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Interoperable solutions for implementing holistic **FLEXi**bility  
services in the distribution **GRID**

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# **Stakeholders' common requirements report**

**Deliverable 2.3**  
**WP2**

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## ABBREVIATIONS

**AMI:** Advanced Metering Infrastructure  
**BRP:** Balancing Responsible Party  
**CHP:** Combined Heat and Power Plant  
**CIM:** Common Information Model  
**DSM:** Demand Side Management  
**DG:** Distributed generation  
**DR:** Demand Response  
**DSO:** Distribution System Operator  
**DER:** Distributed Energy Resources  
**EU:** European Union  
**EV:** Electric Vehicle  
**H2020:** Horizon 2020  
**HV:** High Voltage  
**ICT:** Information Communication Technology  
**IP:** Internet Protocol  
**LV:** Low Voltage  
**MV:** Medium Voltage  
**RES:** Renewable Energy Sources  
**SAIDI:** System Average Interruption Duration Index  
**SAIFI:** System Average Interruption Frequency Index  
**SCADA:** Supervisory Control and Data Acquisition System  
**SLAM:** Smart Low-Cost Advanced Meter  
**TSO:** Transmission System Operator  
**VPP:** Virtual Power Plant

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## EXECUTIVE SUMMARY

This document is the deliverable D2.3 of project FLEXIGRID. It is based on the work done in task 2.2 within work package 2 of said project. The goal of this task is to define the stakeholders' common requirements towards a smart citizen-centred energy system. In that regard, the first action necessary for identification of the stakeholders' common requirements is identification of the stakeholders themselves. The stakeholders were grouped in the following categories:

- Funding bodies: local authorities, policy makers, public bodies
- Experts: regulatory bodies, research institutes, professional associations, technology providers, equipment producers and vendors, energy cooperatives
- Electricity sector: generating companies, energy service provider companies, electricity suppliers, aggregators, balance group leaders and system operators (TSOs and DSOs)
- Consumers: consumers and citizens' associations

In order to define the stakeholders' common requirements towards a smart citizen-centred energy system the document is divided into two sections:

1. Analysis of relevant EU-funded projects' results regarding the stakeholders' requirements
2. A stakeholders' common requirements survey

In the first section results of relevant EU-funded projects on three topics are presented: technological requirements, legal, regulatory and market framework, and end-user engagement. An overview of the project results of relevant EU funded projects provided a detail insight in the current situation regarding the stakeholders requirements in Europe.

The second section describes the process and results of the survey conducted to determine the common requirements of the stakeholders in FLEXIGRID project. A large majority of the stakeholders whose responses were collected through the survey consider the regulatory framework to be the major obstacle for development of flexibility solutions, flexibility service trading and electricity markets at the distribution system level. In addition, a few respondents named the lack of financial support for development of flexibility solutions as the major obstacle. Furthermore, the slow smart-meter roll-out process is identified by the stakeholders as somewhat smaller obstacle than the regulatory framework.

The results presented in deliverable D2.3 will be considered when designing the flexibility services for the distribution grid and customer engagement programmes within FLEXIGRID project.

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# 1 INTRODUCTION

## 1.1 The FLEXIGRID project

The main goal of FLEXIGRID is to allow the distribution grid to operate in a secure and stable manner when a large share of variable generation electricity sources is connected to low and medium voltage grids. In order to fulfil this goal FLEXIGRID project introduced a three-level approach aiming at flexibility, reliability, and economic efficiency through the development of innovative hardware and software solutions.

These solutions will be demonstrated in four demo-sites across Europe, i.e. Croatia, Greece, Spain, and Italy, ensuring their interoperability through its integration into an open source platform able to harmonize the data flow between FLEXIGRID solutions and the real grid.

## 1.2 The objective and scope

This deliverable is based on the work done in task 2.2 of work package 2, which aims at *defining the stakeholders' common requirements towards a smart citizen-centred energy system*. The first step in this process is to identify relevant stakeholders. Identification of the relevant stakeholders across Europe was a collaborative effort of the partners from the demo-site countries in the project. In order to obtain a detail insight into the current situation regarding the stakeholder requirements the most relevant EU-funded project in that context were analysed. In-detail analysis of the project results is provided in the section 2 of this document. The emphasis of this analysis was on the technological requirements, legal, regulatory and market framework, and end-user engagement. The analysis of the relevant projects regarding stakeholders' requirements provided a good starting point for the design of the flexibility services for the distribution grid and customer engagement programmes within FLEXIGRID project. However, in order to determine what FLEXIGRID project's stakeholders consider to be the largest obstacles and what are the opportunities for the development of flexibility solutions for distribution grid, we have decided to conduct a questionnaire. In-detail analysis of the questionnaire is provided in the section 3 of this document.



## 2 ANALYSIS OF RELEVANT EU FUNDED PROJECTS AND TECHNICAL REPORTS

The increasing share of distributed generation across the EU requires a more flexible distribution network and better integration of RES into electricity markets. Furthermore, end-user engagement will also play an important role in increasing the system's flexibility. In this regard, aggregators as new market players will facilitate market integration of RES and enable the use of demand side management (DSM) programs. The degree of adoption of DSM programs as well as RES integration into electricity market will be influenced primarily by the cost and benefits that accrue to each stakeholder in the power system. The goal of the analysis described in this section is to present a review of the results of EU funded projects which could be relevant in the context of stakeholders' requirements for smart-citizen-centred energy systems. In that regard, end-user engagement, regulatory and legal framework, as well as technological requirements, will be analysed. In a changing electricity market environment, where the share of RES in the energy mix is increasing, the question of system flexibility is arising. Aggregators of demand and/or generation are therefore expected to have an increasingly important role to play in the future. The general benefits of the aggregation can be found in end-user engagement, boosted market competition, increased flexibility of the power system, market participation of small RES units, lower energy costs and reduced emissions. Figure 1. illustrates the main potential benefits of aggregation.

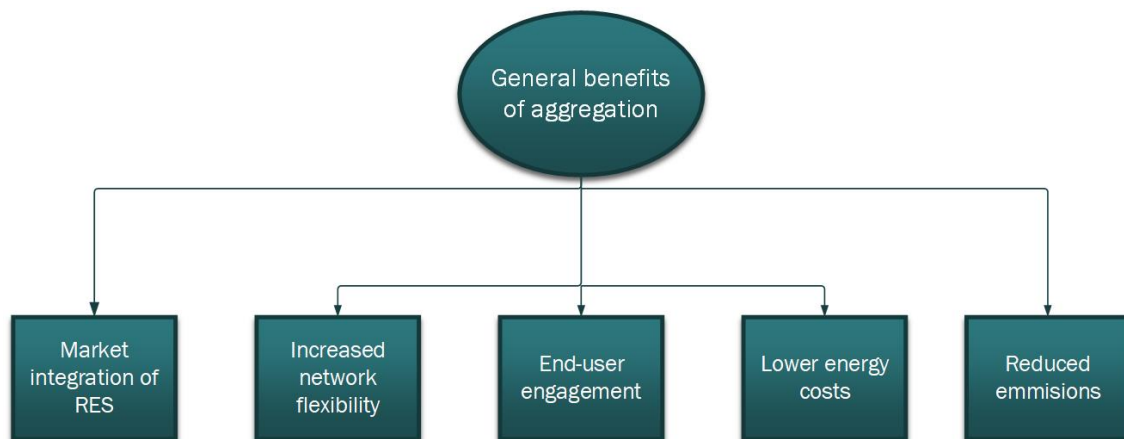


Figure 1. General benefits of aggregation

Despite the fact that the importance of working on the integration of the technological aspects is well recognized as essential for the successful integration of aggregators within the energy systems, the understanding of the needs and expectations from other main stakeholders (end-users, DSO, TSO, suppliers, BRP, etc.), must not be ignored as it can offer a different and more reliable perspective towards smart-citizen-centred energy systems. A numerous EU funded projects use physical pilots to test specific technological solutions regarding monitoring and control of resources located in the distribution network, such as distributed generation and DSM, while enabling them to participate in the provision of ancillary services to the TSOs and DSOs. In addition, these physical pilots located in different EU countries serve as a perfect tool to identify legal and regulatory barriers that prevent the integration of aggregators into the electricity markets. Special emphasis is placed on the understanding of the needs and







expectations from other stakeholders, i.e. end-users, that will motivate them to become an active participant of the distribution network.

Since the future European ancillary services market will be composed of different products (i.e. voltage regulation and frequency regulation) it is essential that physical pilots developed in different EU funded projects demonstrated the feasibility of small-scale RES units and end-users through different DSM programs to provide these services. In that regard, these projects should provide the insight into the following questions:

- What are the requirements on advanced metering infrastructure within the distribution network with special emphasis on smart meters?
- What are the requirements on communication (ICT) infrastructure that will guarantee observability and control of distributed generation, flexible demand, storage systems and the whole distribution network?
- What are the requirements on the coordination scheme between TSOs and DSOs that will clearly define the process of procurement and activation of flexibility by system operators?
- What are possible market schemes that will enable integration of aggregators?

Table 1. presents an overview of the most relevant EU funded projects that to some extent provided answers to the questions raised above. In-detail analysis of the project results is provided in the following subsections.

Project Acronym/Name	Project Description
 (H2020)	This project aims at providing architectures for optimized interaction between TSOs and DSOs in managing the exchange of information for monitoring, acquiring and operating ancillary services (frequency control, frequency restoration, congestion management and voltage regulation) both at local and national level, taking into account the European context.
 INTEGRATED SMART GRID CROSS-FUNCTIONAL SOLUTIONS FOR OPTIMIZED SYNERGIC ENERGY DISTRIBUTION, UTILIZATION AND STORAGE TECHNOLOGIES (H2020)	The main goal of this project is to integrate cutting-edge technologies, solutions and mechanisms facilitating optimal and dynamic operation of the distribution grid.

 <b>BRIDGING THE GAP</b> (H2020)	<p>The main goal of this project is to demonstrate scalable and replicable solutions in an integrated environment that enable DSOs to plan and operate the network with high share of DRES in a stable and secure way using flexibility resources within the distribution network.</p>
 <b>WIDE SCALE DEMONSTRATION OF INTEGRATED SOLUTIONS FOR EUROPEAN SMARTGRID</b> (H2020)	<p>This project aims to provide a set of solutions, technologies and business models which increase the smartness, stability and security of an open, consumer-centric European energy grid and provide cleaner and more affordable energy for European citizens, through an enhanced use of storage technologies and electro-mobility and a highly increased share of RES.</p>
 <b>REAL PROVEN SOLUTIONS TO ENABLE ACTIVE DEMAND AND DISTRIBUTED GENERATION FLEXIBLE INTEGRATION, THROUGH A FULLY CONTROLLABLE LOW VOLTAGE AND MEDIUM VOLTAGE DISTRIBUTION GRID</b> (H2020)	<p>The main goal of this project is to increase the observability and controllability of low voltage and low voltage grids as a way to anticipate technical problems associated with large scale integration of DERs, bringing also end users closer to system planning and operation.</p>
 <b>New Cost-Efficient Business Models For Flexible Smart Grids</b> (H2020)	<p>This project aims to provide advanced tools and ICT services to all actors in the Smart Grid and retail electricity market in order to ensure benefits from cheaper prices, more secure and stable grids and clean electricity.</p>
 <b>Local Use Of Flexibilities For An Increasing Share Of Renewables On The Distribution Grid</b> (H2020)	<p>This project explored new solutions to foster the development of distributed energy resources and to prepare the electric system for new uses, including e-mobility.</p>
	<p>The main goal of this project is to develop innovative business</p>

Best Practices And Implementation Of Innovative Business Models For Renewable Energy Aggregators (H2020)	models for integration of RES by aggregating distributed generation such as PV, wind, biomass, hydro and combining it with demand side management and energy storage.
 Distributed Renewable Resources Exploitation In Electric Grids Through Advanced Heterarchical Management (FP7)	This project demonstrates an industry-quality reference solution for Distributed Energy Resources (DER) aggregation—level control and coordination, based on commonly available Information and Communication Technology (ICT) components, standards, and platforms for all actors of the Smart Grids.
 Active Distribution Networks With Full Integration Of Demand And Distributed Energy Resources(FP7)	This project enables the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants.

*Table 1. Overview of the most relevant EU funded projects*

## 2.1 Technological requirements

Transition towards smart distribution networks with end-users playing an important role in the network management requires the following technological requirements to be fulfilled:

- Network automation
- Rollout of smart meters
- Communication (ICT) infrastructure

In the context of technological requirements, and in the validation process of technological solutions that will enable end-user's engagement, different H2020 projects use physical pilots. In the following subsections the most relevant project results in the context of technological requirements in the transition process towards smart-citizen-centred energy systems are provided.

### *SmartNet project*

SmartNet project identified and implemented three technological pilots in order to demonstrate real-life applicability of different TSO-DSO coordination schemes [1]. The pilots were located in Italy, Denmark and Spain. Each pilot was focused on different aspects of the TSO-DSO coordination value chain. The main activities performed in the Italian pilot were focused on observability and voltage control in the grid. The Danish pilot main activities were focused on indirect control of DER, while the Spanish pilot was focused on communication requirements and DSO's monitoring tools.

The Italian pilot demonstration results have shown that the information of the DER units located in the distribution grid can be aggregated and communicated to the TSO with a very high frequency (aggregated every 4 seconds and communicated every 20 seconds) [2]. In addition, it is shown that DER to some extent can provide voltage regulation services for the TSO.

The Danish pilot demonstration results have shown the technological feasibility of using penalty signals to indirectly modify consumption profile of summer houses [2]. Additional conclusions were that indirect control approach require a strong communication network to have the system working and a deep knowledge by the aggregator to calculate the flexibility function for the DER [2].

The Spanish pilot demonstration results have shown the capability of radio base stations to provide flexibility in a form of ancillary services for the TSO. It is shown that the use of standard communication protocols and an appropriate vendor management are of key importance [2].

SmartNet key findings in the context of technological requirements are listed below [3]:

- Traditional TSO-centric schemes could stay optimal if distribution networks do not show significant congestion;
- Technical reasons and high ICT costs misadvise to give balancing responsibility to DSOs;
- Reaction to commands coming from TSO or DSO in real time of the control loops which were initially planned for real time services can be too slow;
- Communication (ICT) infrastructure is nearly never an issue (for all coordination schemes ICT costs stay one order of magnitude lower than operational costs).

*inteGRIDy: Integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization and Storage Technologies*

inteGRIDy goal is to integrate cutting-edge technologies facilitating optimal and dynamic operation of the distribution network [4]. It is based on a pilot-driven approach to achieve project objectives. Technologically oriented project objectives are listed as follows:

- Integrate innovative smart grid technologies, enabling optimal and dynamic operation of the distribution network resources;
- Validate innovative Demand Response technologies;
- Utilize storage technologies and their capabilities to relieve the DG and enable significant avoidance of RES curtailment, enhancing self-consumption and net metering;
- Enable interconnection with transport and heat networks, forming virtual energy network synergies ensuring energy security.

Pilot locations with the main objectives of each pilot are given in Table 2 [4].

Pilots	Objectives
Lisboa, Portugal	- Demand response in municipal buildings integrating PVs, EVs and thermal storage
Barcelona, Spain	- Smart Grid integration - Self-consumption and enlarged RES penetration factor
Saint-Jean de Maurienne, France	- Novel demand response schemes - Novel virtual energy storage schemes
Isle of Wight, UK	- Smart Grid feat. fast charging EV facilities, demand side response and energy storage
Terni, Italy	- Combining smarter decentralised MV/LV automation with local coordinated DER-DSO operation for improving grid optimization
San Severino Marche, Italy	- Advanced DG monitoring power flows forecasting and optimization
Ploiesti, Romania	- Demand response in residential area
Xanthi, Greece	- Optimum distributed control of islanded grids with high RES penetration and energy storages
Thessaloniki, Greece	- Flexible demand response at residential building in combination with local storage
Nicosia, Cyprus	- Coordinated demand response and demand side management at academic campus and households with RES and CHP

Table 2. Pilot locations in inteGRIDy project

Table 2. shows that pilots cover a vast area and a large number of involved EU countries. Therefore, one of the project results is to analyse technological barriers and obstacles to the application of project's applications in current markets. In detail analyses has been conducted for the countries where pilots are located. The main conclusion is that all countries are still conducting rollout policy for smart meters. Greece and Cyprus expect that rollout of smart meters will be completed by 2025 [5]. In Spain smart meters have been installed in approximately 70% of total number of consumer [5]. Although, at first glance it may seem that smart meters rollout as a precondition in the activation process of end-users is almost achieved the main issue in Spain from technical point of view is that each DSO in Spain use its own protocols and standards for metering (PLC Prime, Meters and More and Cosem). These aspects could slow down wide scale use of demand response and in general end-user engagement across different distribution grids. The main issue in Italy is that the current adopted meters (1G) are not suitable to sustain demand response services [5]. This means that these smart meters should be substituted with more sophisticated meters (2G). General conclusion for all countries

involved in this project is that smart metering will be the most challenging aspect towards a complete smart grid evolution. Standardization of smart meters across the EU is certainly the most important step towards wide scale application of demand response services as well as full activation of end-users.

#### *inteGRID: bridging the gap*

inteGRID goal is to bridge the gap between end-users and technology/solution providers such as utilities, aggregators and all other stakeholders involved in the process of providing energy services [6]. Furthermore, from the technological point of view the project aims to test and validate existing single solutions in each pilot location in an integrated environment enabling DSOs to plan and operate the network in a stable, secure and economic way. The pilots were located in Portugal, Slovenia and Sweden. The Portuguese pilot main objective is to foster the management of the distribution grid, combining DER including the development of end users flexibility, with existing assets over a large-scale environment. Pilot location consists over 1 million smart meters, with home interface, and over 10 thousand smart secondary substation, with the main focus on the Portuguese end users active participation [6]. The main aim of Slovenian pilot is to intelligently integrate existing DSO system like advanced metering infrastructure, electric vehicle charging stations, demand response programs, energy storage and supervisory control and data acquisition system (SCADA) into a holistic system [6]. Part of the grid where pilot is located is supplied by the transformer of 400 kVA (20/0.4 kV). This substation supplies a commercial customer with the nominal power of 250 kVA, 13 households, 4 small enterprises, energy storage and EV charging station. A commercial customer owns a solar power plant (80 kW) and CHP. The Swedish pilot main emphasis is on end user engagement mechanisms, with novel approaches and evaluation methods to overcome the household engagement barriers associated with demand side management programs. This pilots consists of two districts in the city of Stockholm where besides demand side management programs grid side solutions such as smart substations will be deployed and validated [6].

#### *WiseGRID: Wide scale demonstration of Integrated Solutions for European SmartGrid*

WiseGRID intention is to integrate, demonstrate and validate advanced ICT services and systems in the distribution grid in order to provide secure, sustainable and flexible smart grids and give more power to the European energy consumer [7]. An enhanced use of storage technologies, RES and EV charging infrastructure is combined in this project. The project outcomes will be demonstrated and validated under real life conditions in 5 pilot locations (Belgium, Italy, Spain and Greece). All WiseGRID pilots have strategic goals as illustrated in Figure 2.



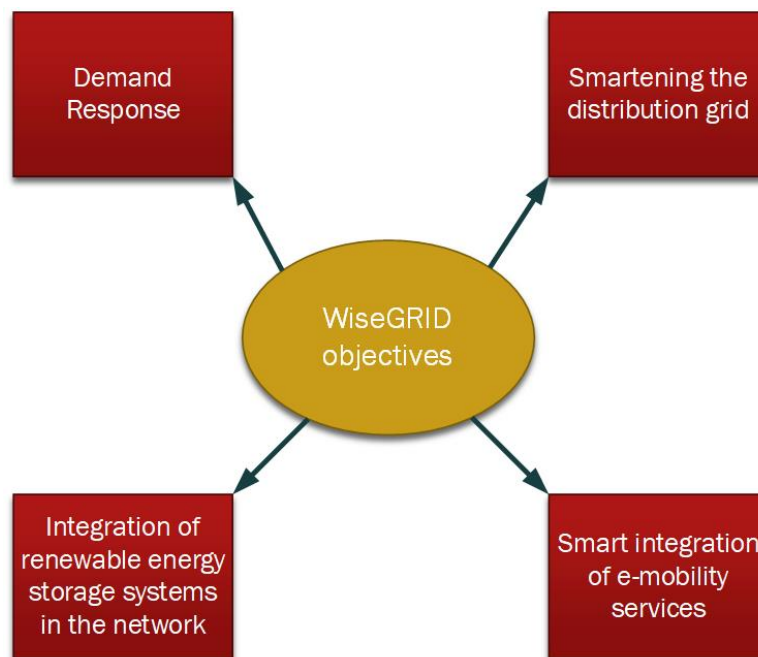


Figure 2. WiseGRID strategic objectives [7]

The different needs of the end-users in each pilot implies the need for testing and demonstrating a variety of use cases to enable the deployment of different tools developed within the project as well as to make sure that proposed solution and technologies can be adapted to diverse environments. In that regards a number of high-level use cases is analysed at different pilot locations within the project. From technical point of view, the following high-level use cases are defined [8]:

- Distributed RES integration in the grid;
- Decentralized grid control automation;
- E-mobility integration in the grid with V2G;
- Battery storage integration at substation and prosumer level;
- Cogeneration integration in public buildings/housing;
- Virtual power plant technical feasibility.

*UPGRID: Real proven solutions to enable active demand and distributed generation flexible integration, through a fully controllable LOW Voltage and medium voltage distribution grid*

This project focuses on addressing the constraints and needs arisen from poor observability of LV grid, local accumulation of DG, risks and difficulties in managing the distribution network, aging infrastructure that inhibit the grid development [9]. Furthermore, the project proposes an open, standardised and integral improvement of the LV grid. Technology related project results are listed as follows:

- Functional specification of LV dispatching;
- Deployment of mobility tools to support LV field crews;
- Integration and processing of meter events in the Outage Management System (OMS);
- Deployment of equipment in secondary substation and MV feeders to achieve a supplier independent solution for further deployment;



- LV grid remote control;
- Combined use of AMI and Home Energy Management Systems for Active Demand Management;
- Improvement of consumer capacity building web-based systems.

Within this project Common Information Model (CIM) is used as the reference data model. The CIM models the information that defines a power system, both static and dynamic way , to facilitate the integration of Energy Management System (EMS) and Distribution Management System (DMS) developed independently by different vendors [10]. The CIM is standardized through the IEC 61970, IEC 61968 and IEC 62325 series. In addition, the CIM provides two methods for transmitting the CIM data using XML format language (CIM RDF XML format for transferring the full CIM model of a power system and CIM XML format for transferring simple changes in the CIM model or add new data, such as meter readings) [10].

Furthermore, the project promotes the development of LV grid remote control operation over smart metering Powerline Intelligent Metering Evolution (PRIME) technology [10]. The main conclusion is that PRIME infrastructure can be used, not only to retrieve metering data from smart meters, but also to support Internet Protocol (IP) traffic which can serve multiple purposes. The first application is to add remote control capabilities in the LV network. Additional application is to use a standard protocol, such as Simple Network Management Protocol (SNMP) to retrieve statistics about PRIME networks performance and bandwidth which can help DSOs to analyse and optimise both metering and remote control traffic.

Additional strength of this project is its pilot-driven approach. Namely, 4 pilots are used to validate the project results. The pilots were located in Spain, Portugal, Sweden and Poland. Pilot location in Spain consists of one district in the city of Bilbao, while the Portuguese pilot consists of one district in the city of Lisbon. The Swedish pilot consists of a typical rural network, while the pilot location in Poland consists of one district in the city of Gdynia. Technical related objectives of each pilot location are illustrated in Figure 3 [11].

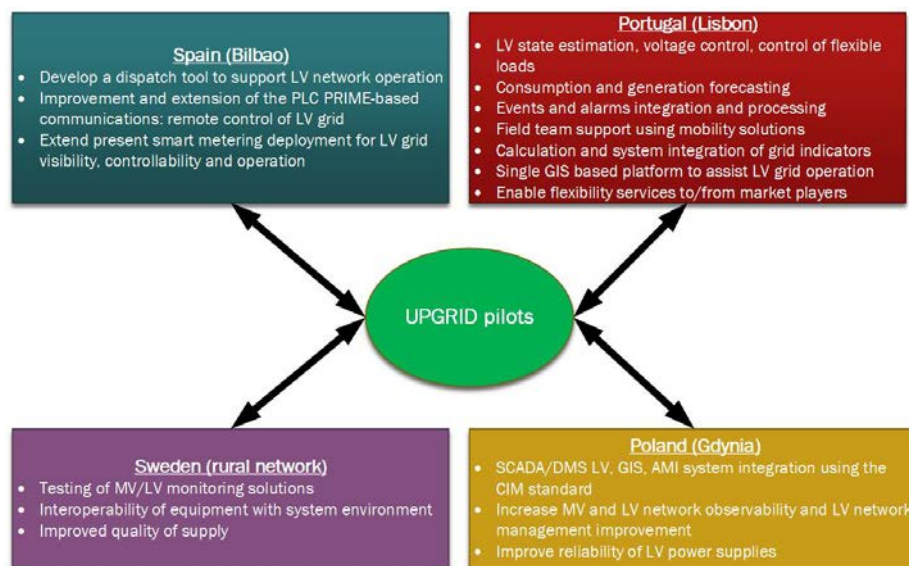


Figure 3. UPGRID pilot locations technical objectives

*NobelGrid: New cost-efficient business models for flexible Smart grids*

The project aims to provide advanced tools and ICT services to all actors in the Smart Grid environment in order to ensure more secure and stable grids. In terms of technology related project objectives, the project has two main goals listed as follows:

- Innovative solutions and tools for DSOs in order to provide secure, stable and robust Smart Grids;
- Smart Low-cost Advanced Meter (SLAM), addressing the needs of all the actors of the Smart Grid.

The project results are validated in pilot sites in five different EU member's states (Spain, Belgium, UK, Italy and Greece). A brief description of tool and applications deployed in pilot locations is given in Table 3 [12].

Enabling tools	Description
Smart Meter Extension (SMX)	- Flexible adaptation of existing commercial smart meters already deployed and being used in the different pilot locations in order to make internet-oriented meter based on the Unbundled Smart Meter (USM) architecture to aggregate functionalities which allow flexible support for billing, for energy and ancillary services markets, and for Smart Grid requirements.
Smart Low-cost Advanced Meters (SLAM)	- Deployment and demonstration of SLAM based on USM architecture. - The main intention is to develop a new generation of smart meters on the market with integrated smart metrology meter (SMM) and SMX enabling smart home drivers and communication means acting as a bridge for new smart grid/smart home applications in the new smart grid architectures.
Smart Home Intelligent Devices (SHID)	- These devices communicate with the SLAM and control a set of switchable prosumer's resources, i.e. selected consumption equipment, renewable energy production and storage with special emphasis on storage behind inverters.
Applications	- Description
Grid Management and Maintenance Master (G3M)	- This is a framework designed and developed in order to embrace different applications and services for the DSO to better manage and maintain the grid and to take advantage of new technologies.
DR Flexible Market Cockpit for aggregators, ESCOs and retailers (DRFM)	- DRFM uses a visualization methods for quantifying and comparing the effectiveness and profitability of a given set of solutions to a demand response problem. - DRFM is able to maximize the performance of consumer's portfolio of aggregators, ESCOs and Retailers and facilitate DR and DER in technical and financial terms.
Energy Monitoring and Analytics application (EMA App)	- EMA App is the front-end for domestic and industrial prosumers to interact with the market and the grid. - It enables the active participation in the balancing and stability of the grid by means of energy behaviour modifications.

Technological tools	- Description
Storage systems and inverters	<ul style="list-style-type: none"> <li>- Batteries used to store the electricity produced from RES are connected in the project pilot sites.</li> <li>- Proven inverters for interfacing the storage systems which use surplus of energy from the network will be used.</li> </ul>

Table 3. Enabling tools and application developed within the NobelGrid project

#### *InterFlex: Local use of flexibilities for an increasing share of renewables on the distribution grid*

The main intention of this project is to investigate the interactions between stakeholders and the technical and economic potential of local flexibilities to relive existing or prevent future grid constraints. In terms of technical solutions, the project has three innovation streams. These streams have been illustrated in Figure 4 [13].

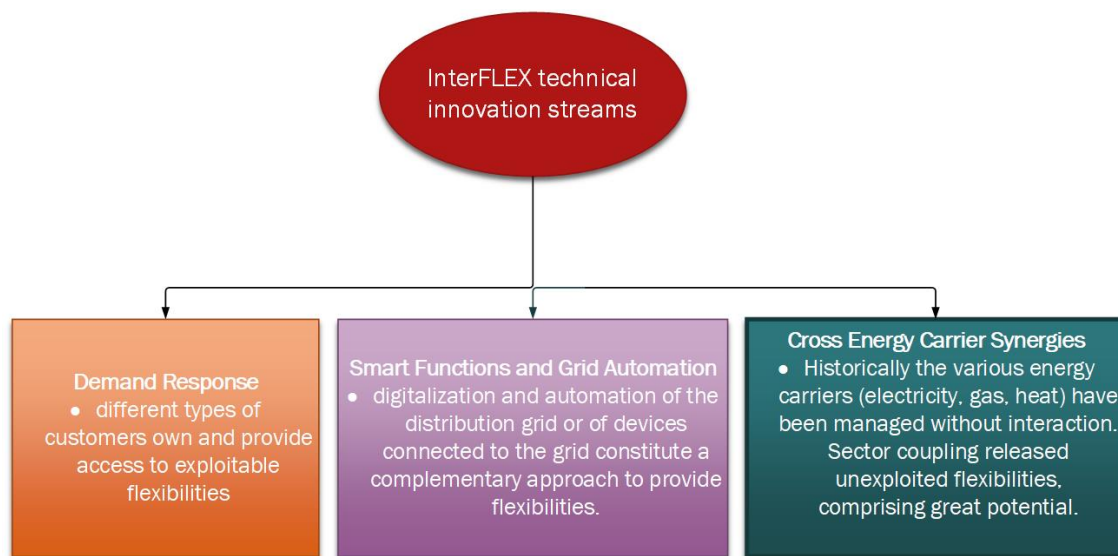


Figure 4. InterFLEX technical innovation streams

By means of the different pilots the project evaluated innovative technical approaches involving the various stakeholders: DSOs and market players, municipalities and the end customers. The first pilot located in Eindhoven in the Netherlands is focused on investigating a local market approach to prevent future grid constraints. The second pilot located in the region of Lüneburg in northern Germany served to develop an IT-control chain bound to the smart meter framework to provide the DSO with direct access to local flexibilities to relive grid constraints and improve DSO operations [13]. Flexibilities included at this pilot location consist of smart PV curtailment and load control of residential storage heaters and heat pumps. The third and fourth pilot are located in Sweden. The third pilot is located in Malmö. The main objective of this pilot is to investigate synergies between different energy carriers [13]. Flexibility resources within this pilot are storage capacity of heat networks and thermal inertia of buildings. The fourth pilot is located in the village of Sölmris. The main goal of this pilot is to explore customers demand response programs. Furthermore, the part of distribution network is separated into islanding mode with the objective to supply that part of the network using 100% RES. The fifth pilot is dispersed along different locations in Czech Republic. The main objective of this pilot is to use grid automation and energy storage in various areas of the country to increase the RES hosting capacity of the distribution network. Sources of flexibility within this pilot are decentralised

residential batteries and smart functions of EV charging stations. The sixth pilot is located in the metropolitan area of Nice on the French Riviera. The main goal of this pilot is to implement a local flexibility market to prevent future grid constraints [13].

#### *DREAM: Distributed Renewable resources Exploitation in electric grids through Advanced heterarchical Management*

The project investigated a novel heterarchical management approach of complex electrical power network providing new mechanisms for stable integration of DER. Furthermore, the project applied the principles of autonomous agent-based systems to the control and management of the electricity distribution grid allowing the system to constantly adjust to current operational conditions and make it more robust to disturbances. From a technical point of view the project presented conceptual solution to enable distributed direct real time control at the distribution level. Figure 5. illustrates distributed agent-based optimization platform of a distribution network with increased DG penetration.

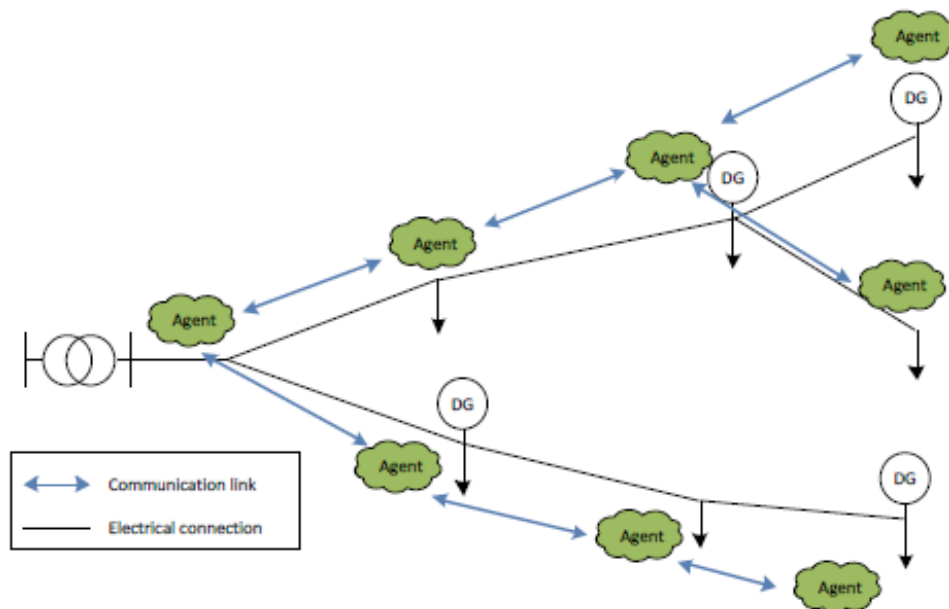


Figure 5. Distributed agent-based optimization of a distribution network with increased DG penetration [14]

A distributed optimization algorithm should be able to optimize the distribution grid operation considering technical constraints with information exchange only between adjacent nodes. Security of supply, resilience and dependability are major features of power systems. The project suggested distributed Internet architecture that might serve as a template of a massively distributed system of system comparable to the future coordination and control system for the power system. Agent based approaches have a number of advantages when looking to robustness of the ICT system as compared to classical centralised control system.

#### *Conclusions regarding technological requirements*

Overview of the relevant EU funded project showed that in order to make transition towards the distribution grid with end-users playing a central role it is essential that the technological requirements are satisfied: smartening the distribution network, roll out of smart meters, integration of demand response programs and use of advanced communication infrastructure

with strong emphasis on standardised communication protocols. Additional important technological request is on standardisation of data types that are exchanged between relevant stakeholders with the distribution network. Table 4. shows overview of the technological requirements that are analysed in different EU projects.

Project acronym	Technological requirements			
	Smart meters	Communication infrastructure	Demand response	Network automation
SmartNet	-	+	+	+
inteGRIDy	+	+	+	+
inteGRID	+	+	+	+
WiseGRID	-	+	+	+
UPGRID	+	+	+	+
NobelGRID	+	+	+	+
InterFLEX	+	+	+	+
DREAM	-	+	-	+

Table 4. Technological requirements

## 2.2 Legal, regulatory and market framework

In parallel with technological requirements a transition towards smart distribution networks with end-users playing an important role in the network management requires a market design that enables active participation of each stakeholder. In that regard, a number of EU financed project investigated potential suitable market design schemes that will primarily enable active participation of aggregators as emerging new market players. Analysed projects also identified potential barriers and obstacles in current regulatory framework and market design that hampers the participation of aggregators in the market. Additionally, analysed project also revealed the importance of aggregator that acts as a bridge coupling small end-users with the market. In the following subsections the most relevant project results in the context of regulatory framework and market schemes in the transition process towards smart-citizen-centred energy systems are provided.

### *BestRES: Best practices and implementation of innovative business models for Renewable Energy Aggregators*

This project main intention is to enable active participation of aggregators in the markets across the EU. Therefore, the project main goals are listed as follows [15]:

- Investigate the existing European business models for aggregation of renewable energy sources, their benefits and the barriers preventing their implementation;
- Improve current business models considering market designs;
- Implement the improved business models with real data and monitor them in the UK, Belgium, France, Germany, Austria, Italy, Cyprus, Spain and Portugal.

Figure 6. illustrates different aggregator business model identified in the project. By and large, aggregator business models can be divided into aggregators with combined roles and aggregators with independent roles. In a number of EU Member States there is no clear

framework for independent aggregators and relationships between independent aggregators, Balancing Responsible Parties (BRPs) are not clearly defined. This is the main reason for two types of problems related with independent aggregation. The first problem is related to balancing responsibility and financial compensation, while the second problem is related to data transfer issues that can complicate the market setup. Furthermore, in cases of independent aggregators additional problem manifests in the fact that the aggregator needs to make a bilateral agreement with the BRP to cover the BRP's sourcing cost, which significantly hinders aggregators' market entrance. By keeping that in mind, it is evident that combined aggregators are more compatible with existing electricity market design since this type of aggregation does not require important regulatory changes.

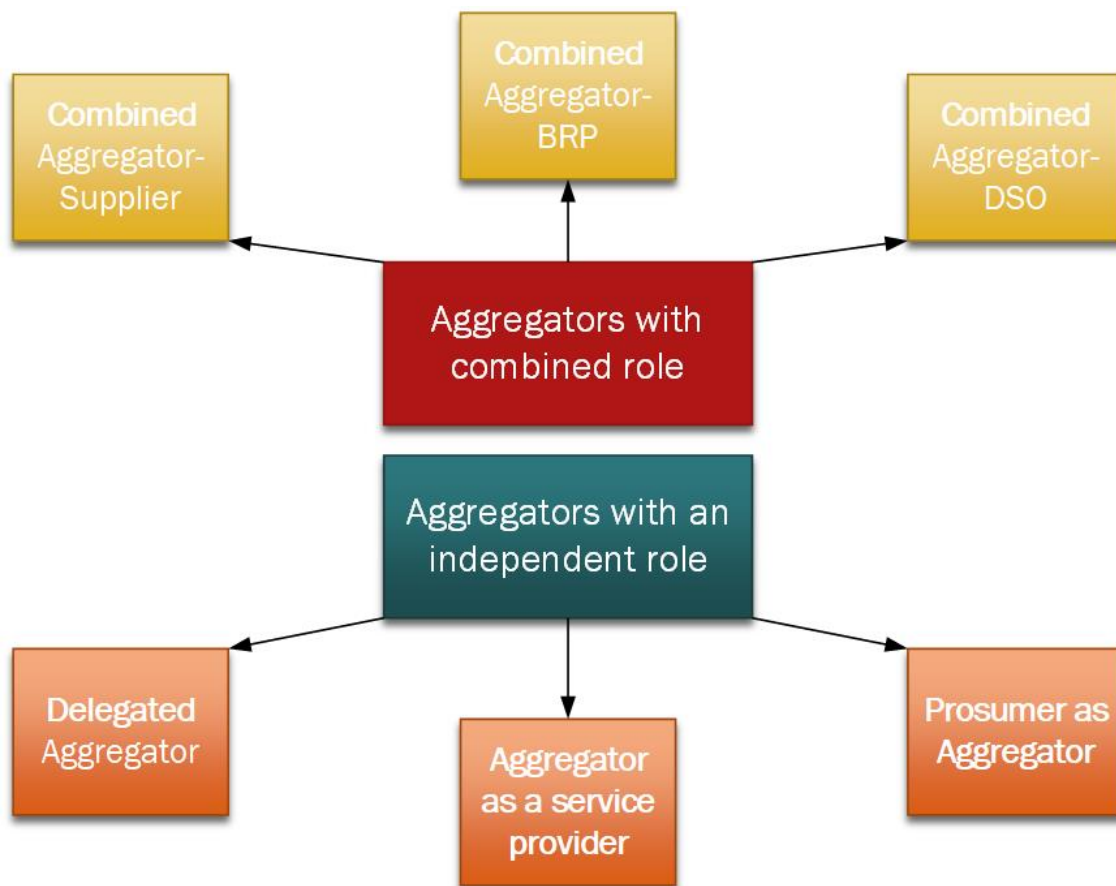


Figure 6. Potential aggregator business models [16]

Table 5. provides short description of each aggregator business model illustrated in Figure 6.

Business Model	Description
Combined aggregator - supplier	Supply and aggregation are offered as a package and there is one BRP per connection point.
Combined aggregator - BRP	In this case there are two BRPs on the same connection point, the BRP (independent aggregator) and the BRP (supplier). The supplier is compensated for imbalances.
Combined aggregator - DSO	It is assumed that regulated and unregulated roles should not be combined. Therefore, this case is not analysed in the project.



Independent aggregator as a service provider	In this case the aggregator is as service provider for one of the other market actors but does not sell at own risk to potential buyers.
Independent delegated aggregator	In this case the aggregator sells at own risk to potential buyers such as TSO, the BRP and the wholesale electricity markets.
Prosumer as aggregator	In this case large-scale prosumers choose to adopt the role of aggregator for their own portfolios.

Table 5. Description of aggregator business models

In terms of legal and regulatory framework the project results stressed that the EU regulation for aggregators is not sufficiently differentiated. General conclusion is that the aggregators are incorporated in the market and accepted as market participants. However, the main issue is that an aggregator-specific regulation does not yet exist in any of the EU Member States included in the project. In addition, legal provision, i.e. definition of the aggregator is not up to date with the variety of existing business models. In that regard, the project identified legal and regulatory barriers for current aggregator business models. Figure 7. illustrates the identified legal and regulatory barriers.

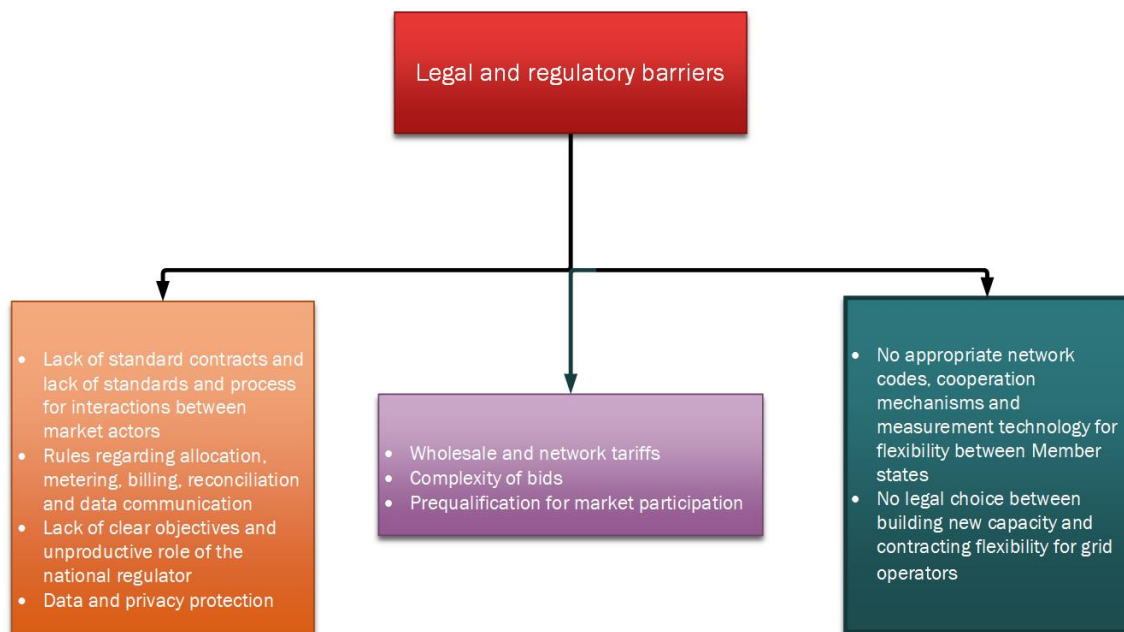


Figure 7. Legal and regulatory barriers for optimal deployment and operations of current aggregation business models [16]

#### ADDRESS: Active Distribution networks with full integration of Demand and distributed energy RESources

The main objective of this project is to help the transition of the old passive distribution networks towards the fully active distribution networks. In that regard, the project analyses the following aspects [17]:

- **FLEXIBILITY**
  - Enhancing end-user's flexibility and adaptability enabling active demand;
- **RELIABILITY**

- Developing technologies for distributed control and real time network management;
- Exploiting load flexibility;
- **ACCESSIBILITY**
  - Proposing solutions to remove commercial and regulation barriers against active demand and the full integration of DG and RES;
- **ECONOMY**
  - Enabling profitable participation in the energy and balancing markets by all market players;
  - Combining active demand with DG and RES to allow sustainable growth and energy consumption.

The most important project result, in terms of adoption of DSM programs by the end-users, is the identification of the key economic factors that may drive the acceptance of these programs by the end-users and in general by all other relevant stakeholders [18]. In that regard, the main conclusion is that the degree of adoption of DSM programs is largely influenced by the cost and benefits that accrue to each stakeholder in the power system. NRA as the main regulatory authority in each EU Member State will primarily be driven by the results of social cost-benefit analyses. The emphasis of this analyses will be on two key factors. The first factor are long-term investments mainly in the communication infrastructure of the transmission and distribution networks. The second factor are potential benefits in avoiding the investments in the networks and power plants. From the DSOs perspective the focus will be on the costs that may be difficult to transfer to end-users, i.e. communication, control and network automation costs. Aggregators, as main facilitators of the DSM programs by the end-users, will be mainly driven by the business opportunity in turns for sharing potential savings with the end-users. The end-users will be interested in the provision of DSM programs depending on their own cost-benefit analysis. They will also analyse non-economic factors, i.e. the desire to save energy or protect the climate. The economic factors, that will primarily motivate end-users to participate in DSM programs, are related to benefits that will come from savings in reduced energy consumption and income from providing flexibility to the DSO. However, the costs will also play an important role in motivating the end-users to participate in DSM programs. Generally, the costs can be divided in two categories. The first one is related to the direct cost to be paid by the end-users in order to adopt the infrastructure behind the meter., i.e. the adaptation of appliances and plugs in their homes. The second one is related to the cost that is passed-on by the DSOs and aggregators to end-users in return for the infrastructure to be deployed beyond the meter, i.e. smart meters and communication and control infrastructure.

Keeping in mind all the previously mentioned aspects the project identified the following system level benefits from adoption of DSM program [18]:

- Reduced energy costs;
- Reduced price volatility;
- More consumer choice;
- Reduced network losses;
- Reduced network investments;
- Reduced loss of intermittent generation;
- Reduction of emissions.



*WiseGRID: Wide scale demonstration of Integrated Solutions for European SmartGrid*

In parallel with technological aspects the project also analysed legal and business model aspects for the creation of flexible smart grids. In terms of regulation barriers, the project identified the following barriers for the creation of smart-citizen-centred energy systems [19]:

- **Demand response might not be accepted as flexibility source** – in this regards general conclusion is that a number of European countries wholesale, balancing and/or capacity markets still do not recognise aggregated demand as a flexibility source;
- **Inadequate and/or non-standardised baselines** – the EU Member States still have not adopted standardised measurements and baseline methodologies for DSM programs;
- **Power markets designed only for conventional providers of flexibilities** – power market should be more adopted to demand response timeframes, i.e. market timeframes should be on 15-minutes basis instead of 1 hour;
- **Aggregators, where existing, are mostly active at the high and medium voltage levels;**
- **Lack of standardised processes between consumers, balance responsible parties and aggregators** – in this regard standardised processes should be designed primarily to protect the relationship between customers and aggregators. Furthermore, standardised processes should govern bidirectional payment of sourcing costs as well as compensation between BRPs/suppliers and the aggregator;
- **Provision of information to end-users** – in this context it is not sufficient only to send energy prices to end-users and information on how much end-users could potentially save by changing their consumption patterns, but also other kind of information. For example, the end-users will be more motivated to participate in DSM programs and choose among suppliers/aggregators depending on the mix of energy sources from which the electricity they consume is produced;
- **Automatization of demand response mechanisms** – DSM programs should be made as easy as possible for end-users to participate.

In order to promote the creation of smart-citizen-centred energy system the project investigated several potential business models which are focused on different stakeholders. For application of each business model potential barriers have been identified. Figure 8. illustrates analysed business models within the project.

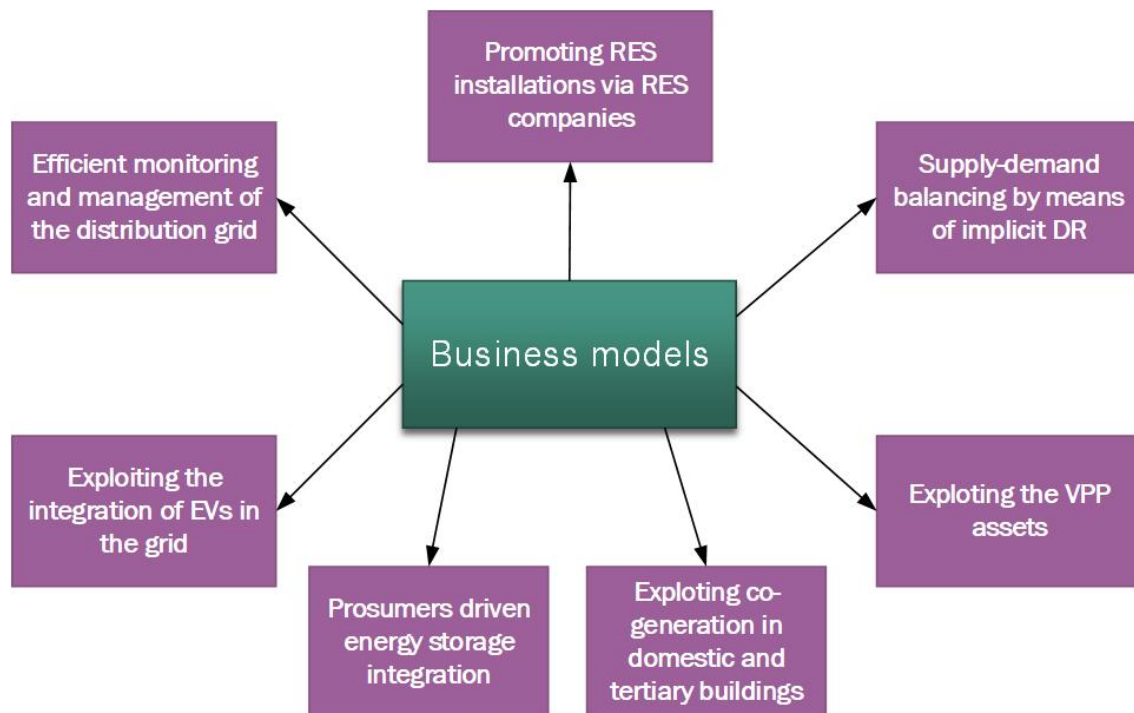


Figure 8. Analysed business models [19]

The first business model investigated the business model concerning RES company (RESCO) renting the rooftop of domestic or tertiary buildings and installing RES when the occupants of the buildings cannot afford the investment cost. The main actors in this model are prosumers (consumers with batteries), RESCO and ESCO. The main barriers for the integration of this model are:

- authorization for the sale of energy by RESCO,
- excessive bureaucracy or lack of regulatory framework for prosumers,
- uncertainty about prosumers flexibility capabilities,
- possible conflict of interest with other market actors such as VPP operator who aim to utilize the prosumers flexibility,
- lack of awareness among residential customers.

The main revenue streams in this model are revenues from energy selling to the wholesale market and revenues from selling energy to the customers in the islanding mode. The second business model investigated benefits from monitoring and management of the distribution grid. Actor in this model is only a DSO. In general, no barriers have been identified. The third business model investigated benefits from the electrification of the transportation sector, i.e. the integration of EVs with appropriate charging infrastructure in the smart grid. Actors involved in this model are prosumer (EV fleet manager), EVSE (charging station operator) and DSO. The main barrier for this model is high purchase price for EVs and their limited autonomy. EV fleet manager main revenue streams in this model are related to decrease of its charging cost by utilizing the EV's flexibility and shifting their consumption during DR event, and participation in V2G services allowing the injection from the EV's batteries in the grid. EVSE operator revenue streams are related with increasing the number of its clientele using the charging stations and paying appropriate fee, and with the portion of compensation provided by DSO for the provision of ancillary services. The fourth business model analysed the case when energy storage has been

installed at the prosumer's premises. Actors involved in this model are prosumer (consumer with batteries and RES), energy storage operator, VPP operator and DSO. Prosumers main revenue stream in this model is related to the reduction of the energy bill through time-of use management and enhanced self-consumption. Additional revenue stream for the prosumers is expected from the active participation in DR events. VPP operator main revenue stream is related to payments received by DSO (or other actors) for providing ancillary services and flexibility to the relevant markets. The fifth case analysed potential business model driven by the integration of Combined Heat and Power (CHP) in domestic and tertiary buildings and the control of the HVAC systems in such buildings, in order to exploit the synergies between the thermal and electrical needs. Actors involved in this model are prosumer (domestic and tertiary occupants with CHP equipment and thermal storage capabilities), gas retailer, gas DSO, electricity DSO, VPP operator and ESCO. The sixth case analyses the optimal operation of the VPP with emphasis on scheduling of an explicit DR event. Actors involved in this model are prosumer, ESCO, VPP operator and DSO. The last business models investigated the case of prosumer's supply-demand balancing by means of implicit DR. Actors involved in this model are prosumer, retailer and ESCO.

#### *inteGRID: bridging the gap*

In parallel with the technological requirements the project also analysed current regulation and market rules in countries where pilots have been located. This analysis covered the following aspects: DSO economic regulation, DSO as a system optimizer and market facilitator, retail tariffs and metering and aggregation and market design [20]. As a part of DSO economic regulation DSO's revenue regulation results in each country are provided in Table 6.

Country	Form of price control	Treatment of CAPEX and OPEX
Portugal	Price cap	Separately for the HV and MV concession. TOTEX approach with price cap for Low voltage.
Slovenia	Revenue cap	Separately
Spain	Revenue cap	Separately
Sweden	Revenue cap	Separately

*Table 6. DSOs remuneration characteristics [20]*

Additional analysis in the part of DSO economic regulation is related to regulatory incentives for DSOs in each country. Results related to the continuity of supply as a main component this analysis are provided in Table 7.

Country	Metrics Considered	Incentive Mechanism
Portugal	SAIDI, SAIFI, and TIEPI	Symmetric bonus-malus
Slovenia	SAIDI, SAIFI	Symmetric bonus-malus
Spain	TIEPI, NEIPI	Symmetric bonus-malus
Sweden	SAIDI, SAIFI and ENS LV	Symmetric bonus-malus

Table 7. Incentives for continuity of supply [20]

With respect of DSOs as system optimizer and market facilitator network charges and market facilitation has been analysed in each country. Table 8. shows network charges for DG in each country.

Country	Connection Charge		Use-of-System	
	Type of Connection Charges	Calculation	Applicable for DG?	Metric
Portugal	Deep	Case-by-case	-	-
Slovenia	Deep	Standard formula	-	-
Spain	Deep	Case-by-case	yes	Energy
Sweden	Deep	Case-by-case	yes	Energy and Capacity

Table 8. Network charges for DG

Table 9. shows to what extent DSOs are market facilitators in each country.

Country	Participation of DG in Voltage Control	Participation of DG in Congestion Management or other ancillary services	DSOs allowed to own DG	Visibility of DG data for the DSO for grid operation purposes
Portugal	Limited to technical requirements	Cannot participate in other services. DSO and TSO interfere in DG in case of congestion.	No	Only DG connected to MV and HV.
Slovenia	Limited to technical requirements	Not foreseen in regulation	No	Not visible for the DSO.
Spain	Limited to technical requirements	Cannot participate	No	Only metering data ex-post.
Sweden	Limited to technical requirements	Not foreseen in regulation	No	DSO has access to DG data.

Table 9. DSOs are market facilitators [20]

In addition, the project also analysed the situation regarding aggregation services in each country. In Spain, aggregation of DG is permitted in spot and reserve markets on a company basis. Independent aggregators are not allowed in Spain. In Slovenia, aggregation is permitted, and the only aggregator is presently offering tertiary reserve to the TSO. Important to emphasize is that the aggregators in Slovenia are currently exempted from balancing responsibility in order to foster this market. In Sweden, no aggregation agent is currently operating [20]. According to Swedish market rules, an independent aggregator is supposed to be a BRP [20].

### 2.3 End-users engagement

Development and implementation of demand response services in distribution networks is not enough to unlock the full potential of such projects. Besides technological and regulatory obstacles, many sociological issues were tackled within EU-funded projects. In that regard many projects identified end-users recruitment and creating/maintaining awareness as the most challenging process for the establishment of the smart-citizen-centred energy systems. A major challenge in many research projects was to motivate and engage the end-users to participate in the project. *The main approach in many EU projects is to shape an engagement strategy solely around offering end-users savings on their energy bill.* This resulted in a low end-users motivation to participate in the project. Additional issue is identified with the engagement of residential users in wealthier areas where monetary incentives are not sufficient to motivate these users. In that case engagement strategy should be focused more on the innovative aspects of the research project and on offering end-users added value, e.g. overview of the consumption in the real time. Furthermore, the complexity of the technology developed in the project could also be a challenge to attract end-users and engage them in the project. Additionally, the key to successful end-users engagement strategy is to shift from technology-push towards a needs-based approach. The first step in this process is to identify end-users needs, while the second step is to make sure that the project creates value for consumers that address these needs [21]. In that regard, Figure 9. illustrates the key values for end-users. In the following subsections the most relevant EU project results in the context of end-users engagement in the transition process towards smart-citizen-centred energy systems are provided.

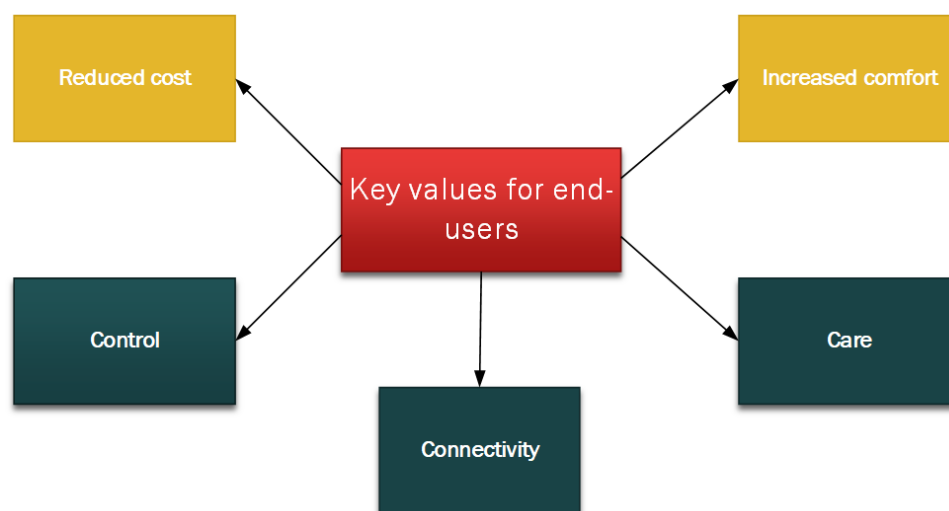


Figure 9. Key values for end-users [21]

In Figure 9. **control**, **connectivity** and **care** values are related to communication aspects. Namely, **control** value tackles people-to-technology communication aspects, while people-to-people aspects are included in **care** value. In addition, technology-to-technology related communication aspects are included in **connectivity** value.

*inteGRIDy: Integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization and Storage Technologies*

In parallel with technological aspects, the project also analysed social barriers and obstacles to the application of inteGRIDy-like solutions in current markets. In the EU, the quality of the electricity supply is high and consumers, i.e. residential users, are more focused on electricity costs. Since electricity costs are relatively low in case of industrial facilities or office buildings electricity costs are not the top priority for savings compared to prices for other resources or other cost factors. By and large, suppliers provide not enough incentive to change customers behaviour, i.e. to activate consumers. General conclusion is that the lack of awareness regarding smart energy solution is caused from passiveness on both sides. The project stressed that barriers may be reduced by stimulating public awareness for smart energy solutions and communicating their advantages. The following advantages of the smart energy solutions have been specially stressed to the consumers [5]:

- **Smart Grids contribute to stabilizing the power grid at a lower cost compared to storage options;**
- **For implementing demand response solutions, no new facilities must be planned, authorized or built;**
- **Intelligent controlling on generation and demand side also avoids bottlenecks on the local level, to the extent that costly extension and retrofitting of the distribution grid could be avoided in some cases.**

Since the project covers a number of EU countries where pilots are located social barriers have been investigated in each country. In that regard, Figure 10. illustrates the main barriers for accepting the smart energy solutions in Italy from a social point of view.

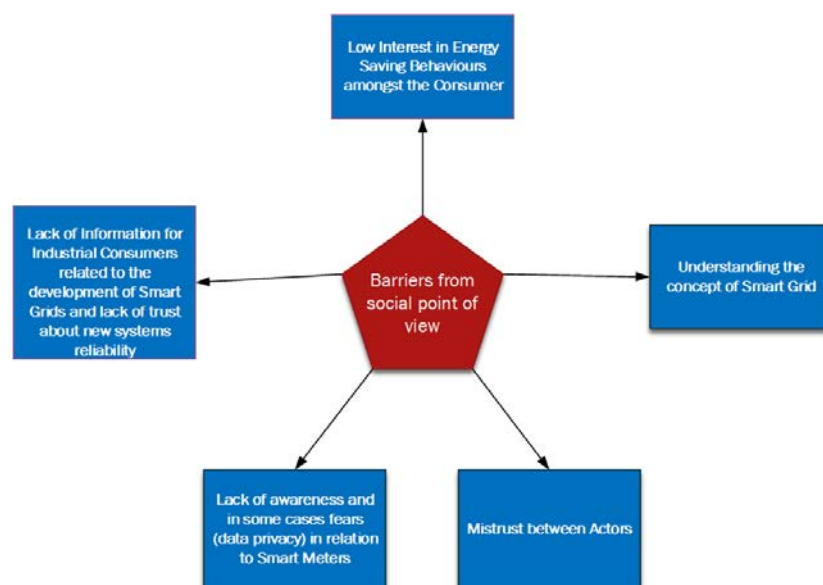


Figure 10. Italian case - Barriers for the acceptance of the smart energy solutions from a social point of view

*WiseGRID: Wide scale demonstration of Integrated Solutions for European SmartGrid*

In parallel with the technological solutions, legislation and business models the project also analysed the development of smart grids with regard to its implications on social and ethical matters primarily on the EU context. In terms of social and ethical issues of smart grids the project focus was on the following topics [19]:

- **How smart grids can contribute to a broader economic transformation?**
- **How the EU is working towards fostering more flexible, open, transparent and dynamic policies within the energy sector?**
- **ICT and smart grids related issues (cyber security and privacy issues)?**

The first topic considered the economic transition occurring globally towards collaborative economics and how the EU plans to integrate new market models into smart grids energy system. Special emphasis was on the potential social and environmental benefits as well as on the challenges that lie ahead in realising the future policy goals. Additional focus was also on the concept of the so-called “collaborative economy”. The collaborative economy is a phenomenon that challenges the foundations of the traditional institutional economic structures. Namely, the age of digital economy has opened up a new and innovative ways for stakeholders to engage in the market. In that regard, market structure is changing, and the traditional business-to-consumer relationship is no longer a norm. A trilateral arrangements between consumer, a provider of service or good, and the intermediary platform with anyone playing the role of one or more of these actors, will replace the existing bilateral relationships.

The second topic considered importance of new concepts in the management of resources, such as circular economy. The main goal of circular economy is to close the loop on waste and inefficiency through the whole product lifecycles.

The third topic considered issues related to ICT and smart grids. Overview of the key issues raised by the integration of ICT into energy systems (cyber-attacks of critical infrastructure, energy and data theft, fraud, denial of service, etc.), as well as cyber security and privacy issues of smart grids were analysed.

*inteGRID: bridging the gap*

An important aspect of this project was to investigate the long-term engagement of end-users in the smart electricity grid. The main outcome of this project in terms of customer engagement strategies can be seen through three project outcomes. These outcomes are illustrated in Figure 11.



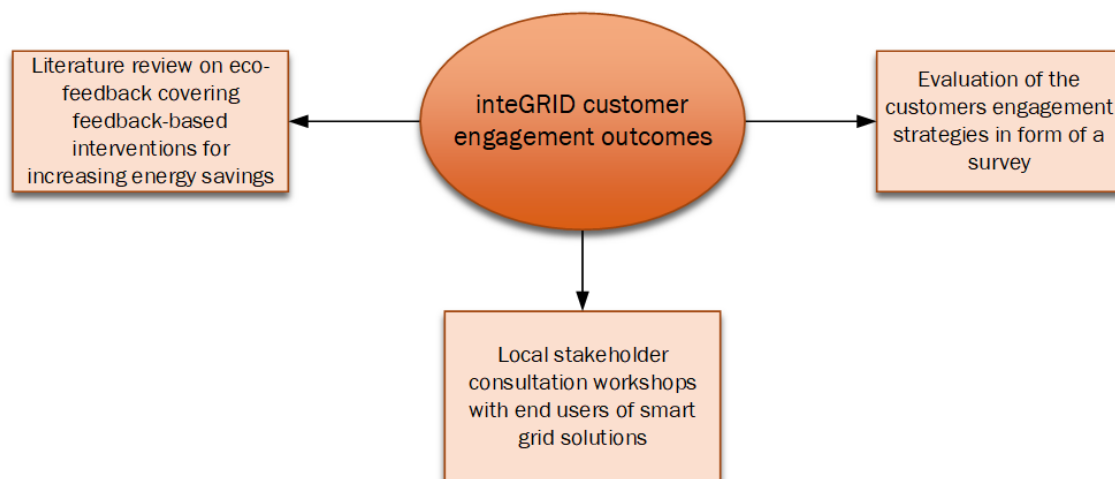


Figure 11. inteGRID customer engagement outcomes

The first outcome of this project in the context of customer engagement strategies is related to the literature review on eco-feedback covering feedback-based interventions for increasing energy savings. Term **feedback** in this context indicates visualisation platform used by the customers in the household. The intention of this review was primarily to identify key design features of devices and/or features related to the implementation of the devices (e.g. device placement) [22]. The main results of this review can be observed through a number of practical recommendations such as feedback timing, duration of feedback, mediums used, content of feedback, granularity of feedback, working with penalties and rewards, design strategies, and specifically, designing devices for families and homes. In addition, specially designed algorithms with household-specific baselines were introduced to customize the feedback to the actual household and to increase customer trust in the feedback.

The second outcome is related to local stakeholder consultation workshops with end-users of smart grid solutions. Namely, a residential stakeholder consultation workshops were conducted in Stockholm and Lisbon where the main topics were community storage and feedback. Additionally, two office employee stakeholder consultation workshops were conducted by Elektro Ljubljana with their office employees in Domzale and Ljubljana. The main objectives of consultation workshops with office employees can be summarized as follows [22]:

- to raise awareness on building energy performance among employees;
- to find out about current habits and attitudes related to energy;
- to identify action points in an upcoming behavioural change program aimed at conserving and shifting energy;
- to build approval of the program among employees.

In that regard the workshops resulted in the decision to focus on two measures in the behavioural change program:

- management of air conditioning;
- close attention to switching off computers and their equipment when not in use.

In addition, as a part of this outcome a literature review was also conducted that emphasized how stakeholder workshops have been used in the energy field sector in the past. These literature review also provided insight on what stakeholders have been included in workshops.



The third outcome is related to the survey that was specially designed to cover end-users energy attitudes, behaviours, and intentions, as well as social identity and cohesion in their neighbourhoods and buildings [22]. Two surveys were conducted and summarized in Stockholm and Lisbon since end-users, i.e. residential users, are located in pilot cities in these cities. The main conclusion of Stockholm survey is that participants energy saving behaviour is mainly influenced by their attitudes and the perceived control they have over energy saving activities. On the contrary, the Lisbon survey did not find an influence of attitudes and perceived control on energy saving behaviour.

#### *Conclusions regarding end-users engagement*

Analysis of the relevant EU funded project showed that in order to make transition towards the distribution grid with end-users playing a central role it is essential to include the social aspects. General conclusion, as indicated in many EU projects, is that the most challenging process for the establishment of the smart-citizen-centred energy system is end-users recruitment and creating/maintaining awareness. Table 10. gives the best practices in the context of social aspects in end-users engagement strategies.

Best practices	Description
Customer's needs and the value provided	- It is essential to identify consumers' needs and make sure that the project creates value for consumers that address these needs.
Analysis of the local socio-technical system to identify needs and values	- Customer engagement strategies should be focused more on local aspects, e.g. role of monetary incentives versus environmental feedback/incentive depend on peoples' living situation and current energy prices.
Constant contact between consumers and (local) partners	- It is essential to establish an ongoing communication with consumers in the project; - This role is best taken by local contact persons and/or organizations which already have strong social bonds with consumers, know their needs, have a communication network and, most important, are trusted by consumers.

*Table 10. Best practices in end-users engagement*

### 3 STAKEHOLDERS' COMMON REQUIREMENTS SURVEY

In order to determine what FLEXIGRID project's stakeholders consider to be the largest obstacles and what are the opportunities for the development of flexibility solutions for distribution grid, we have decided to conduct a questionnaire. The questionnaire-related actions in this task are preparation, translation to national languages, conducting the online questionnaire and analysis of the results. However, the first action necessary for identification of the stakeholders' common requirements is identification of the stakeholders themselves. Table 11 contains the list of actions performed towards identification of the stakeholders' common requirements within FLEXIGRID project.

Actions	Partners involved	Period
Identification of the stakeholders	UNIZG-FER, UNICAN, ATOS, CIRCE, EDYNA, VERD	1/12/2019 – 21/1/2020
Questionnaire preparation	UNIZG-FER	14/1/2020 – 11/2/2020
Questionnaire translation	HEP-ODS, ATOS, UNICAN, EDYNA, VERD, CAP	12/2/2020 – 18/3/2020
Conducting the questionnaire	UNIZG-FER, ATOS, UNICAN, EDYNA, VERD	18/2/2020 – 20/5/2020
Analysis of the results	UNIZG-FER	13/5/2020 – 20/5/2020

Table 11. Actions performed as a part of the stakeholders' common requirements survey

#### 3.1 Identification of the relevant stakeholders across Europe

Stakeholder mapping was a collaborative effort of the partners from the demo-site countries. The main concern was to identify the stakeholders in the demo-site countries: Croatia, Greece, Italy and Spain, as well as the EU-level stakeholders. Partners from each country were asked to suggest the relevant stakeholders, considering the requirements of each of the eight use cases from four demo-sites. The stakeholders were grouped in the following categories:

- Funding bodies: local authorities, policy makers, public bodies
- Experts: regulatory bodies, research institutes, professional associations, technology providers, equipment producers and vendors, energy cooperatives
- Electricity sector: generating companies, energy service provider companies, electricity suppliers, aggregators, balance group leaders and system operators (TSOs and DSOs)
- Consumers: consumers and citizens' associations

#### 3.2 Stakeholders' common requirements survey preparation

The survey was prepared by partners in two steps. First, the questions were chosen based on the groups of identified stakeholders so that their inputs can be analysed separately. The survey was then translated by FLEXIGRID partners to their national languages in order to make it as approachable as possible to the public. The survey was available in Croatian, French, English,

German, Greek, Italian and Spanish. The following are links to the surveys in each of the languages:

- Croatian: <https://forms.gle/gBkwNh1FaFWrEmoz8>
- English: <https://forms.gle/TeCSeY7v1MCmmmoK6>
- French: <https://forms.gle/YfJxoGstM28A253P7>
- German: <https://forms.gle/R7YKeZkouHww7hG28>
- Greek: <https://forms.gle/zAn7jSGJHZAB98xD8>
- Italian: <https://forms.gle/SE9q3fLi1ZLK2qBw8>
- Spanish: <https://forms.gle/62n7PTuUdKFW4nFr9>

The survey was conducted by the partners who participated in stakeholder identification process so that each of the identified stakeholders was approached by a partner from their country. Table 12 shows the response rates for each of the countries where the survey was conducted.

Represented countries	Number of responses
Croatia	55
Greece	21
Italy	13
Spain	13
Total	102

Table 12. Number of responses to the survey from each country

### 3.3 Survey results

Here we present and discuss the most relevant results for FLEXIGRID project. The results are divided into sections, each representing one group of questions from the survey.

#### *Funding opportunities*

In this section, we asked the funding bodies to estimate the share of their budget that goes into funding of the following:

- smart grid-related projects
- energy efficiency-related projects
- RES projects
- building automation projects
- EV infrastructure (charging stations)

Low response rate of the funding bodies makes it difficult to draw general conclusions. However, the results show that funding of all the above listed types of projects are represented by the low share of the respondents' budgets. The energy efficiency projects have the largest share, between 1% and 5%, next are RES and building automation projects with 1% to 2% and the last is EV infrastructure with about 1%. None of the respondents responded that they have budget allocated for smart grid-related projects. These results are not unexpected, knowing that energy efficiency and RES are in the spotlight since the EC's Third energy legislative package. It is

expected that the number of funding opportunities for the other projects will increase with the implementation of the Clean energy package.

#### *Most important aspects of flexibility provision programmes*

Representatives of the electricity sector were asked to choose, out of the following, the most important aspect of flexibility provision programmes:

- Decreasing the operating costs
- Congestion management
- Maintaining the system's stability and security
- Integration of RES
- Integration of EVs
- Decreasing the CO<sub>2</sub> emissions

This question was answered by electricity sector representatives and it received 35 answers in total. Figure 12 and Figure 13 show answers as percentages of the total number of responses. RES integration leads with 34%, followed very closely by the system's stability preservation with 31%. Minimisation of operating costs is next with 23%. Less common answers were CO<sub>2</sub> emission decrease (9%) and congestion management (3%), while EV integration received no responses.

The results illustrate the current situation in power systems throughout Europe quite well. As RES shares in the energy mix are growing, it is becoming more challenging to maintain power system's stability and security. Furthermore, intermittency of RES power output increases the operating costs due to activation of capacities of more expensive peaking power plants. Flexibility services such as demand response and virtual energy storage are promising solutions for these problems. On the other hand, electric vehicles are still not recognised neither as a source of problems or as a relevant flexibility provider in the power systems. The relatively small numbers are increasing and given enough time they are likely to get more in the focus of the distribution grid operators, similar as RES are today.

Besides the abovementioned issues with RES, DSOs are starting to recognise the need for congestion management within their grids. Figure 12 shows DSO responses in blue. While the traditional approach to congestion management in both transmission and distribution systems was oversizing the grid components, demand management is gaining popularity as an alternative to investments and as a way to decrease the system's losses. This is important in the present when more and more RES are being connected to the distribution grid and will be even more important in years to come when electric vehicles become a standard way of transportation.

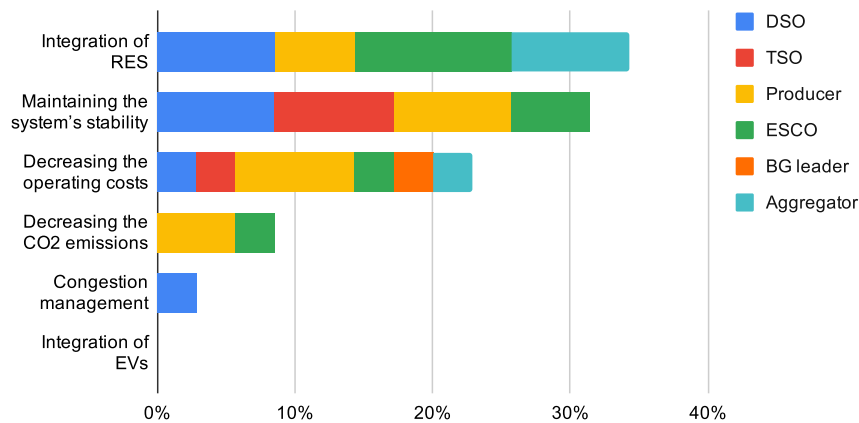


Figure 12. Survey results: most important aspects of flexibility provision programmes by organisation

The results of this survey are confirming the need for developing the proposed solutions of the FLEXIGRID project. Most of the projects' use cases aim at developing solutions for operation of networks with large shares of RES. It is interesting to look at the results from Figure 12 when presented by country, as shown in Figure 13. RES integration is the only option chosen by respondents from every country.

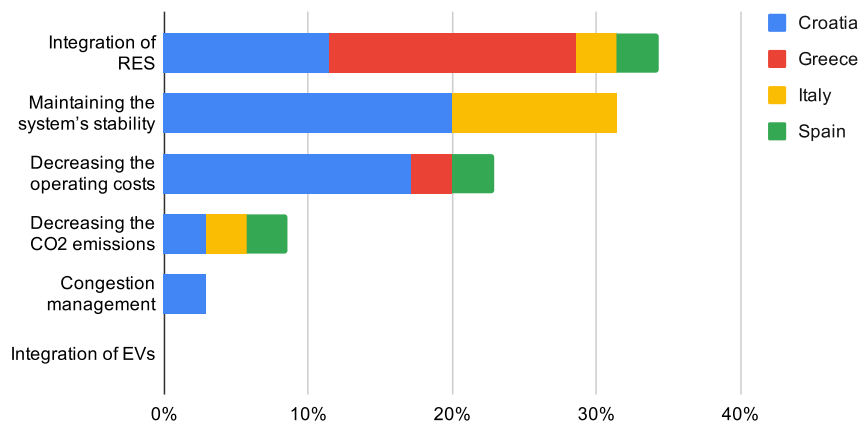


Figure 13. Survey results: most important aspects of flexibility provision programmes by country

#### Obstacles for flexibility service trading at the distribution system level

We asked the stakeholders to grade from 1 to 5 the degree in which they consider each of the following to be an obstacle to flexibility service trading at the distribution level in their country:

- regulatory framework
- inadequate existing infrastructure
- slow smart-meter roll-out process
- the way the network is operated
- structure of retail electricity prices
- uninterested consumers
- level of technological development

This question was answered by electricity sector and other experts and received 48 responses in total. Figure 14 presents average results for these 48 respondents for each of the categories.

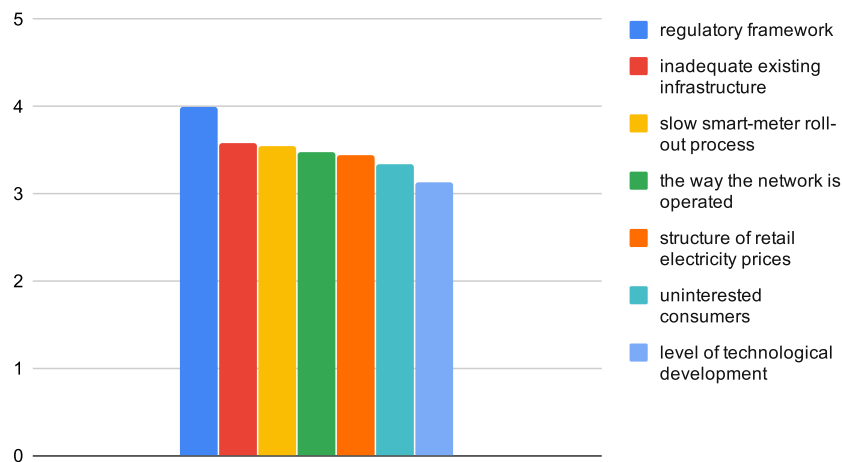


Figure 14. Survey results: obstacles for flexibility service trading at the distribution system level

*Regulatory framework* is singled out as the major obstacle with 4 as an average answer and 37.5% respondents giving it the highest grade. This is in line with the findings of earlier projects presented in the previous chapter. Regulatory framework in most countries is outdated and should be updated to allow flexibility service trading. While the most recent Electricity Directive (EU 2019/944) gives guidelines for the DSO's flexibility services procurement, it remains to be seen how those guidelines will be implemented in national laws.

However, changing the regulatory framework is only the first step in the process of establishing the flexibility service trade at the distribution system level. To identify the other barriers, we should look at the rest of the answers. The rough indicator of their importance is the order in which they appear in Figure 14. Highest on the list are *inadequate existing infrastructure* (3.58) and *slow smart-meter roll-out* (3.54), two issues that are closely connected and are in most states the responsibility of DSOs. According to the EC's report on Benchmarking smart metering deployment in the EU-28 [23], in most of the EU member states the impact of the large-scale smart-meter roll-out was deemed positive. According to the same document, the smart-meter rollout should in most states be finished by 2030. Next issue is *the way the network is operated* (3.48), which is also DSO-related and interconnected with the previous two issues in many ways. Although the *structure of retail electricity prices* with an average answer 3.44 is lower on this list, the DSOs have graded it as high as the regulatory framework. This is not surprising, given that they are regulated entities, depending strongly on network fees set by the national energy regulatory bodies. The fact that the structure of the retail prices is set by the regulatory bodies makes it hard to engage consumers in flexibility service trading. It will be interesting to see how each DSO will handle both the legal bindings and the system's requirements in the following ten years while trying to achieve a high level of consumer engagement.

Although results from the earlier projects show that keeping the end-users engaged can be quite difficult, *uninterested consumers* (3.33) are listed quite low here, which means that the experts from the electricity sector do not see them as a large obstacle for flexibility service trading. This can either mean that they are overly optimistic or that they are not considering the consumers to be an important part of flexibility service-trading schemes. If the former is true, a paradigm

shift might be necessary for the whole electricity sector in order to reach the targets set by the Clean energy package with regard of end-user engagement.

Finally, *level of technological development* is listed last. However, that does not mean that the technology necessary for flexibility service trading at the distribution system level is ready. Average answer for this question is 3.13, which is not low. Therefore, new technological solutions are needed that enable flexibility service trading between DSOs on one the side and service providers on the other.

#### *Obstacles for distribution-level electricity markets*

We asked the stakeholders to grade from 1 to 5 the degree in which they consider each of the following to be an obstacle to the development of distribution-level electricity markets in their country:

- regulatory framework
- slow smart-meter roll-out process
- the way the network is operated
- structure of retail electricity prices
- uninterested consumers
- inadequate existing infrastructure
- level of technological development

This question was answered by electricity sector and other experts and received 48 responses in total. Figure 15 presents average results for these 48 respondents for each of the categories.

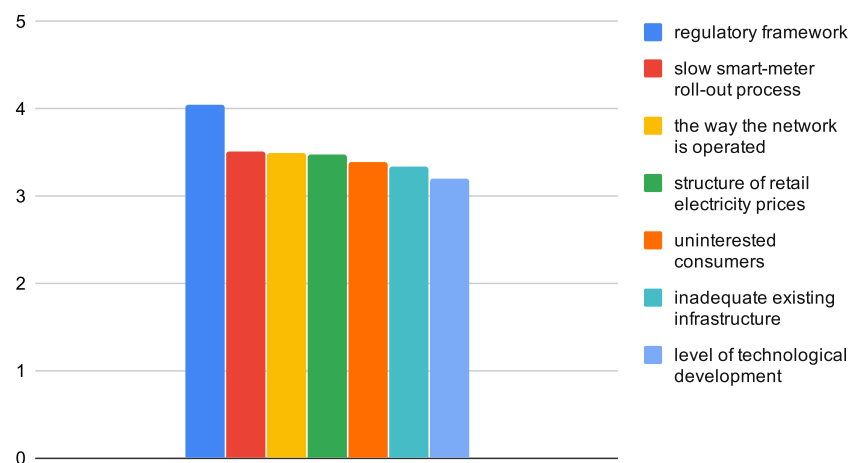


Figure 15. Survey results: obstacles for the development of distribution-level markets

Same as with flexibility service trading, *regulatory framework* with the average of 4.04 is considered the largest obstacle for distribution-level markets. It is necessary to prepare the ground for the aggregators, set-up new trading mechanisms for retail markets, as well as for the more advanced peer-to-peer markets. Again, it remains to be seen how the guidelines from Electricity Directive (EU 2019/944) will be implemented in national laws.

Smallest obstacle of the listed is again the *level of technological development* with an average answer 3.13, and *inadequate existing infrastructure* (3.33) is second from the bottom.

Aggregators are already a commercial technology and changing the way retail markets are organised requires mostly legal and regulatory changes and these two issues are not as relevant. On the other hand, peer-to-peer energy trading at the distribution system level requires development of new devices and trading mechanisms so it is not surprising that level of technological development received higher average grade in comparison with the question about flexibility service trading.

*Slow smart-meter roll-out (3.52), the way the network is operated (3.50) and structure of retail electricity prices (3.48) are graded in similar manner. These three issues describe the current retail market situation. Consumers cannot be engaged in any way without smart meters that allow them and other involved parties to track their consumption in real time. Retail electricity prices are comprised, among other, of network fees set by the regulatory bodies and taxes and levies set by the government. Portion of the price set by the suppliers is in some EU member states as low as 20%. Therefore, it might be difficult to engage consumers to participate in price-based demand response programmes. The way the networks are currently operated does not provide an incentive for creating the markets at the distribution system level. However, projects such as EcoGrid [24] have successfully demonstrated that a new market design is achievable.*

*Uninterested consumers* are considered a larger obstacle for distribution-level markets than for the flexibility trading, with an average of 3.40. There is no point in setting up a new market structure if no one will be there to trade. To overcome this obstacle, it will be necessary to apply various good practices based on social sciences, such as those described in section 2.3.

#### *Obstacles for development of flexibility-service solutions*

In this question, we asked the stakeholders to grade from 1 to 5 the degree in which they consider each of the following to be an obstacle to the development of flexibility-service solutions within their organisations:

- Regulatory framework
- Current electricity market design
- Inadequate existing network infrastructure
- Uninterested consumers
- Slow smart-meter roll-out process
- Not enough opportunities for market placement of such solutions
- Level of technological development

This question was answered by 27 expert organisations: technology providers, energy cooperatives, research institutions, professional associations and regulatory bodies. Figure 16 shows the averages of their answers for each of the items.



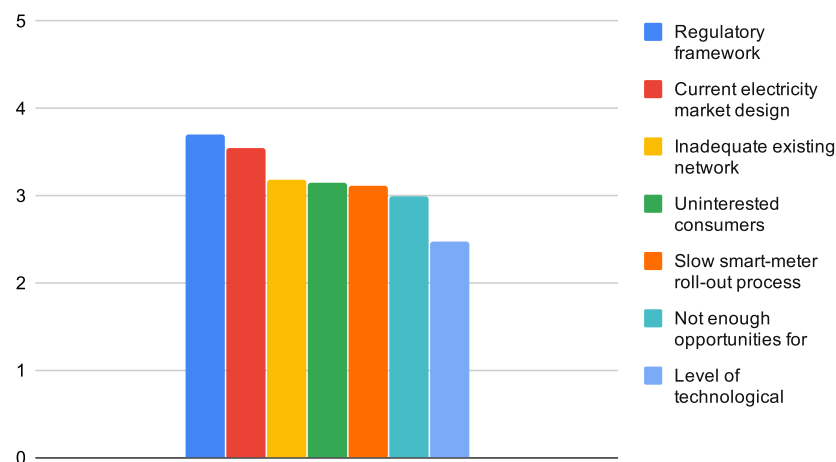


Figure 16. Survey results: obstacles for development of flexibility service solutions

In general, scores here are lower than those for the same answers in previous questions. This shows that the experts outside of electricity sector do not feel as strongly as those inside about the obstacles. As in the previous questions, most respondents ranked *regulatory framework* as the largest obstacle for the development of flexibility service solutions within their organisations. Its average score is 3.70, much lower for this question than for the other ones. Regulatory framework is closely followed by *current electricity market design* with 3.56 average. The fact that the experts consider it to be almost as large an issue as the regulatory framework is a sign that the market design is the first issue to be resolved by the policy makers who wish to stimulate the advancement of distribution grid technologies connected to flexibility service provision.

Next group of items with similar averages are *inadequate existing network infrastructure* (3.19), *uninterested consumers* (3.15), *slow smart-meter roll-out process* (3.11) and *not enough opportunities for market placement of such solutions* (3.00). These are all technoeconomic issues that slow down the innovation processes and can be mitigated by strategic governmental actions. Uninterested consumers here do not necessarily mean end-users. The technology providers might be pitching their ideas or products to the actors such as network operators or aggregators. Therefore, they can have very different ideas about their consumers and ways to engage them. With an average answer 2.48, *level of technological development* is considered to be an even smaller obstacle in this question than in the previous ones (with 3.13 and 3.21). This large gap in average answers between the electricity sector and other experts suggests the sector's lack of trust in the solutions developed or promoted by the outsiders. Given that the electrical grids are always operated robustly, with as little space left for errors as possible, the lack of trust is understandable. Increasing the dialogue between these two groups of stakeholders is necessary for the development of flexibility solutions for distribution grid.

#### Consumers' motivation for participation in flexibility provision programmes

The consumers were asked to grade from 1 to 5 the degree that the following would motivate them for participation in flexibility provision programmes:

- financial incentives
- energy bill reductions
- getting access to innovative technologies

- getting access to an overview of their energy consumption over time
- knowing that they are improving your energy consumption efficiency
- knowing that they are helping with RES integration
- knowing that they are reducing their carbon footprint

This question was answered by consumers, mostly residential (20 answers) and a few commercial (5), as well as citizens' associations (2 answers). There are not enough responses to the survey to draw conclusions about the individual categories, such as commercial consumers, so we present only the cumulative results. Figure 17 shows the average answers for all respondents to this question, 27 in total.

The items in the list can roughly be grouped in financial, environmental and technological motivators. Financial reasons are leading as the motivators for participation in flexibility provision programmes, *energy bill reductions* scoring 4.30 and *financial incentives* scoring 4.07. This confirms results of many previous studies on consumer engagement.

Previous studies have also shown that environmental reasons can be even stronger motivators than financial. The respondents in our study gave an average of 3.78 to *knowing that they are reducing their carbon footprint*, while *knowing that they are improving your energy consumption efficiency* and *knowing that they are helping with RES integration* received 3.59 and 3.56, respectively. It is evident that, even though these three items are connected and might be placed in the same box of ecological motivators, the consumers do not perceive them as equal. This difference of perception should not be disregarded when preparing consumer engagement programmes.

Responses for technological motivators are more varied. *Getting access to innovative technologies* scored a high 3.59, at the same level as environmental group of motivators. On the other hand, getting access to an overview of their energy consumption scored quite low in comparison with the other motivators, 3.26. However, the score for this item is still not as low as to make it not relevant. These results show that the consumers have similar level of need for technological advancement as they have for protecting the environment. For this reason, consumers should be better informed of their opportunities and included in the dialogue when developing novel flexibility services.

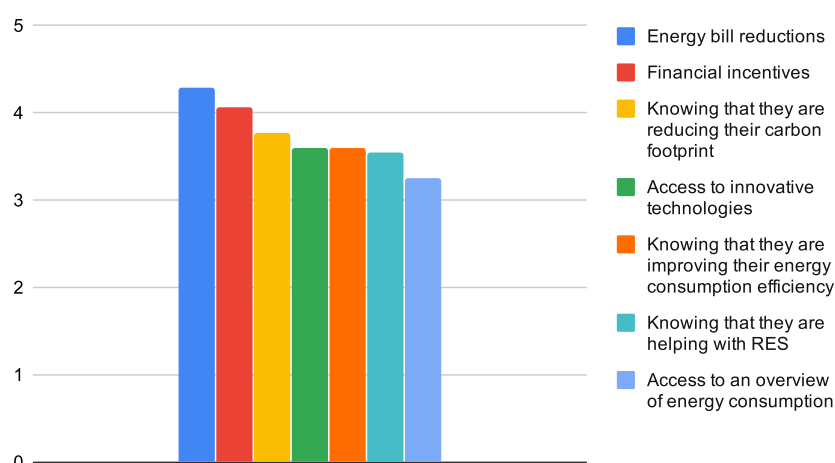


Figure 17. Survey results: motivation for participation in flexibility provision programmes

### 3.4 Main obstacles for deployment of new solutions

Our statistical results show that the regulatory framework is considered by all stakeholders to be one major obstacle to the development of new flexibility solutions at the level of distribution grids. However, we have also presented to all the respondents the following question: *"If you were to point fingers, what or whom would you identify as one major obstacle for deployment of new solutions in your country?"* to which we received free form answers. The main outtakes of this question are presented below.

Many respondents chose to blame the **regulatory framework and bureaucratic procedures** as the largest obstacles. An answer from an Energy Cooperative from Spain illustrates this very well: *"Regulatory framework is the main obstacle. A regulatory framework is needed that not only allows but encourages this type of flexible and intelligent solutions. This is especially so for the residential consumers."* **Monopolies** were also mentioned a few times, such as the answer of a technology provider from Greece: *"Network monopoly and weak regulatory authority."*

An Italian research institution listed some of the most relevant regulatory and market-design issues: *"Rigidity in applying solutions for relevant users also to small customers, which brings with it several critical aspects: minimum size of flexibility ('minimum adjustment power'); assignment to the BSP of responsibility for ensuring the correct behaviour of the aggregate; DSO role limited to the prequalification phase ('fit & forget' for flexibility), instead of facilitator for massive DER participation."* The list was expanded by a consumer from Greece *"Taxation and connection charges."* The regulatory issues are many, so it is not surprising that most stakeholders consider the regulatory framework to be a large obstacle for deployment of flexibility services and markets at the distribution system level.

**Lack of necessary infrastructure** was pointed out more than once. A research institution from Greece wrote: *"The obstacles are many and the omission of some can lead to failure. From a technological point of view, the development and installation of smart meters could be considered as the most important obstacle."* A market operator pointed out the same thing: *"Installation of smart meters by the DSO."*

**Consumers'** inertia, tariff systems and retail price structure, as well as the consumers' lack of trust are some of the issues pointed out. A consumer from Greece said: *"Fear of the unknown, aversity to change, NIMBY."* Lack of interest and inertia were mentioned both in the context of consumers and the electricity sector. A technology provider from Croatia wrote: *"Lack of motivation, incentives by regulatory institutions and indifference and disinterest of system operators for the introduction of new technologies."*

In Spain, **financial obstacles** are mentioned by some, such as this professional association: *"Lack of financing to carry them out."*

### 3.5 Conclusions

The survey presented in this document was conducted with an aim to determine the major obstacles and opportunities for development of flexibility service solutions at the distribution system level.

A large majority of the stakeholders whose responses were collected through the survey consider the regulatory framework to be the major obstacle for development of flexibility

solutions, flexibility service trading and electricity markets at the distribution system level. Therefore, as the first step towards the flexibility services procurement by the distribution system operators, the national legal and regulatory frameworks should be updated to better reflect the distribution system needs and consumers' requirements. Updating the national regulatory frameworks must be done in compliance with the Electricity Directive EU 2019/944 but should also reflect the requirements of the relevant stakeholders within each country.

A few respondents named the lack of financial support for development of flexibility solutions as the major obstacle. This is reflected in the answers to the question on funding opportunities presented in section 3.3.1. Small number of respondents that have resources to fund development of new solutions make it hard to draw general conclusions. However, the answers of those who responded show that funding opportunities at local and national level are not enough to incentivise the other stakeholders to develop new solutions for flexibility service provision and trading at the distribution system level.

Although the level of technological development is deemed not as big an obstacle as the rest of the options, the infrastructure is in most EU member states still does not support wide implementation of flexibility services for distribution grid. The slow smart-meter roll-out process is identified by the stakeholders as somewhat smaller obstacle than the regulatory framework. This process is to be mostly finished by year 2030.

Uninterested consumers are graded at the similar level as the infrastructural issues. Interesting results in this area are presented in section 3.3.6, where consumers' motivation for participation in flexibility provision programmes is presented. The results show that financial reasons are the main incentive for participation for most of the consumers. Environmental reasons, such as CO<sub>2</sub> footprint decrease, are less relevant motivator for our respondents, but should not be disregarded when creating flexibility provision programmes in which end-user participation is required.

Organisation of energy and flexibility service trading at the distribution system level is a collaborative effort of DSOs, suppliers and aggregators, overseen by regulatory bodies. Large number of stakeholders makes setting up new markets and developing new solutions a complex activity. Consumers are placed in the spotlight in this process. To engage them successfully, not only knowledge in the areas of technology and economics is necessary, but also the knowledge of social sciences.

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