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DELIVERABLE D4.1
Barriers that hinder LFM proliferation

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Executive Summary

PARITY will go beyond the traditional "top-down" grid management practices by delivering a Local Flexibility Market (LFM) platform of heterogeneous DER through IoT and blockchain. However, there are barriers that hinder the proliferation of such markets. After surveying the body of knowledge, interviewing experts and consulting end-users belonging to the pilots-buildings through questionnaires, we identified a comprehensive list of barriers that can be classified within the following main themes: (1) fit to current lifestyles, (2) administrative, (3) standardization, (4) trust, (5) technical, and (6) costs, where each category has sub-categories. All these two-tier barriers are interwoven among each other. Moreover, these can be also categorised by their nature (i.e., social, technical, economic and regulatory aspects). The taxonomy is publicly available in ZENODO[1] for other researchers and interested practitioners to draw upon them to design use cases for LFM.

To link and prioritize the barriers against actors of new energy flexibility markets (i.e. prosumers, DSOs, Aggregators, BRP or TSOs), a Delphi method was conducted followed by a statistical analysis of the results from the qualitative method. Each of the first-tier barriers were linked to the participant actors in PARITY ecosystem. The main conclusions we obtained are that the list of barriers that can impact more on the proposed use-cases and business use-cases in PARITY, were those related to standardization. Moreover, trust and costs are also highly relevant for the project when it comes to design the overall architecture. A very important finding was observing that Current Lifestyle is only affecting Prosumers and no other actors. Therefore, the analysis reveals that this barrier has to be treated in isolation from the others with mixed-methods.

[1] https://doi.org/10.5281/zenodo.3863017

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List of Acronyms and Abbreviations

Term	Description
AFID	Alternative Fuels Infrastructure Directive
BRP	Balance Responsible Party
BUC	Business Use Case
CEER	Council of European Energy Regulators
CEO	Chief Executive Officer
COO	Chief Operating Officer
DER	Distributed Energy Resources
DR	Distributed Resources
DSO	Distribution System Operator
ESCO	Energy Service Company
EU	European Union
EV	Electric Vehicle
FCR	Frequency Containment Reserve
FRR	Frequency Restoration Reserves
FFR	Fast Frequency Reserve
IoT	Internet of Things
LFM	Local Flexibility Market
NPF	National Policy Frameworks
P2H	Power to Heat
PEE	Primary Energy Factor
PEF	Primary Energy Factor
TSO	Transmission System Operator
UC	Use Case

1. INTRODUCTION

1.1 Scope and objectives of the deliverable

According to the dictionary, a barrier is a material or immaterial that blocks or is intended to block the passage. Barrier is a synonym of obstacle which in turn is something that impedes something to occur or happen. Drawing on the literature about the proliferation of energy technologies (e.g. renewables, demand response, DER, etc.) we find that barriers are indeed more immaterial than physical. These include cost-effectiveness, administrative barriers, and market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. Some barriers may be specific to a technology, while some may be specific to a country or a region [1].

Taking these definitions into account and according to the Description of Action (DoA) document of the PARITY project, this Task 4.1 pursues an investigation of the current barriers that hinder the penetration of the PARITY LFM framework into existing electricity market schemes. As we committed in the DoA, we examined the latest views and recommendations from Energy Regulators Agencies, the Council of European Energy Regulators (CEER), Eurelectric, National Regulatory Authorities along with proposals contained in related legislations –such as the Clean Energy for All Europeans package-. The main business use cases and requirements of T3.1 are taken into account as an input to this task. On this premise, the various regulatory principles concerning current and future electricity market operation are be evaluated as to how their context would satisfy the PARITY proposed framework, and where the current framework requires adaptation. In parallel, more technical issues such as the different market gate, closure times and settlement procedures as well as socio-economic aspects (such as end-user comfort and reluctance on new technology adoption) are also addressed. A roadmap is conducted with experts, providing deeper knowledge of the factors affecting PARITY LFM energy market adoption and evolution using multi-criteria decision-making methods, in our case, Delphi methodology.

Specifically, in this report we provide a triangulation-based methodology not only to generate barriers extraction related to LFM, but also a way to prioritise them with regards to actors involved in PARITY's Business and Use Cases. These actors are presented in Table 1:

Table 1. Description of actors according to USEF[2].

Actor	Description
Prosumer	The end-user that not only consumes energy, but also produces it.
DER	It represents all types of systems that either demand or supply energy which can be actively controlled.
Supplier	It buys, supplies and invoices energy to its customer.
BRP	It is responsible for actively balancing supply and demand for its portfolio of agents.
DSO	It is responsible for the active management of the distribution grid.
TSO	It transports energy in each region from Producers to Consumers.
Aggregator	Accumulates flexibility from Prosumers and their DER and sell it to the BRP, Supplier, DSO or TSO.
ESCO	Offers all kinds of energy-related services to Prosumers as energy optimization, joint purchase and maintenance of (shared) assets, etc.

The deliverable covers all the aspects and addressed steps to come up with a comprehensive list of barriers related to LFM adoption. Furthermore, we provide a categorisation of these barriers according to a multi-level approach. Finally, we describe how categories on the second tier of the taxonomy are related to actors described above in Table 1 and how the barriers have an impact on them. As in D3.1 -

[2] https://www.usef.energy/app/uploads/2019/02/USEF-White-Paper-Energy-and-Flexibility-Services-for-Citizens-Energy-Communities-final-CM.pdf

Elicitation and analysis of business/use cases and requirements for the PARITY tool suit, use cases and business use cases defined a preliminary list of actors within each situation, we believe that this prioritization will help future tasks that address the configuration of the overall PARITY system architecture and infrastructure.

1.2 Structure of the deliverable

Section 2 of this deliverable presents the overall methodology used to identify and prioritise the barriers. In turn, in this section, the methodology the two methodologies used to identify the barriers in the State of the Art, on one hand the technical and socio-economic barriers and on the other hand legal ones, are described. In Section 3, the identified barriers following the methodologies presented in the previous section are shown. Next, in Section 4, the taxonomy created to the classification of all the barriers is described. In Section 5, the Delphi methodology used for the barriers prioritization with experts is presented and the results obtained. These results link the barriers with the actors, uses cases and business cases that will appear in the several tasks of PARITY project such as T4.2 or T4.3. Finally, the conclusions obtained during task T4.1 are presented.

1.3 Relation to other tasks and deliverables

The results obtained in task T3.1 (Elicitation and analysis of business/use cases and requirements for the PARITY tool suite) that are described in the D3.1 (PARITY Business use cases & Requirements) have been used as input. Namely, on one hand the descriptions of the Uses Cases and Business Cases. On the other hand, the answers to given be consumers and stakeholders to the surveys and interviews that were carried out.

Furthermore, the taxonomy and the prioritization explained in this deliverable will be the input for all the tasks and deliverables in WP4 and the tasks related with the pilots. These are listed next:

- T4.2: Design of next-generation smart-contract-enabled energy contracts.
- T4.3: Investigation of LFM market models for TSO/DSO/Aggregator/Retailer collaboration.
- T4.4: Definition of business models for LFM actors.
- T5.2: Design of PARITY Market Models & Flexibility Monetization Schemes and update/configuration of block-chain platform.
- T7.1: PARITY IoT Framework & Prosumer Services.
- T7.2: Human-Centric P2H Models.
- T8.1: PARITY System Integration.
- T8.2: Community engagement, pilot participant recruitment and integration into local flexibility market.
- T8.6: Holistic impact assessment of PARITY system on local market/network/demand.

2. METHODOLOGY

The process of identifying barriers of any nature can be performed following different strategies. The one which is most adopted consist on conducting an extensive and systematic literature review to come up with a list and a categorization [2] [3]. However, there are other existing methods. Painuly [1] triangulated the barriers detection for renewable energy technologies by conducting a literature review, pilot-sites visits and interaction with stakeholders. Olsthoorn et al. [4] explored barriers to DR, through surveys of consumers. Similarly, Seidl et al. [5] conducted online surveys among German-speaking users linked to open questions in the context of Distributed Energy Systems. In [6] the goal-framing theory was used as the theoretical basis to design motivational statements that activate different self-goals driving the barriers to adopt green energy. Finally, Balta-Ozkan et al. [7] used a combination of in-depth workshops, expert interviews and literature research to investigate the barriers for emerging technologies penetration in smart homes.

Considering this background, we addressed three main phases to detect barriers that hinder LFM proliferation. These are listed hereafter:

1. ***Barriers identification***:
   In this phase, all the barriers were identified but not classified. The major effort was the management of the sources from which the barriers could be extracted. The sources used in this methodology are the **state-of-the-art review** based on technical, social, legal and economic aspects, potential final consumer's surveys, **interviews** with stakeholders.

2. ***Barriers classification (Taxonomy)***
   In the second phase all the barriers identified were classified in different categories and subcategories with the aim of creating a **taxonomy**. During this classification all the duplicated barriers were deleted and the similar ones were merged. The obtained taxonomy provides a clean view of all the barriers detected.

3. ***Barriers prioritization***
   Finally, in the last phase, the barriers of each category and subcategory were prioritized. This prioritization aimed at identifying those barriers that could affect more to PARITY project. This prioritization is done by experts using the **Delphi** methodology and is linked with the use and business cases.

In each of the boxes of Figure 1, we can observe the different steps followed according to the previous phases. In order to perform barrier identification, we first conducted a series of surveys with experts within the consortium; Secondly, we ran two tasks in parallel: On the one side, we provided surveys and hold interviews with end-users, building-pilot managers and other relevant stakeholders. On the other side, we started to review the body of knowledge related to barriers detection in LFM. With all this information, the experts involved in this task generated a two-tier categorisation of barriers. Thus, the taxonomy. Taking this latter outcome as input for the last phase, we discussed the barriers of the first tier of the taxonomy with experts to prioritise them according to the actors provided in the introduction (i.e. Prosumers, BRP, DSO, TSO, DER, etc.)

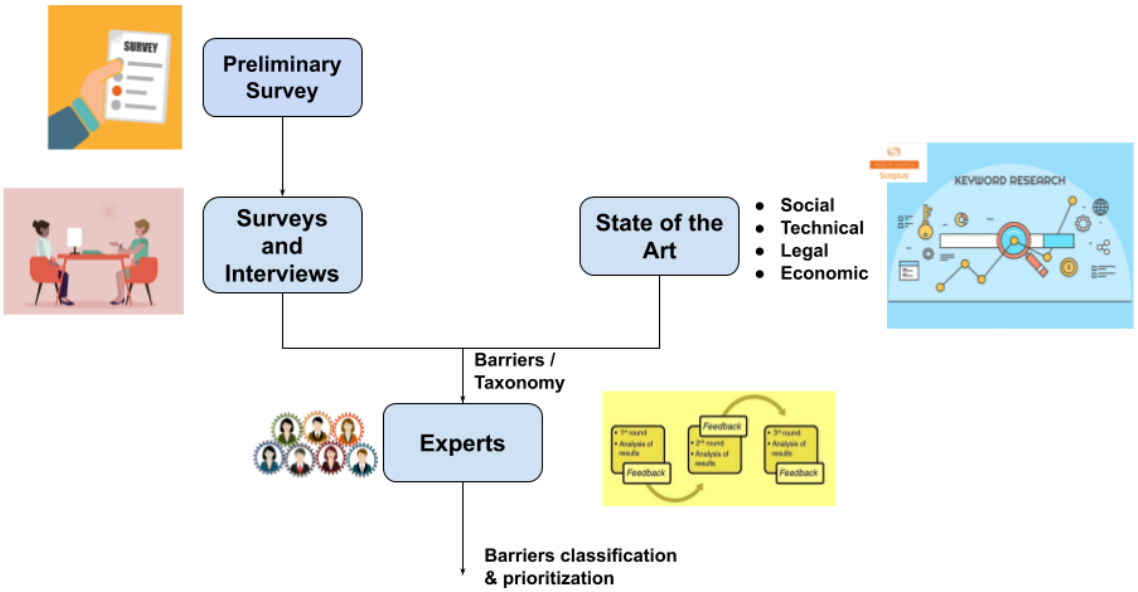

Figure 1. Barrier detection and prioritization methodology.

2.1 Methodology to obtain the socio-technical State of the art in LFM

In this section, we explain the main steps to undertake a systematic review of the body of knowledge related to obstacles in LFM proliferation. The researchers and relevant participants in this PARITY task followed an iterative methodology based on the use of SCOPUS[3] as a primary source of content from the literature. Figure 2 shows the steps that such iteration was composed.

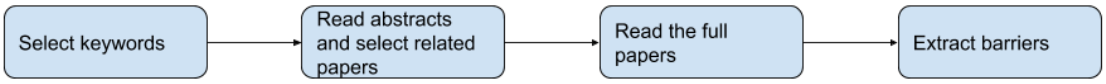

Figure 2. SCOPUS-based methodology.

1. **Select keywords:** In this step a series of keywords were selected (e.g. adoption, attitudes, barriers and drivers or challenges) in these three areas related to the PARITY project: DER, LFM and DR. These keywords were used to obtain papers in SCOPUS.
2. **Read obtained papers abstracts.** Abstracts of all the papers obtained in the first step were read. A selection criterion was applied to just keep those studies with a clear relation with PARITY project.
3. **Read full papers.** In this step, the selected papers were read and those which did not have interesting information were discarded after a discussion with the experts involved.
4. **Extract barriers.** Finally, barriers were extracted from the selected papers by using a shared spreadsheet for this purpose[4].

3 http://www.scopus.com

4 https://zenodo.org/record/3861847#.XtBAKvIzZhE

For this lookup task, nine iterations have been done. In Table 2 keywords used in each of them and the number of papers obtained from SCOPUS are shown.

Table 2. Used keywords in each search and the number of papers obtained.

Keywords	Number of papers
Barriers, "Grid Management"	13
Barriers, Demand, Response	234
Barriers, Local, Market, Energy, Smart, Contract	139
Barriers, Local, Market, Energy, Smart, Contract, Flexible OR Flexibility	49
Barriers, Local, Market, Energy, Flexibility	22
Barriers, Local, Market, Energy, "Smart Contract", Flexible OR Flexibility	7
Barriers, New, Energy, Market, Local	41
Barriers, Local, Market, Proliferation	8
Social, Barriers, Adoption, New, Technology	97
Social, Barriers, Adoption, New, Technology, Energy Market	48

2.2 Methodology to obtain the regulatory barriers in LFM

Institutional and policy barriers include existing industry, infrastructure and energy market regulation. Despite liberalization of energy markets in several countries, current industry structures are still highly concentrated and regulations governing energy businesses in many countries are still designed around monopoly or near-monopoly providers. Technical regulations and standards have evolved under the assumption that energy systems are large and centralized, and of high power density and/or high voltage. Intellectual property rights, tariffs in international trade and lack of allocation of government financial support may constitute further barriers [8]. However, with the proliferation of DER across countries other barriers have appeared (e.g. new actors and therefore new relationships among them).

To identify the legal barriers to the PARITY project, the regulatory frameworks in the four countries was assessed, where the pilot sites are located (Switzerland, Sweden, Greece, Spain). For this analysis, the following approach was applied in each country:

- At first, the available national flexibility markets have been described and the regulatory conditions for participating in these markets have been highlighted.
- Then, the main stakeholders and market participants have been described, with a focus on the roles of DSOs, aggregators and local energy communities.
- As a conclusion of the above, the roles of the market participants have been mapped to the different markets. The results have been summarized in a matrix that will be presented in the following sections.
- Finally, the main obstacles in the national legal framework have been derived and future perspectives to overcome these obstacles have been mentioned.

3. INITIAL FINDINGS ABOUT LFM BARRIERS

Here we present the early results from the surveys and interviews conducted as well as the outcomes and summary of the barriers encountered in the review of the literature (socioeconomic, technology, regulatory and legal barriers).

3.1 Surveys and Interviews

In this section, the surveys and interviews performed with stakeholders and end-users are described. Please note that, according to the methodology diagram presented above, we deliver surveys as two different snapshots and with different people.

3.1.1 Preliminary survey

The goal of this first iteration was to have a first list of barriers that could appear during the project without prior investigation. Thus, it was the first objective of T4.1 according to the diagram presented in Figure 1. The survey, created using Google Forms[5], was answered by partners who are involved in the project. The aim was to be able to better grasp the internal knowledge about LFM barriers from PARITY partners. This survey was divided in two sections. The first part related to the profile of the different respondents. The second part related to the main barriers they identify according to their expertise.

- **Partner profile**

  In the first section, information about the partners was asked. This facilitates a better analysis of the barriers that will be identified in the second section. Table 3 shows the questions this section is composed of and the type of answer that was expected in each one.

Table 3. Questions to gather partner profile.

Question	Type of answer
Partner name	Short answer
Role in Parity project	Multiple choice: • DSO • Aggregator • Facility Managers • Tech developers • Residential Prosumers • Office Building users
Are you responsible for any component in PARITY (e.g. Oracle, STATCOM, Hive, etc.)? If yes, which one?	Short answer

- **Barriers**

  The goal of this section is to identify the barriers that PARITY partners believe that will possibly appear. Third section was composed of four open questions in order to influence partners as little as possible. The questions were created in order to get initial insights on social, technical, legal and economic barriers. Table 4 shows the questions asked.

[5] https://docs.google.com/forms/d/e/1FAIpQLSc-EpHr49BdWlRPllJeA3e6VLIysvId9PLhaUa7dbrIsL6_Jg/viewform

Table 4. Questions to gather partners' barriers.

Question	Type of answer
Please, according to your knowledge provide a list of social barriers that prevent the adoption of Local Flexibility Markets?	Long answer
Please, according to your knowledge provide a list of technical barriers that prevent the adoption of Local Flexibility Markets?	Long answer
Please, according to your knowledge provide a list of legal barriers that prevent the adoption of Local Flexibility Markets?	Long answer
Please, according to your knowledge provide a list of economic barriers that prevent the adoption of Local Flexibility Markets?	Long answer

3.1.1.1 Preliminary survey results

We had 15 responses from partners covering the majority of the roles: Aggregators, DSOs, ESCOs, and Facility managers. Although all kind of barriers were identified by the participants the majority of them agree that trust aspects between stakeholder and the way of how the data is managed is important to all of them. They also explained that **the lack of previous experience** of most of the companies in LFM + Blockchain issues could be a handicap. Finally, the **initial investment** that companies and prosumers must do is something critical for the participants.

3.1.2 Interviews with relevant stakeholders

In T3.1, CIRCE and involved partners performed some interviews with different stakeholders to identify the needs of targeted end-users of the PARITY solutions. Internal (consortium) and external stakeholders' groups were assembled to create a balanced cluster of electricity market stakeholders and flexibility providers (prosumers). From the 13 interviews they conducted, four interviewees were DSOs, five were facility managers and four were aggregators. All the pilot countries (Greece, Switzerland, Sweden and Spain) were represented with at least two interviewees. Regarding the gender balance, unfortunately all the interviewees were male, which is not a rare situation because the majority the employees having a directive role in the energy sector are males[6].

In all these interviews we introduced some questions related to the barriers that stakeholders encounter when trying to deploy or deliver solutions based on flexibility measures. In Annex A, we provide the questions we used to guide the conversation and the semi-structured interview with relevant stakeholders. The results from these interviews are provided hereafter breakdown by actor. However, the general identification of barriers according to everyone are provide next. (i) Possible penalties or low economic incomes with high initial investments. (ii) Lack of technical and economical specific regulations in most countries. (iii) Lack of previous experience in the sector. (iv) The complexity of the systems and contracts is also a perceived drawback, not only because they are not fully understood but because it might be the source of additional technical issues and failures. (v) Personal data and privacy concerns.

3.1.2.1 Facility managers (FM)

- Current restrictive regulations that presently do not explicitly allow the participation of demand response in most electricity markets,
- The complexity of the systems and contracts is also a perceived drawback, not only because they are not fully understood but because it might be the source of additional technical issues and failures,

[6] https://www.compromisorse.com/upload/estudios/000/101/foir2800.pdf

- The lack of previous experience in DR management is a problem by most of the FM interviewed,
- Some FM pointed out the issue of the self-control override in favour of automated systems under control of a third party.
- The low incomes expected is another important perceived barrier, also due to the uncertainty of those incomes.

3.1.2.2 DSO

- Lack of legislation technical and economical in most countries
- Lack of previous experiences in the sector,
- Possible penalties or low economic incomes with high initial investments,
- Learning curve or possible personal data protection problems.

3.1.2.3 Aggregators

- Possible low remuneration in activities that need high initial investments,
- Standardization,
- New developments with their inherent risks,
- Business and legal concerns,
- Limited access to residential customers.

3.1.3 Questionnaires delivered to end-users in pilot-buildings

A series of surveys were performed through questionnaires to define the main user requirements. The key areas of interest were: identification of major challenges that affect their willingness in accepting DR and LFM in the context of new technologies (e.g. cost, technology understanding, or regulations); preferred business cases per user group and what is their view on; desired automation and control levels; expectations towards comfort vs efficiency. In Annex B, we provide the survey used to identify barriers which their main findings are here described.

According to the results of the surveys, barriers and incentives for the participation in DR market are much related for tertiary building users. These customers need **a clear, transparent and secure regulation or legislation**, a **full respect to personal data** and **respect to comfort set points**. Finally, remuneration is an important concern for surveyed building users.

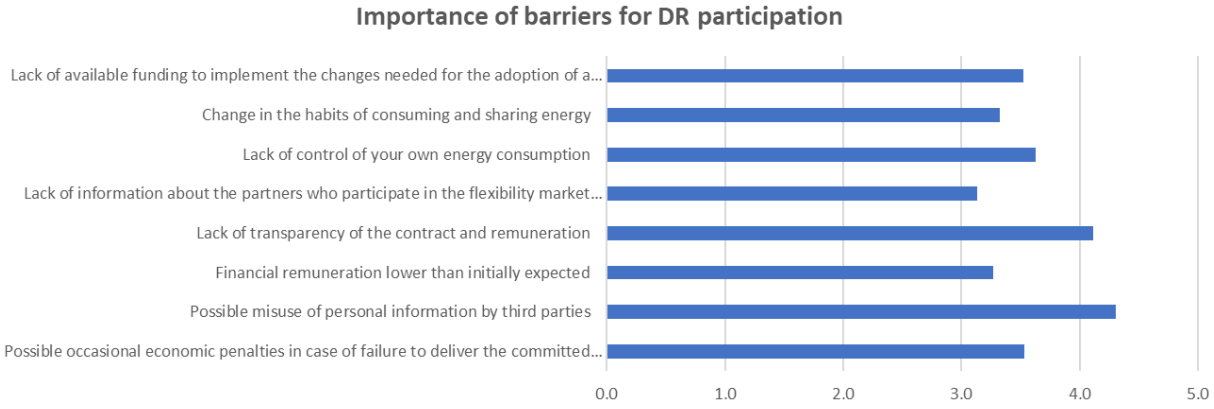

Figure 3. Tertiary building users survey DR participation barriers.

3.2 Outcomes from the State of the Art

The IPCC defined the barriers as “any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy programme or measure”. One of their reports about distributed energy identified four main blocks of barriers when addressing the renewables penetration

across different countries [8]. (i) Institutional and policy barriers related to existing industry, infrastructure and regulation of the energy system; (ii) Market failures, including non-internalized environmental and health costs, where applicable; (iii) Lack of general information and access to data relevant to the deployment of renewables, and lack of technical and knowledge capacity; and (iv) Barriers related to societal and personal values and affecting the perception and acceptance of renewable energy technologies. In the same vein, using a combination of in-depth workshops, expert interviews and literature research, Balta-Ozkan et al. [7] investigated the barriers to the introduction of emerging technologies related to energy and smart homes in several households in the UK. They found the next seven categories of barriers: (i) fit to current and changing lifestyles, (ii) administration, (iii) interoperability, (iv) reliability, (v) privacy and security, (vi) trust, and (vii) costs. Similarly, in the context of energy efficiency, Sorrel [9] built on the separation of barriers into market and nonmarket failures, by defining barriers as: (i) economic; (ii) behavioural; and (iii) organizational. Here, economic barriers (e.g., imperfect information, asymmetric information, hidden costs, risks, etc.) are equivalent to the market failure definition. With behavioural (e.g., inability to process information, form of information, trust, inertia) and organizational barriers (e.g., energy manager lacks power and influence, organizational culture leads to neglect of energy/environmental issues) a mapping to the nonmarket failures. The presented typology by Sorrel is not exclusive, and barriers may have multiple aspects as well as be multiple and overlapping. All these barriers are related to the penetration of new technology to make the energy consumption more efficient. However, when it comes to signal pricing and Demand Response (DR) scenarios, it is important to also emphasise the **role of information** to end-users. As such, Nolan et al. [10] delved into that important barrier, whereas Osthoorn et al. [4] remarked the **lack of competence** about energy efficiency, grid, renewables and signalling as an important barrier to also take into account. Moreover, Good et al. [3] classified DR barriers as either fundamental (i.e., relating to intrinsic human nature/essential enabling technology) or secondary (i.e., relating to anthropogenic institutions/or system feedback). Fundamental barriers were defined as economic, social or technological, whilst secondary barriers related to political regulatory aspects; design of markets, physical (electrical network) issues, or to general understanding of demand response. To conclude this overview, the participants of COOPERaTE project [2] proposed four main blocks of barriers in the context of Energy Positive Neighbourhoods and Smart Energy Districts: **political/regulatory, economic, social, and, technological**. This latter context of application of existing DER, DR and prosumers is much related to the LFM because of the matching actors involved. Hence, we will draw on this latter categorization as a first step to proceed with creating our own PARITY's barriers taxonomy.

3.2.1 Socio-economic barriers to PARITY's project

Socio-cultural barriers are intrinsically linked to societal and personal values and norms that affect the perception and acceptance of LFM and may be slow to change. Thollander et al. [11] referred to work on sociotechnical change, which argues that social and technological change is complex and interrelated. Here, the authors focused on the interaction of people and technology, dividing barriers into technical (relating directly to technologies), technological (related to human interaction with technologies), and sociotechnical (related to largely human factors). According to Good et al. [3], social barriers may, in the first instance, be usefully classified, following the work of Sorrel [9], as organisational and behavioural. In that work, Sorrel explained that organisational barriers may be relevant to commercial parties, as such barriers relate to the social systems of such structured organisations. However, arguably of greater importance for LFM are behavioural barriers, given the high number of individual interactions which can affect LFM provision. For them, behavioural barriers may be described as those factors which explain why the behaviour of any individual deviates from that of the ideal, fully rational (in the classical economic sense) agent. This is in line with the criticism done by Strengers [12] in which the citizen is usually perceived with a unified vision for the smart energy consumer neglecting the social dimension and their daily family-routines.

Balta-Ozkan and colleagues [7] found that experts identified a lack of fit to current and changing lifestyles as one of the most important barriers to adopt these cutting-edge smart homes. The researchers from that study concluded that *"there was a gulf between those developing the technology*

and what people actually want in their homes or districts". We think that this can be clearly brought to the LFM adoption. Therefore, we apply this category to understand the social and behavioural aspects that present a barrier for the purposes of the PARITY project. Similarly, the IPCC found that socio-cultural barriers or concerns have different origins and are intrinsically linked to societal and personal values and norms. Such **values and norms affect the perception and acceptance of emerging technologies** related to energy and the potential impacts of their deployment by individuals, groups and societies. According to the report, from a sustainable development perspective, barriers may arise from inadequate attention to such socio-cultural concerns, which include barriers related to behaviour; natural habitats and natural and human heritage sites, including impacts on biodiversity and ecosystems; landscape aesthetics; and water/land use and water/land use rights, as well as their availability for competing uses. Finally, some of the identified barriers from a social perspective found by Good et al. [3] are listed here. (i) Form of information (the shape and comprehensibility of information). (ii) Credibility and trust (who owns the personal data and to what purpose and if data are anonymised or not). (iii) Values (towards environmental practices). (iv) Inertia (behaviour can take time to change, even if there is clear benefit to doing so). (v) Bounded rationality (even with the necessary information, they may not reach the optimal DR-related or LFM decisions). These with their enablers and drivers are summarised in Figure 4.

Fundamental	Social	
	Organisational	
	Power	• Improve understanding of the value of DR amongst decision-makers.
	Culture	• General education on DR and its benefits.
	Behavioural	
	Form of information	• Careful design of user interfaces.
	Credibility and trust	• Penetration of new, third-parties (such as aggregators). • Legal clarity on data rights. • Modular design of IT systems, to increase security. • Data anonymization.
	Values	• Evolution of DR institutions
	Inertia	• N/A
	Bounded rationality	• Automation.

Figure 4. Social barriers identified by Good et al. in the context of DR.

3.2.2 Technical barriers to PARITY's project

The rapid expansion of urban development around the globe is changing the way the technological environment uses the devices and "things" that are currently present. In the energy sector, the Internet of Things (IoT) represents a new reality, opening the road to innovative applications such as smart homes, industry 4.0, electrical vehicles and renewable energy recourses. Since the beginning of the 21st century, the integration of renewable energy recourses within a smart grid has made a significant progress toward development and implementation. However, despite scientists coming up with viable and persuasive renewable energy technologies, the process of getting customers to switch from using non-renewable energy sources has been rather slow and ambiguous, especially in developing nations. Using solar energy in buildings is by far the most common choice in green building construction or even zero-emission buildings with a fully photovoltaic (PV) power system [13]. Although there has been a rapid development in green smart homes and energy smart grids, there are still some open technical challenges that need to be solved, taking in mind also the technology readiness issues. The most critical technical challenges have been classified in seven categories and are presented below.

3.2.2.1 Integration of Renewable Energy into the Grid:

One of the biggest barriers for implementing smart grids is the underlying populism of the utility. Traditionally, utilities are rewarded for providing reliable service and they have few incentives to implement new technologies that can be viewed as introducing any kind of risk, performance, financial, social, technological or legal [14]. Utilities are often, however, understandably reluctant to implement smart grid technologies. Furthermore, smart grids can be seen as undermining the utility's basic business model: generating and distributing a commodity (electricity) and paying a price representing production costs. Furthermore, technological barriers to the integration of renewable

energy into the grid may exist within the district where the data collection and actuation infrastructure is incomplete. For instance this could be the case for metering systems, which may not be tabulated sufficiently [2] [3].

3.2.2.2 Lack of technology standardization

To begin with, the traditional top-down energy model, has not been built in the light of new types of smart technology. Specifically, these technological developments have resulted in a number of technology standardization barriers, that many local flexibility market participants cannot yet overcome, including different standards and prequalification methods and requirements across Europe[7]. For technology providers, especially those providing smart meters and grid flexibility services, having multiple technology requirements in multiple regions, corresponds to developing a new device and system for each market. This might not be worth it in many situations, which puts prosumers from different countries at a disadvantage, and does not give them access to the same facilities and opportunities. Additionally, different requirements across different countries could lead to the design of different products and services, considering an extra effort and a degree of difficulty for providers who need to adjust their goods accordingly. This not only raises the price of the technologies making them unaffordable to many consumers, but it also presupposes a barrier for businesses that might develop a technology-based platform. It should be stated also though, that too much standardization may also be a barrier. If the meanings of standardized services are too strict, they may exclude energy grid provision, or may imply that the full benefit of the concept of energy grid cannot be perceived and therefore result in sub-optimal performance of the network [2].

3.2.2.3 Privacy and Security

One of the most critical issues about the evolving requirements affecting the implementation of the smart grid is cyber security. Cyber attackers will threaten the smart grid, which emerges as a key concern for network engineers. For example, advanced grid monitoring will detect grid problems (such as failure of the transmission line) early and help to make appropriate adjustments, thus increasing grid protection. On the other hand, a more "open" system could lead to easier access to the grid, which could in itself cause both security and privacy issues [15]. Moreover, distributed energy resources pose problems for electricity companies and grid operators, as the increased amount of energy input points and unreliable existence of most renewable generation making network balancing and supply security more complicated [16]. Last but not least, due to the way data is transmitted, energy IoT devices are inherently vulnerable to most common wireless network attacks [17]. The aforementioned technical barriers are extremely important in terms of privacy and security, considering also that IoT devices that are integrated in the energy grid are a) physically distributed, b) a mixture of very small to very large devices, c) dependent on closed and open or untrusted networks and d) large-scale deployments [2].

3.2.2.4 Interoperability

The absence of accessibility among connected devices creates an immense obstacle to smart energy homes. All home devices should link to and interact with one another in order to achieve maximum intelligence. However, the prevalence of incompatible standards and protocols ,as previously mentioned, used by different energy device manufacturers (e.g. smart meters, batteries etc.) is a significant obstacle, making the seamless integration of equipment from vendors a complicated process [19]. Moreover, diverse vendors, which cannot talk to each other, is leading to flexibility that cannot be exploited. Thus, the existing platforms are still not working together efficiently, making networking a hassle and at the same time discouraging the average energy-aware home and/or facility owner. To give an example, there are conflicts on rewards and accounting for energy flows that occur if, for instance, a consumer has two different contracts, one with an implicit Distributed Recourse (DR) producer (i.e. supplier) and one with an explicit DR autonomous aggregator, and both of them

7 European Smart Grids Task Force, Expert Group 3, Demand Side Flexibility Perceived barriers and proposed recommendations https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf

are operating simultaneously. In such scenario, it may not always be obvious which part of the DR realized and by which actor[8]. In more detail this kind of technological barrier is also related to ownership and control of district devices. If there are multiple owners in a district, who do not wish to contract out provision of energy services then decentralized optimization is required, and the complexity of the system is drastically increased [2]

3.2.2.5 Data Sharing

The quantity of produced and controlled data has exploded and will continue to increase in future. Computational planning and operations tools, such as central exchange of best practices, data databases, data usage information, and data applicability, are growing each year; however, data sets consistency continues to be a problem. Data security and privacy confusion as well as access to information (e.g., data access rights) hinders smart grid technologies from being implemented. The scope of smart grid information technology (IT) has grown to include devices that were previously outside the grid, producing useful data but also creating new security concerns. Therefore, strong pillars and models for data security, grid security and the advancement of smart grid technologies need to be in place [20].

3.2.2.6 Networking

Bandwidth consumption is another challenge for local flexibility markets connectivity, making the management in the smart grid network crucial. In the last years, large amount of data has been generated with the growing number of energy IoT devices, and as a result bandwidth requirement is widespread in modern smart homes, leading to important network problems [21]. Additionally, in relation to networking, resource rates and flexible loads reacting to dynamic demand signals trigger technical problems, as controllers move large portions of power consumption to the lowest price times, overload distribution network assets and result in voltage rise / drop problems [2]

3.2.2.7 Infrastructure

The local flexibility market infrastructure consists of diverse technologies varying widely in maturity, condition, and capability. Some of those within this new infrastructure reach the end of their lifespan or become redundant, while others prove insufficient to accommodate the increased use of new sources of energy, such as wind and solar power. Factors including cost, potential technological risk and substantial learning curves threaten the entry of new technologies and energy resources. Nonetheless, it is still unclear how best to exploit this new infrastructure to support distribution processes and how these technologies can be accounted in the network planning process [22].

To conclude, the energy flexibility environment is significantly occupied with many diverse systems that need to effectively communicate and execute their tasks. Despite the technical barriers to energy flexibility adoption, the smart energy grid technology market is rapidly growing, trying to leverage their versatile operating environment, to provide solutions to the problems related to the understanding and utilization of electrical energy.

3.2.3 Regulatory barriers to PARITY's project

In the following, the energy agencies' policies are reviewed.

3.2.3.1 EURELECTRIC

EURELECTRIC[9] is the association of the Electricity Industry, which focuses on the common interests of the electricity industry in EU and the affiliates of other continents. EURELECTRIC mission is to increase the industry competitiveness and promote a low-carbon electricity mix and has clear objectives:

8 https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf

9 https://www.eurelectric.org/

- Achieve a carbon-neutral electricity mix in Europe well before mid-century
- Ensure a cost-efficient, reliable supply through an integrated market
- Develop energy efficiency and the electrification of the demand-side to mitigate climate change.

EU climate change and Energy policies have a major role in achieving EU Energy targets and EURELECTRIC is analysing these to recommend necessary revisions that support the transition towards energy decarbonisation, the sustainable development of EU economy and price competitive and clean electricity. One of the areas the association is focusing on is the role of DSOs for smarter, flexible and digitised distribution networks and how the current EU Energy Directives are supporting consumers towards energy transition. Each barrier is presented in the Table 5.

Table 5. EUROELECTRIC barriers and recommendations.

Barriers & Policies Recommendation	Reference
Currently the regulated costs (network charges and levies) are charged to consumers impacting the price increase.	Energy Efficiency Directive[10]
Currently the funding scheme focuses to suppliers delivering the energy efficiency measures. A transition of focus towards users (other than levies on energy bills), and tools in the housing sector, financial incentives including tax exemptions is important.	Energy Efficiency Directive[11]
The current Primary Energy Factor is impacting negatively the competitiveness of technologies such as electric heat pumps or smart heat storage, to the benefit of fossil heating technologies.	Primary Energy Factor (PEF)[12]
Rewarding innovation with greater incentives in emerging technologies or solutions will support distributed generation, EVs or battery storage and support grid reinforcement.	EURELECTRIC report, Future of DSOs[13]
Set targets and objectives for DSOs, instead of specifying actions and expenditure for particular projects or activities, will enable DSOs to have greater control over their specific environments.	EURELECTRIC report, Future of DSOs[13]
National Regulatory Authorities (NRAs) need to update their regulations to support the roles of	EURELECTRIC report, The Value of the Grid[14]

[10] European Commission's legislative proposal on common rules for the internal market in electricity, EURELECTRIC, Dépôt légal: D/2017/12.105/14, https://www.eurelectric.org/media/2434/eurelectric_positionpaper_electricity_directive_final-2017-030-0242-01-e.pdf

[11] European Commission proposal to revise the Energy Efficiency Directive, EURELECTRIC, Dépôt légal: D/2017/12.105/29, https://www.eurelectric.org/media/2444/key-amendments-to-the-energy-efficency-directive.pdf

[12] DECARBONISING HEATING & COOLING, https://www.eurelectric.org/media/2076/hc_toolkit-full_version-2016-030-0476-01-e.pdf

[13] Future of DSOs,/ Where does change start if the future is already decided? EURELECTRIC, Dépôt légal: D/2019/12.105/1

, https://www.eurelectric.org/media/3637/ey-report-future-of-dsos.pdf

[14] The Value of the Grid, EURELECTRIC, Dépôt légal: D/2019/12.105/12, https://cdn.eurelectric.org/media/3921/value-of-the-grid-final-2019-030-0406-01-e-h-D1C80F0B.pdf

DSOs as market facilitators.	
The role of DSOs needs to be further defined with the view of future evolution and the alignment with TSOs. Furthermore to support with incentives to implement initiatives that promotes energy transition.	EURELECTRIC report, Future of DSOs[13]
Develop regulations to protect customers, including the fuel poor and to ensure they are not disadvantaged financially.	EURELECTRIC report, Empowering consumers in the energy transition[15]
Consumers are facing difficulties to choose among the high amount of low-carbon energy solutions and understand the benefits (e.g. renewable energy system, home insulation, or an EV), and have limited financial incentives to support them.	EURELECTRIC report, Empowering consumers in the energy transition[15]
EU legislation should allow suppliers to make alternative offerings to consumers that will provide flexibility to adapt to the changing uses of electricity.	EURELECTRIC recommendation to Energy Efficiency Directive[14]
Different levels of granularity for regulated charges: these regulated charges may be conveyed with flat, time of use, peak pricing or dynamic options, depending on consumers' choice.	EURELECTRIC recommendation to EURELECTRIC recommendation to Energy Efficiency Directive[14]
Price changes information obligation towards consumers should be equally applicable to any service provider, supplier, aggregator, ESCO, etc. This is key in order to ensure high level of protection to customers.	EURELECTRIC recommendation to Energy Efficiency Directive[14]
Regarding the difference between "supply price" and "charges", there should be a clearer distinction between general consumer information and the consumer's right to dissolve a contract: the latter should only apply when price changes are due to the supplier/service provider (and not in case of tax changes or network tariff evolution).	EURELECTRIC recommendation to Energy Efficiency Directive[14]
Primary Energy Factor (PEF) methodology does not separate the sources of electricity, including electricity from renewable resources.	Primary Energy Factor (PEF)[16]
Current Directive does not set an adequate framework to incentivise the growth of electric vehicles (EVs).	Alternative Fuels Infrastructure Directive (AFID)[17]

[15] Seeking shared success, Empowering consumers in the energy transition, EURELECTRIC, https://cdn.eurelectric.org/media/4236/eurelectric-accenture-seeking-shared-success-h-22C4F04C.pdf

[16] A bright future for Europe, The value of electricity in decarbonizing the European Union, Depot legal number: D/2017/12.105/7
https://www.eurelectric.org/media/1136/electrification_report_-_a_bright_future_for_europe-2017-030-0291-01-e.pdf

The gap and ineffective EV charging planning strategies across Europe (e.g. some EU members NPF does not even include a 2020 target for charging points.)	National Policy Frameworks (NPF)[17]
Estimations of EV infrastructure sufficiency are currently based on literature and are more indicative for average trends, so these cannot be conclusive for all locations and countries.	National Policy Frameworks (NPF) [17]
The NPFs Directive does not provide accurate information on charging infrastructure, since the number of charging points today equals that of the vehicles.	National Policy Frameworks (NPF) [17]
A differentiation between DC (direct current) and AC (Alternating Current) is not currently reflected in the Directive and neither are the expected technological evolutions of batteries and vehicles.	Alternative Fuels Infrastructure Directive (AFID) [17]
Structural differences in support measures between countries do not exist and in turn lead to diverse market conditions, characterised by different market actors' roles, electricity system operation procedures, and administrative requirements	Energy Efficiency Directive[11]

3.2.3.2 Council of European Energy Regulators (CEER)

This section provides relevant recommendations from CEER that are documented in public reports.

- *New Services and DSO Involvement*

In this public consultation, CEER investigates the role of DSOs in novel services such as EV charging, storage or demand side flexibility services. As a rule, CEER highlights that DSOs must act as neutral market facilitators and in the public interest. It is important to minimise the risk of DSOs making use of their natural monopoly position. Therefore, DSOs should not be allowed to be active in areas that can be open to competition among market participants. CEER acknowledges that these areas include the provision of flexibility services and direct services to consumers. Concerning flexibility, DSOs should be involved mainly by procuring flexibility resources in the distribution system. This means that a DSO should be just a consumer of flexibility in order to perform activities like congestion management, for instance. However, there are examples where DSOs are managing direct load control at consumers' sites, for instance in programmes from the US as well as in R&D projects like the H2020 UPGRID project and the LINEAR project. Against this backdrop, CEER finds it important that network users can always make their own decisions on how to provide flexibility services to either DSOs or the energy market. From CEER's perspective, DSOs should make use of local flexibility resources at distribution system level, but this may require new market entities like aggregators. Furthermore, CEER points out that DSOs should not carry out direct services to consumers. This means that the relationship with the consumers or prosumers has to be routed via suppliers or other competitive market players such as independent aggregators.

[17] Policies for sufficient EV charging infrastructure deployment in the EU, a view from the European electricity industry EURELECTRIC, Dépôt légal: D/2019/12.105/22, https://cdn.eurelectric.org/media/3972/policies_for_sufficient_ev_charging_infrastructure-2019-030-0482-01-e-h-B58FF997.pdf

These limitations of DSOs concerning the involvement in services related to demand side flexibility may contradict its potential role as a coordinator of a local flexibility market. According to CEERs conclusions in this document, a DSO should limit its involvement to grid operation and procurement of locally needed flexibility. In Table 6 barriers identified are shown.

Table 6. Barriers from New Services and DSO involvement paper.

Barrier	Reference
DSOs are obliged to act as entirely neutral market facilitators. Therefore, an involvement in an LFM by performing services that could be opened to competition (e.g. aggregation, load control) is critical.	CEER 2019, New Services and DSO Involvement[18]
Contact to end-consumers should not be routed via DSOs, which can make it difficult for DSOs to fulfil the role as coordinator of the LFM.	CEER 2019, New Services and DSO Involvement[18]

- *Flexibility Use at Distribution Level*

The outcome of this CEER consultation process is a set of high-level guiding principles for National Regulation Authorities in order to enable flexibility use at distribution level and deliver benefits to consumers. The paper recognises, that in order to reduce the risk for market distortion, market participants should be able to provide flexibility to different users in the power system serving different competing flexibility needs. However, it is expected that due to a lack of liquidity in the flexibility services market long-term contracts with a single consumer of flexibility like a DSO will play a major role. In case of a DSO this may lead to a situation of monopsony which requires regulation on the negotiation scope of the DSO as the only buyer when procuring flexibility on local level. In general, this lack of liquidity hinders market development under competitive market-based procurement.

Furthermore, CEER recommends determining the specific roles and responsibilities of DSOs on national level due to the diverse situations, legislation and needs across EU Member States. As a result this could mean a more difficult exploitation of the PARITY business models, as different roles and different requirements towards DSOs need to be taken into account when defining the specific business models applied. Therefore there may be a need for a set of feasible business models for different regulatory requirements.

Finally, CEER points out the need for more confidence in the parties involved on the flexibility markets and towards the expected revenue streams. This due to the novel business models that are expected to emerge and novel entities engaging in these models such as demand response aggregators or energy communities. In Table 7 barriers identified are shown.

[18] https://www.ceer.eu/documents/104400/-/-/ef4d6e46-e0a5-f4a4-7b74-a6d43e74dde8

Table 7. Flexibility use at distribution level barriers.

Barrier	Reference
Lack of liquidity in the flexibility services market may lead to reduced market development and to market distortions due to long term arrangements with single buyers of flexibility.	CEER 2018, Flexibility Use at Distribution Level[19]
Roles and responsibilities of DSOs will be defined in detail on a national level, which could hinder the exploitation of the PARITY business models across all EU member states.	CEER 2018, Flexibility Use at Distribution Level[19]
Lack of confidence towards flexibility market participants and revenue streams.	CEER 2018, Flexibility Use at Distribution Level[19]

- *Regulatory Aspects of Self-Consumption and Energy Communities – CEER report*

The regulatory implications of new and developing practices such as self-consumption and Citizen or Renewable Energy Communities, were analysed by CEER. In this context sharing and selling of locally produced energy plays a central role.

Consumers or prosumers engaged in electricity sharing (or peer-to-peer trading) will generally purchase less energy from their traditional supplier. However, in times when self-generation within the sharing community is not possible, the supplier still has to provide "back-up" supply. Especially if national law determines that the supplier remains responsible for balancing the whole metering point of their "passive customers", the supplier has a higher risk of incurring imbalances, which will be finally charged to the customer. This could mean that suppliers try to charge more to customers that are engaged in electricity sharing (e.g. in an energy community).

A prominent benefit from peer-to-peer trading is the reduction or avoidance from network costs. However, to truly reduce these costs, the local load management activities have to avoid grid constraints persistently also in extreme situations throughout the day and also the whole year. Otherwise there will be costs for providing sufficient grid capacity on a local level in just those specific situations, resulting in high costs for short durations of grid use. CEER finds that these network costs need to be distributed fairly without discriminating against customers who are not able to participate in peer-to-peer energy sharing. This means the higher costs need to be paid by members of the peer-to-peer trading community. In Table 8 barriers identified are shown.

[19] https://www.ceer.eu/documents/104400/-/-/e5186abe-67eb-4bb5-1eb2-2237e1997bbc

Table 8. Barriers: regulatory aspects of self-consumption & energy communities.

Barrier	Reference
"Back-up" supplier is needed for prosumers engaging in energy sharing or peer-to-peer trading, which may lead to more expensive tariffs specifically for members of such schemes.	CEER 2019, Regulatory Aspects of Self-Consumption and Energy Communities[20]
Reduction of network costs can only be realised, if local grid constraints can be avoided persistently. Otherwise high costs may be charged for members of the peer-to-peer trading scheme when using the grid.	CEER 2019, Regulatory Aspects of Self-Consumption and Energy Communities[20]

3.2.4 Legal barriers to PARITY's project

3.2.4.1 Switzerland

3.2.4.1.1 National flexibility markets

In Switzerland ancillary services for TSO's balancing market (primary, secondary and tertiary) are limited up to 5 MW. Pooling is accepted and there are aggregators (usually big utilities or "Spin off" of Telecommunication's companies) offering those services.

On the retail market there are few utilities offering dynamic tariffs, based on stock exchange prices. But for the time being, the number of end users accessing this opportunity is very marginal. It is also limited to commercial users, and it has not been defined yet defining as a proper business model.

AEM as DSO is aiming to introduce in 2021 a "peak power tariff", splitting the grid tariff 70% based on the power flow (CHF/kWh) and 30% based on the maximal peak (CHF/kW) reached during a month (15 minutes frequency). The Federal Electricity Supply Act defines the 70/30 splitting[21]. The "peak power tariff" aims to define price signals for allocating flexibility to smooth users' load profile.

The power market is still partially liberalised (up to 100 MWh/y). Self-consumption communities (like the one in Lugaggia, our pilot site) are generally overtaking this threshold. In theory they could sell the exceeding generated power at the stock exchange, but the limited power amounts are hindering this business and, in general, the fixed price paid by utility at the coupling point, is higher than the market's fixing.

3.2.4.1.2 Market participants

Swissgrid, the Swiss TSO

The national grid company is the owner and operator of the Swiss transmission system (Art. 18 Federal Electricity Supply Act)[22].

The TSO:

a) is responsible for a non-discriminatory provision of the transmission system and calculates the costs of the transmission system,
b) provide the ancillary systems through public auction,

[20] https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

[21] https://www.admin.ch/opc/de/classified-compilation/20042411/index.html

c) ensures the international connection of the Swiss electricity grid, manages grid utilisation across national borders and deals with bottlenecks,
d) is responsible for transporting electricity to customers directly connected to the national grid (either distribution's grids, big industries or the main electricity producers),
e) finally, the TSO shall be responsible for metrology and information services in the transmission system and shall make energy data available to authorized market players ensuring its protection and security according to the Swiss laws and international standards.

Section 3 of the Federal Electricity Supply Act regulates the TSO activity[22].

For fulfilling those tasks and in particular ensuring the ancillary services, the TSO has split the Swiss national supply territory in several balancing groups (Bilanzkreis). The TSO is responsible for allocating the measurements' points for each Bilanzkreis, validating its data into a daily balanced load profile (planning phase) and coordinating its upgrading regularly each 15 minutes, based on the data supplied by each group (management phase). Each measurement point for end consumers, producers and storage facilities is assigned to one balance group and one supplier.

More information about Swissgrid activities are explained on its website[23].

DSO role in Switzerland

DSO's role (rights and duties) is not yet clearly defined by law, although the Federal Energy Act[24] is starting to set some rules about investing in the MV/LV grid. Some examples are, the progressive "smart meters roll out" (to be completed at 80% within 2027), the use of local flexibility (which belongs to the facility owner), the limits to data download (avoiding any commercial use of data collected by grid operations), and finally the introduction of self-consumption districts[25].

In general the legal frame is more protecting the end users' rights (an explicit opt in by the end users is required for managing home devices by remote), than defining "duties and rights" of the DSO and in particular assessing where and when public interest is to be protected. The only exception is listed at art. 8 paragraph 5 of the application code of the Federal Electricity Supply Act", which is stating that the "MV/LV grid operator can remotely manage household consumption/production facilities, without the owner's consent, if the supply security is deeply endangered".

Therefore, despite several upgrading (quoted hereof), the Federal Electrical Supply Act is mainly referring to the ML/LV grid operator (Verteilnetzbetreiber or VNB) as a technical provider, responsible for the MV/LV grid's planning, construction, maintenance and (if it would be the case) phase out. The VNB is also setting the rules for the end users' and, DERs' connections. Finally, in a partially liberalised market, the VNB is responsible for ensuring the small end users full supply.

To this extent, the Federal Energy Act (art. 15 to 18) has defined prosumers' competencies but mainly for protecting its rights to use locally its energy either in its building or in self-consumption communities and accessing the grid with the exceeding capacities. The same for self-consumption communities where the main setback for creating them is defined by the geographical proximity (the plots of land belonging to the community must be contiguous).

3.2.4.1.3 LFM in Switzerland

The main question on LFM remains unanswered. If it is meant mainly as a capacity to be aggregated (in various forms ranging from single prosumers to Energy communities) and used on the TSO auctions (like a commodity, but under the 5 MW threshold's condition precedent) or as a flexibility to be used mainly locally for balancing the local grid, (like a tool) smoothing its (household, Energy Communities, or DSO supply territory) load profile.

[22] https://www.bfe.admin.ch/bfe/en/home/supply/electricity-supply/federal-electricity-supply-act/revision-of-the-federal-electricity-supply-act.html

[23] https://www.swissgrid.ch/en/home/about-us/company/what-we-do.html

[24] https://www.admin.ch/opc/de/federal-gazette/2016/7683.pdf

[25] ZEV under Section 2a, in particular article 17b, https://www.admin.ch/opc/de/classified-compilation/20121295/index.html

The first business model has been exploited by the biggest Swiss Telecommunication Company (Swisscom) has created a Spin Off (TIKO) for aggregating single end user and create a retail base for taking part to the ancillary services market. But the business' results are, for the time being, unsatisfactory. The second one is the model used by AEM at the Lugaggia Energy Community, which is based on a "peak power tariff" (see point 1 above), thus using price signals to induce the use of flexibility to smooth household load profiles.
Peer-to-Peer (P2P) energy business at local level is not allowed by law (because the market is still partially captive).

Participants' roles in each market

Table 9 provides an overview of the roles assumed by the Swiss consortium partner AEM in the different markets:

Table 9. Swiss markets – Participants roles.

	Wholesale market	Ancillary services market for TSOs / Balancing market	Ancillary services market for DSOs	Retail market
Energy retailers	Not relevant	Not relevant	Not relevant	The Swiss Energy Market is partially liberalised, therefore for user with a consumption below 100 MWh/y AEM is fulfilling this role
Aggregators	Not relevant	AEM is evaluating if beside its main activities (DSO) it would be possible to aggregate capacities for participating (together with other companies) to TSO's auctions	Not relevant	Not relevant
BRPs	Not relevant	Not relevant	Not relevant	Not relevant
TSOs	Not relevant	Not relevant	Not relevant	Not relevant
DSOs	Not relevant	Not relevant	AEM is using either its hydro plant (with a capacity of 4 MW) and the main sources of flexibility in the supply territory, both managed by an algorithm, for balancing its MV/LV grid	Not relevant
Prosumers	Not relevant	Not relevant	Not relevant	AEM is offering advices for setting the production devices consistently with the prosumer's load profile
Local energy communities/Microgrids	Not relevant	Not relevant	AEM is organising self-consumption's districts for dealing with grid constraints and increasing the local self-consumption rate and decreasing the power flowing into the LV grid	Not relevant

3.2.4.1.4 Future perspective to overcome obstacles

AEM, in collaboration with SUPSI and Hive Power is building up a "smart grid concept" extended to its entire supply territory, setting up some "self-consumption communities" and changing its grid tariffs scheme based on peak charges. This concept will be used to detect weaknesses and risks related to the actual legal framework, which will be shared and discussed with the Swiss competence centre for Grid (SCCER-Furies), the Swiss Regulator (ElCom) and the Swiss Energy Office.

Nevertheless, the obstacle set by the 30% threshold for peak charges on Grid Tariffs is on the way to be corrected (up to 50%) by the Swiss Legislation. The Swiss utilities' association is reflecting on the DSO duties and rights in the frame of upgrading the existing legislation for making it more consistent with the technological evolution and the new business models in the wake of increased role plaid by the prosumers.

The definition of "Energy communities" will be also upgraded, focussing on the electrical proximity (being connected by the same LV cable) instead of the geographical proximity.

The main obstacle for determining a proper LFM remains on its final purposes: which means if flexibility is to be considered as a tradable commodity or as a tool for (as priority) balancing the local markets (which has also a price and an economic value, see tariffs issue).

Following this last path, one question arises: how spread intelligence at the building's level, associated with districts algorithm, may contribute in reaching the local balancing goals?

3.2.4.2 Sweden

3.2.4.2.1 National flexibility markets

Today's wholesale market of Sweden consists of a day-ahead (Elspot) and an intraday (Elbas) market. None of these are considered a flexibility market, however the intraday market is active up until one hour before delivery thus enabling BRPs to better meet updated consumption and production plans. Regulation state that only BRPs can trade on wholesale markets.

Ancillary services market for TSOs / Balancing market

Ancillary service markets hosted by the TSO Svenska Kraftnät are the focus for discussion like ever before as they are considered vital tools to combat many of the current and upcoming challenges resulting from a changing energy system. Current markets serving frequency regulation needs include FCR-Normal, FCR-Distrubance, automatic FRR and manual FRR. A fifth market, FFR, will be added to the list in summer 2020.
In order to offer capacity to these markets, equipment must be qualified according to the respective requirements. The 'pre-qualification processes' are currently adapted to fit large consuming industries and hydro power plants, but effort is being put to streamline the requirements and allow for participation of aggregated small resources. All frequency regulation markets allow for bids of hourly resolution. In addition to markets for resources providing frequency regulation, the TSO procures a separate disturbance reserve as well as a power reserve, both on a seasonal basis. These can be viewed as markets with separate nature comparing to those regarding frequency regulation, due to the time requirements of both procurement and delivery.

Ancillary services market for DSOs

There are no ancillary service markets available by DSOs in Sweden; however some of the largest DSOs are trying out prototypes. EON (DSO part) and Vattenfall are part of H2020 project Coordinet (also part of the Bridge initiative) and will run a premature version of a capacity trading marketplace during the winter season of 2020-2021.

Retail market (dynamic tariffs, P2P trading)

Electricity consumers get billed by both Retailer and DSO, though this is planned to change within 2-3 years when a retail-centric electricity market will be adopted. When only the Retailer will bill the consumer (prosumer) and in turn pay the DSO. Most consumers choose between a dynamic and a static energy price to the Retailer. The grid tariff paid to the DSO is traditionally composed of a fixed part and one based on the total energy consumption. Larger fuse size connection points, over for example 63, 80 or 125 A (varies between DSOs), are charged a dynamic grid tariff based on hourly peak load per month. With smart meters being rolled out, DSOs are looking into how this can be implemented for smaller connections too. The Swedish Energy Markets Inspectorate is currently composing guidelines on how this should be implemented, which are expected to facilitate widespread establishment of such tariffs.

P2P trading is not possible under current market regulation. The BRP is responsible for the balance in a connection point, and consequently also the trading for it.

3.2.4.2.2 Market participants

Energy retailers

Energy retailers are typically the market participant with the most contact with the end user, being responsible for purchasing energy and selling it to customers. Retailers are allowed to either have an in-house BRP function responsible for its customer's connection points, or have the function outsourced. A few large retailers choose the first option, while a majority choose the second. Retailers have incentives to facilitate and deliver innovative services in order to grow their market share.

Aggregators

Aggregators are a novel type of stakeholder in the Swedish energy industry. It is defined as a stakeholder procuring and/or managing unutilized capacity among electricity consumers, and is considered as a natural part of the energy market of tomorrow. The implementation of a balance service provider (BSP) role in parallel with the BRP is central discussion among legislators and market forming instances. The BSP should be able to act independently of the BRP. Under current market regulation, an aggregator would be sourcing and delivering capacity to the BRP.

BRPs

According to Swedish law, each grid connection needs to have a Balance Responsible Party. The BRP is the only market participant allowed to trade on the wholesale and ancillary services market, being responsible for the balance in each grid connection. Energy retailers and electricity producers either have their own BRP licence or work with an external party delivering the balance. All operation concerning energy or capacity trading has to be done through a BRP.

TSOs

There is one TSO in Sweden, Svenska Kraftnät. Among other responsibilities, they procure all the ancillary services needed to support the stability of the national grid, both in terms of frequency and power.

DSOs

DSOs are operated as legal monopolies. A specific geographical area cannot contain multiple grids or multiple grid operators. Grid infrastructure has historically been subsidized, undermining the case for alternative efficiency increasing investments.

Prosumers

The term prosumer is not used in Swedish legislation, but rather the term micro-producer. A micro-producer have a main fuse of maximum 63 ampere, is able to export no more than 43,5 kW to the grid, and buys more electricity than it is selling on a yearly basis.

Self-generation of electricity is generally encouraged in Sweden, with the government continuing to enforce a 20 % investment subsidy up to 1.2 million SEK for PV installations as well as a 0.6 SEK tax reduction on each kWh exported back to the grid. While the later mentioned support is working to better the business case for PV, it worsens the case for load shifting and increased self-consumption since income per sold kWh is close to the cost per bought kWh for most prosumers.

Local energy communities/Microgrids

As previously mentioned for DSOs and BRPs, distribution is monopolized and trading is limited to one unity per connection point. Thus, local energy communities or micro grids based on self-regulation and trading are not yet feasible under Swedish energy regulation.

Participants' roles in each market

Table 10 gives an overview of the market participants in Sweden and their roles in the different markets.

Table 10. Sweden markets – Participants roles.

	Wholesale market	Ancillary services market for TSOs / Balancing market	Ancillary services market for DSOs	Retail market
Energy retailers	Participation is done through a BRP	The major part of this market is occupied by BRPs that also own the resources that are delivering the service. Retailers that are not BRP can access the market through close collaboration with its BRP.	Such markets do not yet exist.	Operating such markets
Aggregators	Could in theory access the market through close collaboration with a BRP.	Can access the market through a close collaboration with a BRP.	Such markets do not yet exist. It is likely that aggregators of prosumers would participate on such markets in the future.	Can act alongside with a retailer and add to the BRP consumption plan
BRPs	Full participation today	Full participation today	Such markets do not yet exist.	Not relevant
TSOs	Delivers the transmission costs and limitations to the market, which forms the basis for the trading.	Manages the marketplaces and represents the buying side	Such markets do not yet exist.	Not relevant
DSOs	Not relevant	Not relevant	Such markets do not yet exist.	Not relevant
Prosumers	Related through both the retailer and a BRP	Related through both the retailer and/or aggregator and a BRP	Such markets do not yet exist.	Prosumers are central participants of a retail flexibility market. They could participate using the help of an aggregator, but also under autonomous operation.
Local energy communities/Microgrids	Not relevant	Could in theory access the market through close collaboration with a BRP.	Such markets do not yet exist.	

3.2.4.3 Spain

3.2.4.3.1 National flexibility markets

Wholesale market

Currently it is not opened to flexibility services. According to the Directive 2019/944 all organized markets should be opened to demand response.

Ancillary services market for TSOs / Balancing market

Currently only generators can participate in the market from the side of electro intensive demand. However, it has been approved the Term and Conditions by which demand, and storage aggregated can also participate. Indeed, at the end of March 2020 a consultation will be opened to modify/design P.O. affected.

Ancillary services market for DSOs

Currently they are not opened to flexibility services. Just an initiative called Iremel but it is not running yet.

Retail market (dynamic tariffs, P2P trading)

In the household sector there is a regulated tariff PVPC that allow to provide implicit demand response.

3.2.4.3.2 Market participants

Energy retailers

They could start participating in flexibility markets (balancing and other markets) from the end of 2020.

Aggregators

They could start participating in flexibility markets (balancing and other markets) from 2021.

BRPs

They are responsible of all the misbalances created by the market parties.

TSOs

They will have the chance to procure flexibility services not only from generation but also from demand and storage from the end of 2020.

DSOs

They are not allowed to procure flexibility services. The recent approved remuneration regime (in which is established the retribution for the DSOs) do not include flexibility.

Prosumers

They could participate in the flexibility market from 2021.

Local energy communities/Microgrids

They could participate in the flexibility market from 2021.

Participants' roles in each market

Table 11. Spanish markets – Participants roles.

	Wholesale market	Ancillary services market for TSOs / Balancing market	Ancillary services market for DSOs	Retail market
Energy retailers	Retail aggregator	They only act in interruptibility markets	They only act in interruptibility markets	Market responsible
Aggregators	Demand response aggregated from 1MW	Demand response aggregated from 1MW	Demand response aggregated from 1MW	Demand response aggregated from 1MW
BRPs	Responsible of the deviations of the imbalance system, they can be aggregators or not	Market players dealing with TSOs	Market players dealing with DSO	They assume deviations
TSOs	HV Grids Operators	Metering Concentrators	They receive data from the DSO	Energy liquidation
DSOs	LV and MV Grids Grid Operators	They serve TSOs	Responsible of the service	Responsible of the measurements
Prosumers	Interruptibility for large prosumers interrupting their demand in quantities established on 5MW or 40 MW obtaining economic benefits if the operator requests so.	They take instructions from the TSO	They act together with the DSO	Consumers
Local energy communities/Microgrids	They don't act in the wholesale market	Without dependences with TSOs	In charge of the measurements	Final consumers

3.2.4.3.3 Future perspective to overcome obstacles

Spanish legislation is currently in an adjustment process trying to adapt to European directives, but nowadays there is not clear regulatory activities in order to overcome the obstacles, more than some initiatives.

Challenges should be focused on:

a) Driving functional prototypes of local markets.
b) Identifying challenges and opportunities for the proactive role of the consumers and the prosumers in this market.
c) Allowing the active client (prosumers) to manage in a continuous way the energy generated or consumed by some existent price signals, in a direct way or by the aggregator figure.
d) Proving the viability of new technologies that facilitate the management of DERs and their participation in local markets.

3.2.4.4 Greece

3.2.4.4.1 National flexibility markets

As Electricity Markets, the law defines the Day-Ahead Market, the Intra-Day Market and the Balancing Market which function as organized markets according to EU Regulation 1227/2011[26]. The Greek Electricity market is undergoing a transformation to implement the above mentioned market models, however currently the wholesale electricity market is based on a day-ahead mandatory pool mechanism.

The Day-ahead scheduling model is currently implemented for the national wholesale market and the amount of the electricity that is generated, is traded the next day. Generators, auto-producers and importers declare an offer price for each hour of the following day D, according to their available capacity to supply electricity to the system. Currently a cap of EUR 300/MWh applies to all generators' offers.

At the same time, buyers of electricity, retailers, exporter, pumped storage hydro and self- supplied consumers, must submit demand declarations for each hour of the following day D while not submitting price-based offers. The day-ahead market clears on an hourly basis according to a system marginal price (SMP), corresponding to the economic offer of the block lastly accepted in the economic merit order to meet demand.

The Greek wholesale model implements a distinction between the Day-Ahead market and the Balancing mechanism that follows, to have a clarity on the factors influencing prices, the uncertainties involved and the implied risks at these distinct time scales. The day-ahead market provides an indicative unit commitment schedule and a reference spot price (System Marginal Price forecast), which served purely as a signal. Cash-flows are based on ex-post SMP prices derived by re-solving the same cost-minimisation algorithm as in the day-ahead schedule, by inserting metered values of the various inputs (mainly demand, plant availabilities and renewables' output) instead of day-ahead forecasts. These ex-post prices were applied to the actual quantities consumed or produced (the latter reflecting largely the real-time dispatch orders of the TSO).

3.2.4.4.2 Market participants

Currently all segments (production, trade and supply) of the Greek electricity sector are dominated by the vertically integrated Public Power Corporation (PPC).

Regulatory Authority for Energy (RAE) is an independent energy regulator, established in 1999 authorised to control, regulate and supervise the operations of all sectors of the energy market. RAE

[26] Regulation and performance of the electricity market and the natural gas market in Greece, in 2018. Regulatory Authority for Energy (RAE), http://www.rae.gr/site/file/system/docs/ActionReports/national_2019

grants licenses for electricity production a) for conventional production in accordance with the Energy Framework Law and the Licensing Regulation and b) for RES/ CHP production in accordance with the RES Law and the RES Licensing Regulation. Furthermore, according to Law 4512/2018, the Greek Energy Exchange (HENEX S.A.)[27] was founded as a spin-off from LAGIE (Operator of Electricity Market until 2018), and is currently the competent body for operating Electricity, Natural Gas and Environmental Markets. HENEX is undertaking responsibilities of Clearing, Risk Management and Settlement of the transactions.

LAGIE was changed to "RES Administrator & Guarantee of Origins", with the distinctive title DAPEEP. The key stakeholders in the Greek Electricity market are presented below:

TSOs

ADMIE SA (Independent Power Transmission Operator) is the main Operator of the Hellenic Electricity Transmission System (HETS) and was established under the Law no. 4001/2011, in compliance with the requirements of the European Union Directive 2009/72/EC. ADMIE is operating, controlling and managing the maintenance and development of HETS, to ensure the adequate, safe and efficient supply. Furthermore, operates the electricity market of the transactions taking place apart from those of the Daily-Ahead Scheduling (DAS), in accordance with the principles of transparency, equality and free competition.

DSOs

DEDDIE S.A. is the Hellenic Electricity Distribution Network Operator (HEDNO S.A. or DEDDIE S.A.), is a 100% subsidiary of PPC S.A. and is responsible for the development, operation and maintenance of the Hellenic Electricity Distribution Network (HEDN). PPC S.A. remains the owner of the Distribution System assets (herein the “Distribution System activity of PPC S.A.”). HEDNO is also the Power System and Market Operator for the Non-Interconnected Islands (NII) of the country.

Energy producers, Energy suppliers, Energy traders, RES Aggregators and RES Producers are also stakeholders in the Greek Electricity market and registered in the Greek Energy Exchange (HENEX S.A.)

Participants’ roles in each market

Table 12 gives an overview of the market participants in Greece on the different markets.

[27] GREEK ENERGY MARKET REPORT, 2019, HELLENIC ASSOCIATION FOR ENERGY ECONOMICS (HAEE), powered by National Bank of Greece

Table 12. Greek markets – Participants roles.

	Wholesale market	Ancillary services market for TSOs / Balancing market	Ancillary services market for DSOs	Retail market
Energy retailers	As registered in HENEX	Not relevant	Not relevant	As registered in HENEX
Aggregators	As registered in HENEX	Not relevant	Not relevant	As registered in HENEX
BRPs	Not relevant	Not relevant	Not relevant	Not relevant
TSOs	Not relevant	ADMIE (Independent Power Transmission Operator)	Not relevant	Not relevant
DSOs	Not relevant	HEDNO (Hellenic Distribution Network Operator)	Not relevant	Not relevant
Prosumers	Not relevant	Not relevant	Not relevant	Not relevant
Local energy communities/Microgrids	HEnEx	Not relevant	Not relevant	Not relevant

3.2.4.4.3 Future perspective to overcome obstacles

Based on the planned transition of the electricity market in Greece, and as reported in the "Greek Energy Market Report 2019" in Figure 5 is presented the upcoming framework of Greek Energy Market:

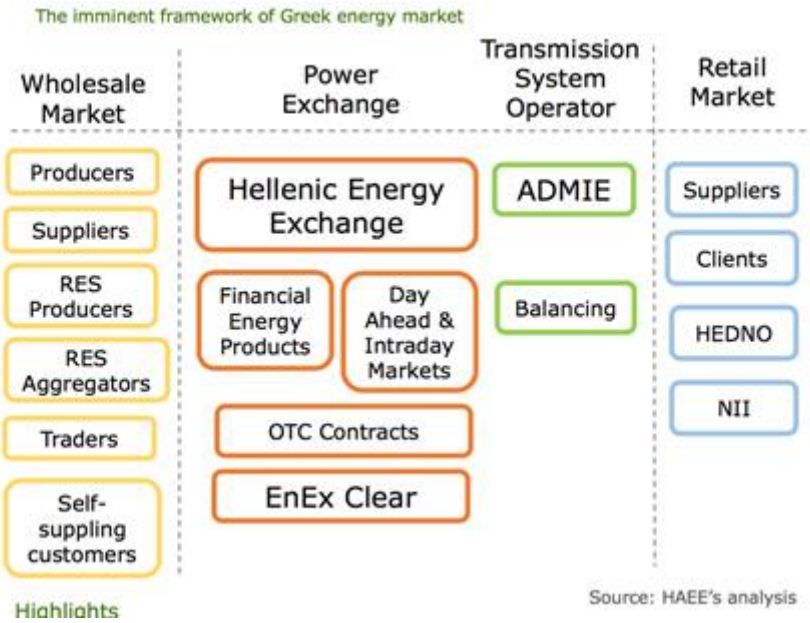

Figure 5. Greek energy market.

In the new energy market, the generators, distributors, traders and the consumers can trade electricity either via OTC contracts or on a power exchange and may use the power exchange price index as a reference for their bilateral contract. The Energy Exchange will operate most of the markets: the day-ahead and the intraday electricity markets, the energy financial market, the natural gas market, including the natural gas balancing market and the environment market. The day-ahead market will be the operator of sales with a physical delivery. The balancing market will be operated by the IPTO in compliance with the balancing code. IPTO will be the regulated operator of the balancing markets for the balancing of electricity and capacity and should also: secure compliance at borders with Regulation 714/2009 and the Regulation on Wholesale Energy Markets Integrity and Transparency.

RES producers will act as aggregators and will gain increased incentives and will be financially responsible for the additional balancing cost of the power system, when this is caused by imbalances between their forecasts and their actual production. These can accelerate the integration of new electricity sources, can complement demand flexibility and decrease the reliance on renewable energy support schemes.

4.BARRIERS IDENTIFICATION WITHIN THE PROJECT

Using a combination of in-depth workshops, expert interviews and literature research, Balta-Ozkan and colleagues **[7]** investigated social barriers to the introduction of smart homes in the UK. They found the next 7 categories: (1) fit to current and changing lifestyles, (2) administration, (3) interoperability, (4) reliability, (5) privacy and security, (6) trust, and (7) costs. In this task, as was explained in Section 2, we followed a similar triangulation approach but we came up with 6 categories for LFM instead as can be observed in Figure 6 (the length of the bars specifies the number of times each barrier was noticed during our triangulation approach. Hence, it seems that changing lifestyles was the most recurrent barrier being cost the least identified). Each of these categories is explained in detail throughout this section.

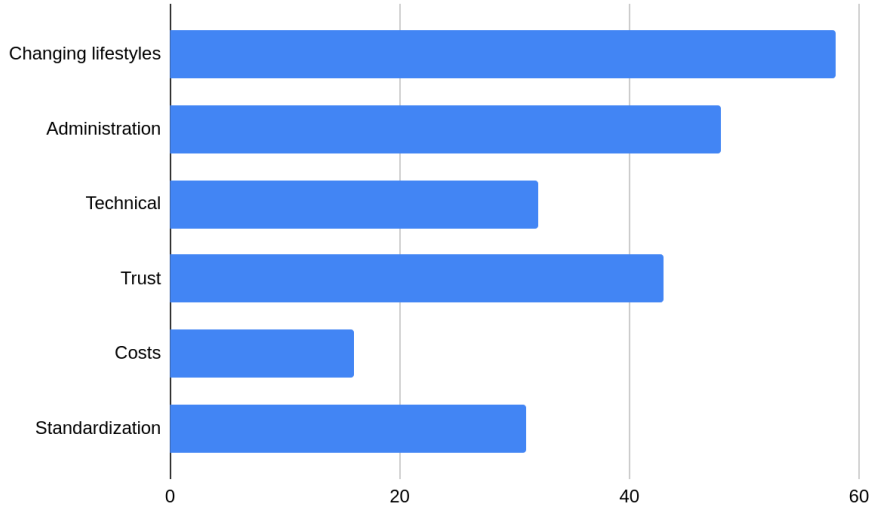

Figure 6. Number of barriers within each of the categories identified.

Figure 7 represents the entire taxonomy of barriers for LFM adoption in a diagram. As can be observed, the colours (labels) reflect the four blocks of barriers we identified during the state of the art (i.e., social, technical, economic and regulatory). In the following, we breakdown each tiers of the taxonomy. The aim is to explain each of them in detail. Note that this taxonomy and the full methodology is publicly available in ZENODO[28].

[28] https://doi.org/10.5281/zenodo.3863017

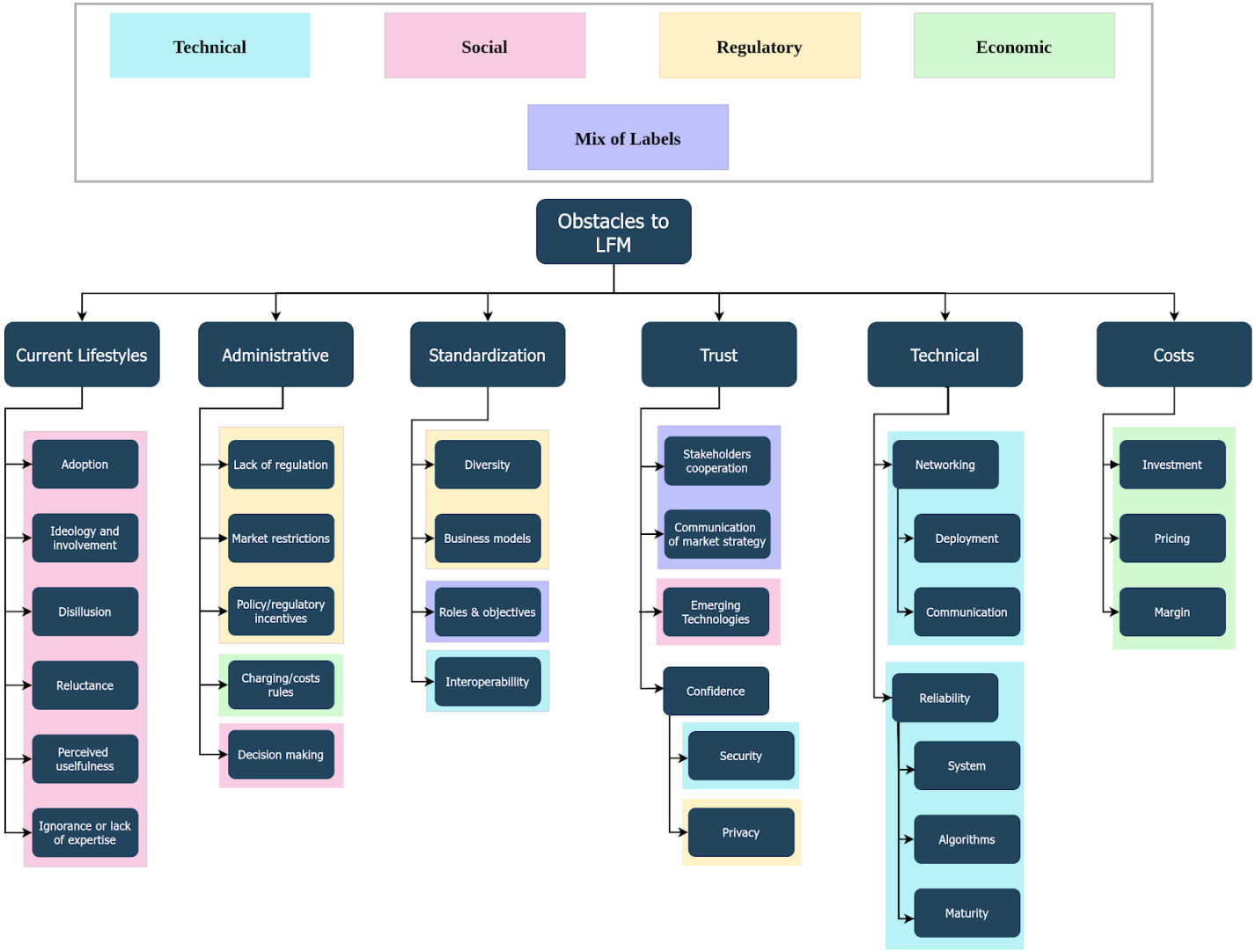

Figure 7. Complete taxonomy of the barriers for LFM adoption.

4.1 Current lifestyles

Balta-Ozkan and colleagues [7] found that experts identified a lack of fit to current and changing lifestyles as one of the most important barriers to adopt cutting-edge technologies for the smart homes. The researchers from that study concluded that "there was a gulf between those developing the technology and what people actually want in their homes or districts". We think that this can be clearly brought to the LFM adoption. Therefore, we apply this category to understand the social and behavioural aspects that present a barrier for the purposes of the PARITY project. Similarly, the IPCC found that socio-cultural barriers or concerns have different origins and are intrinsically linked to societal and personal values and norms. Such values and norms affect the perception and acceptance of emerging technologies related to energy and the potential impacts of their deployment by individuals, groups and societies. According to the report, from a sustainable development perspective, barriers may arise from inadequate attention to such socio-cultural concerns, which include barriers related to behaviour; natural habitats and natural and human heritage sites, including impacts on biodiversity and ecosystems; landscape aesthetics; and water/land use and water/land use rights, as well as their availability for competing uses.

Taking these inputs as background, within this category we identified some subcategories that will help to better understand the emerging barriers in order to give a context to them.

- **Adoption:** Technology adoption is a process. It usually starts with the user becoming aware of the technology and ending with the user embracing the technology and making full use of it. Someone who has embraced a technology is likely to replace the item if it breaks, find innovative uses for it, and cannot contemplate life without it. Within this subcategory the most prominent barriers found were:
    - People have to change the habits of consuming and sharing energy.
    - Meeting the evolving needs, demands and preferences of its occupants.
    - Integration of technology and services into the design, lifestyle and general sense of home.
- **Ideology & involvement:** An ideology is a set of beliefs and values attributed to a person or group of persons. Specifically, a system of ideas and ideals, especially one which forms the basis of economic or political theory and policy. While involvement refers to the willingness of people to participate in the LFM. It is a synonym of engagement. Within this subcategory the most prominent barriers found were:
    - People are not interested in becoming a prosumer as they are habituated to centralized markets and traditional infrastructure providers. People might not want to depend on other participants of their local area.
    - Interdependency among consumers in an individualist society.
    - Adoption of flexibility seems to be a political option and a bottom-up model which leaves more conservative people apart.
- **Disillusion(ment):** disappointment resulting from the discovery that something is not as good as one believed it to be. According to the hype cycle, it refers to interest wanes as experiments and implementations fail to deliver. Producers of the technology shake out or fail. Investment continues only if the surviving providers improve their products to the satisfaction of early adopters.
    - Smart technology leaving people 'constantly worrying' and feeling guilty.
    - Perceived inconvenience of these emerging technologies.
- **Reluctance and lack of trust:** Unwillingness or disinclination to do something because there is no confidence in the technology. This can be observed for different reasons such as feelings of inequality, resistance to change, fear of digital technologies, an inability to keep up with digital transformation initiatives and disruptions, a feeling of not being taken into account by

any given ‘power’, prejudice and the failure of organizations and governments to inform, educate and regulate in a proper and transparent way.

  - Loss of control and apathy, behaviour inertia.
  - Information and Response fatigue, for elderly in particular.
  - Rejection of an intervention that will not last in the mid/long term.
- **Perceived Usefulness:** From the TAM model, this was defined by Fred Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance" [davis1985technology]. It means whether or not someone perceives that technology to be useful for what they want to do. Within this subcategory the most prominent barriers related to LFM found were:
  - Not clear the framing effects and the benefits over population: global (e.g. climate change) vs local (e.g. reduced cost or autarky).
  - Technologies are either little known or still not developed enough to attract the attention of customers.
- **Ignorance / lack of expertise:** Lack of knowledge or information. Not only of how things work, but even the very fact that things are far more complex than we might realize. Within this subcategory the most prominent barriers found were:
  - Lack of access or difficult user interfaces to understand necessary information.
  - Lack of previous user experience in a new business market.
  - DER or Flexibility markets. Too complex for their everyday living. People hesitate to understand if their electric power will be ensured.

In the Figure 8 we can observe the distribution of barriers identified within each of the subcategories for current lifestyles. The figure shows the barriers that were found more and less frequent.

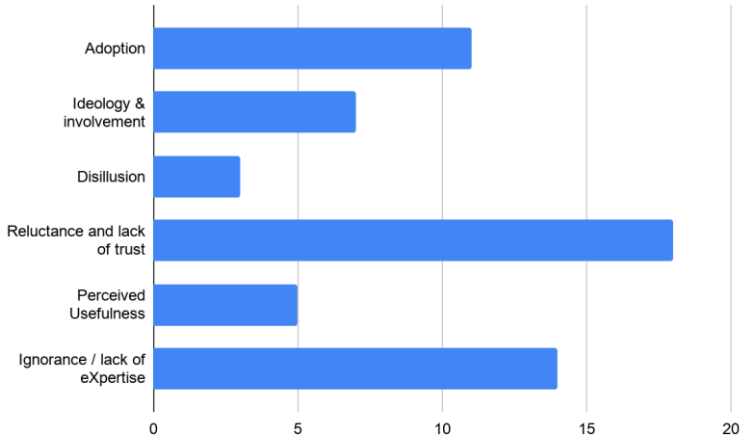

Figure 8. Distribution of barriers over the subcategories of type current lifestyles.

4.2 Trust

Several studies conducted to study technology adoption showed that rather than ‘educating customers’ on the benefits of smart grids, houses, energy demand, etc., industry should focus more on reassuring them that they can and should trust utility companies or vendors. As we can see for this conclusion this category refers to the Trust among end-users (customers), companies, industry and across all relevant actors and stakeholders. Within this category, the following subcategories emerged from the study we have conducted:

- **Security:** It refers to the defence of digital information and IT assets against internal and external, malicious and accidental threats. This defence includes detection, prevention and response to threats through the use of security policies, software tools and IT services.

  - Cyber-attacks that threaten the smart grid and the energy IoT devices.
  - Unauthorized access to LFM services.
- **Privacy:** Human beings value their privacy and the protection of their personal sphere of life. They value some control over who knows what about them. They certainly do not want their personal information to be accessible to just anyone at any time. But recent advances in information technology threaten privacy and have reduced the amount of control over personal data and open up the possibility of a range of negative consequences as a result of access to personal data. Within this subcategory the most prominent barriers found are listed hereafter:
  - Possible misuse of customers' personal data.
  - Big brother-like monitoring was too intrusive.
  - Combining two sets of innocent data leading to 'non-innocent' data.
- **Stakeholders Cooperation:** this subcategory refers to the interaction that stakeholders have to hold to provide overall confidence across all involved agents. Within this subcategory the most prominent barriers found were:
  - Lack of information about the partners (e.g. other prosumers, DSOs, etc.) who participate in the flexibility market and revenue streams.
  - Imperfect information, asymmetric information, hidden costs, risk
- **Communication strategy**: is designed to help you and your organisation communicate effectively and meet core organisational objectives of the service or good provided. Within this subcategory the most prominent barriers found were.
  - Lack of trust in the form/medium/channel of information received about pricing.
  - How the recipient of information regards the sender will dictate how such information will be perceived.
- **Emerging Technologies**: are technologies whose development, practical applications, or both are still largely unrealized, such that they are figuratively emerging into prominence from a background of nonexistence or obscurity
  - Lack of transparency of market rules and remuneration settlements.
  - Lack of transparency of the contract and the remuneration.
  - Dependent on closed and open or untrusted and reliable networks and vendors

In Figure 9 we can observe the distribution of barriers identified within each of the subcategories.

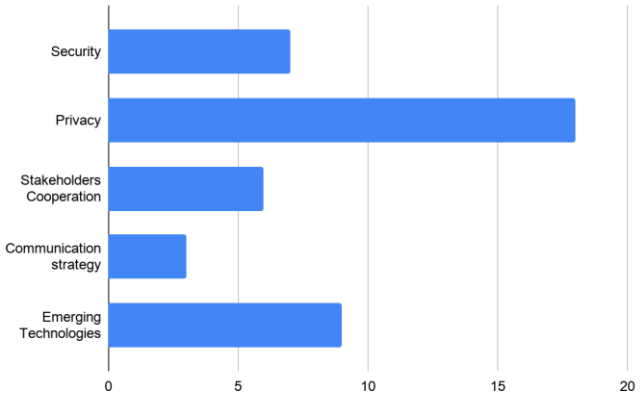

Figure 9. Distribution of barriers over the subcategories of type standardization.

4.3 Administrative

This category comprises all barriers that have a relation with legislation, regulation or policy at all levels. This is one of the most diverse categories as barriers of all types can be found among its subcategories:

- **Lack of regulation:** this category contains all barriers related to the lack of regulation around the flexibility market. Innovation in the energy sector (which is one of the most regulated) is seriously hindered by the slow pace that regulations impose. This is clearly seen in this review as this is one category with the biggest amount of barriers found. For example, barriers in this category include:
    - lack of legislation regarding flexibility markets, blockchain and energy communities.
- **Market restrictions:** in opposition to the previous category, this one contains regulations that hinder the possibility of operating a flexibility market. The biggest amount of barriers in this category relates to the restrictions imposed on DSOs and TSOs. A barrier in this category is the following:
    - DSO is not allowed to operate freely on the market or the exert market power of utilities.
- **Policy/regulatory incentives:** this category contains the barriers related to the lack of incentives or the unintended effects they have over the deployment of the flexibility market. Examples of this category are:
    - the lack of funding schemes to deploy the equipment needed.
    - the fact that the actual regulatory framework incentivises investment in grid expansion.
- **Charging/cost rules:** this category is related to the previous one, but instead of focusing on the incentives (or lack of them), focus on how actual tariff schemes are a barrier to develop flexibility markets. Examples of barriers in this category are:
    - the different regulations that do not allow to increase peak charges in different countries.
- **Decision making:** this category reflects all barriers that the different stakeholders face when deciding to participate or deploy a demand response strategy or solution on its company or to their clients. A barrier in this category is the following:
    - the lack of power of technical staff in companies or the lack of a clear leadership.

In Figure 10 we can observe the distribution of barriers identified within each of the subcategories.

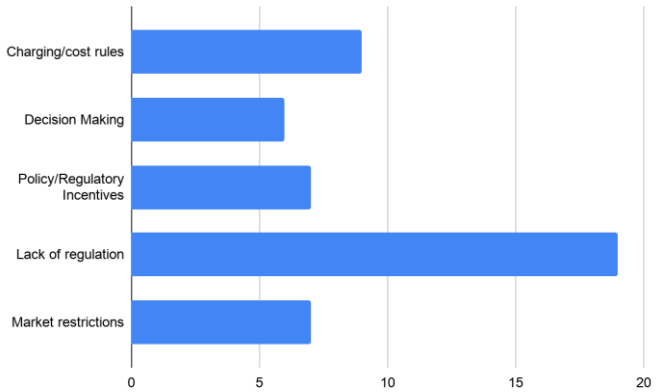

Figure 10. Distribution of barriers over the subcategories of type administrative.

4.4 Standardization

This category comprises all barriers that have a relation with standardization at all levels. This is also a diverse category as it comprise technical, legal and administrative barriers among its subcategories:

- **Diversity:** As in all new markets, there is a myriad of technologies and markets schemes proposed or implemented. This category includes the examples found for the flexibility market.

- **Interoperability:** For the same reason as before, given the novelty of the market, no official or de facto standard has emerged, so every solution implements it on technology stack that is not interoperable. In this category we list them. The most important example is:
    - the intercommunication problems between the different components in a house or building.
- **Business models:** as before, the novelty of the technology made that there is not a clear business model for selling these types of markets in several use cases. An example of this category is:
    - the conflicts between different markets or the lack of previous experience to assess the participation.
- **Roles and objectives:** finally, there is a lack of definition on what a flexibility market should provide to the different stakeholders.

In Figure 11 we can observe the distribution of barriers identified within each of the subcategories.

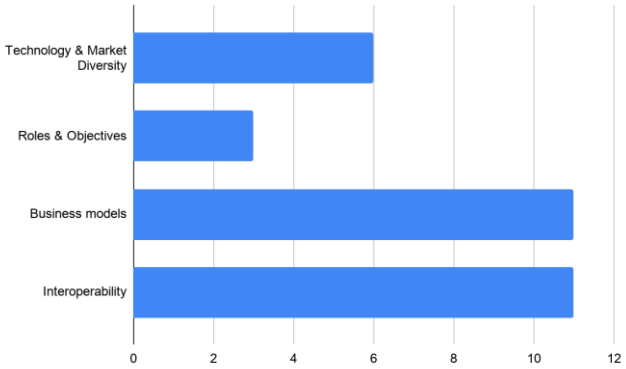

Figure 11. Distribution of barriers over the subcategories of type standardization.

4.5 Technical

This category comprises all barriers that have a relation with the technical issues that could appear at all levels, from component to overall system. Technical category has been divided in the following subcategories:

- **System:** as in all new markets, there is a myriad of technologies and markets schemes proposed or implemented. This category includes the examples found for the flexibility market.
- **Communication:** There are many components (own and external) that will be part of the final solution and they will have to communicate between them. This communication should overcome barriers such as:
    - the security, the balance and the high availability of the network.
- **Algorithms:** The implementation of new algorithms should overcome some barriers for optimum performance. Example of this subcategory is:
    - the lack of historical data to predict the demand.
- **Deployment:** The deployment of the final system in a test or real scenario could have new barriers such as low speed of the transactions in Blockchain or an increase of resources needed.
- **Maturity:** finally, as this is a research project there are some components that are new and the probability of having problems are higher. Examples of this category are:
    - the integration of these new elements in the existing grid.
    - the need of having more real cases and scenarios are needed to prove the feasibility of the idea.

In Figure 12 we can observe the distribution of barriers identified within each of the subcategories.

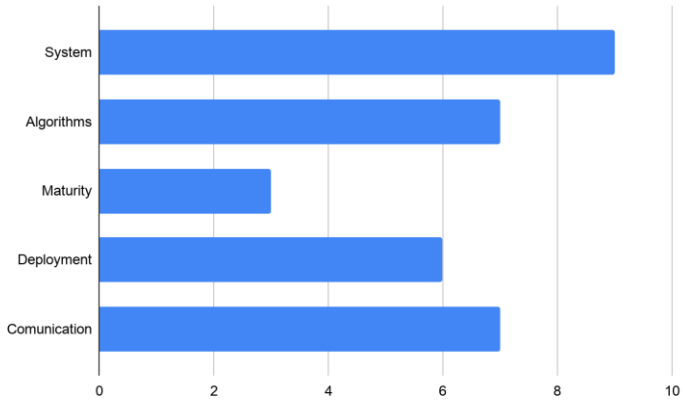

Figure 12. Distribution of barriers over the subcategories of type technical.

4.6 Cost

This category comprises all barriers that have a relation with the economical cost that customers and companies have overcome. Cost category have been divided in the following subcategories:

- **Investment:** The initial and maintenance investment that must be done should be taken into account by customers and companies.
- **Pricing:** These new markets will carry new contracts and the costs related to them. Example of this category is:
  - Supply contracts for LFM members may be expensive if suppliers are not responsible for their customers' imbalances.
- **Margin:** Finally, the situations that affect the margin will have barriers that will difficult the system adoption. Example of this category is:
  - A minimum unit size (families) are needed to adopt DR, DER or flexibility benefits

In the following figure we can observe the distribution of barriers identified within each of the subcategories.

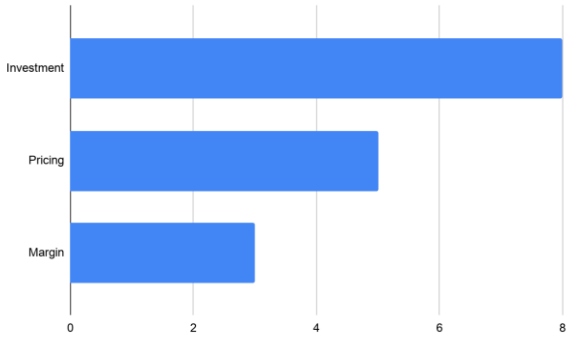

Figure 13. Distribution of barriers over the subcategories of type standardization.

In Annex D the list of barriers by category and subcategories and the references from where they have been extracted are shown.

5.PRIORITIZATION

5.1 Delphi method

The objective of this section is to present the methodology that we have followed to prioritize the barriers found. The methodology loosely follows a traditional Delphi Methodology [23]. The Delphi method has a long tradition in several sectors as a consensus building method. It is based on the fact that group decisions tends to be more accurate that individuals[24]. Delphi method has shown to be superior to other alternatives like prediction market [25] or statistical groups[24]. This approach is an iterative procedure designed to help a panel of experts to reach consensus about a topic. Give its simplicity and flexibility it has been adapted to almost any task where it is needed to reach a consensus as for example to issue judgmental forecast [26] , to select the projects to fund[29] or to forecast the use of technology [25]. It consists on the following steps:

1. A panel of experts is assembled.
2. Forecasting tasks/challenges are set and distributed to the experts.
3. Experts return initial forecasts and justifications. These are compiled and summarised in order to provide feedback.
4. Feedback is provided to the experts who now review their forecasts in light of the feedback. This step may be iterated until a satisfactory level of consensus is reached.
5. Final forecasts are constructed by aggregating the experts' forecasts.

A visual representation of these steps could be seen in Figure 14.

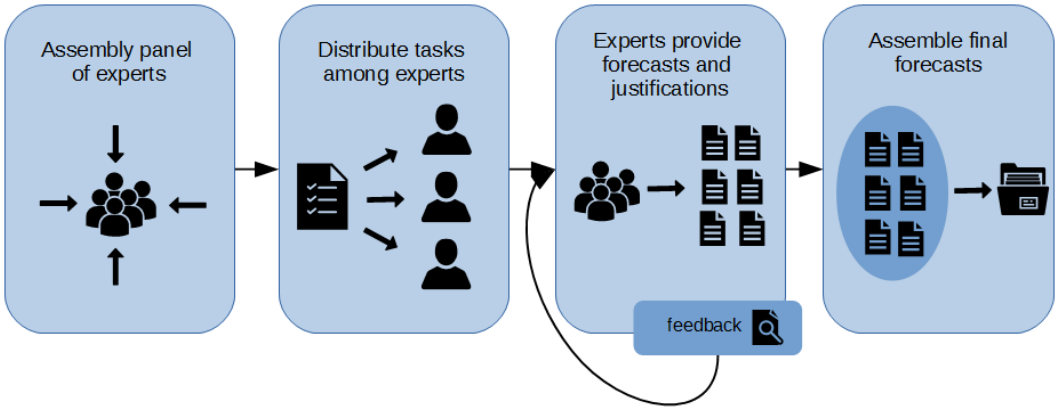

Figure 14. Visual representation of the Delphi method.

The next sections develop how this methodology was applied within this task.

5.1.1 Panel of experts

The panel of experts has been assembled within the consortium of the project as they are the persons that have the best knowledge of the project, their objectives and their potential impact. Every partner has to provide an expert so, in the end, the panels have been quite diverse. The members of the panel cover all the value chain (researchers, producers and users). The final composition consists of:

[29] European Commission (2015) Grants Manual - Section on: Proposal submission and evaluation. http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-guide-pse_en.pdf

Table 13. Panel of experts.

Partner	Description	Keywords		
		Position	Country	Company
AEM	CEO of DSO	Manager	Centre	Utility
BFS	Mechanical engineer and project manager at BFS, facility management company	Researcher	South	Utility
CERTH	Research associate in the energy & Smart Grid domains, with experience in EU-funded projects, and developer in IoT and building automation technologies	Researcher	South	Research
CHECKWATT	(ESCO) Developer of services utilizing DER flexibility	Researcher	North	Research
CUERVA	Head of Innovation: Industrial Engineer by Universidad de Malaga. Master degree in Creativity and Innovation and MBA, in the company since 2018 currently working as a Head of innovation. Entrepreneur for 5 years in different markets such as smart grids for electrical distribution in smart cities and the development of smart hotels through innovative technology. Founder of SP Solutions, as a service company framed in the field of efficiency and innovation in the energy distribution. Born with the aim to position itself as a company of technical solutions to facilitate the implementation of energy philosophies of the Smart Cities.	Researcher	South	Utility
E7	Senior Researcher in the field of energy economics, with a focus on electricity markets (demand response), energy services and development of business cases	Researcher	Centre	Research
EON	Simon Stukelj, project manager at E.ON Energilösningar AB, department for Solar & Energy Storage; formerly working within research on PV systems, inverter-based energy sources and power system stability as well as PV system planning; experienced in distributed energy sources and their integration into electrical grids	Manager	North	Utility
HEDNO	DSO Project Manager/ Head of Mid and Long Term Planning	Manager	South	Utility
HIVE	COO of a smart grid startup	Manager	Centre	Research
MERIT	Business Innovation Consultant, experience in business strategy.	Manager	North	Research
SUPSI	I am a researcher in the area of innovative	Researcher	Centre	Research

	smart grid systems. My work position is director of a research institute			
UNIC	Currently working as Research Assistant in renewable energy resources related EU projects, within the research department of UNIC. She is also a Ph.D. candidate in University of Nicosia, focusing on how blockchain can benefit future generation networks in fast-changing markets.	Researcher	South	Research
URBENER	Currently working in electrical related energy projects and role within the aggregator URBENER in the technical department buying energy from OMIE[30]. Graduated as a chemical engineering specialist in energy projects such as wind propulsion in ships and optimization of a biomass combustion plant by means of statistical image processing	Researcher	South	Utility
CIRCE	Researcher and project manager in CIRCE	Researcher	South	Research
DEUSTO	Researcher on Behaviour and Energy efficiency	Researcher	South	Research

5.1.2 Task

This task has two primary objectives: a) to set the importance of the barriers detected depending on the different stakeholders of the project and b) to forecast what barriers will be presented at the pilots' buildings.

To this end, the following task was carried out by the panel of experts:

- A document explaining the taxonomy of barriers and some basic descriptive statistics of the results of the state of the art is provided to the experts.
- A document with a description of the actors is also provided.
- A spreadsheet was created where every barrier's category is listed in rows and the actors are listed in columns. The task is to score the relevance of the barrier's category from -5 (not relevant at all) to 5 (extremely relevant) for every role.
- When all members of the panel finish giving their contributions, the coordinator of the task will compile all the answers, perform some descriptive statistics and provide the results to the panel to discuss.
- The panel will meet and discuss the results openly and a new round of scoring will be carried out. To this end, the experts could modify their scores according to the discussion.
- When all members of the panel finish modifying their contributions, the coordinator of the tasks will again compile all the answers, perform some descriptive statistics and provide the results to the panel to discuss another time.
- Rounds of scoring - discussion will be carried out until the no significant modifications to the scores are being made.
- Finally, the coordinator of the task will perform the final statistical analysis and provide the end prioritization of the barriers.

[30] https://www.omie.es/

5.1.3 Feedback

To foster the discussion among the panellist some rules were introduced in the feedback rounds. Below could be found the exact rules given to the panellist are presented:

> *As member of the panel of expert for the Delphi process, you have been provided a google folder with three files:*
> - *the presentation of the activity made on the 27th of April*
> - *a document describing the barriers subcategories and the 8 actors identified in the project*
> - *a template to grade the importance of the category of barriers for every actors.*
>
> *Please read carefully the instructions below before starting the tasks:*
> - *Read carefully the description of the category of barriers and actors.*
> - *Please fill a sentence describing you. For example: Researcher on energy behaviour; CEO of a DSO; developer of some cool technology; etc.*
> - *For every actor, you have to grade the relevance of the barrier subcategory for them using whole numbers from -5 (not relevant at all) to 5 (extremely relevant). The spreadsheet is locked, so only information in the grey cells could be provided.*
> - *If you are not sure about a grade, please LEAVE THE CELL EMPTY. Moreover, AVOID USING 0 (neutral) as a grade.*
>
> *Please complete this task no later than 19:00 hours of Monday 5th of May.*
>
> *Thanks for participating in this task.*
>
> *Deusto Team*

The document with the description of the categories includes previous section of this deliverable.

5.1.4 Statistical analysis

The objective of this analysis is twofold: on the one hand, we wanted to assess the homogeneity of the grades between experts and, on the other hand, we wanted to assess the relative importance of the barriers categories for the actors and pilots in order to assess the suitability of the solution proposed.

The grades provided by the experts are at subcategory and role level, but the statistical assessment is only provided at category and role. Please note that to transform the scores from subcategories to categories we have just averaging over the scores of the barriers in that category. Please note that both the raw scores at barrier and subcategory level and the statistical results of this analysis at subcategory level are provided in Annex C.

To assess the homogeneity, it is needed to assess the measure of the agreement not only of the scores provided by the panellists but also the homogeneity of its variances. Namely, we wanted to assess not only if the experts provide the same scores but also if the variability of their scores are similar in order to make them comparable. Two measures of the Inter-rater agreement were provided, the Intraclass correlation coefficient [27] and the Fleiss' Kappa test [28]. On the other hand, to test the homogeneity of the variances the Fligner-Killeen test [29] were used.

To assess the relative importance, the Friedman Test [30] were carried out for every category and actor. The Friedman Tests is an omnibus test for differences in the scores distributions. If the test is significant (namely, there are statistically significant differences between the subcategories), a post hoc analysis has to be carried out using a suitable multiple comparisons correction. In this case, we have used the Exact All-Pairs Comparisons Test [31]. This analysis will provide us not only a set of barriers' categories but also (and more important) their relative distance. Using this information, the set of critical barriers is constructed. It contains the set of barriers that has the highest scores. Finally, a Judgmental Adjustment [26] has been carried out in order to include in the critical set of barriers any

barrier category that the panel considers of extreme importance even as, given the grades provided, it was not included.

Additionally, the differences among the scores given by experts depending on their profile were assessed. To this end, the experts have been classified by three criteria.

- **Position in the company**: The experts were classified in two classes under this category, managers and researchers. The first one consists of all positions with a clear responsibility (like director, head of area, CEO, or similar). The second one groups not only researchers but also technical profiles.
- **Country where the company is based**: The countries were grouped in categories: North and South. The first one includes Sweden, Switzerland and Austria while the second one includes Spain, Cyprus and Greece.
- **Type of company**: We group the companies into research-based companies (including universities, technological centres and consultancy firms) and utilities (including not only DSOs but also ESCOs).

As all criteria include two classes, a Mann-Whitney Test [32] was used to verify the existence of differences among the scores.

5.1.5 From scoring barriers for roles to prioritizing barriers for the use cases

Finally, the categories of barriers are linked to the Use Cases and Business Use Cases. For this end, two sets will be constructed based on the methodology defined in [33].

On the one hand, a *fuzzy union* of the critical set of barriers of all actors that are involved in every Use Case and Business Use Cases is constructed. To this end, to each actor in each Use Case (respectively Business Use Case) will be given a weight and to each barrier in the critical set of these actors is assigned the score 1. Please note that the critical set for the actors includes the Judgemental Adjustment from the panel of experts. Then, a weighted sum of the scores in the critical set is produced. From this information, a prioritization is extracted taking the two barrier categories with the largest scores.

On the other hand, the weighted average grade of the barriers is calculated following a similar procedure to the previous one. The process begins as before using the weights assigned to each actor in each Use Case (respectively Business Use Case). Then, instead of using the critical set, the raw average scores produced at the end of the Delphi process will be used. Next, as before, a weighted sum of these scores is produced. Finally, as before, a prioritization is extracted taking the two barrier categories with the largest scores.

5.2 Results

In this section the results of the Delphi method to prioritize the barriers is provided. Three rounds of the iterative process where needed and the fifteen experts participate in all of them. Four online meetings were carried out:

1. **Kick-off meeting** (27th of April): During this meeting, the facilitator of the action presents the taxonomy along with the description of the tasks to be carried out (see Annex D and Zenodo's link[31]). Finally, the deadlines of every step of the process are discussed and agreed.
2. **1st Round meeting** (6th of May): During this meeting the facilitator of the action presents the results of the first round. Apart from the metrics defined in the previous section, two metrics were used to track the level of agreement between the experts: the average and standard deviation of the interquartile range of the score distribution given by the experts to the different roles for every barrier. To ease the discussion, the facilitator defined a threshold to

[31] https://zenodo.org/record/3861847#.XtFM3vIzaV5

these metrics to decide if the experts have reached an agreement or not. The thresholds were defined as:

- If the intraclass correlation coefficient is larger than 0.2 or if the average and standard deviation of interquartile ranges are less than 2.5 and 1.5 respectively it is concluded that the experts have reached an agreement.
- If the interquartile range is larger than 3 it is concluded that the experts have a strong disagreement.

With these definitions, the following barriers have reached an agreement:

- All barriers from Administration and Standardization categories
- All barriers from Trust category except Communication Strategy and
- Maturity from Technical category

And the following barriers have a strong disagreement:

- All barriers from Changing Lifestyles category
- System and Algorithms from Technical category

In total, 50 % of the barriers have reached an agreement and 29 % have a strong disagreement.

Next, the facilitator explained that barriers where an agreement was reached was not going to be discussed anymore and presented the results of the rest of the barriers. A series of figures similar to Figure 15 was presented for every barrier to discuss. This figure presents the boxplot of the distribution of scores given by the panel of experts for every role for a particular barrier. As only barriers where the experts disagree are presented, in all cases the boxes were wide and in general with strong differences between roles. A discussion "barrier per barrier" was made. Focus was put on DER, Aggregator, ESCO, BRP and Supplier roles as these seem to be the most complex and with more prone to a different interpretation.

The meeting ends setting a new deadline to provide the new scores after the discussion held in the meeting.

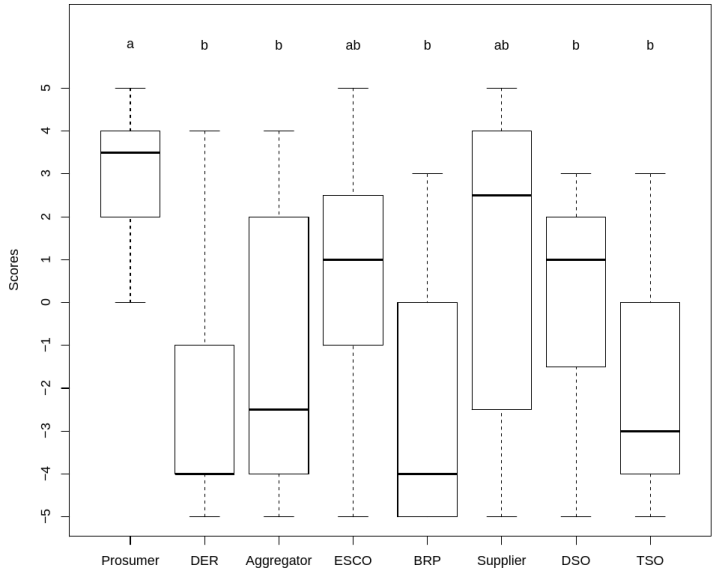

Figure 15. Distribution of scores for barrier Disillusion on the first round.

3. **2nd Round meeting** (12th of May): During this meeting the facilitator of the action presents the results of the second round:
    - The level of agreement between the experts has slightly decreased.
        - from 0.043 to 0.039 according to the Inter rater agreement and

        - from 0.182 to 0.162 according to the Intraclass correlation coefficient.
    - But their scores have improved their homogeneity:
        - The Homogeneity of Variances test failed in a 57 % of the cases in the first round and only a 32 % in the second.
    - The scores distributions have narrowed,
        - The average interquartile distance went from 2.43 to 2.35 and the standard deviation went from 1.43 to 1.36.
    - All barriers have left the strong disagreement category but no new agreements were reached. In the end, we continue with 50 % of the barriers having reached an agreement.

Next, the facilitator presented a table with the main changes in the scores (Table 14). In red can be highlighted the biggest differences. As it can be seen, DER, Aggregator, ESCO and TSO are the roles that have the biggest changes. This is an expected result given that these roles were the most discussed in the previous round. It can also be seen that the Technical and Changing Lifestyles concentrate the biggest changes. This is also expected as these two categories concentrate almost all barriers that were discussed.

Table 14. Mean differences between the scores of the first and second round.

Barriers / Actors	Prosumer	DER	Aggregator	ESCO	BRP	Supplier	DSO	TSO
Changing lifestyles	-0.13	0.70	0.48	-0.11	-0.09	0.17	0.11	0.52
Administration	0.00	0.04	0.00	0.06	0.04	0.14	0.00	0.02
Technical	0.11	-0.02	0.12	0.34	0.14	0.08	0.22	0.00
Trust	0.00	0.04	0.02	-0.06	-0.02	-0.02	-0.08	-0.06
Costs	0.00	0.00	0.00	0.03	0.10	0.00	0.10	0.16
Standardization	0.02	0.05	-0.10	-0.08	-0.05	0.02	-0.05	0.07

Finally, the barriers that have not reached an agreement were discussed. To this end, the facilitator presented a slightly different figure than before (Figure 16). In this figure the scores achieved during the first and second round are compared using boxplots. After several barriers analysed, the panel decide that it is needed to make some modifications to the roles to be assessed:

- **Merging DER and Prosumer**: as DER are not actors per se but devices that are operated by a prosumer, we consider that DER is contained in Prosumer and should be removed.
- **Merging Aggregator and Supplier**: Aggregator and Suppliers take a quite similar role in general and are almost interchangeable in this project in particular. For this, it was decided to merge these two under the role of Supplier.
- **Removing ESCO**: Under the definition of ESCOs used in the project, they are not affected by the sort of barriers we are assessing. In fact, their role in the energy system would be to help the rest of actors to overcome these barriers, but are not affected by them. Obviously, they also have many barriers but are different in nature, so we decide to just not consider this assessment. Please note that under different description of what an ESCO is, its role could be quite similar (or even interchangeable) with the Aggregator and thus, this role is considered in the previous one.

The meeting ended setting a new deadline to provide the new scores after the modification to the roles.

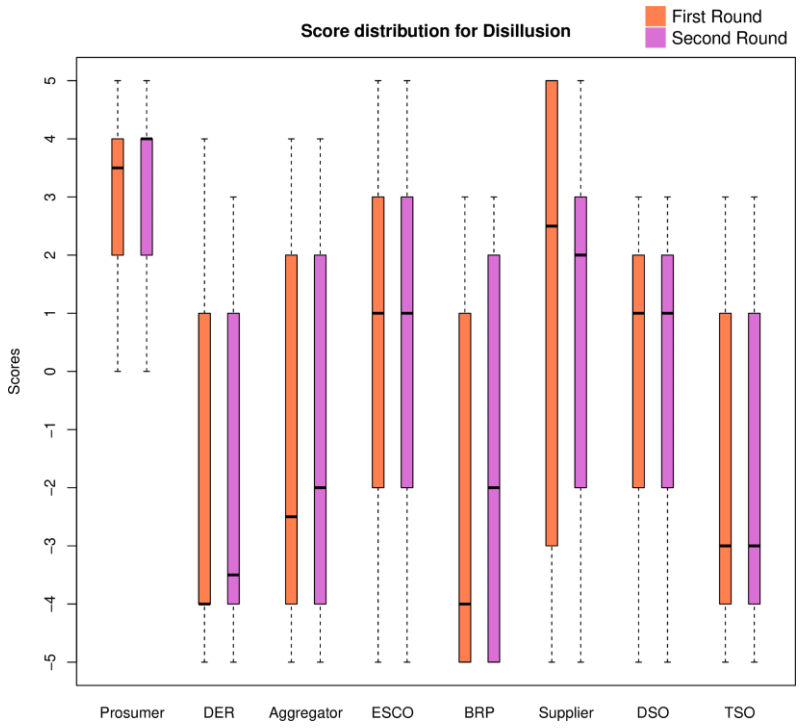

Figure 16. Score comparison for barrier Disillusion between the first and second round.

4. **Final meeting** (18th of May): The final meeting was quite similar to the previous one. It starts with the facilitator of the action presenting the results of the third round:
    - The level of agreement between the experts has slightly decreased again:
        - from 0.039 to 0.028 according to the Inter rater agreement and
        - from 0.162 to 0.118 according to the Intraclass correlation coefficient.
    - But their scores have reached homogeneity (all barriers pass the test).
    - The scores distributions have narrowed again:
        - The average interquartile distance continue in 2.35 but the standard deviation dropped from 1.36 to 1.31
    - No differences were found between the scores by country, type or position.
    - Trust and Technical categories have reached agreement but Current Lifestyles and Cost continue without. In general, 61 % of the barriers have now reached agreement.

Next, the facilitator presented the table with the main changes in the scores (Table 15). As before, red highlighted the biggest differences. Now, the biggest differences are in the supplier and TSO columns, with also a big change in BRP. The change in the Supplier score is an expected result given that this role was the most affected in the modification. The changes in BRP and TSO are triggered most probably by the discussion clarifying these roles, as BRP, in particular, is not a role very familiar for some of the experts.

Table 15. Mean differences between the scores of the second and third round

Barriers / Actors	Prosumer	BRP	Supplier	DSO	TSO
Changing lifestyles	-0.05	0.01	0.31	-0.17	-0.20
Administration	0.00	-0.10	0.44	-0.04	0.04
Technical	-0.03	-0.57	-1.37	-0.14	0.48
Trust	-0.10	-0.02	-0.14	-0.04	0.18
Costs	0.00	-0.13	-0.27	-0.10	-0.11

Standardization	-0.03	0.00	-0.08	-0.02	0.35

Finally, the panel discusses the main results. To this end, the facilitator presented the final distribution plus the average score per barrier category and role (Figure 17). By default all barriers with scores above 3 were selected in the critical set for the role. This was in large agreement with the results of the Friedman Test post hoc used. This is highlighted in red on the column with the scores. Yellow scores are those above 1 and in most of the occasions correspond to barriers that cannot be ruled out of the critical set by the post hoc. The Panel made a Judgmental Adjustment in order to reconsider all barriers in the critical set. For example, in Figure 17, Trust was discussed and included in the critical set even as it was initially not. This was highlighted in purple. The results were quite satisfactory as the panel just wanted to include barriers in yellow in the critical set and in all cases it was quite near 3.

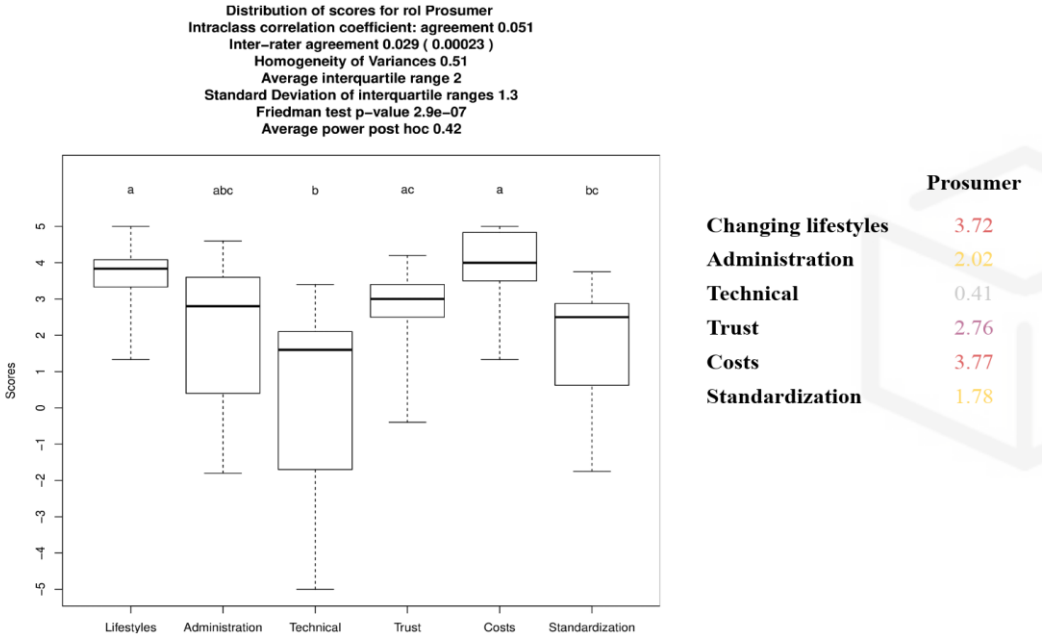

Figure 17. Final distribution of scores for all barriers category role Prosumer. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score.

5. **Extra meeting** (27th of May 2020): An extra meeting was needed to be carried out. After the assessment of the Use Cases and Business Use Cases it was found that BRP role was not clearly presented in any of the Use Cases. This was not unexpected given the problems found during the evaluation of the barriers. In this meeting several of the experts from the panel meet and review the description of the Use Cases to include the BRP in those that are more suited.

5.2.1 Final results from the Delphi Method

In this section it will be presented the main results of the prioritization carried out. For every role, it will be presented the distribution of scores over the different barriers categories, the statistics assessment carried out to test if the differences between the scores are significant and the end critical set of barriers.

5.2.1.1 Prosumer

Figure 18 presents the main results of the Delphi method for the role Prosumer. As commented before, according to [34] the level of agreement between the scores is poor as both the Intraclass correlation and the Inter-rater agreement coefficients are low. This means that the reviewers have not provided the same scores to the different barriers. Nevertheless, this is the expected result as the experts come from different backgrounds and as such will have different opinions. On the other hand, the results show

that the variances provided to the scores are homogeneous[32]. So, even as the reviewers have not provided the same scores to the barriers, these are comparable.

In Figure 18 can also be seen that there are differences between the different barriers categories. Clearly, the Technical and Lifestyles barriers are different. The results of the Friedman test confirm this hypothesis and the post hoc shows that there are 3 groups of barriers (there are 3 different letters above the boxplots) but only 3 barriers are clearly classified: Lifestyles and Costs belong to the group *a* and Technical to the group *b* but the rests of barriers belongs to more than one group.

The rule of thumb used to select the barriers to include in the critical set (all barriers with score above 3) completely agrees in this case with the statistical test. Nevertheless, the panel of experts decide to also include Trust in the critical set given their experience. Please note that Trust is also in the group *a*, so this decision is compatible with the statistical decision.

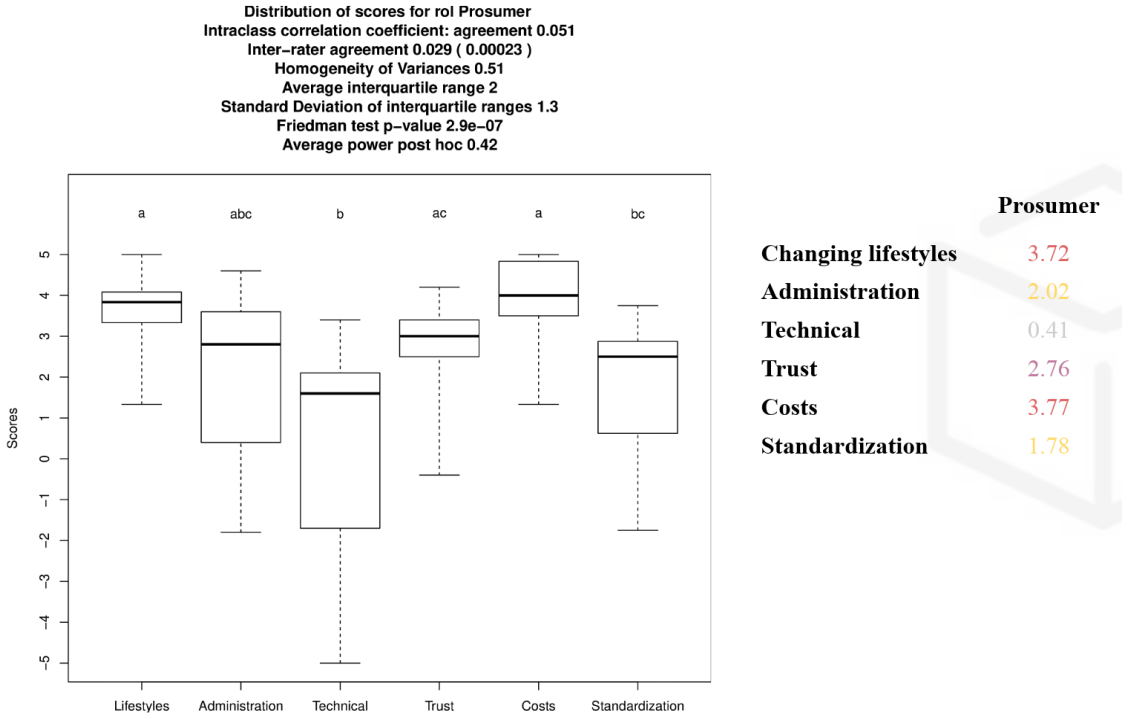

Figure 18. Final distribution of scores for all barriers related to the role of Prosumer. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score.

5.2.1.2 BRP

Figure 19 presents the main results of the Delphi method for the role BRP. As with all roles, the level of agreement between the experts is poor. In fact, in this case there is such disagreement between the scores of the experts that the Intraclass correlation is negative[33]. This means that the scores provided by the reviewers in each category have more variance than the differences between categories. On the other hand, as in the previous case, the variances of the scores are homogeneous so the scores are comparable.

As in the previous case, there are differences between the different barriers categories. Clearly, the Lifestyles belong to a different group than the rest of categories. The results of the Friedman test

[32] More precisely, the data collected does not allow us to conclude that the score distribution is not homogeneous, that is not exactly the same thing.

[33] http://www-personal.umich.edu/~gonzo/course/new.html

confirm this hypothesis and the post hoc shows that there are 2 groups of barriers and all the categories are clearly classified (every category belongs to only one group). Even as it seems like the statistical test has provided a good answer, the reality is that it is not provided a way to discriminate between the 5 categories in group *b* even as Cost and Technical (for example) seems to have a quite different behaviour than Administration. The most probable cause of this behaviour is due to the same issue that produces the negative result of the Intraclass correlation coefficient. As the variability between the scores provided by the experts is so large, the tests have problems separating the clusters of barriers.

In this case, the rule of thumb used to select the barriers is probably more helpful. In this case, it is stricter than the statistical test and only includes Administration and Standardization. Nevertheless, as before, the panel of experts decide to also include Trust in the critical set given their experience. Please note that Trust is also in the group *b*, so this decision is compatible with the statistical decision.

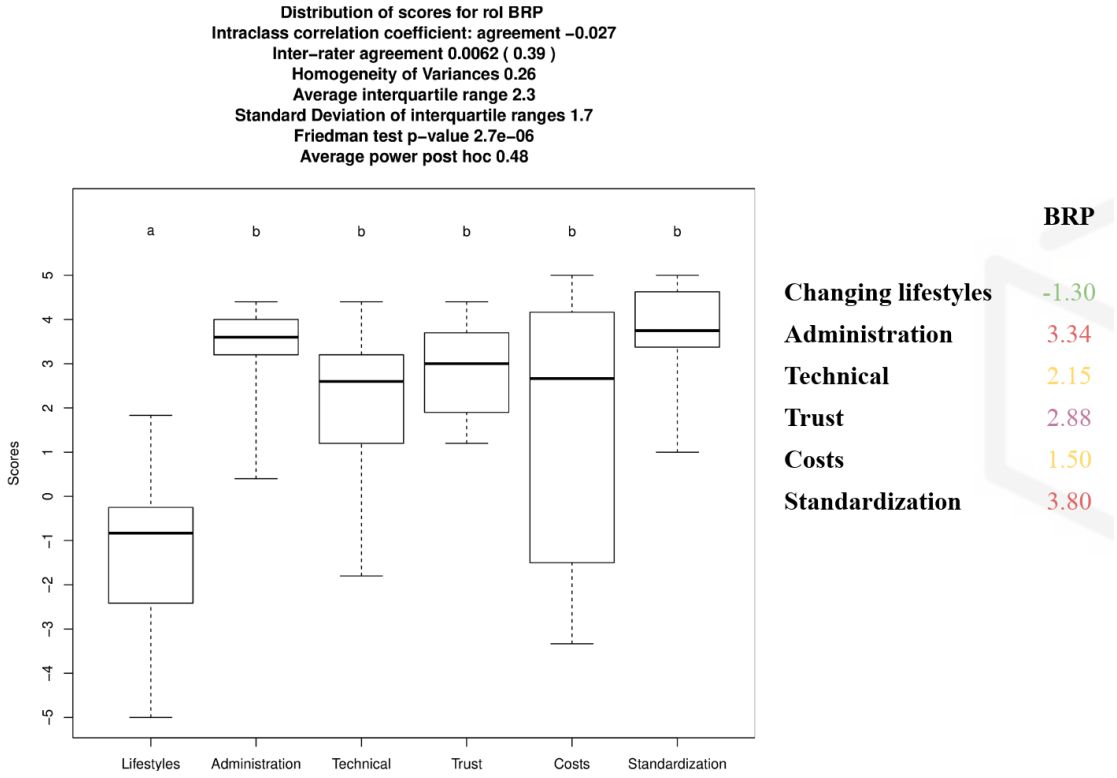

Figure 19. Final distribution of scores for all barriers category role BRP. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score.

5.2.1.3 Supplier

Figure 20 presents the main results of the Delphi method for the role Supplier. As before, the level of agreement between the experts is poor. This means that the reviewers have not provided the same scores to the different barriers. Nevertheless, as in the previous case, the variances of the scores are homogeneous so the scores are comparable.

As in the previous case, there are differences between the different barriers categories. As before, Lifestyles belong to a different group than the rest of categories but the separation is not so clear than in the BRP's case. The results of the Friedman test confirm this hypothesis and the post hoc shows that there are 2 groups of barriers but Technical and Trust are not possible to assign to a single category.

The rule of thumb used to select the barriers agrees with the statistical assessment and select Administration, Cost and Standardization in the critical set. Nevertheless, as before, the panel of experts decide to also include Trust in the critical set given their experience. Please note that Trust is also in the group b and has a higher mean score than Technical (even as the box seems the contrary).

Technical has a very imbalance score distribution: it has a large median but a low mean value. The most probable reason is the presence of an outlier score.

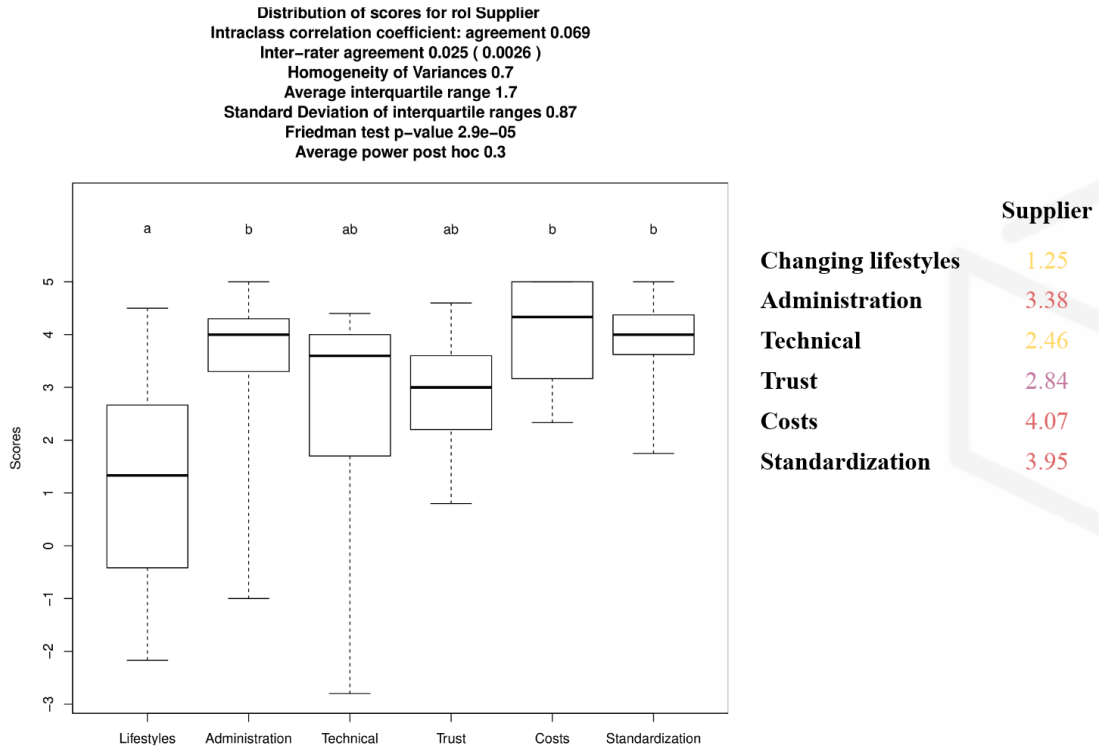

Figure 20. Final distribution of scores for all barriers related to the role Supplier. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score.

5.2.1.4 DSO

Figure 21 presents the main results of the Delphi method for the role DSO. Even as this is the role with the highest agreement between the experts, it continues to be poor. Nevertheless, as in the previous case, the variances of the scores are homogeneous so the scores are comparable.

As in the previous case, there are differences between the different barriers categories. As before, Lifestyles belong to a different group than the rest of categories but the separation, again, is not so clear. The results of the Friedman test confirm this hypothesis and the post hoc shows that there are 2 groups of barriers, but it is not possible to assign Cost to a single category.

The rule of thumb used to select the barriers in this case does not improve the situation as it will select all the barriers categories except Costs. Nevertheless, the panel of experts decided to also include it, so in this case, the only barrier category ruled out of this role is Lifestyles.

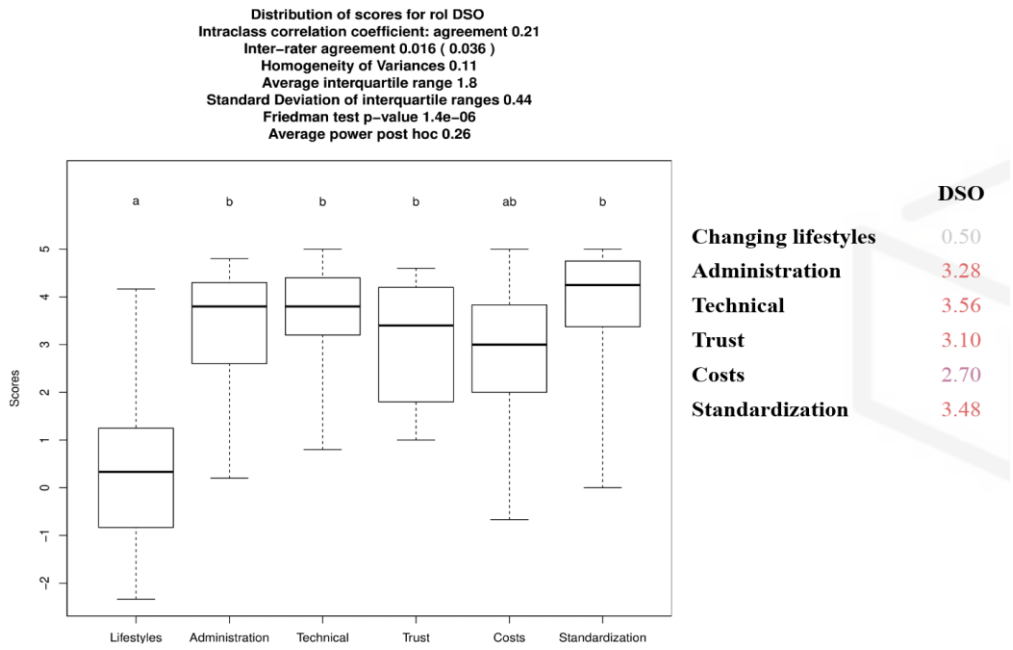

Figure 21. Final distribution of scores for all barriers related to the role DSO. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score.

5.2.1.5 TSO

Figure 22 presents the main results of the Delphi method for the role TSO. As in all previous cases, the level of agreement is poor but the variances are homogeneous, so the scores are comparable.

The situation here is quite similar to the BRP: clearly, Lifestyles category belong to a different group than the rest of categories, the Friedman test confirms this hypothesis and the post hoc shows that there are 2 groups of barriers with all the categories of barriers clearly classified. As before, this situation is not good as it is not possible to discriminate between the 5 categories in the group *b* even as Cost and Administration (for example) seems to have a quite different behaviour than Technical.

As with the BRP, the rule of thumb is probably more helpful. In this case, it is stricter than the statistical test and only includes Technical in the critical set. Nevertheless, the panel of experts decide to also include Standardization in the critical set given their experience. It is the only case where the panel includes a barrier category in the critical set that does not have the closest score to the critical set.

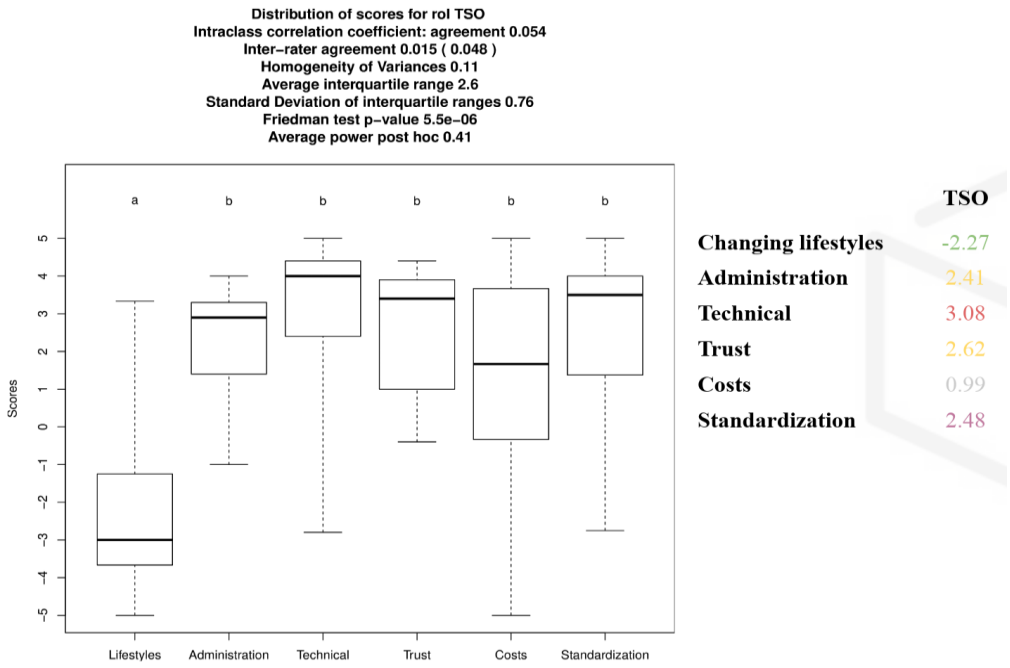

Figure 22. Final distribution of scores for all barriers related to the role TSO. Letters above the barriers denote significant different groups accordingly to the post hoc selected. The data at the right is the mean score *UC and BUC barriers.*

5.2.3 UC and BUC barriers

In this section we provide the most important barriers that affect every Use Case and Business Use Case. Following the methodology explained in Section 5.1.5, first it is needed to weigh the relevance of the roles participating in each Use Case and Business Use Cases. From the description of the Use Cases and Business Use Cases provided in Deliverable D3.1, the panel of experts defines for each the main (M) and supporting (S) roles involved in each of the use cases. Table 16 and Table 17 provide this information for the Use Cases and Business Use Cases respectively. It has been decided that main roles have a weight of 1 and smaller roles have a weight of 0.5. In order to make the proposed weight convex, we have just divided them by the sum.

The next step is to use this information to weight the critical set and the average scores assigned per role. Table 18 and Table 19 present the critical set and the average scores respectively and Table 20 and Table 21 the results of weighting this information.

Finally, Figure 23 presents the end prioritization using the two methods. As can be seen, there are significant differences among the two methods. On the one hand, when looking at the weighted average prioritization, the most important barriers (purple and blue) are more spread across the use cases even as the most important barriers are clearly Cost and Standardization (almost all purple barriers are in these two categories). Nevertheless, when looking at the results using the critical set the importance is less scattered. In fact, it seems like in almost all cases the two most important categories are trust and standardization. Please note that in this last case there are lots of ties between the scores and two barriers categories could have the same colour.

It is important to highlight that Lifestyle is not an important barrier category in any of the two methodologies. This is a shocking result as not only is the barrier category with more subcategories and barriers included but also the highest cited in the literature. Nevertheless, this result is entirely consistent with both, the definition of the Use Cases and the Role model used. As we have evaluated the barrier that directly affects each role, namely we have explicitly indicated to the experts that they should not consider indirect effects, lifestyles only affect directly to the prosumers. From this fact, it is normal that the only role with Lifestyle in its critical set are the Prosumers. On the other hand, in any

of the Use Cases the prosumers have the main role. From these two claims, the shocking result can be derived.

In any case, Lifestyles are clearly a different type of barrier than the rest (see for example[11]). Not only because it is the one that affects the prosumers but also because it needs a different approach (generally not technological). To this end, it has been decided to split the focus on the barriers from now on and consider the Lifestyles barriers as a transversal barrier that should be worked on independently and the rest of the barriers for which the proposed results of the project should provide means to overcome.

Table 16. Actors involved in the Use Cases.

	Prosumer	BRP	Supplier	DSO	TSO	
UC1	S		M			Building estimation for the LFM at individual level
UC2	S		M	S		Building estimation for the LFM at aggregated level
UC3	S		M	S		EV estimation for the LFM at individual and aggregated level
UC4	S	S	M			Energy flexibility market operation
UC5	S	S	S	M		Flexibility action for economic or environmental reasons in a green status of the grid
UC6				M		Control by the DSO of the STATCOM to balance their own grid
UC7				M	S	Control by the DSO of the STATCOM to sell flexibility to TSO
UC8	S	S	S	M		Flexibility action for technical reasons in a potential yellow or orange status of the grid
UC9	S	M	S		S	Flexibility sold by the BRP to the TSO
UC10	S	M	S		S	Flexibility sold by the BRP to the wholesale market
UC11				M		Flexibility action for technical reasons in a potential red or black status of the grid
UC12	S		M	S		Flexibility market between energy communities

Table 17. Actors involved in the Business Use Cases.

	Prosumer	**BRP**	**Supplier**	**DSO**	**TSO**	
BUC1	S	S	M	S	S	Aggregator as a participant in the LFM buying flexibility from prosumers and selling the aggregated flexibility
BUC2	S	S	M	S	S	Supplier as LFM operator and also assuming the aggregator role
BUC3				M		Neutral position of the DSO for market coordination
BUC4	S			M		DSO equipped with novel smart grid management tools buying flexibility on the LFM from aggregator(s)

Table 18. Critical set of barriers for every role.

Roles	**Lifestyles**	**Administration**	**Technical**	**Trust**	**Costs**	**Standardization**
Prosumer	X			X	X	
BRP		X		X		X
Supplier		X		X	X	X
DSO		X	X	X	X	X
TSO			X			X

Table 19. Average scores of barriers for every role.

Roles	Lifestyles	Administration	Technical	Trust	Costs	Standardization
Prosumer	3.7	2	0.4	2.7	3.8	1.8
BRP	-1.3	3.3	2.1	2.9	1.5	3.8
Supplier	1.2	3.4	2.5	2.9	4.1	3.9
DSO	0.5	3.3	3.6	3.1	2.7	3.5
TSO	-2.3	2.4	3.1	2.6	0.99	2.5

Table 20. Weighted critical set of barriers for every use case.

	Lifestyles	Administration	Technical	Trust	Costs	Standardization
UC1	0.33	0.67	0.00	1.00	1.00	0.67
UC2	0.25	0.75	0.25	1.00	1.00	0.75
UC3	0.25	0.75	0.25	1.00	1.00	0.75
UC4	0.25	0.75	0.00	1.00	0.75	0.75
UC5	0.20	0.80	0.40	1.00	0.80	0.80
UC6	0.00	1.00	1.00	1.00	1.00	1.00
UC7	0.00	0.67	1.00	0.67	0.67	1.00
UC8	0.20	0.80	0.40	1.00	0.80	0.80
UC9	0.20	0.60	0.20	0.80	0.40	0.80
UC10	0.20	0.60	0.20	0.80	0.40	0.80
UC11	0.00	1.00	1.00	1.00	1.00	1.00
UC12	0.25	0.75	0.25	1.00	1.00	0.75
BUC1	0.17	0.67	0.33	0.83	0.67	0.83
BUC2	0.17	0.67	0.33	0.83	0.67	0.83
BUC3	0.00	1.00	1.00	1.00	1.00	1.00
BUC4	0.33	0.67	0.67	1.00	1.00	0.67

Table 21. Weighted average scores of barriers for every use case.

	Lifestyles	Administration	Technical	Trust	Costs	Standardization
UC1	2.07	2.94	1.77	2.82	3.97	3.21
UC2	1.68	3.03	2.22	2.89	3.66	3.28
UC3	1.68	3.03	2.22	2.89	3.66	3.28
UC4	1.23	3.04	1.86	2.83	3.34	3.35
UC5	0.93	3.07	2.42	2.94	2.95	3.29
UC6	0.50	3.29	3.56	3.11	2.71	3.48
UC7	-0.42	3.00	3.40	2.94	2.14	3.15
UC8	0.93	3.07	2.42	2.94	2.95	3.29
UC9	0.02	2.90	2.05	2.79	2.35	3.15
UC10	0.02	2.90	2.05	2.79	2.35	3.15
UC11	0.50	3.29	3.56	3.11	2.71	3.48
UC12	1.68	3.03	2.22	2.89	3.66	3.28
BUC1	0.52	2.97	2.35	2.84	2.85	3.23
BUC2	0.52	2.97	2.35	2.84	2.85	3.23
BUC3	0.50	3.29	3.56	3.11	2.71	3.48
BUC4	1.57	2.87	2.51	2.99	3.07	2.91

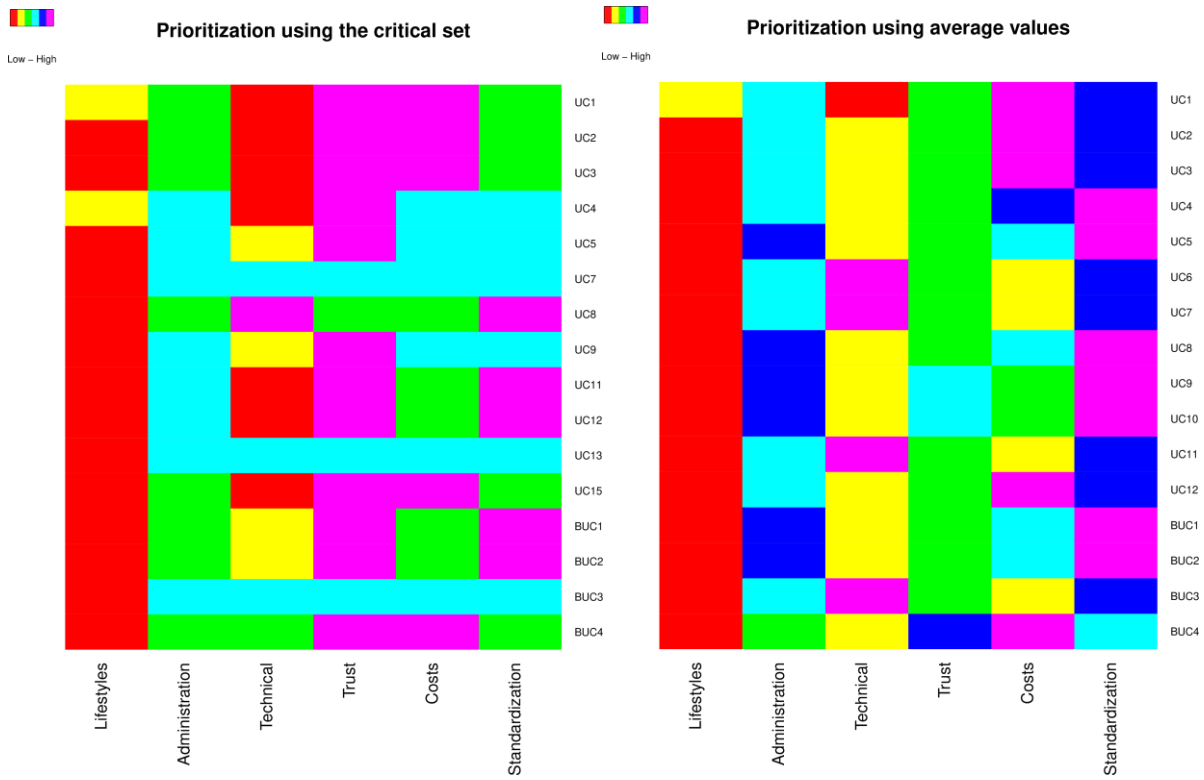

Figure 23. Final prioritization for each use case using the critical set (left) and average scores (right). Red means low priority.

6. CONCLUSIONS

In this document we have provided a comprehensive study of the background of barriers according the state of the art. Furthermore, we interviewed and delivered questionnaires to relevant stakeholder, partners within the consortium and end-users from pilot-buildings. With all this information, we have provided a taxonomy of barriers for LFM adoption that it is publicly available in ZENODO[34]. Taking the identified barriers as an input, we have linked them to actors and use/business cases through a Delphi methodology followed to a statistical analysis of the results from the qualitative method. In the following, we highlight the most important findings for each important block of the taxonomy and the prioritization. Nevertheless, isolating them is difficult because during the conducted analysis, it was realized that some barriers were initially identified as technical (for example), but could potentially affect other aspects as well. For instance, security and privacy are technical challenges at their core, but when it comes to the wide adoption of LFMs, such barriers could lead to luck of trust, affecting social, economic and even regulatory aspects as well.

6.1 Socio-economic conclusions

The barriers identified from the socio-economic dimension were the most recurrent and frequent type of barriers encountered in this study. Specifically, these were related to: Adoption, Ideology & involvement, Disillusionment, Reluctance and lack of trust, Perceived Usefulness, Ignorance / lack of expertise. Among all of them, Reluctance and Lack of trust followed by Lack of expertise were the barriers more end-users and other stakeholders reported to face when it comes to join or adopt a LFM program. Similarly to penetration of DR or other emerging technologies related to energy for the future home, we found tensions in the adoption phase. Indeed, what we obtained in our study was not very different when compared to the state of the art. However, it was an interesting finding to observe that privacy or reluctance appeared as the most important barriers because of the introduction of new contracts and agreements that did not exist before. Finally, we emphasise that lack of adoption or involvement can be due to a poor campaign explaining the LFM market. Future attention of retailers, aggregators and DSOs has to be put on making citizens understand the advantages of having an exchange of flexibility among peers. Thus, to trust more on the interdependence and that the service will be always ensured. Finally, the stakeholders that sell the flexibility to end-users have to fully understand that the family-unit need can evolve along the time and that there is no rationality when it comes to cope with the changing daily routing.

6.2 Technical conclusions

The technical barriers within LFM are various and heterogeneous. Although energy smart grids and LFMs have evolved rapidly, some open technical challenges still need to be addressed, even considering the technology readiness issues. During the literature review, the identified technological barriers are classified in seven types: a) Integration of Renewable Energy into the Grid, b) Lack of technology standardization, c) Privacy, Security and Data Sharing, d) Interoperability, e) Networking and f) Infrastructure. Within D4.1 taxonomy of all identified barriers was implemented, including the technological ones. During the barriers taxonomy and the obstacles towards LFMs, the technological challenges were categorized in smaller groups, taking into consideration the PARITY ecosystem. From the technical point of view, the issues are related to the underlying flexibility market system and its deployment, the communication between internal and external components, the need for new algorithms implementation considering the performance of LFMs and finally, the maturity of the technology, especially when it comes to innovative components that are going to be introduced through PARITY. It should also be mentioned, that during the conducted analysis, it was realized that some barriers initially identified as technical, could potentially affect other aspects as well. For instance, security and privacy are technical challenges at their core, but when it comes to the wide

[34] https://doi.org/10.5281/zenodo.3863017

adoption of LFMs, such barriers could lead to luck of trust, affecting social, economic and even regulatory aspects as well. Moreover, comparing the initial review to the final taxonomy, it is clear that lack of standardization is not considered only as a technical barrier, but it could characterized as a mixed category, including also barriers from the legal and administrative perspective. Some examples include markets' diversity and business models issues, the lack of definition on what flexibility really refers to in LFMs and clearly interoperability concerns since no official standard has emerged yet when it comes to the technology stack. To sum up, the energy efficiency ecosystem is heavily occupied with many complex structures that need to interact efficiently and carry out their tasks. Despite the technological obstacles to the adoption of energy efficiency, LFM is increasing rapidly, seeking to exploit their flexible operating environment to provide solutions to the problems associated with the understanding and usage, and this clearer considering the prioritization of the technical barriers, where at most of the cases all the different actors have come to an agreement.

6.3 Conclusions on national legal frameworks

The legal framework represents a barrier for the utilization of DERs as sources for flexibility in many ways. For the participation in existing flexibility markets such as the wholesale and balancing market there are prequalification criteria that keep small loads out of the market in most countries. Especially when it comes to local utilization of this flexibility in order to solve constraints for the DSO, there is a clear lack of an ancillary service market at DSO level. This is a crucial issue, as the LFM concept aims at introducing such markets and therefore a legal basis is required. Moreover, regarding peer-to-peer trading, currently it is not possible in the legal framework to enable direct transactions between prosumers.

6.4 Conclusions on prioritization

Taking as inputs the six categories pertaining to the first tier of the taxonomy, we decided to conduct a Delphi methodology with experts representing different roles in the flexibility market to (i) set the importance of the barriers detected; (ii) to forecast what barriers will be presented at the pilots' buildings. In essence, we wanted to assess the relative importance of the barriers categories for the actors and pilots in order to assess the suitability of the solution proposed.

The prioritization process showed that the most important barriers were those related to Standardization as it is highlighted in all the assessment produced (i.e., using the critical set and average scores). Moreover, trust and costs are also highly relevant depending on the method used. A very important finding was that, according to the analysis conducted, Lifestyle is not selected for the Use cases and Business Use cases of PARITY. However, this is, as have been pointed out before, one of the most cited barriers in the body of knowledge. Such a result of the way we have measured the importance of barriers against the UC and BUC. In following tasks of the PARITY project the members should discuss whether to put more emphasis in the end-user for LFM adoption by creating a new separated UC or investigating it separately. Alternatively, the consortium would decide to remain with those barriers which are of more important to technical actors (i.e. BRP, TSO, DSO, and Aggregator).

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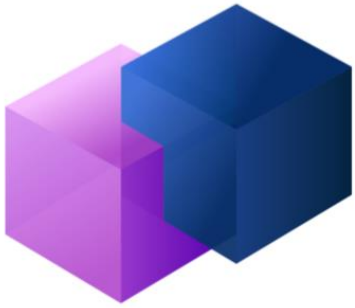

PARITY

ANNEXES
of DELIVERABLE D4.1

ANNEX A: Interviews - Barriers questions

- Aggregators

This part of the interview has to be answered rating from 1 to 5 incentives or barriers to the development and deployment of Demand Management schemas and flexibility markets.

(Incentives). Rate from 1 (not important) to 5 (very important) how the following aspects can incentive the development and spread of Demand Management schemas and flexibility markets:

(1 - 5):_____ Fair remuneration for flexibility providers coming from the participation in DM markets.

(1 - 5):_____Contribute to the electricity system balancing services by means of demand response mechanisms.

(1 - 5):_____Contribute to your clients microgrids balancing mechanisms.

(1 - 5):_____Offer an additional value-added service to your customers.

(1 - 5):_____Diversify your business portfolio to mitigate business risks

(1 - 5):_____Participate in newly open demand response markets and give access to small domestic consumers.

(1 - 5):_____Improve your control and management over your members/clients energy consumption and DER characterization.

(1 - 5):_____Contribute to the sustainability of the electricity system by reducing environmental impacts.

Other incentives. Please state: _____

(Barriers). Rate from 1 (not important) to 5 (very important) how much of a hurdle the following aspects are for you as a potential aggregator of demand flexibility for domestic users:

(1 - 5):_____ Initial investment on sensoring, data gateways and smart monitoring and control equipment.

(1 - 5):_____ Possible economic penalties in case flexibility providers fail to deliver the committed demand flexibility.

(1 - 5):_____ Incomes from flexibility markets lower than initially expected.

(1 - 5):_____Possible new technology failure or malfunctioning.

(1 - 5):_____Lack of transparency of market rules and remuneration settlements.

(1 - 5):_____Lack of previous aggregator experience in a new business market.

(1 - 5):_____Difficulty of managing the integration between all the components.

(1 - 5):_____Lack of historical data needed for the forecast algorithm

(1 - 5):_____Possible conflicts with demand flexibility services already existing in some of European countries

(1 - 5):_____Possible misuse of customers' personal data.

(1 - 5):_____Lack or not settled legislation regarding the flexibility markets in most of European Union' countries

(1 - 5):_____Non established financial regulation regarding Blockchain

(1 - 5):_____Lack of regulation concerning the rights and obligations of the entities that control customers' loads

(1 - 5):_____Lack of available funding to implement the changes needed for the adoption of a flexibility market.

Other reasons. Please state: _____

- Building Managers

This part of the interview has to be answered rating from 1 to 5 incentives or barriers to the development and deployment of Demand Management schemas and flexibility markets.

(Incentives). Rate from 1 (not important) to 5 (very important) how motivating the following aspects are for you as a building facility manager to participate in of Demand Management schemas and flexibility markets:

(1 - 5):_____Fair remuneration coming from the participation in DM markets.

(1 - 5):_____Contribute to the electricity system balancing services by means of demand response mechanisms.

(1 - 5):_____Contribute to your own microgrid balancing mechanisms.

(1 - 5):_____Offer an additional value-added service to your members and clients.

(1 - 5):_____Diversify your business portfolio to mitigate business risks

(1 - 5):_____Improve your control and management over your members/clients energy consumption and DER characterization.

(1 - 5):_____Contribute to the sustainability of the electricity system by reducing environmental impacts.

Other incentives. Please state: _____

(Barriers). Rate from 1 (not important) to 5 (very important) how much of a hurdle the following aspects are for you a building facility manager to participate in of Demand Management schemas and flexibility markets:

(1 - 5):_____Initial investment on sensoring, data gateways and smart monitoring and control equipment.

(1 - 5):_____Possible economic penalties in case of failure to deliver the committed demand flexibility.

(1 - 5):_____ Incomes from flexibility markets lower than initially expected.

(1 - 5):_____Possible new technology failure or malfunctioning.

(1 - 5):_____Lack of transparency of market rules and remuneration settlements.

(1 - 5):_____Lack of previous aggregator experience in a new business market.

(1 - 5):_____ Large-scale installation of smart electricity meters is required.

(1 - 5):_____Possible misuse of customers' personal data.

(1 - 5):_____Lack or not settled legislation regarding the flexibility markets in most of European Union' countries

(1 - 5):_____Lack of regulation concerning the rights and obligations of the entities that control customers' loads

(1 - 5):_____Lack of available funding to implement the changes needed for the adoption of a flexibility market.

Other reasons. Please state: _____

- DSOs

This part of the interview has to be answered rating from 1 to 5 incentives or barriers to the development and deployment of Demand Management schemas and flexibility markets.

(Incentives). Rate from 1 (not important) to 5 (very important) how the following aspects can incentive the development and spread of Demand Management schemas and flexibility markets:

(1 - 5):_____Fair remuneration for flexibility providers coming from the participation in DM markets.

(1 - 5):_____Contribute to the electricity system balancing services by means of demand response mechanisms.

(1 - 5):_____Contribute to your own grid balancing mechanisms.

(1 - 5):_____Offer an additional value-added service to your clients, as they could become flexibility providers.

(1 - 5):_____Participate in newly open demand response marketplaces and give access to small domestic consumers.

(1 - 5):_____Improve your control and management over your members/clients energy consumption and DER operation.

(1 - 5):_____Contribute to the sustainability of the electricity system by reducing environmental impacts.

Other incentives. Please state: _____

(Barriers). Rate from 1 (not important) to 5 (very important) how the following aspects can limit/slow the development and spread of Demand Management schemas and flexibility markets:

(1 - 5):_____Initial investment on sensoring, data gateways and smart monitoring by flexibility providers, and smart monitoring and control equipment. (200 € -300 € per user)

(1 - 5):_____Possible economic penalties in case flexibility providers fail to deliver the committed demand flexibility.

(1 - 5):_____Financial remuneration for providers lower than initially expected.

(1 - 5):_____Possible new technology failure or malfunctioning.

(1 - 5):_____Lack of transparency of market rules and remuneration settlements.

(1 - 5):_____Lack of previous aggregator experience in a new business market.

(1 - 5):_____Difficulty of managing the integration between all the components.

(1 - 5):_____Possible conflicts with demand flexibility services already existing in some of European countries

(1 - 5):_____Possible misuse of customers' personal data.

(1 - 5):_____Lack or not settled legislation regarding the flexibility markets in most of European Union' countries

(1 - 5):_____Non established financial regulation regarding Blockchain

(1 - 5):_____Lack of available funding to implement the changes needed for the adoption of a flexibility market.

Other reasons. Please state: _____

ANNEX B: Surveys - Barriers questions

In this annex, the sections created to get information about barriers in the surveys done to Building users and residential users are described.

- Building users

This section requests information about your perception of incentives and barriers to participate in demand response programs or in the new flexibility markets, with or without an aggregator. Please, mark how important the given statements are for you (5 most important to 1 least important)

In case your company or your building facility manager considers the possibility of using demand flexibility for market or grid stability issues, how would the following statements make you back that decision? (5 very important, 1 not important).

(1 - 5):_____ Clear, transparent and consumer-protecting regulations that ensures customer rights and market rules.

(1 - 5):_____Full respect to private information non-disclosure

(1 - 5):_____Full respect to comfort standards as stated by the user.

(1 - 5):_____Fair remuneration based on transparent, clearly communicated methodologies.

(1 - 5):_____ Savings in the energy bills for moving consumptions from high energy price periods to low price periods.

(1 - 5):_____Contribution to electricity system sustainability by moving consumptions to higher renewable generation hours.

(1 - 5):_____Contribution to the sustainability and greenness of the National and European electricity system by providing clean grid balancing solutions based on demand response, and reducing the electricity system gas emissions.

(1 - 5):_____Use of high level inter-communicated smart technologies for automated control of building equipment and devices.

(1 - 5):_____Other reasons. Please state: _____

In case your building facility manager considers the possibility of using demand flexibility for market or grid stability issues, how would the following statements refrain you from supporting that decision? (5 most important to 1 least important).

(1 - 5):_____Possible occasional economic penalties in case of failure to deliver the committed demand flexibility.

(1 - 5):_____Possible misuse of personal information by third parties.

(1 - 5):_____Financial remuneration lower than initially expected.

(1 - 5):_____Lack of transparency of the contract and the remuneration.

(1 - 5):_____Lack of information about the partners (e.g. neighbours, DSO...) who participate in the flexibility market.

(1 - 5):_____Lack of control of your own energy consumption.

(1 - 5):_____Change in the habits of consuming and sharing energy

(1 - 5):_____Lack of available funding to implement the changes needed for the adoption of a flexibility market.

(1 - 5):_____Other reasons. Please state: _____

- Residential users

This section requests information about your perception of incentives and barriers to participate in explicit demand-response markets by means of a demand flexibility aggregator. Please, mark how important the given statements are for you (5 most important to 1 least important)

In order for you to feel keener to participate in the demand flexibility remuneration programmes through a demand aggregator, how important are the following statements for you? (5 very important, 1 not important).

(1 - 5):_____ Clear, transparent and consumer-protection regulations that ensures customer rights and market rules.

(1 - 5):_____Full respect to private information (non-disclosure)

(1 - 5):_____Full respect to comfort standards as stated by the consumer

(1 - 5):_____Empowerment of small domestic consumers in electricity markets and balancing markets

(1 - 5):_____Fair remuneration based on transparent, clearly communicated methodologies

(1 - 5):_____Savings in the energy bills for moving consumption from high cost periods to low cost periods.

(1 - 5):_____Contribution to the sustainability and greenness of the National and European electricity system by providing clean grid balancing solutions based on demand response, and reducing the electricity system gas emissions.

(1 - 5):_____Use of high level inter-communicated smart technologies for automated control of home appliances and devices.

(1 - 5):_____Contribution to electricity system sustainability by moving consumptions to higher renewable generation hours.

(1 - 5):_____Other reasons. Please state: _____

What of the following statements would make you feel more uneasy to participate in the demand flexibility markets described above, evaluate from 1 to 5 the following statements in your case. 5 most important to 1 least important.

(1 - 5):_____Initial investment on smart monitoring and control equipment. (200 € -300 €)

(1 - 5):_____Possible occasional economic penalties in case of failure to deliver the committed demand flexibility.

(1 - 5):_____Possible misuse of personal information by third parties.

(1 - 5):_____Financial remuneration lower than initially expected.

(1 - 5):_____Lack of transparency of the contract and the remuneration.

(1 - 5):_____Lack of information about the partners (e.g. neighbours, DSO...) who participate in the flexibility market.

(1 - 5):_____Lack of control of your own energy production, distribution and selling price.

(1 - 5):_____Change in the habits of consuming and sharing energy

(1 - 5):_____Lack of available funding to implement the changes needed for the adoption of a flexibility market.

(1 - 5):_____Other reasons. Please state: _____

ANNEX C: Data to generate prioritization

The raw information and the scripts to generate the figures, tables and the statistical results of the prioritization (Section 5) can be consulted in 10.5281/zenodo.3861847. A list of the information contained in this file is:

- **data folder**: this folders includes the scores given by the 15 experts in the 3 rounds. Every round is in an individual folder. There is a file per expert that has the scores between -5 (not relevant at all) to 5 (completely relevant) per barrier (rows) and actor (columns). There is also a file with the description of the experts in terms of their position in the company, the type of company and the country.
- **fig folder**: this folder includes the figures created to assess the information provided by the experts. For each round, the following figures are created (in each respective folder):

    - Boxplot with the distribution of scores per barriers and roles.
    - Heatmap with the mean scores per barriers and roles.
    - Boxplots with the comparison of the different distributions provided by the experts of each group (depending on the keywords) per barrier and role.
    - Heatmap with the mean score per barrier weighted depending on the importance of the role in each use case and the final prioritization.

    Finally, bar plots with the mean scores differences between rounds and boxplot with comparisons of the scores distributions are also provided.

- **stat folder**: this folder includes the files with the results of the different statistical assessment carried out. For each round, the following figures are created (in each respective folder):

    - The statistics used to assess the scores (Intraclass correlation coefficient, Inter-rater agreement, Inter-rater agreement p-value, Homogeneity of Variances, Average interquartile range, Standard Deviation of interquartile ranges, Friedman test p-value Average power post hoc) per barrier and per role.
    - The results of the post hoc of the Friedman Test per berries and per roles.
    - The average score per barrier and per role.
    - The mean value of the scores provided by the experts grouped by the keywords per barrier and role. P-value of the comparison of these two values.
    - The end prioritization of the barrier for the use case (averaging the scores or fuzzy merging of the critical sets)

Finally, the differences between the mean and standard deviations of the scores between two consecutive rounds are provided.

ANNEX D: Barriers list

This annexes presents all the barriers identified classified by category and subcategories. For each barrier the source from which it has been identified (papers, interviews/surveys, reports/policies and legislation) and the number of occurrences in each source is shown.

- Fit to current and changing lifestyles

Table 22. Fit to current and changing lifestyles barriers.

Subcategory	Barriers	References			
		P	I	R	L
Adoption	Legal framework is difficult to understand	1			
	People have to change the habits of consuming and sharing energy	2	2		
	Meeting the evolving needs, demands and preferences of its occupants	1			
	Smart technology as divisive (exclusive to tenants, elderly, computer illiterate, smartphone users, people living in older house)	1			
	Integration of technology and services into the design, lifestyle and general sense of home	1			
	Accommodating the integration and installation of new technological components	1	2		
	Accepting automation and contributing to network flexibility (lack of perfect information)	1			
Ideology & involvement	People are not interested in becoming a prosumer as they are habituated to centralized markets and traditional infrastructure providers. People might not want to depend on other participants of their local area	1			
	Primary Energy Factor (PEF) methodology does not separate the sources of electricity, including electricity from renewable resources	1			
	Lack of local initiatives to engage citizens overall in cities	1		1	
	Interdependency among consumers in an individualist society.	1			
	Adoption of flexibility seems to be a political option and a bottom-up model which leave more conservative people apart	1			
	Besides cash cost minimisation, consumers may be influenced by their values (e.g., environmental values, energy conservation values)	1			
Disillusion	Technical gap between expectations and current solutions	1			
	Smart technology leaving people ‘constantly worrying’ and feeling guilty	1			
	Perceived inconvenience of these emerging technologies	1			

Reluctance and lack of trust	Values, beliefs and norms do not match with emerging technologies (DER, DR, Flexibility)	1			
	Rejection of an intervention that will not last in the mid/long term	1			
	Usually users struggle appropriating technology even that benefit them (socially diverse context present a major challenge)	1			
	The reluctance of employees or family units. You have to explain they are going to lose the control but comfort level will be the same	1			
	Loss of control and apathy, inertia	2		1	
	Smart homes making more affluent people less conscientious regarding energy saving	1			
	Smart home services as non-essential, luxurious, or 'gadgetry'	1			
	Lack of trust that financial savings made by utility companies will be passed onto the consumers	2			
	Veto over third party control of personal devices				
	People need some evidence of value. This is not usually demonstrated in Business cases. Chicken-egg paradox	1			
	Less control over electricity use	1	1		
	Information and Response fatigue for elderly in particular	2			
	People do not have time to think in this new distributed market.	2			
Perceived Usefulness	Declining customer engagement over time			2	
	The benefit to the individual when adopting Flexibility markets is not clear				
	Not clear the framing effects and the benefits over population: global (e.g. climate change) vs local (e.g. reduced cost or autarky)	1			
	Technologies are either very little known or still not developed to attract the attention of customers				
	Environmental and economic concerns are not generally regarded as important within the organisation / family unit	1			
	Inference of householders' desired outcome	1			
Ignorance / lack of expertise	Consumers are facing difficulties to choose among the high amount of low-carbon energy solutions and understand the benefits (e.g. renewable energy system, home insulation, or an EV)			1	
	Lack of access or Difficult user interfaces to understand necessary information	2			
	Knowledge deficit	2			
	Lack of previous user experience in a new business market.		3	1	
	Energy manager lacks power and influence to end users. Organizational culture leads to neglect of energy/environmental issues	1		1	

	Markets for energy trading at local/community level are at an early stage with only a small number of such communities in existence today.			1	
	DER or Flexibility markets are too complex for their everyday living. People hesitate to understand if their electric power will be ensured	2			

- Administration

Table 23. Administration barriers.

Subcategory	Barriers	References			
Charging/cost rules	Taxation issue for battery storage behind the meter (tax is charged the same as for actual consumption)	1		2	
	Regulated consumer prices preventing market price signals reaching ultimate consumers				
	High threshold of power capacity required in order to participate in ancillary services market for TSOs				1
	Peak charges (kW/€) are limited by law to a specific share of the grid tariff (in Switzerland 30%)				1
	Liberalization of energy system markets or absence of significant market failures (such as no incorporation of externalities related to CO2 emission).	1			
	Critical peek tariff schemes are needed to offer incentives for the prosumers to engage in flexibility management scenarios			1	
	Need for a bigger price gap between peak and off-peak periods in energy markets		1	1	
	Pre-qualification processes (certifications to be available to trade) de-facto lock out small DERs from participating in ancillary services markets (for both TSO and DSO), conditions on minimum unit size or telemetry may be unnecessarily restrictive (particularly for small consumers with DR capabilities)	1			1
	Currently the funding scheme focuses to suppliers delivering the energy efficiency measures. A transition of focus towards users (other than levies on energy bills), and tools in the housing sector, financial incentives including tax exemptions is important.	1			
Decision Making	People do not have a clear idea about who should pivot the flexibility: From the country (governments), to ESCOS, to SMEs, municipalities or themselves.	1			
	Power (lack of it) to decide to adopt/implement DER, DR or Flexibility measures. Overall, in organizations or neighbourhoods or flats.	1			

	Not clear who owns the technology and systems				
	Power inside an organisation to take decisions	2			
	Lack of intermediary agents to bridge the whole chain (close the gaps between business models, citizens and technical solutions)	1		1	
Policy/Regulatory Incentives	Regulatory framework for grid operators incentivises investments in grid expansion rather than operational expenditures for making use of DR	1			
	The current Primary Energy Factor is impacting negatively the competitiveness of technologies such as electric heat pumps or smart heat storage, to the benefit of fossil heating technologies.			1	
	Set targets and objectives for DSOs, instead of specifying actions and expenditure for particular projects or activities, will enable DSOs to have greater control over their specific environments.	1			
	Curtailing renewables discourages development of alternative solution			1	
	Current Directive does not set an adequate framework to incentivise the growth of electric vehicles (EVs).			1	
	Lack of funding schemes from local and global administration	1	1		
	The gap and ineffective EV charging planning strategies across Europe (e.g. some EU members NPF does not even include a 2020 target for charging points.)	1			
Lack of regulation	Lack of P2P legislation	1	1	1	
	The NPFs Directive does not provide accurate information on charging infrastructure, since the number of charging points today equals that of the vehicles.	1			
	A differentiation between DC (direct current) and AC (Alternating Current) is not currently reflected in the Directive and neither are the expected technological evolutions of batteries and vehicles.				
	Lack of legislation regarding the new services of the Balancing market				1
	Lack of legislation regarding the rules of the Ancillary services market for DSOs				1
	Lack or not settled legislation regarding the flexibility markets in most of European Union' countries		5	1	
	Non established financial regulation regarding Blockchain		2		
	Policy (weak legislation, limited or perverse incentives)	1			
	Regulatory framework at EU level to increase the implementation of smart metering solutions			1	
	Missing a regulatory framework for local energy communities			1	

	which incorporate storage				
	Lack of regulation concerning the rights and obligations of the entities that control customers' loads		1	1	
	Delay in adoption of the EU Target Model				1
	Legal relationship between prosumers and aggregators				1
Market restrictions	DSOs are obliged to act as neutral market facilitators without end-consumer contact; this limits DSO involvement in LFMs				1
	Regulatory barriers because the DSO is not allowed to operate freely on the market and offer services,			1	
	National Regulatory Authorities (NRAs) need to update their regulations to support the roles of DSOs as market facilitators.	1			
	The principle of BRPs' complete balance responsibility does not allow real P2P trading				1
	Exert market power of utilities	1			
	Regulations enabling peer-to-peer trading, new energy communities, and active operation of the distribution network are uneven and unfamiliar.			1	
	DERs are not defined as tools for balancing the local grid, but rather as a commodity to be traded with the TSO				1

- Technical

Table 24. Technical barriers.

Subcategory	Barriers	References			
		P	I	R	L
System	Malfunctioning	1	5	1	
	Scepticism regarding the functionality of the system	1			
	Sensors going off by mistake	1			
	Due to break down of remote control units house going in limbo	1			
	Technology readiness issues	1			
	Speed of transactions a blockchain system can support	1			
Algorithms	Lack of historical data needed for the forecast algorithm		1	2	
	Inadequate data acquisition and actuation infrastructure	1			
	Behaviour recognition forming key aspect of smart homes	1			
	Development of energy optimization algorithms through the rise of domestic participants in demand response programs			1	

	Accessing to reliable and right signalling information to take action is not clear.	1			
Maturity	DES and flexibilities are not mature enough for end-user adoption (emerging technologies)				
	Integration of Renewable Energy into the Grid	1	1		
	Estimations of EV infrastructure sufficiency, are currently based on literature and are more indicative for average trends, so these cannot be conclusive for all locations and countries	1			
	More real cases and scenarios are needed to prove the feasibility of the idea	1			
Deployment	Communications network breaking down and other systems getting out of control	1	1		
	A technology adaptation regarding advanced control, monitoring, communication and IT infrastructure is needed				1
	Increasing levels of resources and flexible loads responding to dynamic price signal	2			
	Speed of transactions a blockchain system can support	1			
Communication	Network balancing and supply security	2			
	Secured/encrypted communication required			1	
	Highly available and reliable communication networks required		1	1	
	Efficient communication network scaling bandwidth and real-time data			1	
	Not use of standardized communication protocols and data models			2	

- Trust

Table 25. Trust barriers.

Subcategory	Barriers	References			
		P	I	R	L
Security	Cyber attacks that threaten the smart grid and the energy IoT devices / Cybersecurity - Attacks	2	1	1	
	Unauthorized access to LFM services	1			
	Systems being compromised	1		1	
Privacy	Violations of privacy	1		1	
	Combining two sets of innocent data leading to ‘non-innocent’ data	1			
	Lack of perceived privacy would not worth it for lower bills	1		1	
	Data falling into wrong hands	1		1	

	Data sharing	1		1	
	Big brother-like monitoring as too intrusive	1			
	Concerns over third parties knowing daily routines and occupancy	1			
	Companies responsible for smart home services selling on personal data	1			
	User of personal data in an ethic way is a major impediment for adoption.	1			
	Possible misuse of customers' personal data.	1	8		
Stakeholders Cooperation	Lack of trust among involved community agents (e.g. if they have to get into home-owners' premises)	1			
	Lack of information about the partners (e.g. neighbours, DSO...) who participate in the flexibility market and revenue streams		1		1
	Imperfect information, asymmetric information, hidden costs, risk	1			
	Aggregator does not behave in a way which is in the interest of the consumer	1			
	Some parties free-riding (get economic benefits of other actions)	1			
Communication strategy	If information is not regarded as intended by the sender, the corresponding behaviour of the recipient will not as expected by the sender.	1			
	Lack of trust in the form/medium/channel of information received to end-users about pricing	1			
	How the recipient of information regards the sender will dictate how such information will be perceived.	1			
Emerging Technologies	Lack of transparency of market rules and remuneration settlements.		2		
	Lack of trust on the potential value of DR	1			
	Lack of transparency of the contract and the remuneration.		1		
	Difficulty finding a reliable vendor	1			
	Physically distributed devices	1			
	Mixture of very small to very large devices	1			
	Large-scale deployments	1			
	Dependent on closed and open or untrusted networks	1			

- Costs

Table 26. Cost barriers.

Subcategory	Barriers	References			
		P	I	R	L
Investment	High initial investment costs	2	4	1	
	People do no have a clear idea about the potential cost on investment/savings	1			
	Hidden costs related to the costs associated with participation in markets (negotiation and enforcement transaction costs)	1			
	High repair and maintenance costs	2	1		
Pricing	Lack of dynamic tariff systems or mechanism for signalling the value from relevant markets to consumers	1		1	
	Grid tariffs charged may be higher for LFM members if local grid constraints cannot be avoided persistently				1
	Currently the regulated costs (network charges and levies) are charged to consumers impacting the price increase	1			
	Supply contract for LFM members may be expensive if suppliers are not responsible for their costumers' imbalances				1
Margin	Manufacturers are competing with very low margins		1		
	Small margins for prosumers and service providers in the flexibility services market		2		1
	Need for a minimum unit size (families) to adopt DR, DER or flexibility benefits	1			

- Standardization

Table 27. Standardization barriers.

Subcategory	Barriers	References			
		P	I	R	L
Technology & Market Diversity	Multiple technology requirements in multiple regions	1			
	Diverse technologies in the LFM infrastructure	1			
	Different standards and prequalification methods	1	1	1	
	Structural differences in support measures between countries do not exist and in turn lead to diverse market conditions, characterised by different market actors' roles, electricity system operation procedures, and administrative requirements	1			
Roles & Objectives	There is a mismatch between the idea that policy-makers, energy agents and end users have over the expectations of flexibility markets and DER	1			
	Too much standardization for businesses that might develop a technology-based platform	2			

Business models	Conflicts with demand flexibility services already existing in some of European countries	1	1		
	Heterogeneous regulatory situation for second life battery installations around the EU			1	
	Expertise for operational and management needs of smart homes	1			
	Current business models are not reliable since they are sustained on the uncertainty of demand				
	Lack of previous aggregator experience in a new business market.		3		
	Baselines models are usually difficult to be created to assess the performance and potential enhancements of the energy technology related to energy	1			
	Roles and responsibilities of DSO/aggregators/retailers/prosumers are different in each EU MS, which makes it difficult to apply standard LFM business models			1	1
	New contract types between prosumers and consumers (Business model)	1	1		
Interoperability	Communicating with other devices and technologies	3		2	
	Complexity related to ownership and control of district devices	1			
	Interference of devices with each other in a home setting	1			
	Strong path-dependencies and lock-ins (tech is intertwined with user practices and life styles, business models, value chains, organizational structures, regulations, and institutional and political structures)	1			
	Integration of heterogeneous equipment from diverse vendors / Difficulty of managing the integration between all the components.	3	1		