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Deliverable D2.2
Overview of the regulatory and market framework for energy services in the residential sector

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ABBREVIATIONS

Abbreviation	Name
ACER	Agency for the Cooperation of Energy Regulators
ACM	Authority for Consumers and Markets (Spain)
AESG	Agreement on Energy for Sustainable Growth
aFRR	Automatic Frequency Restoration Reserve
AMI	Advanced Metering Infrastructure
API	Application programming interface
BIM	Business Integration Manager
BRP	Balance Responsible Party
BSP	Balance Service Provider
CAGR	Compound Annual Growth Rate
CEER	Council of European Energy Regulators
CNMC	National Commission for Markets and Competition in Spain
CO	Confidential, only for members of the Consortium (including the Commission Services)
CRE	Commission de Régulation de l'Energie (France)
CRM	Capacity Remuneration Mechanism
CROPEX	Croatian Power Exchange Ltd
D	Deliverable
DA	Day-Ahead Market
DER	Distributed Energy Resources
DHW	Domestic Hot Water
DR	Demand-Response
DRMS	Demand - Response Management System
DRS	Demand-Response settlement
DRSR	DRS and remuneration
DSM	Demand Side Management

DSO	Distribution System Operator
DSR	Demand Side Resources
DSS	Dispatch Service System
DSU	Demand Side Unit
DoW	Description of Work
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EDF	Electricité de France
EE	Energy Efficiency
EED	Energy Efficiency Directive
EIB	European Investment Bank
EMO	Energy Market Operator
EMS	Energy Management System
ENDEX	European Energy Derivatives Exchange
ENTSO-E	European Network of Transmission System Operators for Electricity
ESDN	European Sustainable Development Network
ETS/non-ETS	Emission Trading System / non- Emission Trading System
EP	European Parliament
EU	European Union
EV	Electric Vehicle
FCR	Frequency Containment Reserve
FRR	Frequency Restoration Reserve
G2V	Grid to vehicle
GC	Garantie de Capacité
GDEM	Global Demand Manager for Aggregators
GDPR	General Data Protection Regulation
GEFF	Green Economy Financing Facility

GHG	Greenhouse Gas
H2020	Horizon 2020 Programme
HERA	Croatian Energy Regulatory Agency
HROTE	Croatian Energy Market Operator
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and communication technology
IFI	International Financial Institution
ISP	Imbalance Settlement Period
ID	Intraday Market
IEQ	Indoor Environmental Quality
IPR	Intellectual Property Rights
IPS	Integrated Power System
IRR	Internal Return Rate
L	Law
mFRR	Manual Frequency Restoration Reserve
MGT	Management
MIBEL	Iberian Electricity Market
MS	Milestone
NCEP	National Climate and Energy Plan
NEEAP	National Energy Efficiency Action Plan
NPV	Net Profit Value
NRA	National Regulatory Authority
nZEB	Nearly Zero-Energy Buildings
OE	Opérateur d'Effacement (France)
OMIE	Operador del Mercado Ibérico-Polo Español
OMIP	Operador del Mercado Ibérico-Polo Portugués
OS	Open Source

OTC	Over-the-counter
P2H	Power-to-Heat
PCM	phase change materials
PF4EE	Private Finance for Energy Efficiency
PM	Person Month
PMV	Performance, measurement and verification
PRP	Programme Responsible Party
PSO	Public Service Obligation
PU	Public
PV	Photovoltaic
PVPC	Precio Venta a Pequeño Consumidor (regulated tariff in Spain)
R	Report
RD	Royal Decree
RDL	Royal Decree Law
REE	Red Eléctrica Española
RES	Renewable Energy System
RR	Replacement Reserve or Regulating reserve
RTD	Research Technology development
RTD	Research and Development
SEAC	Security Access Control
SEM	Single Electricity Market
SLA	Service Level Agreements
SM	System Manager
SME	Small- and Medium-size Enterprises
SPV	Special Purpose Vehicle
TEN-E	Trans-European Networks for Energy
TFEU	Treaty on the Functioning of the European Union

TM	Task Manager
ToU	Time of Use
TSO	Transport System Operator
VAT	Value-Added Tax
V2G	Vehicle to Grid
VPP	Virtual Power Plant
VRES	Variable RES
VTES	Virtual Thermal Energy Storage
WP	Work Package
Y1	Year 1

TABLE OF CONTENT

EXECUTIVE SUMMARY

This document aims at providing a review of the regulations that apply to the current and new hybrid energy services that are envisaged in the frESCO project for consumers and prosumers. This regulatory framework analysis frames the project activities and ambitions within the national regulatory constraints at every demo-site country (France, Spain, Croatia and Greece) and at the European level and reveals the main legal barriers and market constraints for frESCO's innovative energy services.

The document starts by reviewing the European Directives that guide the national regulatory bodies with specific adaptation to the legal systems of each country. An analysis of the market structure is also useful to identify actors, rules and actual practices in each country. It has been observed that service markets and electricity systems are independent and locally governed, but that they are also homogeneous between countries since they are inspired by the same EU targets and Directives.

The frESCO innovative energy services rely on a big-data platform to apply the adequate artificial intelligence to provide real-time services to obtain combined revenues from energy efficiency in buildings and demand flexibility traded in qualified markets, besides other non-energy services. The main markets where frESCO intervenes are: the electricity market, including the wholesale and domestic retail markets, the emerging demand flexibility markets, and the self-consumption in the residential sector. Additionally, the energy efficiency regulations for buildings are studied with a focus on residential buildings.

This review reveals that there are still some limitations in the local electricity markets, especially concerning the participation of low-volume demand response in some markets, like wholesale and ancillary service markets, and the limitations for aggregated flexibility due to minimum volume bids and the lack of simple and accepted Measurement and Verification Protocols. For energy efficiency in buildings, the market is open and offers a variety of services based on energy performance contracts, but the domestic sector is rarely targeted due to low benefits and high operation costs.

Existing regulatory frameworks also offer a number of financing schemes and regulated aids, coming from both private funding such as investment funds, corporate bonds or crowdfunding initiatives, and from public funding mechanisms such as EU funds, national funds or

international financial institutions. These funding systems help to diminish the capital burden of the necessary initial investment but have been monopolised by high-investment projects related to renewable uptakes or building refurbishments.

The report is completed with an analysis of regulatory future trends based on the current state of the Energy Union, the short- and medium-term targets and the gap closing to reach these objectives at national level as stated in the National Climate and Energy Plans of the four demo countries. The conclusions of the regulatory future trend analysis lead to optimism, since the necessary and increasing uptake of renewable energy sources to meet the ambitious EU targets and the important size of the domestic sector makes room for a large number of end-users' participation in demand flexibility schemes and pay-for-performance efficiency services. The regulatory barriers identified in this report limit the project's service deployment, exploitation and replication potential for a near future, but they do not jeopardise the project demo activities in the four countries studied. Although the full potential of frESCO's set of solutions for residential prosumers cannot fully be deployed in all countries as of today, the necessary convergence towards 2030 and 2050's EU objectives will remove the existing local limitations concerning market and regulatory constraints.

1 INTRODUCTION AND OBJECTIVES

This document is the result of the work done in Task 2.2 "Evaluation of the regulatory and market framework on the demo-sites", led by CIRCE. This task is included in WP2 and is part of the research done to establish a baseline to accurately assess the Energy Service Companies' (ESCO) market in Europe and, particularly, at each demo-site country of the frESCO project, Croatia, France, Greece and Spain.

The new frESCO energy services and business models must accommodate the existing regulatory framework and market structure in the first stage, but they have to be prepared for the future regulatory trends, which are driven by European Union energy directives that envision a more active role of citizens and consumers. Domestic consumers will be empowered, not only to decide energy providers and generators, but also to become prosumers by investing in Distributed Energy Resources (DER). Ultimately, prosumers will be allowed to provide services to the electricity system by managing their own demand and participating in demand flexibility markets.

Although ESCOs have not played an active role in the domestic market yet due to e.g. unattractive payback periods, they represent a key actor for energy management solutions in both the energy efficiency market for residential buildings and the electricity markets for self-consumption/production and demand response (DR). This deliverable focuses on these two main markets and the regulations and practices that are currently in place. The results of these analyses will allow for an assessment of the regulatory framework for the implementation of frESCO services in each country and will set the basis for their replication potential throughout the EU (Task 7.4) and policy change recommendations (Task 7.5)

1.1 Task objectives and scope.

The specific objective of the task is to give an overview of the EU regulatory framework, moving down to national regulations in the demo site countries, identifying regulatory barriers at both grid and end-user level, and analysing future trends both in regulation and market practices. The top-down approach is described in the following figure:

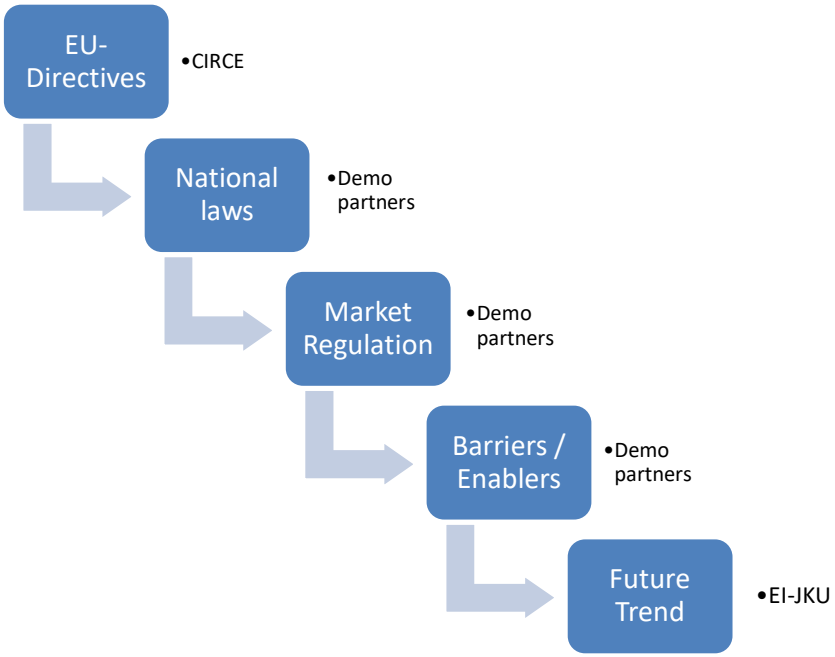


Figure 1. Top down approach for the regulatory analysis and markets at EU and demo-country level and involved frESCO partners.

1.2 frESCO Market identification

This report focuses on two main sectors for analysis, the energy efficiency of residential buildings, where the traditional energy efficiency market is located, and the electricity market that can enable trading of self-generated energy and demand response flexibility aggregated by means of the frESCO tool suit.

1.2.1 Energy efficiency in residential buildings.

The residential building sector is the 'traditional' ESCO sector despite the low presence of ESCOs for domestic residents. The regulation that has to be considered in this sector includes Construction Efficiency Standards, Building equipment characteristics, mainly for Domestic Hot Water (DHW) and Heating, Ventilation and Air Conditioning (HVAC). Finally, it is important to check the regulations on requirements for Renewable Energy Sources (RES) integration and the total building demand over the usage phase of its Life Cycle (LC).

For each aspect of regulation, this report focuses on different markets or activities. Building Standard Regulations deal with the Energy Efficiency market, building equipment affects

energy consumption, and hence, the demand management for flexibility provision. Finally, RES integration rules the self-consumption activities and the savings derived from it.

1.2.2 Electricity market for residential prosumers.

The European Union guarantees security of supply to all European citizens in the EU Energy Security Strategy Communication [1]. This is the traditional sector for electricity retail markets and aggregators. frESCO's regulatory analysis focuses on the domestic electricity supply sector analysing the electricity retail market and the main practices and tariffs in place that affect the economic value of the savings that can be attained by energy efficiency measures. As an innovation, frESCO set of tools will be able to aggregate demand flexibility from a number of consumers and trade it in available markets. The main application addresses the grid balancing efforts by grid managers and distribution operators (DSO) and the derived local and global Ancillary Service Markets, usually served from the generation side.

Both regulations and associated markets are shown schematically in the following chart.

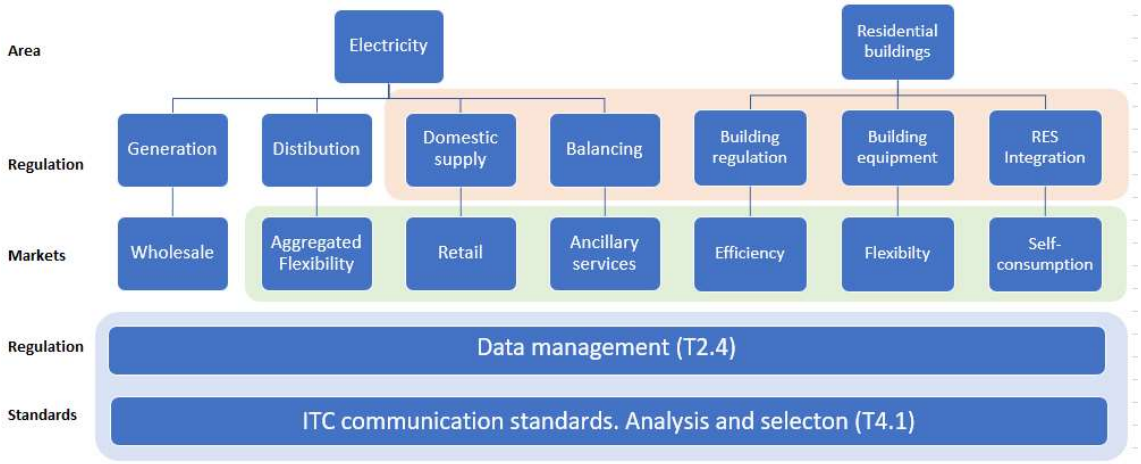


Figure 2. Schema of sectors, regulations and markets analysis.

Additional regulation that needs to be considered are the data management and protection rules. This topic is also covered in more detail in Task 2.4. Besides, ITC communication standards are dealt with in Task 4.1.

2 EU DIRECTIVES AFFECTING THE FRESCO PROJECT.

The European Strategic Energy Technology Plan (SET-Plan) is an integrated plan to boost the transition towards a climate neutral energy system through the development of low-carbon technologies in a fast and competitive way. One of the key areas is the development of new technologies and services for consumers [2]. This is the focus of frESCO , leveraging from existing big-data technologies that enable new personalised and human-centric services as a result of a joint cooperative research effort among companies and institutions from across the European Union.

The frESCO project is affected by the EU directives regulating the electricity market for domestic consumers, and the energy service market for residential buildings. The most recent European directives about the regulation of the internal market for electricity date from 2019 and are listed in **Error! Reference source not found.**Table 1. Directives for the promotion of Renewable Energy Sources (RES) and Energy Efficiency (EE) in buildings are from 2018.

Table 1 – Main EU regulations affecting frESCO

EU regulation	Topic
Regulation (EU) 2019/941 [3]	Risk-Preparedness Regulation
Regulation (EU) 2019/942 [4]	ACER Regulation
Regulation (EU) 2019/943 [5]	Internal market for electricity
Directive (EU) 2019/944 [6]	Common rules for the internal market for electricity
Directive (EU) 2018/2001 [7]	on the promotion of the use of energy from renewable sources
Directive (EU) 2018/2002 [8]	Energy Efficiency Directive
Regulation (EU) 2018/844 [9]	Revised Energy Performance of Buildings
Regulation (EU) 2016/679 [10]	General Data Protection Regulation

The EC has recently published the Renovation Wave Strategy [11] to improve the energy performance of buildings. With this strategy, the European Commission aims to, at least, double renovation rates in the next ten years and make sure renovations lead to higher energy and resource efficiency.

2.1 Electricity Market Directives

In 2019, the European Union issued the Clean Energy Package to prepare the way for an integrated and competitive EU electricity market, starting from the current fragmented national and local electricity markets. Four pieces of regulation are worth mentioning in the framework of frESCO setting the rules for this new future united market of electricity:

- Regulation (EU) 2019/941 [3] of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC [12] (Risk-Preparedness Regulation)
- Regulation (EU) 2019/942 [4] of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators (ACER Regulation)
- Regulation (EU) 2019/943 [5] of 5 June 2019 on the internal market for electricity (recast) (Electricity Regulation)
- Directive (EU) 2019/944 [6] of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (Electricity Directive)

This set of directives aims to facilitate the transition towards a decarbonised and decentralised European electricity system, transforming the current market rules supported by higher RES uptake, energy storage, electrification (mainly of transport sector, but also building HVAC) and flexible demand. The focus of this directive is to allow consumers and energy communities to take an active role in electricity markets, to adjust their consumption according to market signals and become service providers by accessing the markets to trade their demand flexibility and self-generated energy.

To ensure consumers direct market participation, Member States may put in place dynamic electricity price contracts provided in a competitive way by different suppliers and where customers and communities may switch freely at no extra charge. Billing information must be understandable, clear and accurate and based on smart metering, if possible. Self-generators must account separately the electricity consumed from the grid and supplied to the grid.

Concerning frESCO's ambitions, this Directive entitles customers to operate in demand response markets directly or through an aggregator, and actively participate in flexibility schemes and energy efficiency schemes, either directly or through third party energy management companies in charge of the installation, operation and maintenance (ESCOs).

Aggregated demand response flexibility should be allowed to participate, together with producers, in all electricity markets, including supply and balancing markets.

Another interesting novelty in this Directive is that all individual consumers and producers, whether individually or by means of energy communities, are made financially responsible for the imbalances they cause in the electricity system. This renders demand flexibility a suitable and cost-effective way to provide local balancing and avoid imbalance costs. Finally, interoperability of energy services of the kind frESCO is envisaging should be ensured to promote retail market competition and avoid excessive data handling costs.

The Electricity Directive should be transposed at national level legislation before the end of 2020. Therefore, all frESCO demonstration activities should take place within similar and flexible regulations depicted in the directives. However, delays may be expected in some countries. Results of the Directive implementation are expected to be reviewed in 5 years by the European Parliament and the Council.

2.2 Renewable Energy Source (RES) Directive

The Directive (EU) 2018/2001 [11] on the promotion of the use of energy from renewable sources (RED II) builds upon RED I and aims at increasing the EU target of RES in primary energy consumption from 20% to 32% allowing each Member State to apply support schemes. These support schemes go from reducing the cost of RES generation, to creating renewable energy obligations, by using investment aids, tax reductions and refunds, or direct price support programmes such as feed-in tariffs or market premium prices under competitive, non-discriminatory and cost-effective principles.

A novelty is that RES actions may be formed in each Member State. Distributors and System operators should dispatch energy on market-based criteria, abolishing priority to RES dispatch set by RED I, promoting the cost-efficiency of RES technologies in use.

As far as the frESCO project is concerned, RED II promotes the installation of highly efficient renewable heating and cooling systems in buildings, and opens local district heating and cooling to RES generators setting a minimum annual increase of RES in district heating and

cooling of 1% by replacing or expanding existing conventional heating and cooling systems with RES technologies.

The most important impact of RED II for frESCO is the explicit commitment of Member States to allow consumers to generate, store and consume their own energy from renewable sources, selling the excess of energy to the grid through Power Purchase Agreements (PPA), Peer-to-Peer arrangements (P2PA), or other support schemes while retaining their rights and liabilities as final consumers. These individual rights at consumer level should be also ensured at community level, where renewable energy communities will be allowed to participate in support schemes on equal basis with large participants for small installations. Energy communities will be ensured access to all suitable energy markets, directly or through aggregators in a non-discriminatory procedure.

Finally, RED II simplifies the legalization formalities for small installations, reducing the administrative burden, allowing simple-notification procedures for grid connection for installations not larger than 10.8 kW.

2.3 Building Efficiency Directive

The revised Energy Performance of Buildings Directive (EU) 2018/844 [9], the new EPBD, features a thorough revision of directive (EU) 2018/2002 [8] the so-called Energy Performance in Buildings Directive (EPBD). The new EPBD prompts each Member State to set a long-term renovation target to achieve a gradual renovation of the European residential building stock. Renovations must follow cost-effective approaches from a Life Cycle perspective, thus considering the energy consumption in the building use-phase as well. Public funding should leverage private investments in a transparent and non-discriminatory manner. A strategy involving the public building stock towards a nearly Zero-Energy Building (nZEB) stock was put in place in December 2018. Private new buildings should be nZEB from 2021.

The new EPBD specifies the requirements of technical building systems in new buildings and buildings going through major refurbishment works. The new EPBD also makes an effort to link financial incentives for the renovation of buildings to the energy savings achieved out of the refurbishment. This is related to the ESCO's Energy Performance Contract (EPC) schemes that frESCO intends to develop into Pay for Performance (P4P) contracts.

Finally, and very relevant for frESCO, the 2018 revision of the EPBD pays due attention to the building's smart-readiness and how to rate it as a function of interconnection capabilities with the grid and other intelligent devices, by means of a smart-readiness indicator (SRI) [14]. This indicator rates the ability of buildings to adapt their energy consumption to the residents' needs (energy efficiency) and to the various signals received from the grids (energy flexibility). This indicator can stimulate the use of building automation and monitoring to provide both flexibility and efficiency by means of enhanced functionalities based on big data algorithms. Efforts for the development of the indicator and the implementation were completed in the EU-funded VITO project [14]. A definition and calculation methodology was proposed by the Commission services in November 2019 [15].

2.4 General Data Protection Regulation (GDPR)

All frESCO data and information should comply with Regulation (EU) 2016/679 of 27 April 2016 [10] on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC [16], also known as General Data Protection Regulation (GDPR) [17]. There are several types of data handled by the frESCO project:

- Consumer personal data and opinions gathered through surveys, conducted interviews and other participatory processes. Given directly by the involved stakeholders and consumers after having been informed of the data privacy measures taken, the objectives and use of the information for project related studies and the non-disclosure commitment.
- Sensor measurements and energy meter readings, taken and used for the new service provision, with prior explicit consent of users.
- Third party data from other sources like market price indexes, weather station data etc.

Task 2.4 is fully dedicated to the customer research data handling, management and protection and a more exhaustive data protection analysis is provided in frESCO's deliverable D2.4 and in future deliverable D1.3.

3 NATIONAL REGULATION AND MARKET STRUCTURE

EU directives are transposed into national laws to enable a better fit into national regulatory systems and to take into account the social, economic and legal constraints of each country. This section briefly describes the regulations in force in the four demo countries, which affect the electricity markets and the building efficiency markets.

3.1 Spain

The approval of Law 54/1997 on the 27th November on the Electricity Sector [18], was the beginning of the process of progressive liberalization of the sector through the opening of the networks to third parties, the establishment of an organized energy negotiation market and the progressive reduction of public intervention in the management of the system.

The basic regulation that currently normalises the structure and operation of the sector is Law 24/2013, of 26th December on the Electricity Sector [19]. This rule maintains the distinction between regulated and non-regulated activities, already included in the previous rule, while promoting effective competition in the sector, introducing, among other measures, an increase in competition from so-called "reference retail companies" (*comercializadoras de referencia*), improving the position of the consumer regarding the information available and facilitating the processes of supplier change.

3.1.1 Wholesale and domestic Retail electricity markets.

The electricity wholesale market in Spain is divided into the following markets depending on actual energy delivery:

- Forward and future market: from weeks to years in advance, price is agreed upon today as a strategy to reduce risk for both price decreases (generator perspective) and price increases (large industrial consumer perspective). Electricity can be traded between market zones, requiring a previous purchase of the cross-border transmission capacity.
- Day-ahead market: electricity is traded one day before the delivery. This allows that, at the end of the day-ahead market session, scheduled generation equals the forecasted demand plus exports, balancing the market zone a day in advance. In this market, energy and

transmission capacity is traded together for cross-border allocation. Also, Balance Responsible Parties (BRP) submit their balanced portfolios to the TSO at the end of the day-ahead market.

- Intraday market: for delivery in a quarter or an hour, this market enables actors to correct changes in their day-ahead projections. After the intraday market, the BRP's intraday portfolio might result in imbalances. These differences are solved in the imbalance settlement market as mentioned before.

The day ahead market, or spot market, is run by OMIE[1] that sets up the daily auctions on an hourly basis to allocate the energy generation for the day-ahead based on the lowest price needed to cover the auctioned demand. The Transport System Operator (TSO) is Red Eléctrica Española (REE). They are in charge of ensuring the technical feasibility of the day-ahead programme, make the necessary changes and run the Ancillary Service markets for grid balancing at country level. Distributing companies (DSO) operate locally and regionally and are in charge of building and maintaining the medium and low voltage grids and provide the distribution and metering service to domestic consumers.

In respect to Renewable Energy Sources, only generators with a production power of at least 50 MW can participate as sellers in the wholesale market. Flexibility resources are able to participate in the spot market through demand bids with indication of price.

The electricity retail market in Spain is a fully open supply market where hundreds of retail companies compete with different sets of tariffs for the domestic and industrial consumers. Consumers have the right to choose their own supplier and type of contract. Fair market competition is controlled by the Agency for the Cooperation of Energy Regulators (ACER) and the National Regulatory Authorities (NRAs). NRAs must ensure all Member States comply with the EU regulatory policy and are responsible for imposing sanctions to operators according to the regulatory framework. The Spanish NRA is called The National Commission for Markets and Competition (CNMC).

In Spain, the retail market is not dealing with flexibility trading yet. There is no independent market for demand-side aggregation in Spain at present. The retail market is soon to deal with

[1] OMIE: Operador de Mercado, polo español. www.omie.es

the compensation schemes for the prosumers' surplus of self-generated energy, but this new activity is still in the deployment phase.

In the residential retail market, domestic consumers can choose between the free market and the regulated market. The regulated market tariff is determined by the Government and provided by a limited number of appointed traders, nominated by the Government to offer the so-called PVPC[2] tariff. Royal Decree 216/2014 [20] regulates this tariff, also allocated to those who have not explicitly chosen a free-market trader and those with a social tariff. PVPC is an hourly-based tariff with a fixed amount that is charged per unit of hired power and is regulated by the Government. This fixed amount is about half of the total electricity bill for an average household. The variable amount is about 30% of the total bill and is charged as a function of the electricity consumption. The rest are taxes (electricity tax for consumers, 5.11%, and Value Added Tax, 21%). The variable component depends largely on the energy wholesale market price and therefore, it is settled on the previous day, a few hours later after the day-ahead daily auction run daily by OMIE. PVPC or regulated ToU tariffs may be one or two periods.

3.1.2 Demand response Market

Spain is one of the few countries in the world where domestic default prices are based on hourly spot prices, which is important for **Implicit Demand response**. This is possible as the smart metering deployment programme is fully finalised as of today. However, these hourly-based prices only affect the default regulated tariff and the price signal from the cheapest to the most expensive hour is very low (about 1 cent€ on a day and 2-3 cent€ within a year). The real effect on implicit demand response is hence, limited.

Although the smart meter roll-out was completed in Spain in 2018, enabling real-time data reporting, distributing companies often publish meter readings on a daily basis and hence, one day later. This is not useful for implicit DR. However, this smart meter deployment might

[2] PVPC: Precio de Venta a Pequeño Consumidor. Default Regulated Retail Market Tariff for residential consumers in Spain.

contribute to the adoption of DR schemes since final demand flexibility settlements should be done on official meters.

Nowadays, the only **Explicit Demand response** scheme is the interruptible load programme, regulated by Law 24/2013 of the Electricity Sector [19], and managed directly by the TSO (Red Eléctrica Española REE). This scheme is available only for large industrial consumers having pre-qualified to take part in it. This programme is for congestion management and it is for emergency actions only, in case the system loses generation and the balance resources are not enough to cover all power. The total capacity is around 3,000 MW demand reduction in peak hours. It is only open in blocks of 5 MW and 90 MW, which is inaccessible for non-aggregated domestic loads. The interruptible load programme does not allow offering of aggregated demand directly to the TSO or the DSO. When large customers are connected to the DSO's network, the DSO does not participate in the programme, and it is not even able to forecast it in advance. The participants must have a specific ICT system, which links them directly to the TSO and not to the DSO to whom they may be connected. Therefore, the retailer's imbalance is directly managed by the TSO. In the auction for 2016, 2,890 MW of interruptible demand was assigned, with a total cost of €503 million.

The electricity system managed by the TSO remunerates both the curtailment power disposition and the energy actually curtailed by the TSO, should this curtailment take place. This programme has not been called on for years due to the good and renewed distribution grid and the decrease in demand due to the recent economic slump .

In terms of demand response flexibility markets, and according to the SEDC market of Explicit Demand response [21], the electricity markets in Spain are overall closed for demand response. Demand-Response aggregation is not allowed for now. In general, demand response does not have access to the balancing market nor to ancillary services, but since 2016, an exception occurs with generation based on decentralised renewable generation. Demand response is partially permitted only at the tertiary control band of balancing services, but not at the frequency restoration bands (primary and secondary). The flexibility served in this tertiary reserve is open since then to RES generators, in particular wind generators and it is the first step towards fully open markets, which is an important development in paving the way for aggregated demand response to participate in this market. In the same way, flexibility

resource units of at least 50 MW are allowed to bid in the wholesale spot market as a Virtual Power Plant (VPP).

There have been some pilot projects at city level such as those in Málaga and Barcelona smart cities' projects. More recently, REE has started to launch debates and meetings with relevant stakeholders to suggest the best way to open the markets to aggregated explicit demand response, beginning with the ancillary service market.

Table 2. Demand response market access in Spain

Market	Market status regarding DR
Wholesale (Intraday and day-ahead)	Wholesale market is limited to sellers with a generation capacity of at least 50 MW.
Frequency Containment Reserves (FCR)	Aggregated DR is not accepted in the balancing market. Since 2016*, decentralised and RES (in particular wind generators) have been able to participate in the RR. This might be a step forward for future demand-side flexibility participation. *Spanish Official Gazette (2016): BOE-A-2016-9364 "Resolución de 7 de octubre de 2016", published on 12 October 2016 [22]
Automatic Frequency Restoration Reserves (aFRR)	
Manual Frequency Restoration Reserves (mFRR) and Replacement reserves (RR)	
Other products	**Interruptible load Contracts.** There is an available capacity of 2,000 MW of demand reduction in peak hours. Only consumers with contracted power above 5 MW have access to interruptible demand service managed by the TSO, auctioned or based on annual bids.
Congestion Management	Does not exist.
Capacity mechanism	Only generators participate in CRM
Distribution Network Services	DSOs have the possibility to request the TSO to call for the use of the interruptible load service or ask for re-dispatching and curtailment of generators.

3.1.3 Self-consumption in the residential sector

Law 24/2013, 26th of December, of the Electricity Sector [19], in its article 9, defines self-consumption and distinguishes several modes of self-consumption without surplus or with it.

The regulation contained in the aforementioned Law 24/2013, of 26th December [19], in relation to self-consumption, aims to guarantee an orderly development of the activity, compatible with the need to guarantee the technical and economic sustainability of the electrical system as a whole.

The first regulation about self-consumption in Spain was RD 900/2015 [23]. This regulation sets up a monthly net metering self-consumption system where excess energy could be exchanged via the public grid on a monthly basis, thus allowing recovery of the excess energy not consumed at mid-day or in the summer for other consuming periods. However, both grid energy and self-generated energy had an added access and consumption levy to compensate the grid operator for using the grid as a buffer. These tolls made the investments economically unfeasible. The result is that almost no RES facility for self-consumption was installed in Spain from 2015 to 2020 despite the favourable and abundant resources.

Law 24/2013, 26th of December [19], of the Electricity Sector, in its article 9, was modified by the Royal Decree-Law 15/2018, of 5th October [24], on urgent measures for the energy transition and consumer protection.

In this sense a new Royal Decree RD 244/2019 [25] has entered into force in regard to self-consumption. This new regulation not only has removed the access and the consumption levyset up in RD900/2015 [23] but allows generators and consumers to share the same internal grid and benefit from collective generation facilities, as long as they are not more than 500 m from one another, or under the same transformer unit, or when production and consumption are within the same cadastral reference.

The following schemes or modes of self-consumption are distinguished:

Supply mode with self-consumption without surplus

- Corresponds to the modalities defined in article 9.1.a), in its current wording, of the aforementioned Law 24/2013, of 26th December [19].
- In this mode, the physical devices installed will prevent the injection of any excess energy into the transmission or distribution network. In this case, there will be only one type of subject from those provided for in article 6, which will be the consumer subject.

Supply mode with self-consumption with surpluses

• Corresponds to the modalities defined in article 9.1.b), in its current wording, of Law 24/2013, of 26th December [19].

• In this mode, the generation facilities can, in addition to supplying energy for self-consumption, inject surplus energy into the transmission and distribution networks for selling it or as well just for compensating it (simplified compensation mechanism). In this case, there will be two types of subjects from those provided for in article 6, the consumer subject and the producer, i.e. prosumer.

• With the aim to simplify compensation mechanism, a so-called simplified compensation mechanism was created.

• Finally, it should be noted that self-consumption can be individual or collective depending on whether it is one or more consumers who are associated with nearby production facilities and associated with consumer facilities.

What is the simplified compensation mechanism?

Within the mode of supply with self-consumption with surpluses, the producer may sell the surplus energy or benefit from the simplified compensation mechanism.

The latter is a mechanism designed so that small renewable consumers of up to 100 kW can offset the energy consumed through the grid with the surplus energy that they are not consuming at any given time. This mechanism allows deferred consumption throughout the billing period of the generated energy.

So this legislation (RD 244/2019 [25]) simplifies connection permission for small size facilities (< 100 kW) and establishes a compensation system for feeding excess electricity to the grid, to be negotiated by each user or community with a retailer company.

Furthermore, in relation to access and connection to the network, article 7 of Royal Decree 244/2019, of 5th April [25], includes the exceptions and simplifications provided for in Royal Decree-Law 15/2018, of 5th October. Therefore, the following are exempt from obtaining access and connection permits for generation facilities:

• All those self-consumption facilities covered by the modes of supply with self-consumption without surpluses.

• Those production facilities for self-consumption covered by the self-consumption modalities with surpluses and with a generation power equal to or less than 15 kW (that is the

case of the Madrid Demo-site, which is exempted) that are located on urbanized land that has the provisions and services required by urban legislation.

The rest of the self-consumption facilities must comply with the connection and access procedure to the network regulated in Royal Decree 1699/2011 [26], of 18th November, or in Royal Decree 1955/2000 [27], of 1st December.

Table 3. Self-consumption modalities in Spain according to RD 244/2019

Individual Self-Consumption. **One user associated** **OR** **Collective Self-Consumption.** **Several users associated**	Facility Installation **close to interior site (electrical) network**. Linked to interior electric network.	**WITHOUT Surplus** (individual) Zero Injection Mechanism. **WITHOUT Surplus.** **LINKED to compensation** (collective) Zero Feed injection Mechanism.	**CONSUMER** supply holder **PRODUCER** Does not exist **OPERATOR** Consumer **OWNER** Could be anyone
		WITH surplus **LINKED to compensation** Renewable source. Production Power ≤ 100kW. If applies, single contract for auxiliary consumption. Compensation Contract There is no other remuneration scheme.	**CONSUMER** Holder supply **PRODUCER** Holder Installation **OPERATOR** The one subscribed in the self-consumption register **OWNER** Could be anyone
		WITH surplus **NOT LINKED to compensation** Installations with surplus willing to sell energy.	**CONSUMER** Holder supply **PRODUCER** Holder Installation **OPERATOR** The one subscribed in the self-consumption register and RAIPRE **OWNER** Could be anyone

	Facility installation close to **through LV network**. Linked to a LV network belonging to the same electrical power transformer. Distance between consumption and generation < 500m, both linked to LV. Same cadastral code (firsts 14 digits).	**WITH surplus** **NOT LINKED to compensation** Installations with surplus willing to sell energy.	**CONSUMER** Holder supply **PRODUCER** Holder Installation **OPERATOR** The one subscribed in the self-consumption register and RAIPRE **OWNER** Could be anyone

Royal Decree 244/2019 [25], of 5th April, which regulates self-consumption, establishes the creation of coefficients to distribute energy in collective self-consumption. The value of these distribution coefficients depends on the agreement between the participants, with the only requirement that they be constant values. These criteria and coefficients must be included in the agreement between the parties that each consumer must send to the DSO directly or through their retail company. Annex I of Royal Decree 244/2019, of 5th April [25], establishes that:

> *"The value of these coefficients may be determined based on the power to be billed from each of the participating associated consumers, the economic contribution of each of the consumers for the generation installation, or any other criteria provided there is a signed agreement by all participants and provided that the sum of these coefficients βi of all consumers who participate in collective self-consumption is unity. In any case, the value of said coefficients must be constant".*

In the first place, the community should reach an agreement for the shared facility and those who do not wish to participate in the agreement should give their consent to the completion of the work, at least with regard to the use of common areas for this purpose. Those who freely participate must agree on a formula for the distribution of the electricity produced by the installation for self-consumption (in equal parts, by coefficients according to square meters (m^2) of each dwelling, according to individual consumption or demand contracted powers, proportion in which they participate in the cost of the installation, etc.). This agreement will have to be communicated to the distribution company (DSO) so that it can

apply that distribution formula to the different co-owners of the installation. Once the installation is completed, each neighbour will be able to take advantage of reductions in their energy consumption derived from the self-consumption of the electricity produced by the installation according to the percentage in which each of them participates. Among the possible consumers associated with a collective self-consumption installation, the supply to the common elements of the Community can also be included, which would be considered as one more consumer. This modality allows benefits from economies of scale and fewer required meters, which significantly reduces the price of the facility, while optimizing its production by combining consumption. In addition, these facilities could benefit from surplus compensation, which increases the individual savings of each neighbour. This is most likely the preferred approach for the Madrid demo site PV facility to be installed during the frESCO project.

In any case, both the individual and the collective generation facilities may be placed in the common neighbourhood community areas, such as the building roof top, as long as it is agreed in a neighbourhood general assembly, as established by the applicable legislation regulating neighbourhood communities (*Ley de Propiedad Horizontal*).

Currently RD 244/2019 [25] regulates a **static system of fixed distribution coefficients,** previously agreed upon. However, the fifth provision of Annex I leaves the door open to *modify, develop and include the mechanisms and requirements that are necessary to allow the implementation of* ***dynamic distribution coefficients*** *for collective self-consumption or associated with an installation through the network*».

Thus, at the date of this study (February 2021), Annex I has not yet been modified. The static coefficient system poses questions such as how excess or deficits of energy are dealt with. The only mechanism available is the compensation through a contract with a retailer.

3.1.4 Energy efficiency in residential buildings

In Spain, the two main regulations about energy efficiency in buildings are given by the Technical Building Code (CTE), issued by RD 314/2006 [28], and last revised in December 2019, and the Thermal Equipment Technical Regulation (RITE), issued by RD 1027/2007 [29]. The last version dates from 2013, updated after the Energy Efficiency Directive 2012/27/EU [13].

The ESCO market in Spain has undergone an unprecedented development in recent years since it was first launched by RDL 6/2010 [30], following a partial transposition of Directive 2006/32/EC [31]. This legislation defines the scope of energy services, linking economic revenues to energy performance, and provides some contracting templates for Public Administration contracting of energy services. However, the market is not regulated in-depth and the ESCO companies, mostly local installers and energy system designers and manufacturers, are left free to design and offer services, mainly to Public Administrations, where public lighting retrofit is the most successful service due to the high and certain savings expected and the large volume of contracts. ESCO associations (ANESE , AMI , A3E) try to differentiate from traditional installing companies by offering Energy Performance Contracts (EPC) and standardizing solutions. These contracts use Protocols of Measurement and Verification (PMV) are applied to large tertiary building contracts and Public Administration contracts, but they are scarcely used in residential building services.

The EED 2012/27/UE [32] stresses the role of ESCOs as enablers of the 20/20/20 objectives, proposing the ESCO's EPC with guaranteed savings as the best way to boost private investment in Energy Efficiency by both industrial and residential investors, and the use of District Heating and Cooling (DHC) and Heat and Power (H&P) systems. The lack of enough exemplary ESCO contracts with the Public Administration, the Spanish mild weather that cause DHC payback periods to be comparably longer, add to a lack of interest for ESCOs in the residential sector. High transaction costs and fragmented consumption are also factors that historically led to a poor development of the ESCO market in the Spanish residential sector.

Achieving the 2020 objectives requires investments both public and private; to renew equipment, heating & cooling installations and lighting in buildings (either residential or tertiary use) as well as to renew building envelopes. As for the implementation of this objective, Law 18/2014 [33] transposed EED's Article 7 about energy obligations into Spanish law and established, in accordance with Article 20 of that Directive, the National Energy Efficiency Fund (Article 72) administered by the Secretariat of State for Energy (Article 73). In addition, Law 18/2014 [33] creates a national system of energy efficiency obligations as well as a national fund meant to finance energy efficiency mechanisms for economic, financial,

technical assistance, training, information sharing and other measures about final energy consumption efficiency.

The" Royal Decree 56/2016" [34], 12th February, partially transposes Directive 2012/27/EU [32] with regards to energy audits, accreditation of energy service providers and auditors and promotion of energy supply efficiency. It also incorporates some definitions established in Directive 2010/31/EU [35], of 19th May, regarding the energy efficiency of buildings. Furthermore, Directive 2010/31/EU [35] is also partially transposed to the Spanish legal framework through the Royal Decree 235/2013 [36] and its modification in Royal Decree 564/2017 [37], which approve the basic procedure for the certification of the energy efficiency of buildings as follows:

1. No later than 31-12-2020, new buildings will be almost zero energy consumption buildings, as defined in the "Royal Decree 56/2016" [34], in relation to energy audits, accreditation of service providers and energy auditors and promotion of energy supply efficiency.
2. The new publicly owned buildings will be nZEB after 31-12-2018.
3. The minimum energy performance of new buildings is determined in the "Technical Building Code" (CTE) approved by RD 314/2006 [28], and revised in 2017 (RD 564/2017 [37]), setting the minimum share of renewable energy generation by type of building, and solar energy application (solar thermal or PV) by climatic zone for new buildings, as a percentage of expected energy demand. The CTE covers the building energy efficiency in five documents:

- HE0 Limiting energy consumption
- HE1 Conditions for energy demand control
- HE2 Conditions of thermal installations
- HE3 Lighting Facility Conditions
- HE4 Minimum contribution of renewable energy to cover the demand for domestic hot water
- HE5 Minimum power generation

According to the "Transitory Provision" of the above-mentioned "RD 564/2017" [37], the presentation or availability of the energy efficiency certificate shall be required for the purchase-sale or lease agreements coming in force since June 2013. This certificate issues an

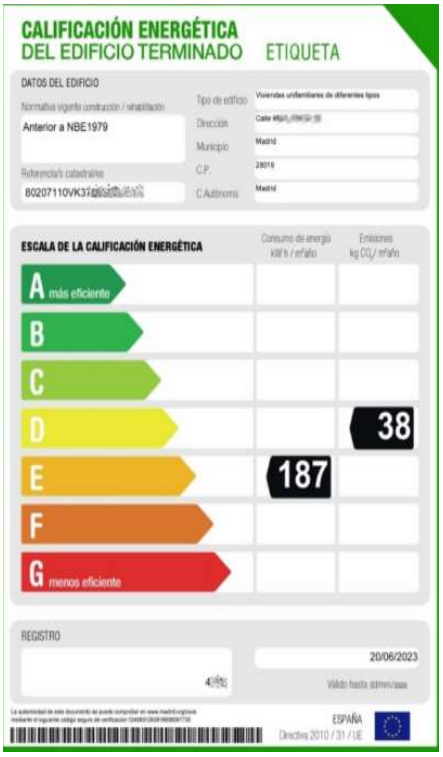


Figure 3. Building Energy Certificate in Spain

energy efficiency label, varying from class A, for the most energy efficient, to class G, for the least efficient.

The new Building Thermal Facilities Regulation (RITE) lays down the conditions that facilities must meet to meet the demand for thermal well-being and hygiene through heating, air conditioning and domestic hot water facilities, in order to achieve rational use of energy.

The technical instructions stated in IT 1.2 foster energy efficient installations by regulating these topics:

- Energy Performance in heat and cold generation equipment, as well as those for fluid movement and transport.
- Insulation in thermal fluid equipment and pipework.
- Better regulation and control to maintain the design conditions provided in the air-conditioned premises.
- Use of available renewable energy, especially solar energy and biomass.
- Incorporation of energy recovery subsystems.
- Mandatory consumption posting systems for collective installations

As a summary, steps forward for energy efficiency, energy certification and self-consumption in buildings are being taken as a result of the EU directive discussed above, but they mainly affect buildings constructed after these laws came into force. The real estate and financial crisis in 2010-2012 stopped the construction sector and few new buildings complying with the new regulations have been built since then due to the large stock of unsold dwellings in the country. More focus should be made in the refurbishment and energy remodelling of the existing stock of buildings to obtain short and mid-term results in the energy efficiency domain.

3.2 Greece

Law 2773/1999 [38] began the process of gradual liberalization of the electricity market, by allowing privately owned conventional producers to participate in the market, as well as privately held renewables (mostly wind farms) to be constructed. The right to choose one's supplier was initially available only to industries connected to High and Medium Voltage grids. With Law 4001/2011 [39], the structure of the market changed significantly, and the unbundling processes began, resulting in an Independent Transmission System Operator (TSO), an Independent Distribution Network Operator (DNO) and an Independent Market Operator (IMO).

In the meanwhile, the retail electricity market for residential consumers also became fully liberalized. Following some drawbacks in 2012-13, competition steadily grew the following years and a significant number of actors currently participate in the market, allowing consumers to choose between an appropriate variety of suppliers and billing plans.

3.2.1 Wholesale and domestic Retail electricity markets.

The wholesale electricity market in Greece is in a transition phase. Until 31/10/2020, the "Mandatory Pool" model was used. In short, this type of organized market obliges energy producers to submit Priced Production Declarations, sorted low to high, whereas suppliers and traders submit Non-Priced Load Declarations and a different market price is cleared for each hour, based on the Supply/Demand law in an aggregated level. Another characteristic of this market structure is that it utilizes a central dispatch approach.

Yet as of 1st November 2020 the electricity wholesale market is in accordance with the EU "Target Model".

That means that four distinct markets are now fully operational:

- The Forward Market (Futures): Energy is traded in both physical as well as financial aspects. This way, market participants (producers or suppliers) can hedge price fluctuations and improve their position.
- Day-ahead market (DAM): Electricity is traded in day D-1 with obligation for physical delivery in day D. At the end of the session, the generation schedule is created.

- Intraday market (IDM): This market enables participants to correct their energy positions that have occurred via the DAM procedures, taking into consideration the day ahead market results and possible limitations emerging from the balancing market. At the end of the day, balance responsible parties' portfolios are determined and are cleared in the Balancing market.
- Balancing market (BM): In this market energy imbalances are subjected to clearing, by the TSO. Dispatchable assets proceed to bids as Balancing Services Entities.

The Futures, DAM and IDM Markets are run by the Hellenic Energy Exchange (HEnEx) and the Balancing Market is run by IPTO (which stands for Independent Power Transmission Operator, i.e. the Greek TSO).

Renewables of a certain capacity and above depending on technology (e.g. for PV plants of 400 kW + installed capacity) participate in the market either through RES aggregators or as distinct entities, and are responsible for any imbalances they create. This is mandatory, regardless of the compensation scheme (Feed-in- Tariff or Feed-in-Premium).

Retail electricity market in Greece is fully liberalized with approximately 15 active suppliers. These suppliers offer a variety of contracts to residential and business consumers (SMEs and Industries), that differ from each other in both tariffs and structural ways.

Residential consumers have the right to select both the type of contract as well as their supplier. In general, markets are monitored by the Greek NRA (Regulatory Authority for Energy- RAE), that takes steps to enhance the integrity and transparency of the electricity markets. While this regularly applies to wholesale markets, RAE has recently taken steps to ensure that residential customers are offered both variable and fixed price contracts that can be validated by an average consumer.

A regulated tariff exists (Social Residential Tariff -Ministerial Decision 16027/6.8.2010 [40]) only for residential consumers, with economic and social criteria ensuring that a significant discount is offered to citizens that are considered to be energy poor. These discounts are offered in two categories (-75€/MWh and -45€/MWh), and are determined by the aforementioned criteria. Yet, these discounts apply only when residential customers do not exceed a pre-determined consumption (based on number of people in the household), and

thus could be regarded as an energy efficiency mechanism. The discounts and limitations are revisited when existing measures are deemed inefficient.

Variable contracts depend on the settlement prices of the DAS Market (and now DAM) and are applied in a retrospective manner. Yet, as a note, consumers' behaviour is rather irrelevant, since smart meters are deployed on a very limited scale so far and thus, they cannot actually control the energy they are charged with.

3.2.2 Demand response Market

Flexibility services are not offered by residential customers at the moment and there is no structured market for demand-side aggregation. This is programmed to take place after the smart meters' roll out, that is already underway and is planned to be concluded by 2022. As it stands, residential consumers cannot actively participate in the market mainly due to such infrastructure reasons.

When the smart meters' roll out program is completed, flexible charges based on market price signals are expected to emerge, joined by the appropriate legal and regulatory framework.

At this moment, a demand-response market is available only for industries (Ministerial Decision 66759/9.7.2020 [41]). Similar to other EU markets, this mechanism compensates industries for their availability to curtail consumption on request by the TSO, as well as the actual curtailed energy. Severe penalties apply in case the industry does not comply when asked to curtail its load demand. This takes place in emergency situations, when the system is unable to maintain power or frequency specifications and load has to be balanced by the TSO.

According to this procedure, which is specifically defined in the Hellenic Electrical System Code, MWs of interruptible demand are auctioned and allocated to the lowest bidder(s). Cost for these services is covered by suppliers as an extra cost (in €/MWh) as well as by RES Producers.

The introduction of new markets (EU Target Model markets) is expected to cause the auctioned power to drop significantly by about 800 MW per year. The total auctioned capacity is currently 4500 MW per year. Demand side aggregation is not allowed at this point. Demand response mechanisms such as the above, do not participate in the Balancing Market or ancillary services.

As far as RES are concerned, only dispatchable RES units can actually participate in the markets as a Balancing Services Entity. Non dispatchable RES units are Balance Responsible Entities and are subjected to the Balancing Market rather than actively participating.

Energy communities (Law 4513/2018 [42]) are expected to play an important role over the next few years, as they could operate in both the capacity of a Virtual Power Plant, as well as aggregators of every kind, including RES aggregation, demand response aggregation etc.

3.2.3 Self-consumption in the residential sector

Government initiatives towards promotion of self-consumption and dispersed production in the residential sector are divided into two different actions as outlined in the sections below. Figure 4, also shows the necessary equipment required for these new modes.

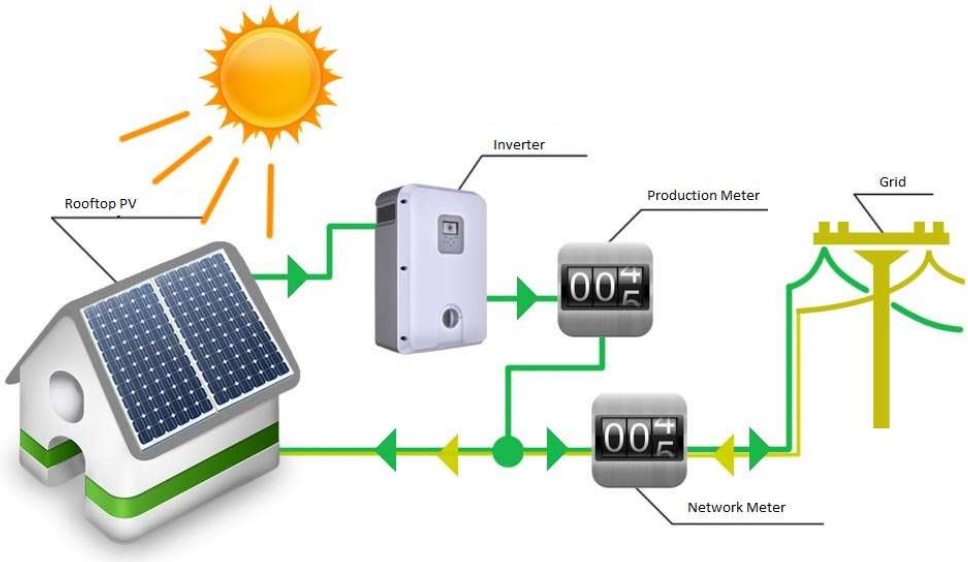


Figure 4. Self-consumption main components and schematic connections

3.2.3.1 Special Programme for buildings

The Special Program was launched on the 1st of July 2009 (Ministerial Decision Greek Gov. Gazette/1079 B/4.6.2009 [43]) in mainland and in interconnected islands and on 10th of January 2011 for the non-interconnected Islands. The maximum capacity per installation is defined as 10 kWp for the mainland, the interconnected islands with the mainland system, as well as for Crete and to 5 kWp for the rest of the non-interconnected Islands. This action offers the possibility to install Photovoltaic systems on buildings, which are used as a residence or

very small businesses, mainly on roof-top structures and roofs of legally-existing buildings, by the building owner. This also applies to public buildings as well. A necessary condition is the existence of an active power supply in the building of installation under the name of the PV system owner (natural/legal person). Additionally, when the building on which the PV system is installed is used as a residence, then as a prerequisite the fact that part of the thermic needs in hot water will be covered by the use of renewable energy sources (such as solar water heaters, solar thermal systems) is considered according to the Joint Ministerial Decision.

The PV system is connected with the Low and Medium Voltage network by using the same supply as the building consumption. This way, the measurement of the PV system generating energy and the measurement of the energy consumed by the installation are correlated and basically, they constitute a unified total. Yet, PV production and demand from the grid, are registered differently. The PV owner is considered as a self-producer and for this reason he is provided with the highest price and he is exempted from income taxation concerning the sale of the PV system energy. Only one such PV system can be deployed per beneficiary.

Subsequently, a Netting Agreement (**financial**) is signed by the PV owner and the electricity supplier of the building. The price of the energy generated by the PV system is defined by the relevant Ministerial Decision (2317/B/10.08.2012 [44]), that decays over time. The price that a prosumer can actually obtain at this point is 0.080 €/kWh. The Netting Agreement signed between the Supplier and the owner of the PV system is applied for a duration of 25 years, starting from the date of the PV system connection activation. If the PV owner switches supplier at some point the original Netting Agreement is cancelled and a new Netting Agreement has to be signed for the rest of the 25-year period, with the new applicable compensation prices.

The metering of the energy generated by the PV system is realized simultaneously with the consumed energy metering, that is, the same cycle of metering is applied with the one realized for the consumed energy.

The credit from the energy generated by the PV system is displayed on the electricity bill of the PV system owner. The electricity bill is considered as a purchase invoice. This amount of credit is offset with the obligations deriving from the Power Supply Agreement. In a case in

which the total electricity bill is a credit bill, the amount is credited to the bank account of the PV system owner on the expiration date of the electricity bill.

3.2.3.2 Net-metering rooftop installations

In contrast to the special Rooftop programme, net-metering installations (Ministerial Decision 24461/2014 [45]) do not perform financial netting, but energy netting. The maximum capacity per installation is defined as 20kWp or up to 50% of installation capacity (whichever is bigger) for the mainland, the interconnected islands with the mainland system, as well as for Crete and to 10 kWp for the rest of the non-interconnected Islands. This action offers the possibility to install Photovoltaic systems on buildings, which are used as a residence or very small businesses mainly on roof-top structures and roofs of legally existing buildings, by the building owner.

Similarly to the special programme for buildings, the PV system is connected with the Low and Medium Voltage network by using the same supply as the building consumption. This way, the measurement of the PV system generating energy and the measurement of the energy consumed by the installation are correlated and basically, they constitute a unified total. For this reason, the connection corresponds to the existing supply number of the property of the PV owner. The small capacity of the PV systems ensures that the generated energy corresponds to the one required for the coverage of the energy needs of the system owner, considering him as self-producer and for that he is provided with significant benefits. The capacity of the PV systems that can be installed per beneficiary is limitless.

Subsequently, a Netting Agreement (**energy**) is signed by the PV owner and the electricity supplier of the building. The Netting Agreement signed between the supplier and the owner of the PV system is applied for a duration of 25 years, starting from the date of the PV system connection activation. If the PV owner switches supplier at some point the original Netting Agreement is cancelled and a new Netting Agreement has to be signed for the rest of the initial 25-year period. The PV owner is not compensated for the produced energy of his/her PV installation, but is charged only if there is a positive difference between the electricity consumed minus the electricity generated. In case of excess electricity generation, the PV owner is charged for zero electricity by the supplier and excess electricity energy is virtually

stored in the grid until it is cleared at a later clearing cycle. Clearing is performed every four months. Every three years and in case of surplus energy, this is credited to a special RES Logistical account (RES Account), in favour of the system and the prosumer's energy balance is reset. Grid charges, as well as RES levies are applied to the electricity taken from the grid. Public Service Obligation (PSO) levies are applied to consumed electricity (Consumed electricity = electricity taken from the grid + Generated electricity - electricity injected in the grid).

The metering of the electricity generated by the PV system is realized simultaneously with the consumed electricity metering, that is, the same cycle of metering is applied with the one realized for the consumed energy.

Net metering can also take place in a virtual manner with the PV installation being located in a different area of the consumption to be netted. Yet this does not really apply to home owners, but rather businesses.

In both schemes, suppliers are compensated by the RES Account [46].

3.2.4 Energy efficiency in residential buildings

3.2.4.1 "Regulation on Energy Performance in the Building Sector – KENAK"

Law 4342/2015 transposes the 2012/27/EU [32] Directive to Greek National Law, especially regarding energy audits, energy auditors, energy service providers and energy efficiency.

As far as buildings are concerned, the following measures are in force:

- 3% of Public Buildings are retrofitted per year
- Public organizations are obliged to prefer energy efficient products, services and buildings (when leased, at least Class C)
- Since 1/1/2017 Utility companies (including suppliers) must achieve an aggregated energy savings target (1,5% per year) by 31/12/2020
- Incentives programmes are realized (Exoikonomo and Electra)

The main Legal and Regulatory document concerning energy efficiency in buildings in Greece is the "Regulation on Energy Performance in the Building Sector – KENAK" [47] (Ministerial Decision D6/B/5825/9.4.2010), that outlines the general calculation method and overall approach that is in accordance with European standards EN ISO 13790 2008 [48].

KENAK introduces the use of a reference building for benchmarking, the requirements for EPCs based on an asset rating accounting for heating, cooling, ventilation, sanitary hot water and lighting, the minimum energy performance requirements, and thermal envelope heat loss constraints, etc. The reference building is a carbon copy of the studied building with the same architecture and geometric characteristics, at the same location, orientation, use and operational characteristics, but it automatically adapts the characteristics of the building elements and electromechanical (E/M) installations in accordance with the minimum energy efficiency requirements.

According to KENAK, every building receives a score that effectively categorises it in classes of energy efficiency. The reference building is defined as class B. All other classes are defined as a percentage of the reference building's primary energy consumption. The building's ranking is based on the calculated primary annual energy consumption normalized per unit floor area (kWh/m²).

KENAK applies only to buildings that are constructed after it was issued, for which it is mandatory to be at least class B. For older buildings it is mandatory prior to sola, inheritance or leasing to issue an "Energy Certificate" (after an energy audit) that depicts thecurrent class. The last update dates from 2015 (Law 4342/2015 [49]) after the Energy Efficiency Directive 2012/27.

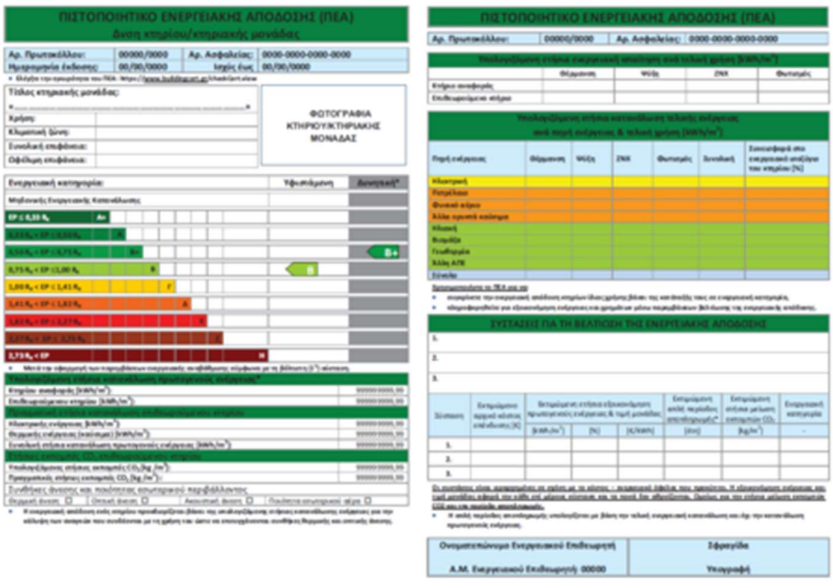


Figure 5 – A two-page Energy Certificate in Greece

3.2.4.2 ESCOs in the Greek Market

Energy Services and ESCOs in particular are defined and regulated by the Ministerial Decision 13280/2011 [50], last updated in 2018 (Ministerial Decision amendment 176381/2018 [51]). Legislation as a whole defines Energy Services, Energy Services Contractual Agreements, Revenue calculations and every other aspect of this market in general. Additionally, a registry of Energy Services Companies (ESCOs) is established and held by the Ministry of Energy.

Concepts such as Energy Savings, Energy efficiency improvements, Energy Services Company, Final beneficiary of Energy Services, Energy Services Contract, Energy Services budget etc., are defined in a flexible way that allows ESCOs to design and procure a variety of services.

In the beginning, ESCO services that were based on Energy Performance Contracts were limited to large-scale lighting retrofitting of large buildings due to the fact that savings were high and relatively easy to project over time, via Energy Performance Contracts (EPCs).

Another main aspect of Energy Services had to do with the Rooftop PV programme installations, since initial tariffs were significant when the programme began and consequently attractive to owners. As the prices degraded overtime, so did the demand for this particular service, as unattractive payback times began to emerge from rooftop PV production projects. Yet, demand for net-metering projects has gradually recovered, as retail prices (mainly of the incumbent supplier), started to rise. These projects do not usually take place in a performance manner, but in a classic Engineering – Procurement-Construction turnkey solution.

In general, ESCO services for residential consumers in Greece were stalling in other fields other than rooftop PV systems. This is due to a number of reasons that have to do with the climate situation in Greece (namely mild weather conditions) and a long payback period for instalments such as heat pumps, as well as with the severe economic crisis in Greece, that affected all kinds of economic activity in buildings. Yet, since 2018, there is renewed interest, mainly in retrofitting old buildings, but also in other energy services.

3.2.4.3 The “Exoikonomo” Incentive

The “Exoikonomo” programme, that literally means “I save”, was first introduced in 2011 (Joint Ministerial Decision 244/6/2011 [39]) and was an initiative by the Greek government to boost economic activity in buildings with a green agenda. Its total budget was 396 M € and the program remained active until budget depletion.

A household could benefit from the program to deploy a number of energy-saving adjustments to the building using government subsidies ranging from 15-70% (inversely proportional to household income). The target for each household was to ensure that it would move up by at least one KENAK Class or achieve 30% savings in comparison to the KENAK Reference building.

Since 2014, the program has been renewed by utilizing both EU funds as well as Public investment funds, but usually smaller than the initial budget (2018 budget: 292 mil €).

An updated version of the “Exoikonomo” funding scheme, started end of 2020, took into consideration the increased interest in energy efficiency by household owners and the new allocated budget is 850 mil €. For the first-time actions for smart energy systems (including storage equipment), that could lead to energy autonomy can beeligible for funding. Additionally, EV charging points, smart Heating/Cooling Systems, remote control smart Home Systems and IoT devices are eligible under similar circumstances as well. Subsidies can range from 55-85% (inversely proportional to household income). Also, apartment buildings as a whole can benefit from the programme and not only individual households.

This is expected to furtherincrease demand for energy services in Greece, mainly for refurbishment, retrofitting and energy redeployment of equipment in the following years, giving ESCOs a great opportunity to evolve and offer new services and solutions.

3.3 Croatia

The whole process of liberalization of the electricity sector in the Republic of Croatia commenced as part of the EU accession negotiations, as one of the conditions for the final membership. The ultimate goal of its liberalization was, above all, to increase competitiveness

in the electricity sector but also to provide customers the opportunity to choose a supplier from whom to buy electricity at an affordable price.

The entire process of harmonization with EU legislative framework started in 2012 following in 2013 with the introduction of the Electricity Market Act and the Energy Activities Regulation Act. Therefore, transmission and distribution remained regulated activities while production and supply of energy became market based. Thus, the retail market for residential customers became fully liberalised. Nowadays, several actors are participating in the market and customers may choose between various electricity suppliers.

Formally, the market is fully open but the overall maturity of the market for advanced services leaves room for improvement. Having in mind the scope of frESCO, which is delivering new business models for innovative energy services, the introduction of terms such as demand response or aggregator in the national regulatory framework should be mentioned. In this regard, in Croatia there is a specific situation where it is mostly energy efficiency regulations that are pushing the establishment of the energy savings market related to demand response potentials of buildings. In other words, as of mid-2020, the energy efficiency law and related acts are the most advanced in the Croatian energy system legal framework.

3.3.1 Wholesale and domestic Retail electricity markets

The Electricity Market Act (OG 22/13, 102/15, 68/18, 52/19) [52] defines rules and measures for secure and reliable generation, transmission, distribution and supply of electricity, as well as for electricity trade and organization of the electricity market as part of the European Union's electricity market. Furthermore, rules relating to the protection of final customers, the organization and functioning of the electricity sector, open market access, the determination of general service obligations and the rights of electricity customers are defined.

Pursuant to Article 10, paragraph 3 of the Electricity Market Act (OG 22/13, 102/15, 68/18), the electricity producer has the right to provide ancillary services and balancing energy under the conditions set out in the law. The electricity producer is therefore obliged to provide ancillary services to both transmission and distribution system operators. As the Electricity Market Act represents the "umbrella" Act for all energy-related activities, several terms are still pending to be defined: demand response, new energy services – aggregated demand

response, active customer (prosumer), aggregator as a new energy market entity, energy cooperative and customer data protection.

In compliance with the Energy Market Act, the Croatian Energy Market Operator (HROTE) with the consent of the Croatian Energy Regulatory Agency (HERA) prescribes Rules of Organizing the Electricity Market (OG 107/2019) [53]. The rules determine the market model, operation, types of contracts, products for trading, standards and procedures for registration, production, verification and change of daily electricity purchase schedules, rules and procedures for user's network related measurements data exchange and the rights and obligations of market participants. Additionally, rules for organizing balancing groups within the Wholesale Market, relations between the balance responsible parties (BRPs) and the Croatian Energy Market Operator (HROTE) as well as relations between BRPs and balancing group members are set. Rules are also regulating market planning for the day ahead and the delivery day. Similar to the Electricity Market Act, several terms are still not defined: aggregator, energy cooperative as well as the terms of trading, responsibilities, and other obligations required for market participations. It is imperative to define what is demand response, flexibility service provider and the model for market participation of the flexibility provider.

All wholesale electricity market activities are performed on the Croatian Power Exchange Ltd. (CROPEX) market, which is responsible for organizing and operating CROPEX Markets in the Republic of Croatia. CROPEX Markets consist of the Day Ahead Market and the Intraday Market. Power exchange is a central place for trading electricity between buyers and sellers. Members of the power exchange can all be market participants who have the right to trade on the Croatian electricity market.

Trading on a short-term market is conducted through a central auction with gate closure time as a deadline for submission of orders with delivery on the next day, with the calculation of the marginal market price. The price is determined on the basis of aggregating all purchase and sale orders received by the power exchange members in a way that, based on their orders, the aggregated supply and demand curve is formed, for each hour of trading. The intersection of these curves gives the market price and the members of the power exchange whose orders have been accepted trade electricity with the same unique price for a specific hour of trading. [54]

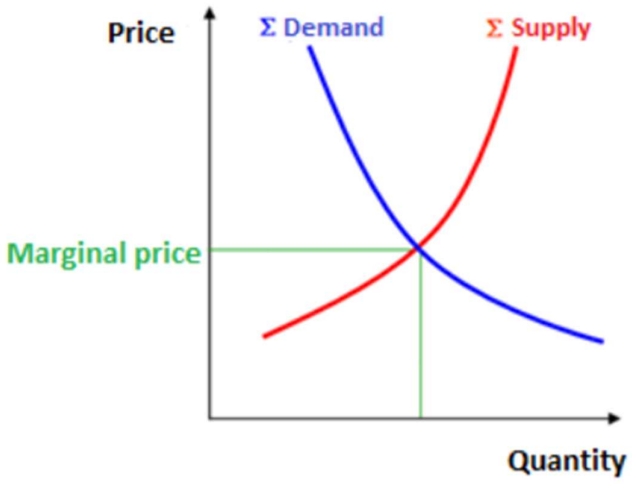


Figure 6 Day Ahead Market price definition CROPEX [54]

The intraday market is a market for continuous trading in products during trading hours where transactions are matched automatically when concurring orders are registered in the Intraday trading platform. Transactions may be made up to 30 minutes prior to delivery and the gate opening is at 15:00 D-1. [54]

Concerning the **Retail Market**, from July 2008 the market is open for all electricity customers, including household customers. A supplier is an energy entity with the licence to perform the activity of electricity supply and is allowed to buy and sell electricity in the market. Liberalisation of the electricity market has enabled suppliers to enter the market, and customers the right to choose and change electricity suppliers according to their own preferences. The Croatian Energy Regulatory Agency (HERA) monitors the electricity market in the Republic of Croatia. A register of suppliers licensed to perform electricity supply activities is available on the HERA website [55].

The final electricity cost of a household consumer consists of the energy generation cost, costs for the use of the transmission and distribution network and other fees determined by law (i.e. fees for stimulating renewable energy sources and value added tax (VAT). All customers from the household category, regardless of whether they are supplied within the universal service (assigned supplier in the absence of selection) or through the market supply, pay their supplier a unique bill for both electricity and network use. [56]

In the Republic of Croatia, single-tariff and multi-tariff meters are used by household consumers, thus depending on the type of meter, electricity consumption is calculated

accordingly. With a single-tariff meter, electricity is always calculated according to the same daily tariff, i.e. the price per kilowatt-hour is the same throughout the day. With a multi-tariff meter, depending on the choice of the tariff model the electricity cost calculation can be executed according to the same daily tariff or to the higher and lower daily tariff mode (Tariff model Blue, White and Red). During wintertime, the higher tariff covers the period between 7-21 hours, and the lower tariff applies in the period between 21-7 hours. During daylight saving time, the higher tariff covers the period between 8_22 hours, and the lower tariff covers the period between 22-8 hours. Most household consumers connected to the low voltage grid in the Republic of Croatia choose the White Tariff model, which consists of tariff items for the following tariff elements: working energy at a higher daily tariff (HRK / kWh), working energy at a lower daily tariff (HRK / kWh) and fee for billing metering point (HRK / month). [57]

3.3.2 Demand response Market

Both DSO and TSO are able to purchase flexibility (demand response) under bilateral contracts from ancillary service providers in line with the respective Grid Codes.

According to the Distribution Network Grid Code [58], the contract for providing ancillary services (in this case demand response) should be concluded between the grid user and the grid operator which in sequence determines the procedure and the terms of providing ancillary services to the system operator, the methodology for calculating the use of those services, the contract duration, notice period, warranty etc.

In the Transmission Network Grid Code [59], for each type of ancillary service, the TSO conducts a validation process and monitors the declared parameters and the ability of network users to provide such services.

It is imperative to point out that, in order to achieve full integration of demand response as a mechanism to provide ancillary services in the demand response market for operators, a relative DSO-TSO coordination platform needs to be developed. In the Republic of Croatia, a demand response market in a wider term exists solely as mFRR balancing service for the Croatian TSO – HOPS.

3.3.2.1 mFRR balancing service from Demand Side Response ('DSR')

The Croatian TSO HOPS started a pilot project in 2018 'Securing Manual Frequency Restoration Reserves (mFRR) balancing service from Demand Side Response (DSR)'. Upon TSO request, DSR providers can reduce or redirect their consumption and thus provide balancing services. After signing the contract with HOPS to provide the mFRR balancing service, DSR providers can participate directly in the balancing market and are paid according to the fee set in the Balancing Service Agreement. DSR can be provided by providers that can reduce their consumption upon TSO request. User sites usually have devices such as electrical furnaces, pumps, compressors, etc which are able to provide flexibility within a certain time.

Potentially interested DSR providers must pass through the prequalification process and upon completion can sign the Balancing Service Agreement. The public tender for securing mFFR balancing services from DSO is issued on a weekly basis. Offers need to be submitted by 12pm of the second working day of the week for the next week (e.g. on this Thursday by 12pm for providing services next week from Monday to Sunday). All prequalified users that have signed Balancing Service Agreements for DSR with TSO can submit offers. HOPS publish the required total capacity on a weekly basis, and currently the amount of balancing capacity from DSR is 46 MW. Balancing capacity offers are selected starting with the least expensive to most expensive offer price to the full balancing capacity amount.

When all offers are submitted, HOPS forms a merit order list. If HOPS decide to activate a DSR capacity provider, the request will be made via phone call. The service provider must activate the service within 15 minutes from the call. Of course, the lowest price service provider will be called first. [60]

3.3.3 Self-consumption in residential sector

In compliance with the Act on Renewable Energy Sources and High-efficiency Cogeneration (OG 100/15, 123/16, 131/17, 111/18) [61], the end-user with own production is determined as a an energy consumer on whose installation an electrical energy generation plant from renewable sources or high-efficiency cogeneration is connected, which meets the needs of self-sufficiency with the ability for delivering excess electrical energy to the distribution or transmission network. Correspondingly, self-consumption of electrical energy is defined as

meeting own electricity needs (self-sufficiency) from the generation plant connected to the consumer installation.

According to Article 44 of the aforementioned Act, electrical energy suppliers are obliged to take over the electrical energy surpluses from the end-users with own generation or users of plants for self-consumption which cumulatively meet the following requirements:

- have the status of a preferential electricity producer (ex-feed in tariffs user);
- the total connected power on a single billing metering point does not exceed 500 kW;
- the connected power of a consumer with own generation or user of plant for self-consumption in the direction of delivering energy does not exceed the connected power of the related consumer in the direction of electricity supply;
- consumer with own generation or user of plant for self-consumption delivers electricity through the same billing metering point as buys grid electricity from the supplier;
- consumer with own generation or user of plant for self-consumption stores and monitors the data of produced and delivered electricity to the grid.

The electricity takeover is regulated trough the supply contract, which is concluded between a consumer with own generation or a user of a plant for self-consumption and the supplier which contains provisions of electricity surpluses takeover. Grid fees are calculated based on the difference between the delivered and supplied energy in the respective tariff.

3.3.4 Energy efficiency in residential buildings

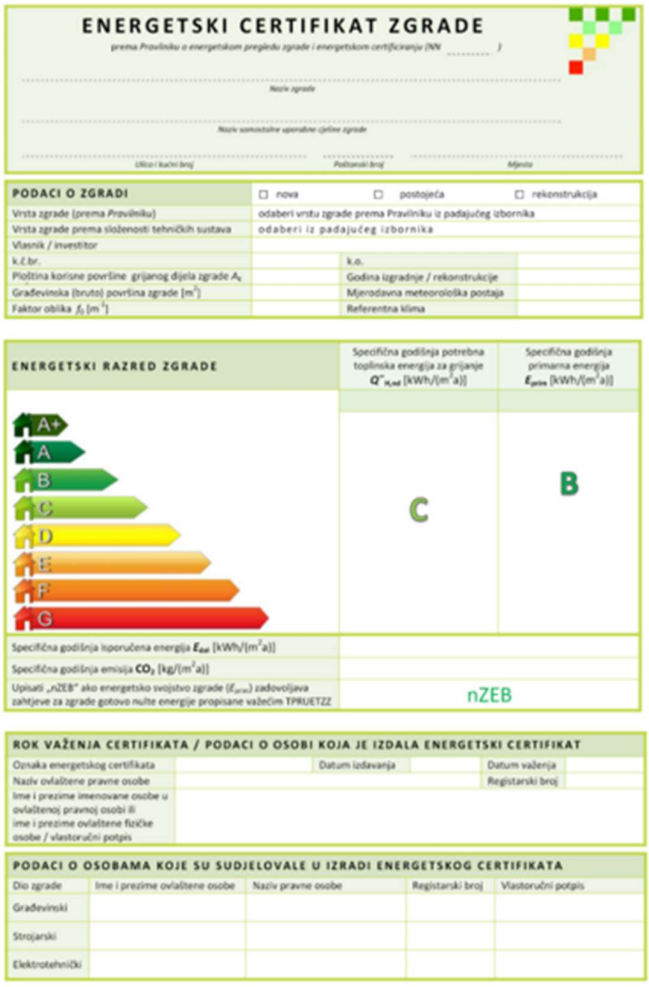
3.3.4.1 Energy certificates obligations for residential buildings

The energy certificate is a document that displays the energy performance of buildings and is made by authorized persons – energy auditors. The Ordinance on Energy Audit of Buildings and Energy Certification (OG 88/17, 90/20) [62] regulates terms and conditions for the implementation of building energy audits and regular checks of the heating and cooling systems or air conditioning in the building, the contents of the report on these inspections, the way energy certification, content and appearance of the energy certificate and criteria for low-energy buildings, managing energy and water consumption, and finally identifying measures to improve energy efficiency and their cost-effectiveness.

Pursuant to the Ordinance, a residential building is defined as a family house or an apartment building in which more than 90% of the construction (gross) area is intended for housing. The energy certificate is compulsory for all residential buildings except for buildings which are used less than four months per year or are a detached building with less than 50 square meters. The investor, i.e. the owner of the building is obliged to obtain an energy certificate before issuing the use permit, unless otherwise prescribed by law. The owner of a building or a part of a building is obliged to obtain an energy certificate before selling, renting or leasing a building or a part of it and to present it to the future buyer, tenant etc.

Residential and non-residential buildings are classified into eight energy classes according to the energy scale from A + to G, with A + denoting the most energy-efficient and G the most energy-unfavourable class. Parameters all calculated and scaled based on reference climatological data.

In the process of energy auditing the following systems are analysed: methods for energy management, thermal conditions of the building envelope, thermal system; cooling system; HVAC system; hot water preparation system; system for electricity supply, distribution and consumption; lighting system; water supply.



ENERGETSKI CERTIFIKAT ZGRADE

prema Pravilniku o energetskom pregledu zgrade i energetskom certificiranju (NN _____)

Naziv zgrade

Naziv samostalne uporabne cjeline zgrade

Ulica i kućni broj | Poštanski broj | Mjesto

PODACI O ZGRADI	☐ nova ☐ postojeća ☐ rekonstrukcija		
Vrsta zgrade (prema Pravilniku)	odaberi vrstu zgrade prema Pravilniku iz padajućeg izbornika		
Vrsta zgrade prema složenosti tehničkih sustava	odaberi iz padajućeg izbornika		
Vlasnik / investitor			
k.č.br.		k.o.	
Ploština korisne površine grijanog dijela zgrade A_k		Godina izgradnje / rekonstrukcije	
Građevinska (bruto) površina zgrade [m^2]		Mjerodavna meteorološka postaja	
Faktor oblika f_o [m^{-1}]		Referentna klima	

ENERGETSKI RAZRED ZGRADE	Specifična godišnja potrebna toplinska energija za grijanje $Q''_{H,nd}$ [kWh/(m^2a)]	Specifična godišnja primarna energija E_{prim} [kWh/(m^2a)]
A+ / A / B / C / D / E / F / G	C	B
Specifična godišnja isporučena energija E_{del} [kWh/(m^2a)]		
Specifična godišnja emisija CO_2 [kg/(m^2a)]		
Upisati „nZEB" ako energetsko svojstvo zgrade (E_{prim}) zadovoljava zahtjeve za zgrade gotovo nulte energije propisane važećim TPRUETZZ	nZEB	

ROK VAŽENJA CERTIFIKATA / PODACI O OSOBI KOJA JE IZDALA ENERGETSKI CERTIFIKAT					
Oznaka energetskog certifikata		Datum izdavanja		Datum važenja	
Naziv ovlaštene pravne osobe				Registarski broj	
Ime i prezime imenovane osobe u ovlaštenoj pravnoj osobi ili ime i prezime ovlaštene fizičke osobe / vlastoručni potpis					

PODACI O OSOBAMA KOJE SU SUDJELOVALE U IZRADI ENERGETSKOG CERTIFIKATA				
Dio zgrade	Ime i prezime ovlaštene osobe	Naziv pravne osobe	Registarski broj	Vlastoručni potpis
Građevinski				
Strojarski				
Elektrotehnički				

Figure 7 Energy certificate of a building (Croatia) – page 1 of 4 [62]

Residential buildings can be exempted from the obligation for regular checks of the heating and cooling systems or air conditioning in the building provided they are equipped with a function of continuous electronic monitoring which measures the efficiency of the system and informs the owners or informs building managers of significant reduction of efficiency and required system servicing and efficient management functions to ensure optimal generation, distribution, energy storage and use.

3.3.4.2 Obligations for energy suppliers set by the Act on Energy Efficiency

The Energy Efficiency Act (OG 127/14, 116/18, 25/20) [63] introduces the term 'aggregator' as 'a demand service provider that combines multiple short-term consumer loads for sale or auction on organized energy markets'. However, it should be noted that this definition needs

to be refined to allow participation of aggregators in the provision of balancing services and other ancillary services for network operators. The Act points out that dynamic tariffs enabling implicit demand response should reflect the curve of real time prices on the energy market especially during peak load times.

Additional stimulus for demand response proliferation which is set in Article 13 [63] can be found in the energy efficiency obligation. Namely, energy suppliers are obliged to achieve energy savings in final consumption by means of:

- investing in energy efficiency improvements and encouraging energy efficiency in final consumption in such a way that these investments are realized as new energy savings compliant to the Ordinance on the system for monitoring, measurement and verification of energy savings, not excluding investment in electricity generation equipment and electricity self-sufficiency, small and micro-cogeneration, advanced meters for monitoring energy consumption of final costumers and all related investments and encouragements for which the bond party proves new savings;
- purchasing determined energy savings;
- or paying the prescribed fee (as a penalty) to the Fund for Environmental Protection and Energy Efficiency of the Republic of Croatia.

The mentioned legal provisions allow suppliers to use energy savings delivered from demand response mechanisms to meet their energy efficiency obligations. On the other hand, energy services providers have the interest in including these measures in their portfolio, as they can sell the savings to suppliers (bond parties). It should be taken into consideration that this is solely possible for those types of demand response which implicate a complete avoidance (reduction) of a certain energy consumption and not just a delay of consumption. Hitherto, a methodology for determining energy savings by implementing demand response measure has still not been developed by the regulatory bodies.

3.4 France

To set the scene, the below figure illustrateshow the market is structured in France in terms of roles and responsibilities:

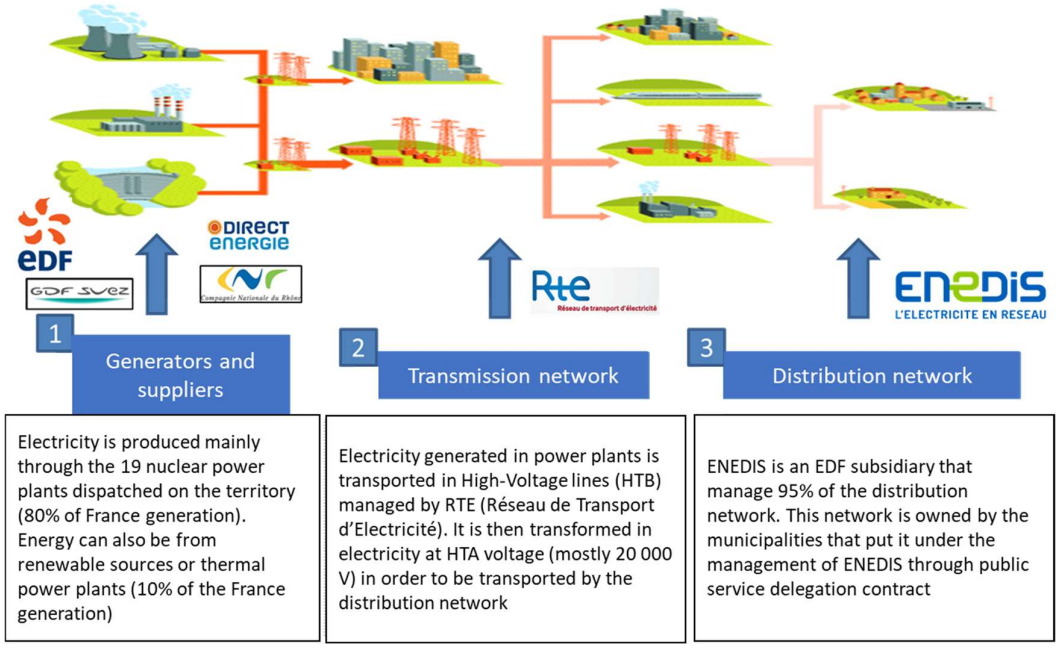


Figure 8. Energy market structure in France.

3.4.1 Wholesale and domestic Retail electricity markets

The French wholesale market is divided between the future energy markets and the spot markets. The future market lets market players negotiate electricity contracts bilaterally for delivery in the future: weeks, months, quarters and even years. Those future products are standardized so as to facilitate their exchange on the market. The prices allow market players to hedge in advance the revenue from their power production or the cost from their power consumption.

The spot market encompasses the day-ahead and the intraday markets and are managed by the company Epex Spot. The day-ahead market prices, which are the reference price for the electricity market, result from a matching of selling bids and purchasing orders for the next day and it is done every day. The Intraday market on the other hand is a continuous market where orders are traded up until 5 minutes before the delivery period. On the intraday market, a trade is executed as soon as a sales order matches a purchase order.

The figure below shows how the global demand response is handled in France and why different markets are integrated in this global balancing.

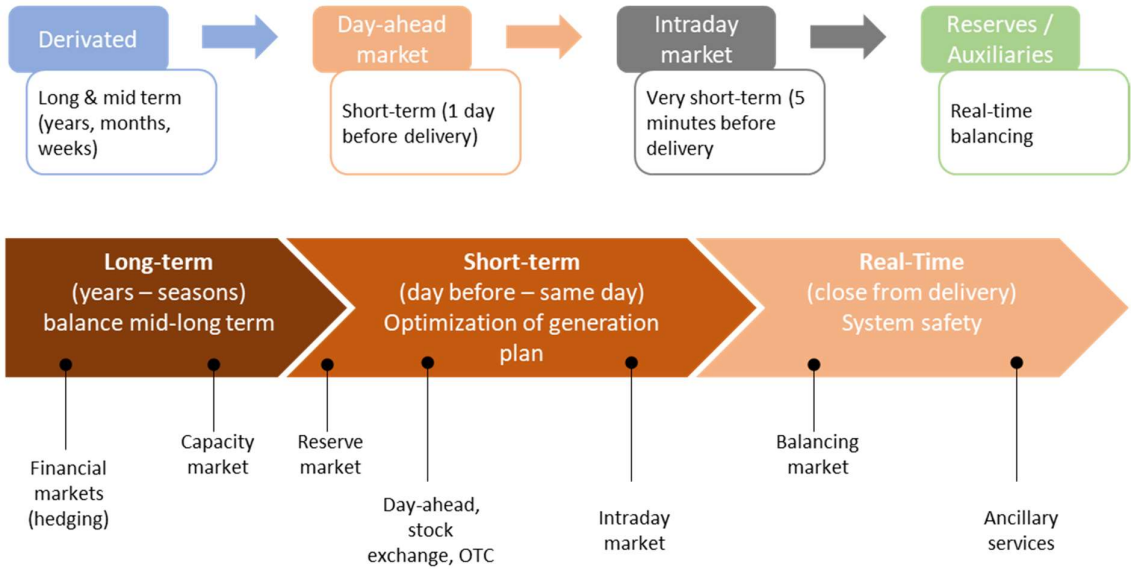


Figure 9. Global demand response mechanisms in France's electricity market.

Capacity Market

This market exists since 2016 in order to allow the different players to valorise their different power capacities towards electricity providers that are obliged to be balanced. These players obliged to be balanced are called *"Acteurs Obligés"*. They therefore need to buy a *Capacity Guarantee* (GC) equivalent to the level of consumption of their customers during national peak demands. The GCs can then be exchanged through regular bids or directly over-the-counter between players. This mechanism has replaced public tenders as the mechanism to push for more capacity to support the Grid during the peak hours.

Due to the high penetration of electric heating, the French market accounts for half of the thermosensitive market in Europe: if the temperature drops by 1°C, it is estimated that the peak consumption will increase by 2.4 GW nation-wide. The demand peaks are defined by signals called PP1 and PP2 defining Grid stress times that may occur from 10 to 25 days per year.

This mechanism is only operating during the winter period, from October 1st to March 31st, from 7:00 to 15:00 and then 18:00 to 20:00 (10 hours per day).

Retail markets for residential customers

The French Energy Regulatory Commission (*Commission de Régulation de l'Energie,* CRE) defines residential power consumers as consumers whose yearly consumption is below 10 MWh and whose subscribed power is less than 36 kVA, they account for 86.7% of the consumers and 36% of the total consumption.

The market is fully open, and consumers have access to regulated tariffs (*tarifs réglementés de vente*, TRV) offered by classic retailers only and market offers that can be offered by classic and new retailers. Even though up to 29 retailers are active in the residential segment, 73% of consumers are still supplied by classic retailers.

3.4.2 Demand response Market

As of today, the French market is one of the most-advanced markets in Europe in terms of demand response. Demand response Aggregators (OE for *Opérateurs d'Effacement*) are allowed to participate both in Energy and in Capacity markets, here are the markets that are fully open:

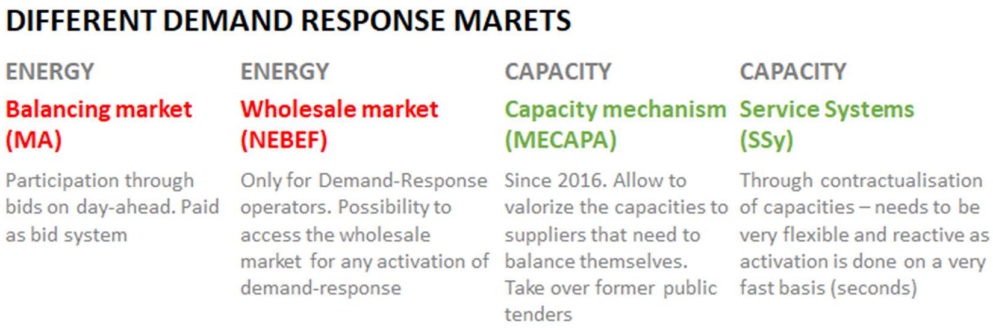


Figure 10. Different demand response markets available in France.

Since last year, as seen in the figure above, it has also been decided to start to open ancillary service markets to demand response. However, this is still limited to a maximum of up to 10 MW for aggregators in the ancillary service market.

Overall, demand response (and demand response operators) can access most electricity markets in France: balancing and ancillary services (primary and tertiary reserves), the

capacity markets and most notably the wholesale day-ahead market where aggregators can offer their flexible capacities that compete with power production units.

The ability to sell demand response volumes on the wholesale day-ahead market is essential as the balancing market is by nature smaller and very competitive as new technologies such as EVs and storage are allowed to participate.

However, even though demand response can participate in the wholesale day-ahead market, it is not on an equal footing with power production and faces significant entry barriers. Such barriers for participation would have the long-term consequence of preventing aggregators to build profitable business models and, therefore, preventing any flexible capacity to be offered to the power system. It is also important to note that such participation will be removed with the implementation of the European Directive EU 2019/444 [7]. Indeed, according to article 17, paragraph 4 of this directive, such financial participation cannot prevent aggregators from entering the market and further developing themselves.

Focus on the participation in the wholesale market

A series of rules published by the French TSO (*NEBEF rules* [64]) detail the participation of demand response aggregation in the spot day-ahead market. The rules specify a number of key points for the participation of demand response to the wholesale market:

- The possibility for demand response and demand response aggregation to bid on the market alongside power producers
- The ability for aggregators to use the data that they gather through their own metering devices for settlement purposes, such data can be audited by the TSO afterward.
- Rules to establish a consumption baseline, actual consumption is compared against the baseline to establish the actual amount of curtailed power.

However, demand response aggregators also have to compensate retailers for the curtailed power. Aggregators pay the electricity supplier a compensation for the electricity unsold to erased consumers. The erased consumers do not have any role except energy savings. Because of this, demand response cannot compete economically with production and this barrier to entry could in effect prevent DR to participate in the market and provide its flexibility

to the power system. Directive EU 2019/944 [6] guarantees that such barrier to entry should be removed, if it is implemented correctly by the Member States.

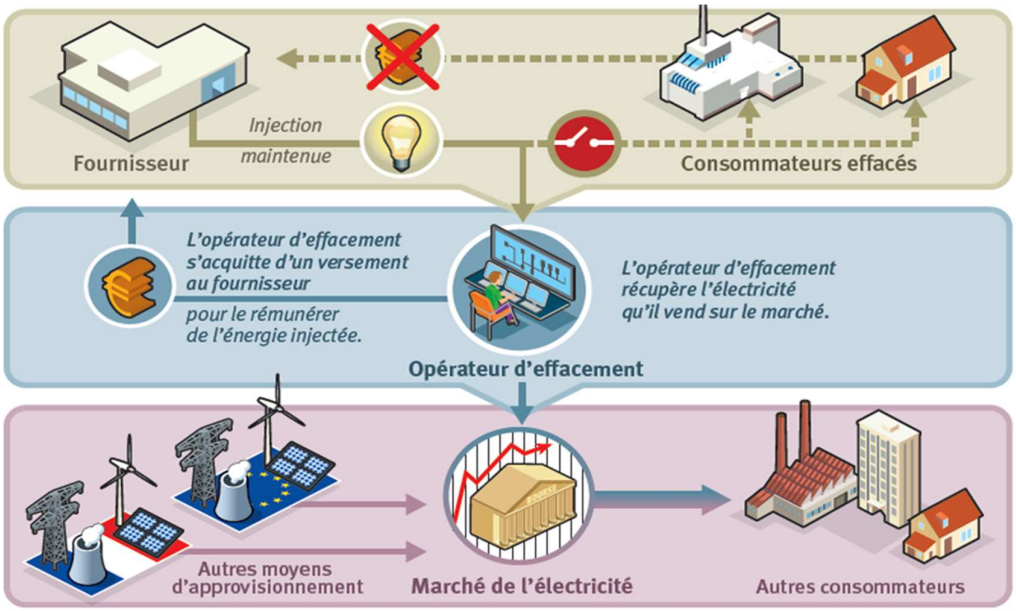


Figure 11. Wholesale market access for Demand Response Operators

3.4.3 Self-consumption in the residential sector

In France, 71,000 PV installations lead to a total capacity of 283 MW for self-consumption. 14,000 of them do not inject any power to the grid and 57,000 do. Installations between 0 and 6 kWp represent 96% of the installations and 80% of the capacity of installations that inject power on the grid [65].

Self-consumption is regulated by Law 2017-227 [66] of 24th February, 2017 and the Decree 2017-846 of 9th May. Grid operators have the obligation to connect residential PV installations to the grid and producers that connect to the grid have two options: either to sell the entirety of the production or to self-consume and only sell the excess power. The latter is encouraged, notably via a fixed bonus paid to the producer and based on the capacity of its installation.

It is also possible for several production and consumption points to be directly connected to each other, if they are all downstream of the same grid distribution transformer. This is called 'collective self-consumption'. Consumers need to be within 1 km of each other, even though it is possible to extend this limit to 10 km in rural areas.

4 FINANCING SCHEMES AND REGULATED AIDS

The implementation of energy-related projects like those of interest for the frESCO project can be supported through public or private funds. Public sources include direct and indirect EU funds, national and regional funds, International Financial Institutions (IFIs), National and International Development Banks, etc. Private funds include those from commercial banks, investment funds and crowdfunding platforms. Both kinds of funding bodies are interested, for different reasons, in supporting the energy transition process, with the aim on the public side to reach carbon-neutrality objectives set at EU level for 2050 and, on the private side, to meet mandatory and voluntary targets for socially responsible investments and minimum financial performances to generate revenues for investors.

Private financial actors offer both equity and debt instruments throughout the whole EU, although different players operate in different Member States or regions; they are generally more interested to support the implementation of projects already present in their portfolio, such as renewable energy production and energy efficiency.

Investment funds are generally interested in large-scale investments, at least totalling 5 or 10 million Euros, which may constitute a barrier to financing small projects at building level; another potential barrier is constituted by the required profitability in terms of Internal Return Rate (IRR) of minimum 7-8%. In some cases, it can hardly be achieved without public support.

To conclude the introduction to private sources, crowdfunding may be an interesting solution for energy-related projects with small or medium size, since they typically support a mix of different small projects and accept a lower profitability (generally minimum 5%).

As concerns public institutional funding, in addition to direct funds provided by EU or national/regional authorities, a solution worth being mentioned is constituted by platforms set at EU level and implemented through IFIs and development or commercial banks allow de-risking energy related projects, thus reducing the cost of capital.

The funding opportunities briefly described above are schematized below and then analysed in the following paragraphs.

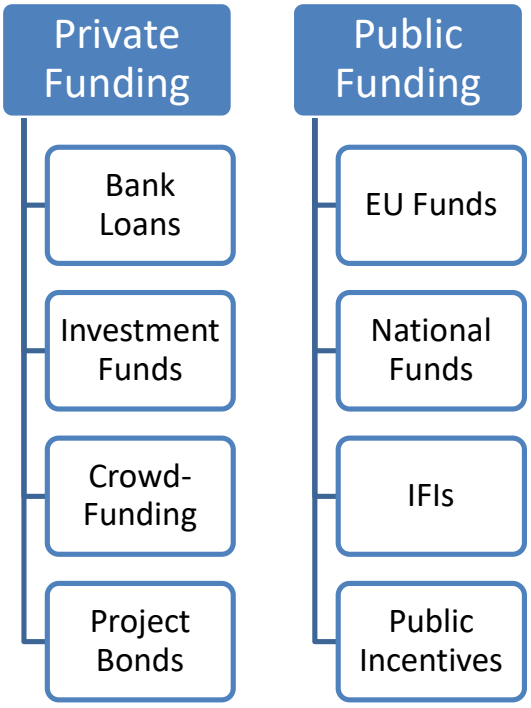


Figure 12: Scheme of Private and Public Funding Opportunities

4.1 Private Funding Opportunities

The most common financial product from private commercial banks is constituted by **loans**; they are applicable to projects of any scale and to any client, depending on the financial solvency evaluation of the borrower (corporate loans) or on the financial performance of the project to be realized (project-related loans). Funds provided by banks through loans can typically cover only part of the investment, with an equity component to be provided by the project promoter through equity or other sources of funding including public grants. Specific credit lines or financial products may exist for supporting energy-related investments, but these are generally related either to the presence of public incentives (e.g. transfer of tax credit) or to the support of an international financial institution (e.g. The EIB's Private Finance for Energy Efficiency (PF4EE) [67] facility and the EBRD with the Green Economy Financing Facility (GEFF) [68], implemented through local commercial banks).

Another potential source of private finance is constituted by **investment funds**, whose aim is to invest funds collected from individuals and corporate investors into medium/long-term risk capital of companies with high expected growth potential, in order to generate revenues for

investors. The time horizon of projects supported by investment funds is, at least, five years and may be longer for patient capital like those from pension funds. Investment funds specialized in energy transition projects exist, which different to commercial banks may also have technical experience in the sector to evaluate the potential risks from project implementation.

Crowdfunding is a funding scheme that relies on capital collected from a large number of private investors (both individuals and corporates) through an online crowdfunding platform [69]. In case of equity crowdfunding, investors are rewarded with the dividends generated by the supported company (or project) whereas in case of loan crowdfunding, investors are rewarded with their capital plus the agreed interest rate. This solution is particularly of interest for projects to be realized at small and medium scale, like in the case of the creation of energy communities, i.e. a group of citizens and small businesses acting jointly to self-produce energy from renewables.

Another potential opportunity is constituted by **project bonds** (also named "green bonds" when the focus of the investment is a sustainability project [70]), i.e. financial instruments aiming at collecting funds from individuals and corporate investors through the emission of bonds linked to the implementation of a specific project. These bonds may be issued by private companies or by Special Purpose Vehicles created among private companies or in the context of Private-Public Partnerships. They have a fixed duration and periodic settlements at a fixed interest rate, thus constituting an interesting source of finance for companies as an alternative or an integration of conventional bank credit, especially in the case of medium/long-term investments or refinancing of existing projects.

4.2 Public Funding Opportunities

Public investments in the energy transition are very important to reach national and EU level targets for energy efficiency, penetration of renewables and mitigating climate change. They may act directly to support the implementation of projects or indirectly to stimulate and mobilize private investments in specific areas like strategic infrastructures, enabling technologies, early-stage projects or solutions perceived as high risk by private investors.

Public funds may involve EU, Member States and regional/local authorities; however, the main sources of finance are related to EU funds (directly managed or managed by member states or by the European Investment Bank, EIB) and to national funds (direct or indirect, through regions or local banks).

As concerns **EU funds**, this is a quite generic definition and covers all opportunities falling under the umbrella of the EU Multi-annual Financial Framework; the EU budget is prepared on a 7-year horizon, with the last completed period being 2014-2020 and the next period with budget currently under discussion being 2021-2027 [71].

Over a half of the EU budget is articulated into five structural funds, i.e.: European Regional Development Fund (ERDF), European Social Fund (ESF), Cohesion Fund (CF), European Agricultural Fund for Rural Development (EAFRD), and the European Maritime and Fisheries Fund (EMFF). In addition, other programmes have been created like the Clean Energy for all Europeans and the European Green Deal packages, to support the EU energy transition through grants, loans and technical assistance.

During the 2014-2020 period, the EU had committed to allocate 20% of expenditures on climate actions, whereas in the 2021-2027 period it is expected to set a more ambitious target of 25% of expenditure contributing to climate objectives.

The support to energy transition is also a priority for single Member States, which typically allocate **national funds** to invest directly in projects related to public assets (public buildings, energy infrastructures, public transport systems, etc.) or to attract private investments through incentives and grants (e.g., for buildings retrofitting, for energy efficiency interventions, for renewable energy production, etc.). The mentioned national funds may, on one hand, rely on funds allocated from the EU budget or, on the other hand, be channelled through regions or other local authorities.

Another relevant potential funding body is constituted by **International Financial Institutions** (IFIs) and to a lesser extent also by national development banks. [72] The main actor in this field is constituted by the EIB, operating in all EU Member States, and for some areas also by the European Bank for Reconstruction and Development (EBRD, working – among EU Member States – in Bulgaria, Croatia, Cyprus, Estonia, Greece, Latvia, Lithuania, Poland, Romania,

Slovakia and Slovenia), the Black Sea Trade and Development Bank (BSTDB, operating – among EU Member States – in Bulgaria, Greece and Romania).

These kind of institutional banks typically provide direct financing only for large-scale projects (with CAPEX higher than 5 million Euro), whereas they implement credit facilities through local commercial banks (providing loans and guarantees) to support also smaller projects.

Two institutions and their most relevant credit lines are worth mentioning, i.e. the EIB with the Private Finance for Energy Efficiency (PF4EE) facility and the EBRD with the Green Economy Financing Facility (GEFF) initiative.

The EIB is an international financial institution with EU Member States as shareholders, having invested in 2020 an amount of 24.2 billion Euro towards climate change initiatives. The focus of EIB activities on energy is on four areas: unlocking energy efficiency; decarbonising energy supply; supporting innovative technologies; and new types of energy infrastructures and securing the enabling infrastructures. [72]

The EIB promotes, with the support of the European Commission, the Private Finance for Energy Efficiency (PF4EE) instrument, which aims at making energy efficiency lending a more sustainable activity within European financial institutions and at increasing the availability of debt financing to eligible energy efficiency investments. It operates through a 480 million Euros long-term financing to local banks, plus 80 million Euros to cover a risk sharing facility and expert support services. [67]

The PF4EE technical eligibility criteria differ according to the focus given in each Member State but are typically based on the investment belonging to a list of standard measures for low-CAPEX and on meeting specific criteria on percentage energy savings and Net Profit Value (NPV) of the investment for medium- and high-CAPEX (up to 10 million Euros of project cost and 5 million Euros of covered loan).

The EBRD is owned by 69 countries, plus the EU and the EIB, and operates to support the economic development in Central-Eastern Europe, Southern-Eastern Mediterranean, former CIS Countries and Central Asia [72]. The energy sector is a key area, with EBRD supporting projects to improve energy efficiency, move towards a low-carbon energy sector or mitigate climate change. The EBRD directly acts on large projects (from 3 to 250 million Euro), whereas smaller initiatives can receive support through local commercial banks.

A notable initiative is the Green Economy Financing Facility (GEFF) constituted by the EBRD, which supports companies and individuals wishing to invest in green technologies. Eligible projects include energy efficiency, renewable energy sources but also water and resource efficiency, circular economy and climate change mitigation and adaptation.

The GEFF program operates through more than 140 local financial institutions across 26 countries with almost 4 billion Euro of EBRD finance; over the last years, more than 130,000 clients benefitted from the programme, collectively avoiding almost 7 million tCO_2/y of Green House Gas (GHG) emissions. [68] The eligibility criteria for GEFF slightly differ from one initiative to another, but typically they include a maximum investment of a few million Euros, a minimum IRR of 10% for energy efficiency projects and 0% for renewable energy projects and an energy saving ratio of at least 15-20% compared to the baseline situation.

To conclude, among funding sources promoted by national and local authorities two are especially relevant in the context of the frESCO project: Public-Private Partnerships on one hand and public incentives to support private investments in the energy field on the other.

Public-Private Partnerships are created as cooperation between a private actor and a public institution in order to jointly realize projects on public infrastructures or assets of public interest [73]. Typically, a Special Purpose Vehicle (SPV) is created [74], with shares partly owned by the private company and partly from the institution and investment for project implementation shared among shareholders when needed, with the support of external financing sources. These kind of partnerships are typically characterized by long-term agreements, which also make feasible investments with relatively low-return and long payback.

In terms of **public incentives**, they are usually implemented in different ways in EU Member States. For instance, mechanisms rewarding the operation rather than the realization of projects are feed-in tariffs for renewable energy projects, which are paid by national regulatory authorities per unit of electricity produced, or white certificates for energy efficiency projects, which are issued per unit of saved primary energy. [75]

Another mechanism supporting the realization of investments is based on tax deduction, which allows subtracting from taxes part of the expenses borne for an energy efficiency or renewable energy project. This is applicable both to individuals and legal persons and is of

particular interest in Member States with high tax rates. The tax deduction can typically be recovered over a time-span of 5-10 years but in some cases it is also possible to transfer the tax credit to a bank or even to the contractor that realizes the works. [76].

Finally, it is worth commenting about the EU level measures to revamp the European economy from the COVID-19 slump. As a result, an important financial recovery fund is being mobilised by the European Union to act in several critical cross-European issues. Two of them are the energy transition (37% of the budget) and the digital transformation agenda (20% of the budget). It is expected that financial resources for these two sectors will be made available from 2022 on at European level. frESCO solutions target both sectors, which could facilitate a wider scope and extension of the frESCO solutions in a near future.

This financial fund is called “Recovery and Resilience Facility” (RRF), also known as “Next Generation EU” and amounts for up to 672.5 billion euros. It has been approved on February the 11th 2021 and 70% will be distributed between 2021 and 2022.

5 SUMMARY OF BARRIERS AND ENABLERS FOR FRESCO DEMONSTRATORS.

This section summarises the positive aspects of the current regulation and market structures that are helpful for the frESCO project objectives, and more particularly, for the demonstration activities in each country. The new energy services and business models should not only comply with the regulations in force, but also leverage from the mechanisms in place that are in line with the aims of the frESCO project. Additionally, it is important to pay attention to the limitations and barriers imposed by the current regulations, to minimise potential negative impacts for the project and be able to issue policy recommendations for more favourable regulation framework. This information will be later used as the base for T6.5 "Regulatory market reform recommendations" at the end of the frESCO project.

5.1 Spain

Enablers

- Self-consumption in Spain has been hindered by the net metering regulation enacted in 2015 RD 900/2015 [23], where investments at household level for self-consumption have been discouraged with barriers such as the so-called "Sun Tax". The new RD 244/2019 [25] enables a friendlier framework for individual and collective self-consumption, reducing the administrative burden, wiping off the tolls for the generated energy and entitling prosumers to be compensated for surplus energy poured into the grid.
    - Producers adhering to the surplus compensation schemes set in RD 244/2019 [25] may sell the energy surplus or benefit from the simplified compensation mechanism. This enables prosumers of up to 100 kW to partially offset the energy consumed from the grid with the surplus energy that they are not consuming at any given time.
    - Those self-consumption facilities sticking to the self-consumption modalities with surpluses and with a generation power equal to or less than 15 kW, are exempt from obtaining access and connection permits for generation facilities

(that is the case of Madrid Demo-site which is exempted), which has a clear impact in the residential sector.

- The new revised Technical Building Regulation (CTE) states the maximum energy consumption of new and refurbished buildings and sets a minimum contribution of renewable energy from different sources, usually solar thermal for domestic hot water (DHW) demand and solar photovoltaic for electricity demand. The CTE is mandatory for new buildings and refurbishment of the existing stock. As the old building stock gets refurbished or replaced by new buildings the energy performance of the buildings will increase, and so the demand for innovative energy services.
- The smart metering roll-out is finished and successfully completed in Spain. This system is crucial to set in place energy management systems and smart systems capable of monitoring consumption on real-time bases and allow for implicit or explicit demand response strategies in front of grid-driven requests and needs.
- Default regulated domestic retail tariffs are already hourly based, permitting implicit demand response strategies should the price signal be wide enough. A new regulation is being drafted to extend Time of Use (ToU) tariffs to at least 3 periods per day, and should be in place sometime in 2021.

Barriers

- It is important that electricity markets open to demand response bids for both wholesale energy supply and grid balancing services. Currently they are all closed to this energy source.
- The ban of demand response flexibility aggregation deters the participation of the domestic sector and SMEs in the wholesale and in the ancillary service markets.
- Although the smart meter rollout is fully completed in Spain, it has been done by the distribution companies operating regionally and locally. These companies are the owners of the metering equipment and hold the connection rights to the devices, usually issuing the readings to the retail companies once a month for billing. Although agreements can be negotiated with these companies to access the meters for real-time monitoring, it is not a common practice and energy service companies usually

have to install their own metering equipment to ensure real-time readings. This is the case in frESCO and it is a real barrier to have access to real-time metering.

- The large stock of buildings not adapted to the new stricter regulation on energy efficiency and the Real Estate sector slump slow down the renewal of residential buildings. Retrofitting and refurbishment strategies should be encouraged and supported to speed up the energy performance in the residential sector.
- There is not yet an efficiency obligation scheme in force as depicted in Article 7 of the EED. However, this can become an opportunity as soon as this directive is fully transposed in national law.

5.2 Greece

Enablers

- Electricity prices in Greece have risen significantly in the past 10 years. Only for the energy part of the bill, the rise is estimated at about 18-20%. This applies not only to energy alone, but also to grid fees and RES and PSO levies. Though an investment in self-consumption may have a significant initial construction cost, it turns out that in cases of high consumption the investment breakeven point is estimated at only 4-5 years.
- There is a large number of residential buildings in the Greek countryside, that are not inhabited all the time, but may be used as an installation point for purposes of virtual net-metering to counter-balance large hub demands and, at the same time, increase the asset value.
- Prices for the deployment of rooftop PV installations have dropped over the last decade to a point that an investment is feasible to middle incomes, in comparison to the situation before, when it was only available to higher income households.
- Since 2020, financial incentives have been in place for net metering installations, through Government programmes for PV rooftop installations and storage equipment.

Barriers

- Smart meters are an essential part of the self-consumption procedure, since they will allow consumers to use grid energy from the grid and inject energy to it, when it is financially to their benefit. As the deployment of smart meters is not complete (and there is no clearly defined roadmap to date for full roll-out, prosumers cannot react to market signals and take advantage of the energy they produce but are rather passive towards the market.
- Investments in self-consumption are not yet financially attractive, since there is no option to offer flexibility for ancillary services to the Network and System Operator or participate in the wholesale electricity market via an aggregator and thus create extra revenues through a demand-response mechanism or the market itself.
- The high compensation tariffs for PV roof top installations that have increased household income are now practically over. The incentive as it stands is to reduce energy cost via self-consumption. In order for a household to proceed with an investment such as this, there have to be significant consumptions that contradict with the energy efficiency targets. Meaning that the more energy efficient a household becomes, the longer it takes the investment to break even.
- There is currently a lack of defined obligation for the network operator to perform the approval and completion of net metering installations within a certain timeframe; this often leads to prolonged periods that may reach over a year.

5.3 Croatia

Enablers

- Since the Croatian TSO HOPS is implementing a pilot project 'Securing Manual Frequency Restoration Reserves (mFRR) balancing service from Demand Side Response', potential energy service providers, under conditions set by the tender, may upon TSO request, reduce or redirect their consumption, and thus provide balancing services.
- Compliant to the Act on Energy Efficiency (OG 127/14, 116/18, 25/20), energy suppliers are obliged to achieve energy savings in final consumption and could

potentially purchase determined energy savings from an energy service provider. The mentioned legal provisions allow suppliers to use energy savings delivered from demand response mechanisms to meet their energy efficiency obligations as well as energy service providers have the interest to include these measures in their portfolio.

Barriers

- Several terms are still pending to be defined in the Electricity Market Act, Grid Code for the Distribution Network and Grid Code for Transmission Network and all the related regulatory framework: demand response, new energy services – aggregated demand response, active customer (prosumer), aggregator as a new energy market entity, energy cooperative and customer data protection.
- In order to enable residential consumer flexibility trading on the wholesale market or through bilateral contracts to operators or suppliers a smart metering device should be installed in the consumers' premises. Since a smart metering regulation is still not in force, potential energy services providers need to grant the service of meter installation and calibration to current distribution operators. It is also unclear on how the DSO, who holds the exclusive role and legal obligation to manage the metering data and meters, would communicate with aggregators – the DSO currently has established interfaces only with the suppliers/retailers. In the meantime, a potential solution could rely on behind-the-meter devices installed in customer premises, with all the consequent implications to the aggregator business model.

5.4 France

Enablers

- Demand response and Demand response aggregation can participate in most markets alongside generation. In addition, the thermo-sensitiveness of low-scale demand response is taken into account in the Capacity Market, ensuring that flexibility for heating demand can participate.

Barriers

- Specific rules in the day-ahead market create barriers to entry for demand response aggregation, this explains why the volumes actually exchanged on the day-ahead market are still very low (48.9 GWh since the implementation of the mechanism in 2014) compared to the country's potential (France has more than 7 million households with direct electric heating).
- The most important barrier is the compensation to suppliers that is fully taken in charge by demand response operators (aggregators), decreasing automatically and in a significant way all revenues from demand response.
- The second barrier is about synchronisation constraints imposed by the TSO: Demand response on the wholesale market cannot be done for more than six consecutive hours. This adds to yet another constraint that limits the activation of the total capacity only for a maximum of one third of the possible time. Therefore, volume is more or less divided by three compared to what could theoretically be achieved without this arbitrary constraint.
- The last barrier is about the impossibility to participate simultaneously in all markets. This should be at the system operator's will (looking at the potential and the consumers base) instead of being forced by specific rules.

6 REGULATORY FUTURE TRENDS

This section seeks to shed light on the regulatory future trends marked by the new directives enacted and the EC communications and new regulatory projects in discussion for the coming years to achieve the ambitious 2030 sustainable targets. The focus is on general measures and programmes to reach the respective goals set out by the Clean Energy for all Europeans package as well as trends in the electricity and residential building sector. This is a preliminary analysis of future trends that will be completed in T7.5, "Future trends of the market for the provision of energy services", at the end of the frESCO project. In order to do so (i.e. detect regulatory future trends) the National Climate and Energy Plans (NCEPs) of Spain, France, Croatia and Greece have been analysed to that end. The proceeding sections in this chapter summarize aspects of the respective country's NCEP unless cited directly.

Given the fact that the EU is currently debating on whether to increase the GHG emission reduction targets from -40%, on which these NCEPs are based, to between -55 and -60 % by 2030, the NCEPs presented here provide a road map for the respective countries transition, which must be adjusted in coming years to reflect any updates in EU GHG emission targets. Currently, the Covid-19 pandemic and its effect on societies and economies dominates international developments on all political and economic levels. The short and long-run impacts of the pandemic are expected to be significant which could affect the EU's transition trajectory. The European Commission has emphasised the role that the NCEPs can have in developing "robust and future-proof national recovery and resilience plans" [67].

They have also emphasised the critical role of energy, climate and environmental policies in this recovery. In the following sections, a brief overview of aspects related to frESCO in the most recent report on the state of the Energy Union is provided to give context to the subsequent assessment of the NECP.

6.1 The current state of the Energy Union

Against the backdrop of the European Union's Green Deal ambitions to establish a climate neutral, resource efficient and inclusive economy by 2050, the latest report on the current state of the Energy Union [67] presents an overview of ongoing initiatives in the European

Union and the current progress towards establishing the Energy Union. In the following, those aspects of the report that directly relate to frESCO's ambitions are highlighted.

6.1.1 Greenhouse Gas Emissions & Renewable Energy

The European Union member countries achieved the significant GHG emission reduction agreed upon in the *United Nations Framework Convention for Climate Change* (UNFCCC). Between 1990 and 2018, overall GHG emissions decreased by 25.5%. GHG reductions were successful due to a significant decrease in emissions from activities covered by the EU emissions trading system (EU ETS), whereas the non-ETS sector has not achieved significant reductions yet. While current GHG emissions are at their lowest since 1990, more ambition is needed to reach the proposed climate neutrality by 2050 for which the European Commission has proposed a European Climate Law (currently under consideration by the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions [67]).

For the four demo site countries in frESCO, latest data shows that France (-18.9%), Croatia (-25.4%) and Greece (-10%) reduced their GHG emissions compared to 1990. GHG emissions in Spain increased by 15.5 %, which according to European Environmental Agency (2020) was "largely due to emission increases from road transport, electricity and heat production, and households and services".

With regard to the share of renewables in the gross final energy consumption, positive developments are observed. The overall share of renewables has increased to 18% by 2018 in the EU and current projections find that only three members states are at "severe risk" of not meeting their 2020 target (Belgium, France, Portugal) and two are at moderate risk (Netherlands and Luxembourg) [67] .

A look at frESCO's four demo site countries shows that all of them have achieve their target values and that Greece and especially Croatia significantly overachieve them. Croatia is also the country with the highest positive deviation from the RES target value, followed by Bulgaria, Czech Republic and Italy (see Table 4).

Table 4: RES share vs target by 2020. Source: EU 2020. The modelling also calculated absolute deficits and surplus in the Member States including the cooperation mechanisms (p11)

	Renewable Energy Directive (RED) target RES share in the year 2020 in % of final energy demand	Expected RES share 2020 (CPI scenario) min-max in % of final energy demand
Spain	20 %	22 % -22.4 %
France	23 %	20 % -20.3 %
Croatia	20 %	34.6 % - 34.9 %
Greece	18 %	23.4 % - 23.8 %

6.1.2 Energy Efficiency

The latest available data show that the European Union as a whole was 2.6 % above the 2020 target value for primary energy consumption and 2.2% above the target value for final energy consumption. The European Commission (2020) reports that partially available data for the year 2020 indicates that the 2020 targets might be reached, but the significant impact of the Covid-19 pandemic is responsible for the observed drop in consumption. Rebound effects are expected as soon as the member states' economies start to recover, and the consumption reduction observed in 2020 has not led to structural changes. Therefore, significant actions are needed to achieve the 2030 goal of at least a 32.5% improvement of energy efficiency (compared to projections of the expected energy use in 2030) [68] . While the national strategies to achieve the 2030 energy efficiency goals are to be designed by the member states themselves, the European Commission has identified seven flagships, which target energy efficiency aspects relevant for all member states. Their core ambition is very briefly outlined below [67].

- **Power up**: is about future-proof clean technologies and aims at establishing hydrogen-led markets in Europe.
- **Renovate**: aims at contributing to the doubling of the renovation rate of public and private buildings and to foster deep renovation. This is directly connected to frESCO's targets.
- **Recharge and refuel:** aims at supporting the uptake of sustainable, accessible and smart transport, including the necessary infrastructure.
- **Connect**: aims at establishing European wide rapid broadband services.
- **Modernise**: aims at the establishment of EU-ID and key digital public services

- **Scale-up:** aims at doubling the production of semi-conductors in Europe and to produce 10 times more energy efficient processors.
- **Reskill and upskill:** aims at re- and upskill Europeans with a focus on digital skills and educational and vocational training for all ages.

6.1.3 Internal energy markets

Positive progress towards a strong internal energy market has been made in the past several years. With the Clean Energy for all European package, even more measures are implemented to strengthen consumer rights and participation in the energy sector. Among them, European Commission (2020) lists data interoperability measures as a way to allow customers as well as service providers a stronger role in the market, among others. Also highlighted is the European Union's goal to tackle the challenge of energy poverty for which the European Commission published recommendations in October 2020. [69]. These recommendations are in line with the Green Deal ambition, which asks for a just and inclusive transition, where no one is left behind.

6.2 Future trends in the overall energy market

6.2.1 Spain

The Spanish NECP identifies the **National Energy Efficiency Fund** as the main source for funding energy efficiency initiatives between 2021 and 2030. It is estimated that Spain will need 83.54 billion euros in order to reach the INECP targets by 2030. Of which, it is expected that 30 billion euros of national and European funds become available to finance energy efficiency endeavours.

The main immediate important change in Spain is the creation of a National Energy Fund to be financed by green taxes and dedicated to pay for political past decisions of the energy system, mainly electrical system, such as Feed-in Tariff programmes, regulated tariff freezing, Grid expansions and the cost of the electricity system debt, now in the hands of the banking system. This law proposal is under discussion in the Spanish Parliament as of now.

6.2.2 France

France has stipulated a number of mid- and long-term legislative and strategic programmes to galvanize the transition towards a carbon-neutral society. Among these are the **Law on Energy Transition for Green Growth (LTECV)** that sets medium- and long-term targets for reducing GHG emissions, energy consumptions and increasing the share of renewable energies while promoting sustainable economic growth and the creation of sustainable jobs. The French **Climate Plan** sets the objective of carbon neutrality by 2050 whereas the **National Low-Carbon Strategy (SNBC)** describes a roadmap for the implementation of the country's climate change mitigation policy in order to reach climate neutrality by 2050. The mid-term **Multiannual Energy Plan (MEP)** covers the period until 2028 and sets priorities for action by public bodies and institutions in order to move towards a more efficient energy system. The MEP covers many areas among which are the renovation of building envelopes and the transition to an increased number of renewable heating systems. In addition, the MEP stipulates an increase in PV capacity from 8.3 GW in 2018 to 40 GW in 2028. The **Law on Energy and Climate** establishes concrete tools and policy that ensures France remains on track to achieve carbon neutrality by 2050. It incorporates the concept of ecological and climate emergency into French law and creates an independent professional **High Council on Climate** to assess climate strategies and policies implemented. It also introduces (from 2023) carbon budgets for France and encourages democratic debates on established targets with its **Five-yearly programming law**. It also sets concrete measures such as the **Coal-Generation-Exit** by 2022 and renovation targets for buildings. The **Finance Law** for 2020 changes some government regulations that have perverse climate impacts such as reducing rates on fuel like diesel as well as an end to government export guarantees for coal-related operations and certain operations associated with hydrocarbon exploration. Another measure that intends to reduce GHG emissions are changes made to the energy consumption tax, which will nearly double the tax on CO_2 emissions by 2022. However, this measure has yet to be approved officially.

6.2.3 Croatia

The **Strategy on Climate Change Adaptation in the Republic of Croatia for the period until 2040 with an outlook to 2070** is Croatia's first major step to create a **Climate Change Adaption Strategy**. The strategy focuses on improving the resilience of the Croatian people and sectors of the economy that are especially susceptible to the impacts of climate change (e.g. agriculture, forestry, fisheries, energy and tourism). Through **Implementation Action Plans,** that are segmented into five-year periods, the country will focus on adaptation strategies and prioritize actions that improve public education/awareness, research, and development based on need.

Another important piece of legislation to aid in the transition towards a carbon-free society is the **CO_2 emission tax for the non-ETS stationary sources**. The measure stipulates that stationary entities that had annual CO_2 emission greater than 30 tons between 2007-2014 or greater than 450 tons since 2015 are expected to pay an emissions tax. The tax will be established and issued by the **Energy Efficiency Fund.** This measure will be continued during the period of 2021 – 2030 and might be changed to a CO_2 tax applicable to different types of fossil fuels and different energy sectors outside the ETS from 2023 onwards.

The **Energy Efficiency Obligation System**, **further defined by the Ordinance on the Energy Efficiency Obligation System (OG 41/19)** that transmits the **Energy Efficiency Directive** into Croatian law will be altered in order improve the functioning of the system and to ensure the purpose-bound allocation of gathered funds, namely the building sector. The amendment of the **Energy Efficiency Act** intends to provide improved access of private actors to energy services such as the implementation of energy efficiency projects and energy performance contracts.

6.2.4 Greece

The Greek NECP outlines the countries roadmap for combatting climate and energy issues along with the strategies in place to achieve specific goals by 2030. The **Government Committee for Energy and Climate** was created to develop and monitor national climate priorities. Between 2021 and 2030 Greek authorities will focus on ten different policy priorities to reduce GHG emission and other gaseous pollutants. Such as, **Phasing Out Lignite Coal by**

2028, or **Urban bioclimatic restructuring and smart cities.** The later covers a large array of aspects from improving public spaces lighting or water management, establishing green rooftops and walls, to improving city infrastructure in order to promote walking and biking. The country plans on updating energy demand infrastructure and making smart meters and smart networks the new norm. These actions are expected to enhance the role of cities and people in the transition and ultimately change the face of the energy sector that is seen today. The **National Energy Efficiency Fund** intends to jumpstart the transition with an influx of money that can be used to finance new energy efficiency investments and allow stakeholders to access previously untapped energy saving tools. Lastly, to ensure a more active involvement of stakeholders at local and regional levels **Action Plans for Sustainable Energy** and the **Action Plan for the Energy Efficiency of Buildings** will be created.

6.3 Future trends in the Electricity Market

6.3.1 Spain

6.3.1.1 Renewables

In the period between 2021 – 2030 Spain wants to achieve a significant increase in the share of renewables for energy end-use from 20% in 2020 to 42% in 2030. The country expects this transition to be supported by enhancing the role of renewable electric and thermal energy sources. Similarly, the country expects a notable increase in the share of renewables in the electricity mix by 2030. The country sets the mark at 74%, adding 59 GW of renewable capacity between 2021 – 2030. To increase the share of renewables in the national energy mix, tenders are considered to be the main tool in accordance with **Directive 2018/2001** [70] on the promotion of the use of energy from renewable sources. Tenders will feature fixed prices that provide for security of financing and planning, differentiating between technologies. A support mechanism will be established through which participatory citizen projects can enter into a contract of sale for their electricity at a fixed price tied to the result of the tenders. The deployment of renewable energy sources will also be supported by a new regulation that simplifies administrative operations as well as eliminating tariffs and charges for self-consumed energy and allowing compensation for surplus fed into the grid.

6.3.1.2 Demand side management

In order to increase the electricity system's flexibility, Spain plans to add 6 GW of pump and battery storage by 2030 in addition to an increase in thermal storage in combination with a concentrating solar power capacity of 5 GW by 2030. Electricity demand management including storage is intended to be enforced through direct or indirect participation of all market actors in the energy sector including public authorities, ESCOs and aggregators, the roles of actors are planned to be actively developed during the transition. Additionally, the country intends to develop the legal framework that allows distributed (decentralized) electricity producers to participate in the energy market.

In order to allow users to actively take part in the energy market as well, a system of dynamic pricing will be implemented with tariffs featuring a minimum of three periods per day. Identification and removal of all barriers that inhibit this means is also set to occur, to ease the transition. In addition, users will be given free real-time access to their energy data, which also serves the purpose of improving consumers' energy literacy and the transparency of information on the energy system.

6.3.1.3 Self-consumption

In addition to eliminating tariffs and charges for self-consumed energy, self-consumption of produced renewable electricity will be enforced by allowing the collective self-consumption of several consumers within the same community according to the **Royal Decree 244/2019** [25]. Mechanisms to promote self-consumption include a National Self-consumption Strategy, soft financing, management by third parties or the energy services model as well as a manual for self-consumption in urban environments.

6.3.1.4 Renewable energy communities, citizen energy communities and citizen participation

The appropriate legislative framework will be developed to define the two legal entities "renewable energy community" and "citizen energy community" and to promote their development, in order to comply with Article 22 of Directive 2018/2001 [71] and Article 16 of Directive 2019/944 [6].

6.3.2 France

6.3.2.1 Renewables

France wants to reach the target of a 40 % renewable energy share by 2030, starting from a share of 17 % in 2018. To increase the share of renewables in the energy mix, France wants to increase the visibility of the tender processes, reduce administrative barriers, support crowdfunding investments and prepare the large-scale recycling of end-of-life installations. Additionally, the country aims to promote ground-mounted PV installations on urban or degraded land, install 300 MW/a of PV power on small- and medium-sized roofs and promote PV power plants with a focus on self-consumption, aiming to have a total of 200,000 PV generation sites for self-consumption installed by 2023, including 50 collective self-consumption operations. In order to increase the share of renewable electricity generation, France also plans to pay the price difference between the sales price of electricity and the costs borne by the various sectors.

6.3.2.2 Demand side management

In collaboration with the main grid operator (ENEDIS) and the Association of Electricity Distributors (ADEeF) France aims to increase the options for the use of demand modulation to manage local problems with the operation of distribution systems. In addition, suppliers are to be encouraged to develop deals promoting flexibility, by taking advantage of the new potential offered by smart meters. Lastly, during the first period of the Multiannual Energy Plan (MEP), a framework is to be set up for rolling out the development of virtual lines using battery storage facilities, to avoid grid reinforcements and the capping of renewable energies, by 2028.

6.3.2.3 Self-consumption, citizen energy communities and citizen participation

In order to increase the amount of self-consumption of electricity by renewable energy power plants (mainly PV), France intends to provide information about the various factors that could have an influence on the level of profitability of self-consumption operations. In addition, new possibilities for collective self-consumption are to be designed along with facilitating the

funding of such projects. The legal framework to implement renewable energy communities and citizen energy communities will also be elaborated.

6.3.3 Croatia

6.3.3.1 Renewables

Croatia aims to increase the national share of renewable energy from 28.6 % in 2020 to 36.4 % in 2030 in accordance with the targets set forth by the EU [72]. In order to achieve this, the Croatian Energy Market Operator (HROTE) will continue to pay incentives to generate electricity and heat from renewable energy in the form of tenders or investment subsidies. The funds for which will be generated by the renewable energy fee based on premium system under the Renewable Energy Sources and High Efficiency Cogeneration Act. HROTE is charged with preparing three-year renewable energy plans and public announcements of tenders that assign market premiums to specific technologies. The programme also incorporates the continued application of the surplus energy absorbing model.

6.3.3.2 Storage and demand side management

In order to increase the energy storage capacity of the system and increase the regulatory capacity of the electricity system, it is planned to build additional reversible power plants with a capacity of 150 MW before 2030 [72], as well as increasing the amount of thermal, battery electric and underground (compressed gas) storage capacities. In order to change consumers into prosumers by taking part in the energy market, Croatia plans to establish the role of an aggregator and to define additional services these prosumers can provide to the energy system (e.g., flexibility, battery capacity) and to remove respective legal and regulatory barriers.

6.3.3.3 Citizen participation

To increase citizen participation, Croatia relies (among other measures) on providing information on energy efficiency, partaking in the Covenant for Mayors for Climate and Energy as well as information, education and capacity building for renewable energy use. Renewable energy communities and citizen energy communities are not mentioned in their NECP.

6.3.4 Greece

Renewables

The objective of Greece is to increase the renewable energy share in gross final energy consumption to at least 35% by 2030. The renewable energy share in gross final electricity consumption is planned to reach at least 60% by 2030 with wind and PV power responsible for a major share of the renewable electricity generation increase. To this end, Greece will apply net metering and active consumer schemes, assuming that they will increase the installation of renewable power plants and the implementation of energy efficiency measures. The quantitative goal is to install additional self-consumption and net-metering projects with a total power output of 600 MW by 2030.

In addition, Greece plans on expanding the implementation of a competitive bidding mechanism for renewable power generation combined with sliding feed-in-tariffs.

The key financial instruments for furthering the renewable energy generation capacity will be national and international financial resources, a special renewable energy fund, national operational programmes, a new investment law and resources from national and EU research programmes.

6.3.4.1 Storage and demand side management

Storage systems are expected to play an important role in reducing renewable energy power cuts in the system as a whole, to address local congestion problems, to ensure more adequate capacity and better system flexibility and to open up possibilities for participation in additional energy markets, such as the balancing market and the long-term capacity compensation scheme, which will increase the profitability and viability of the investment.

In order to provide a basis for the installation of decentralized low-capacity electrical energy storage capacities, Greece plans to adapt the institutional framework accordingly. New buildings and renewable energy power plants might even be obliged to install storage capacities. Integration of low-capacity electrical storage devices in a smart system would improve optimization of the individual units and could lead to cost reduction of the energy system.

6.3.4.2 Dynamic pricing, aggregators and citizen participation

Digitalization is assumed to allow consumers and decentralized power plants to join the energy market as prosumers, aided by the newly developed role of an aggregator, and by providing flexible energy tariffs in order to keep the system costs as low as possible. The aforementioned participation in the electricity market is to be made possible by the roll-out of smart meters for all electricity consumers which is expected to take place within the next decade.

In that context, **Law 4414/2016** [73] stipulates that all new power plants above a certain power limit will have to participate in the electricity market by submitting an appropriate, priced supply-forecast either on their own or through aggregators. If they submit an incorrect forecast, RES plants will be charged with the corresponding charges-fines.

6.4 Future trends in the Building Efficiency Market

6.4.1 Spain

6.4.1.1 Thermal energy, space heating and cooling

Thermal energy, space heating and cooling accounted for 33% of the final energy consumption in Spain in 2015, only 16.8% of which were derived from renewable energy sources. The Spanish NCEP aims to double that share by 2030, exceeding the 1.3% annual renewable energy quota increase stipulated by the **EU Renewable Energy Directive** [70].

6.4.1.2 Energy upgrading of residential buildings

In the period 2021 – 2030 Spain aims to renovate the thermal envelope of 1,200,000 homes (building up on the successful PAREER and PAREER-CRECE programmes of the past), starting with 30,000 homes/a in 2021 and finishing with 300,000 buildings in 2030. In addition, 300,000 homes/year are to improve the efficiency of their thermal heating and DHW installations. The implementation of these measures will be achieved through taxing as well as legislative and public subsidy programmes that aim to trigger € 22.4 billion worth of investments requiring € 5.6 billion in public funding. In order to avoid complications for small installations simplification of the current administrative processes is scheduled.

The technical building code, Código Técnico de la Edificación — CTE [28], as well as the Regulations on Thermal Installations in Buildings, Reglamento de las Instalaciones Térmicas en los Edificios — RITE [74]) will be reviewed in order to increase the energy efficiency and renewable energy requirements in new buildings and refurbishments.

In addition to the above, the tax system is to be revised in order to avoid subsidizing fossil fuels and to incentivise electrification and installation of renewable energy power plants.

6.4.2 France

The building sector in France represents close to 45% of the national final energy consumption and 25% of the greenhouse gas emissions, which is why its contribution to transforming France towards carbon-neutrality is crucial. The average annual emissions of the building sector in France will be reduced to 43 Mt CO_2 for the period from 2029 – 2033 starting from 78 Mt CO_2 for the period 2019 – 2023. Over the period between 2015 – 2030 an average of 370,000 renovations are to take place every year, reducing the final energy consumption of buildings from 745 TWh in 2016 to 636 TWh in 2028.

6.4.2.1 Thermal energy, space heating and cooling

The French **Energy Code** stipulates a 38% share of renewable energies in final heat consumption by 2030 as well as a five-fold increase in the amount of renewable and recovered heating and cooling supplied by district heating and cooling networks by 2030 (compared to the situation in 2012).

Within the MEP 2 renewable heating is to be increased from 196 TWh in 2023 to up to 247 TWh by 2028. The technological solution to achieve this comprises mainly (equalling 80 % of the renewable energy increase) the installation of biomass boilers and power plants and air heat pumps.

6.4.2.2 Energy upgrading of residential buildings

To enforce the energetic upgrading of residential buildings France aims to set an obligatory minimum of renewable heat in new buildings in the environmental regulation on new buildings (ER 2020) and to include life-cycle emissions of buildings in the ER 2020. Also, the **Building Energy Renovation Plan** will be implemented and actions will be taken in three

phases in accordance with the **Law No 2019-1147 of 8 November 2019 on Energy and Climate** [75] in order to eradicate inefficient homes. These phases include a mandatory energy audit prior to the sale or lease of an inefficient home beginning in 2022, secondly the requirement for homeowners of inefficient homes to undertake renovations by 2028 and thirdly the application of fines to property owners if they do not comply with the obligations to renovate inefficient homes.

To finance the energetic upgrading of residential buildings a number of instruments are and will be available in France. In this context, the **Heat Fund** will be simplified and strengthened, providing a budget of EUR 350 million annually from 2020 onwards. In addition, the energy transition tax credit (CITE) and its replacement **MaPrimeRénov'** will be made more effective by setting a flat-rate amount and differentiating between technologies. Value-added tax is to be kept at 5.5% for renewable heat equipment eligible for the CITE and zero-rate eco-loans **("ecoPTZ"**, since 2019) apply for works eligible for the CITE.

Both air/water and geothermal heat pumps as well as geothermal cooling and solarthermal projects will continue to be supported by the above-mentioned funding schemes. In total, the CITE and the MaPrimeRénov' together will provide funds totalling € 800 million per annum for furthering the generation of renewable heat.

Other instruments of financial support for energetic upgrades include the National Housing Agency (ANAH) grants, eco-subsidies for social housing distributed by the Caisse des Dépôts et Consignations (CDC) and relief on energy-saving works for low-income housing.

6.4.3 Croatia

Croatia has designed several programmes and established regulations to increase the energy efficiency of buildings. Among these, the **Programme of Green Infrastructure Development in Urban Areas** defines both objectives and measures for increasing the energy efficiency and improving the overall ecological footprint and sustainability of urban areas.

The Circular Spatial and Building Management Development Programme on the other hand defines objectives and measures that help to improve the circular economy of buildings and spaces.

The most important document in this context is the **Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia by**

2050 that includes a number of key energy renovation programmes for the period between 2021 and 2030 and is expected to be adopted for apartment buildings, family houses and public buildings. Among the key points of this strategy are the following:

1.) Nearly-zero-energy-standard requirements for public buildings built after 2020
2.) An Energy renovation programme for public sector buildings (continuation of the implementation of the Public Sector Buildings Renovation Programme 2016-2020), leading to an expected renewal of 350,000 m² annually, resulting in annual savings of 0.169 PJ.
3.) An energy renovation program for heritage buildings, leading to an expected renewal of 900,000 m² annually, resulting in annual savings of 0.5 PJ.
4.) An energy renovation programme for multi-apartment buildings (a continuation of the implementation of the Energy renovation programme for apartment buildings for the period from 2014 to 2020), encouraging the deep renovation of multi-apartment buildings, leading to an expected renewal of 520,000 m² annually, resulting in annual savings of 0.148 PJ.
5.) An energy renovation programme for single family houses (a continuation of the implementation of the Energy Efficiency Programme for single-family homes from 2014 to 2020, with co-financing from the Environmental Protection and Energy Efficiency Fund), encouraging energy-efficiency measures in single family homes, leading to an expected renewal of 350,000 m² annually, resulting in annual savings of 0.191 PJ.

The current regulatory framework for the use of renewable energy sources is covered by several laws, a key one of which is the **Renewable Energy Sources and High Efficiency Cogeneration Act** with a series of by-laws. The existing legal solutions need to be complemented by the development of a regulatory framework for active customers (prosumers), aggregators, energy communities, renewable energy communities (participation in local energy production, distribution, storage and supply and provision of energy and aggregation services) and the energy production for self-consumption, in accordance with the provisions of the renewable energy promotion directive, the electricity directive and the

internal electricity market regulation. If necessary, an action plan will be developed for the development of energy and renewable energy communities.

6.4.4 Greece

The energy efficiency improvement in the period 2021 – 2030 includes twelve different policies among which are an energetic upgrading of 12 – 15% of the Greek building stock between 2021 – 2030, which is expected to also support the construction industry and provide operating benefits for Greek households in the process.

Financing programmes are intended to support the implementation of renewable heat and cold power plants and to increase the energy efficiency in tourism and gastronomy establishments while the installation of PV power plants is to be supported by (virtual) energy offsetting schemes.

The Greek NECP also stipulates the objective to use natural gas as a bridging technology used to reduce GHG emissions in all relevant sectors by replacing other petroleum products. This also involves the necessity to develop and improve the respective transmission and distribution infrastructure to ensure a higher penetration of natural gas. The quantitative goal in that context is to increase the final consumption of natural gas by 50% compared to 2017.

A regulatory framework for the mandatory share of renewable energy on buildings embedded in the **Regulation on Energy Efficiency of Buildings** and the provisions for nearly zero-energy buildings are further assumed to significantly increase the adoption of this underused source of energy in the building sector. Public buildings will play an exemplary role in that context.

7 CONCLUSIONS

The two principal markets where frESCO project activities can make a difference are the energy efficiency market in residential buildings, regulated by directives EU 2018/2002 (energy efficiency) and EU 2019/843 (building energy performance), and the electricity market, ruled by directive EU 2019/943 and EU 2019/944 about the internal common Electricity Market. These directives are still being transposed into national regulations and mark the tendency of both markets in the future to align policies with the ambitious European 2030 and 2050 targets.

This analysis at European and national level aims at identifying the main positive and negative aspects of today's regulatory framework in relation to frESCO's intended energy services. The main important barriers imposed by the current regulatory frameworks in the demo site countries are:

- Flexibility trading is only partially allowed in some countries. This demand-response resource is only open to large consumers and scarcely used for grid constraint management (Spain). In those countries where demand-response is tradable (France), there exists synchronisation constraints and other limitations such as the fact that compensation to producers for the downward demand flexibility is borne by the aggregators, thus limiting the revenues of this emerging business model.
- Aggregation of flexibility is still only allowed in France. Aggregation is mandatory since demand response trading, where permitted, only accepts minimum bids of up to 1 MW, which requires a lot of aggregated domestic users to meet this minimum bid.
- Difficulty and high cost to obtain real-time readings. In some countries the smart meter rollout is not finished yet (Greece and Croatia). In others, there are no clear mechanisms in place to allow third-party service providers, aggregators and ESCOs to directly connect to DSO's metering devices (Spain, Croatia). Additional metering systems may be needed at the demo sites, which increase the cost of real-time data collection.

- A multilateral agreement has to be signed between consumers (data owners), DSO (data reader) and ESCOs/aggregators (data consumers) in order to ensure the provision of AI services while ensuring data protection and privacy.
- Self-consumption assets in the domestic sector are still scarce in all the four countries analysed. In Greece, incentives are declining whereas in Spain the previous regulation imposed high grid usage fees, rendering them unfeasible despite the large resource potential. This restrains the services offering savings or flexibility out of these generation sources in frESCO. On the other hand, this barrier is a huge opportunity for the near future.
- Although the recast directive of Energy Efficiency in Buildings sets ambitious performance targets for new buildings, the economic downturn in 2010 and 2020 has slowed down the building rate in Europe. A higher effort should be paid to refurbish the existing building stock to the new regulation standards, as part of extended ESCO services.

However, there are already a number of positive aspects that play in favour of frESCO targets. Among others:

- Demand response and aggregated DR can participate in most markets alongside generation in some EU countries, like France, in accordance with the European Energy Directive. It should only be a matter of time before this successful model is implemented in the rest of the European countries.
- The digital meter rollout is ongoing in the European Union. Some countries are already putting in place measures to make real-time consumption accessible to domestic consumers as a powerful decision-making tool.
- The low cost of today's silicon-based photovoltaic systems and the more friendly regulation for domestic self-consumption easing the grid connection requirements is going to cause a likely burst of the use of this technology for self-consumption in Europe. This equipment enables not only direct savings but an additional source of prosumers' flexibility that can be elicited and made available at the corresponding marketplace as a clean and alternative energy source or as a straight-forward grid balancing tool.

- The current ambitious European goals and set of Directives affecting Energy Efficiency, Electricity market and Building efficiency already rely on the increasing use of renewable assets and the participation of the domestic users in Demand-Response schemes. The current NECPs in many countries are already pointing in this direction and should become a reality in a time period of between 1 to 4 years throughout Europe.
- As a measure to revamp the European economy from the COVID-19 slump, an important financial resource is being mobilised by the European Union to act in several critical cross-European issues. One of them is the energy transition and digital development. It is expected that financial resources for these two sectors will be made available from 2022 on. frESCO solutions target both sectors, which could facilitate a wider scope and extension of the frESCO solutions in a near future.

To conclude, although some of frESCO's services may not be fully deployed like flexibility trading, and others may be limited by the availability of self-generation devices and access to third party's digital meters, they can be tested and refined to get them ready for a near future when they can become a reality.

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