shown that only allowing a certain use case to be implemented often results in high uncertainty for the involved stakeholders due to the lack of further regulatory definitions, hindering the potential of the use case.

  Examples can be found in the recent EU regulation, such as the fostering of independent aggregation and the participation of demand response in electricity markets. In the former case, i.e. independent aggregation, it is far from enough for regulation to simply open markets to these agents since, unless uncertainties regarding balancing responsibility, financial compensations and inadequate market design rules are solved too, this business case will be unviable in many countries (Bray and Woodman 2019; Poplavskaya and de Vries 2018). Similarly, the participation of demand response in balancing markets has been already allowed in many countries, but the remaining practical barriers have prevented their effective market participation so far (smartEn 2018, 2020). Therefore, the need for complete regulatory solutions is needed, especially in areas of high uncertainty and innovative business models. This can be the case for LEC, a central concept in the IElectrix project.

- It is possible to observe that several regulatory topics are interlinked. For example, network reinforcement planning policies may affect the need for local flexibility services in the short term, and the rules on individual self-generation/consumption may influence the establishment of LECs. Therefore, not only individual recommendations for individual barriers are needed, but in addition, recommendations must follow an **integrated approach**. Such an integrated approach will help avoid negative feedbacks from one regulatory decision into another.

The deliverable D4.5 should address how the individual barriers can be lifted in a complete and integrated way. Moreover, when prescriptive recommendations are not possible, due to high dependence on local conditions, it should recommend best practice and design option for discovery tools such as sandboxes, enabling regulators and policymakers to implement complete and integrated regulatory solutions in an effective and timely manner.

7. Conclusions

In this IElectrix deliverable, key regulatory barriers for the development of the HLUCs proposed in the project were identified. For this purpose, firstly, regulatory topics were mapped against HLUCs, according to their importance for the solutions described. Secondly, both European regulation and the national regulatory frameworks were analysed. Thirdly, regulatory barriers were extracted from the observation of the regulatory conditions in countries, up to 13 different potential barriers, and later contrasted to the regulatory barriers identified by each demonstration activity.

The result of this analysis shows that important barriers still exist for all HLUCs to some degree. One may notice that the transposition of the CEP is expected to overcome several of the barriers identified. However, the complete transposition also depends on the capability of NRAs to reach a conclusion with regards to open topics in a timely and efficient way. The delay in transposing and implementing the directive from the CEP also creates regulatory uncertainty, which is a barrier in itself, as identified by the demonstration activities in IElectrix. Regulatory sandboxes and large scale pilot projects can aid NRAs in this process. However, this too was identified as a missing aspect in the national regulations.

In all countries, barriers can be observed, in a higher or lower number, with no country leading or legging when considering the project as a whole. In fact, the comparison among countries does not serve as a benchmark, but rather to illustrate the existence of the specific regulatory barriers, and indicated that these barriers might be present not only in the target countries of IElectrix but also in other countries in which replication could be considered.

The country analysis also has to take into consideration the differences that exist between the European target countries and India, which is not under the regulatory influence of the CEP, for instance. The DISCOMs in India and DSOs in Europe coincide in several objectives and guiding principles, but not all. For example, the expected limitation in ownership and usage of BESSs by DSOs in Europe stated in the CEP may not be a regulatory concern in India, as DISCOMs are not fully unbundled. Aspects such as this one should be taken into account when regulatory recommendations are provided.

Appendix A: Regulatory questionnaire

1. Scope, purpose and instructions for filling in the questionnaire

1.1. Purpose of the document

The scalability and replicability of the solutions tested within IELECTRIX can be hampered by existing regulation if certain aspects are not permitted or the stakeholders involved lack the necessary incentives to adopt these solutions. One of the major goals of WP4 is to identify potential scalability/replicability regulatory barriers and, subsequently, develop recommendations to overcome these barriers.

The first step in this task is to characterize existing regulation in the seven target countries defined in the DoA. These include the four demo countries (Austria, Germany, Hungary and India) as well as three replication countries (France, Sweden and Greece). In order to monitor existing regulation and market rules in the target countries, this document contains a comprehensive questionnaire relative to all topics previously identified as relevant.

This questionnaire will consist on different sets of open questions in which you are encouraged, to the extent possible, to provide complete but concise answers. Feel free to add any reference or link you may deem relevant to provide further information.

Please help us define the regulatory framework in your country by reviewing/answering this questionnaire. Considering both current regulation and any potential legislation change that you consider may take place in the near future. Please provide any references where this regulation may be found.

2 DSO economic regulation

Power distribution is a regulated network monopoly within a given geographical area. Therefore, the revenues of DSOs are determined or supervised by NRAs and policy-makers. The economic regulation of electricity distribution companies defines how the allowed levels (i.e. those passed-through to the network tariffs) of network investments, other CAPEX, and OPEX are determined and recovered by DSOs. In addition to revenue regulation, distribution regulation has increasingly included additional incentive mechanisms related to the performance of DSOs in areas such as energy losses or quality of service.

This section includes questions related to all the topics mentioned above, with an emphasis on how expenditures related to DER and smart grid solutions are treated in the national regulation.

2.1 Revenue regulation

1. What is the general type of remuneration approach implemented in your country? What is the length of regulatory periods? Can you provide the remuneration formula?

   Form of price control:

☐ Cost of service	☐ Price Cap	☐ Revenue Cap	☐ Hybrid

   Length of regulatory period:

☐ 1 year	☐ 2 years	☐ 3 years	☐ 4 years	☐ 5 years	☐ 6 years	☐ 7 years	☐ 8 years

Please comment below (remuneration formula, general regulatory process description)

2. Are CAPEX and OPEX calculated and regulated separately or jointly? Are there any mechanisms to provide DSOs with equal incentives to reduce OPEX and CAPEX equally?

☐ **Separately**	☐ **Jointly (TOTEX)**

Please comment below

3. How are new allowed investments determined and included in the RAB? Do DSOs need to submit investment plans? If yes, do regulators use any benchmarking or cost assessment tool to evaluate these investment plans and which one? If yes, how are deviations between approved investment plans and actual investments treated?
4. How are allowed OPEX determined? Do regulators use any benchmarking or cost assessment tool to evaluate OPEX efficiency? If yes, which type of approach is used and in what way?
5. If you have not already done so in the questions above, please describe whether and how the costs related to DER penetration and smart grid implementation are treated in the regulation of DSO revenues (investment plans, benchmarking, other).
6. Are there any relevant changes expected or planned for the next years?

2.2 Regulatory incentives

2.2.1. Energy losses

1. Are there specific regulatory mechanisms to encourage DSOs to reduce energy losses? If yes, what kind of mechanism is used (symmetric bonus-malus, only penalties, only bonus)?

☐ **Symmetric bonus-malus**	☐ **Only penalties**	☐ **Only bonus**	☐ **Others (please describe)**	☐ **No incentives**

Please comment below

2. Do DSOs buy energy losses directly at the market or ad-hoc auctions, or are they simply subject to an economic bonus/penalty on top of their allowed revenues?
3. How are the parameters of the mechanisms to promote loss reduction determined? These parameters typically include the level of recognized losses (also referred to as reference or target losses) and the unit value of losses (usually associated to market prices). Do these parameters vary by DSO or region, time of the

day or season of the year? Is the impact of DER on distribution losses considered somehow when calculating these parameters?

4. Are there any relevant changes expected or planned for the next years?

2.2.2. Continuity of supply

1. What reliability indices are used to monitor continuity of supply? Are the faults occurring in the LV network included in these indicators, either jointly or separately? What network users are considered when calculating these indicators (only consumers or also DG units)?

2. Are there specific regulatory mechanisms to encourage DSOs to improve continuity of supply? If yes, what kind of mechanism is used (symmetric bonus-malus, only penalties, only bonus)?

☐ Symmetric bonus-malus	☐ Only penalties	☐ Only bonus	☐ Others (please describe)	☐ No incentives

Please comment below

3. How are the parameters of the mechanisms to improve continuity of supply determined? These parameters typically include the reference or target value and the unit incentive (usually related to the value of non-served energy). Do these parameters vary by DSO, region, or voltage level? Is the impact of DER on distribution losses considered somehow when calculating these parameters?

4. Are there any relevant changes expected or planned for the next years?

2.2.3. Other incentive mechanisms for DSOs

1. Are there any other incentive schemes for DSOs?

2. What type of incentives? How are they designed?

3 Pilot projects and regulatory sandboxes

Some of the solutions tested in IELECTRIX, e.g. DSO procurement of grid services from demand response of BESS, may not be adequately reflected or even permitted by existing regulation. More specifically, this questionnaire inquiries about the possibility for DSOs to implement pilot project and recover the associated costs, or request exemptions from some regulatory constraints (sandboxes) to test new solutions. This section includes questions related to these topics.

1. Are there specific regulatory mechanisms funded through the electricity tariffs to encourage DSOs to test innovative solutions or fund pilot projects? If yes, what kind of mechanism is used (tendering schemes, additional WACC, accelerated depreciation, other)?

2. Does regulation enable the creation of regulatory sandboxes? Does regulation set specific conditions to allow these? What are these conditions? How could a DSO/LEC apply for a sandbox? Who approves/evaluates these sandboxes?
3. Are you aware of any plans to implement such schemes or to modify existing ones?

4 Grid access and connection

Regulation should ensure fair and non-discriminatory network access for DER units whilst allowing DSOs full recovery of efficient connection costs. In this regard, there is a trade-off between providing incentives for the optimal and cost-reflective siting of new generation capacity and facilitating entry for small-sized DG operators. For this purpose, connection charges and use-of-system (UoS) charges may be designed by the regulator for all agents connected to the distribution network, including DG. Likewise, grid access rules may affect the connection process of new DG units as well as its impact on the distribution grid. The following block of questions focuses on these issues.

4.1. Connection charges

1. What kind of connection charges (deep, shallow, shallowish) are applied to DG connections in your country?

☐ Deep	☐ Shallow	☐ Shallowish

Please comment below

2. Are they calculated and by whom, or they are set by simple and transparent rules? Who sets these rules? How are they approved?

3. Do DSOs publish openly information enabling new applicants to estimate in advance (before submitting the application for connection) their connection charges ?

4. Have DG to pay UoS charges in your country? What is the structure of current DG UoS charges? Are they applied to kWh, to kW, or both? Are there differentiated by network voltage levels, by DG sizes or technologies?

☐ No UoS for DG	☐ UoS for DG as Energy (€/kWh)	☐ UoS for DG as Capacity (€/kW)	☐ Both (€/kWh + €/kW)

Please comment below

5. Do centralized generators pay UoS charges? If yes, are these calculated using the same rules as DG?

6. How are network charges for DG designed? Flat-tariff, Time-of-use (ToU) tariff, dynamic tariff, other?

7. Are there any plans to modify in the near future the current situation regarding network charges applied to DG (plans or pilots for ToU or dynamic tariffs, for instance)?

4.2. Determination and allocation of available network access capacity

1. What criteria are used for the determination of available network capacity for new connections? Are these somehow predefined (share of transformer of feeder capacity, short-circuit power limits, etc.)? Who sets these criteria (DSO, regulator, standards)?

2. Do DSOs publish openly information enabling new applicants to identify areas of the grid with more available hosting capacity (e.g. on-line calculators, heat maps, etc.)? In what format is this made available? How often is this information updated?

3. Once the available capacity has been determined, according to what criteria is available capacity assigned (first-come/first-served, batch allocation, priority to some technologies, market-based allocation)? If the approach differs per type of user (generation/demand, voltage levels, size, etc.), please indicate so.

☐ First-come/first-served	☐ Priority for RES or other types of users	☐ Market-based or auctions	☐ Other, please specify

Please comment below

4.3. Technical connection requirements

1. Does regulation set limits in size/capacity for new distribution network users at each voltage level? Are these limits the same for generators and consumers?

2. Are new LV connections made as single-phase or three-phase connections? Are there specific rules in this regard for DG units (e.g. PV) or EV charging posts?

3. What are the operating voltage limits (voltage drop and voltage rise) allowed by the regulation? Are they different from standard IEC50160? Are they specific to the MV and LV systems? Are they monitored and enforced or simply used as ex-ante planning and connection criteria?

4. Is there any other relevant grid connection rule that may impact DER?

4.4. Firmness of access capacity

1. May new connection applicants be offered some form of non-firm access? Under what conditions can new grid users be granted a non-firm access contract? What options/discrimination for non-firm grid access are applied (time discrimination, regional granularity, etc.)?

2. Are DSOs entitled or mandated to offer it? Are the options optional or mandatory for grid users?

3. Are those options applied to all grid users? Are generation and demand (or storage) treated differently?

4. If non-firm access is in place, what criteria are followed to carry out the curtailment?

☐ Pro-rata among users with non-firm access	☐ Last-in/first-out (Last user to connect to the grid is the first one to be curtailed)	☐ Technology discrimination	☐ Market-based allocation	☐ Other, please specify

Please comment below

5. Are there any plans to introduce non-firm access or modify existing arrangements?

5 New roles of DSOs

In a highly distributed power system, the role of DSOs will not only be that of network planning and operation. They would increasingly need to interact more closely with the network users as a means to support their own operations. Moreover, islanded operation, as tested in the Indian demo, may or may not be allowed by regulation. This sections also addresses the current regulatory framework related to islanded operation. Lastly, DSOs may also act, at least on a transitory stage, as owners and/or operators of some types of DER, including storage systems.

5.1. Local flexibility services

1. Can DER (DG/BESS/DR) participate in voltage control? Is there any specific requirement for voltage support (a fixed power factor, reactive consumption, constant voltage, etc.)?
2. How is the provision of this service regulated (mandatory requirements, incentive mechanisms, contractual agreements, non-firm connection, market mechanisms)? What types of DER are eligible (DG, DR, batteries)?
3. Can DSOs curtail DG connected at distribution level? Under what conditions? Does this involve some kind of economic compensation?
4. Can DER participate into local congestion management or other services to the DSO besides voltage control in your country? How is the provision of this service regulated? Can DSOs interact with aggregators or VPPs for these purposes? What types of DER are eligible?
5. Can DSOs own and operate DER (DG/BESS) under specific circumstances (e.g. to compensate for the energy losses, under emergency conditions)?
6. Are there any plans to modify in the near future the current situation regarding DER as a provider of network services?

5.2. Islanded operation

1. Is islanded operation by DSOs allowed and implemented in your country?
2. May this involve the participation of grid users (generation or storage not owned by the DSO)? Is this service remunerated or compensated somehow?
3. What are the requirements to be met for an islanded operation (if allowed)? Are there any rules for the connection and disconnection of the microgrid to the network?
4. Are there any plans to modify in the near future the current situation regarding islanding by DSO?

5.3. Ownership and operation of storage assets

1. Is the connection of storage systems to the distribution grid regulated? Are there any specific connection requirements for distributed storage systems?
2. Are prosumers allowed to own storage behind their meters? If yes, under what conditions (size limitations, technical requirements, pricing options)?

3. Can prosumers provide services to the DSO using storage? If yes, under what conditions (size limitations, technical requirements, pricing options)?
4. Are DSOs allowed to own or operate directly storage systems? If yes, under what conditions (size limitations, constraints to prevent interference with competitive activities, time limitations, tendering mechanisms required)? Are BESS costs included in the DSO RAB and, consequently, network charges?
5. Is the electricity produced by RES and stored in BESS legally considered as renewable and eligible to guarantees of origin or other type of support schemes? What conditions must be met for this?
6. How does regulation consider BESS concerning charges and levies for importing/exporting electricity to/from the grid?
7. Are there any plans to modify in the near future the current situation regarding DSO storage ownership and operation?

6 Smart metering

Smart metering is a key enabler for demand flexibility and well-functioning retail electricity markets. European directives place a strong emphasis in the need for deploying this infrastructure by 2020 and beyond. However, different countries may opt for different smart metering deployment and data management models. In this section, you will be asked to characterize the current situation in your country.

6.1. Roll-out model and responsibilities

1. Is the implementation of smart metering regulated (is it mandatory, or left to DSO or market initiative)? Are there any specific smart metering rollout programs? Who is responsible for its deployment? What is the current rate of deployment in the country?
2. What is the infrastructure considered by regulation (just the smart meters at consumers' location, does it also include data concentrators, communication networks, etc)?
3. What are the functionalities considered for smart meters (remote reading, load limitation, etc)?
4. Who is the owner of the required infrastructure (AMI) (the DSO, the supplier, an independent agent)? In case it is property of the DSO, how is it accounted for by regulation? Is it included in the asset base? How are these costs passed through to consumers (do consumers pay a fixed amount for meter rental)?

6.2. Metering data management

1. Who is in charge of meter reading and billing (the DSO, the supplier, an independent agent)?
2. How often can consumption be recorded (15min, 1h…)?
3. Do smart meters record data only on consumption? Or also on events (voltages, supply interruptions, etc.)? If yes, does the DSO have access to this data? How often?

4. What agent is responsible for third-party access to metering data for commercial purposes (DSO, supplier, independent data hub)?
5. How can data be accessed? Which third parties can access consumption data and under which conditions (anonymized, aggregated, etc)?

7 Retail tariffs

The price signals seen by consumers are a key variable affecting demand behaviour including their level of engagement, actual flexibility provision, or investment decision in grid-edge technologies (PV, storage, heat pumps). In order to properly assess the response of end users, it is necessary to consider the complete breakdown of costs in the retail tariffs (energy, grids, policy costs, levies) as well as the structure of these tariffs. Retail tariffs can be broken down into i) regulated charges needed to recover the costs of non-competitive activities and policy costs (transmission, distribution, system operation, capacity mechanisms, regulator costs, RES subsidies, other), ii) the cost of producing the electricity, and iii) taxes.

This section aims to characterize the composition of retail tariffs and their structure, as well as the regulation of self-generation in each target country.

1. What is the cost breakdown of the power system in your country? How are these costs passed-through to the different tariff categories? What is the level of taxation on the electricity bill (consumption tax, excise tax)?
2. What is the structure of the regulated charges paid by end users (energy, capacity, fixed, minimum bills)? Is this structure different for different consumer categories?
3. Are there still fully regulated tariffs for some groups of consumers? If yes, what is the structure of this tariff, who can offer it and what types of consumers are eligible to these tariffs?

8 Self-generation

Self-generation allows end-users to use local production to offset their consumption and thus reduce their energy bills. Self-consumption may happen at individual level (only possible to offset loads behind the same electricity meter) or collectively (the production of one generation unit can be used to offset loads behind several consumption meters somehow associated to this generator).

1. Is self-generation allowed in your country? If yes, are instantaneous energy surpluses remunerated in any way? How? Is net-metering permitted? At which timescale is net-metering applied (monthly, yearly)? What types of consumers are eligible to self-generation?
2. Are there any particular grid connection requirements or procedures for prosumers?
3. Are there any limitations in terms of installed capacity? Are there special requirements in terms of metering equipment? Are prosumers subject to any specific charge or levy?
4. Is collective or shared self-generation permitted in your country? What conditions have to be met in order to be allowed to collectively self-consume your own electricity (size, distance, generation technology, etc.)?
5. If collective self-generation is permitted, what are the rules to distributed the energy production across the different consumption points? How is the economic settlement performed?

9 Energy communities

The Clean Energy package recently introduced the concept of "Energy communities" for residential consumers into the EU body of law. Two types of energy communities are defined: Citizen Energy Communities (CECs) (Directive 944/2019) and Renewable Energy Communities (RECs) (Directive 2018/2001). Nonetheless, the EU Directives leave some room to MSs to transpose these figures into national law concerning topics such as what activities these communities may carry out, economic arrangements, administrative requirements, etc.

1. Are energy communities legally defined in your national regulation? Does this include both REC and CEC? Is there any difference among these definitions? What are the conditions set in the regulation to become a CEC and/or REC?
2. Does regulation set any limits to the ownership structure and/or the activities to be carried out by the energy communities (REC and/or CEC)? Specifically, are CECs entitled to own/operate the distribution grids?
3. What type of grid users may join/leave these communities and how?
4. May energy communities collectively engage in self-generation activities? In that case, how are the energy and economic flows settled within the community? Are there any particular requirements for this (metering, size, distance, etc.)?
5. Are there any plans to modify in the near future the current situation regarding energy communities?