MARKET ENABLING INTERFACE TO UNLOCK FLEXIBILITY SOLUTIONS FOR COST-EFFECTIVE MANAGEMENT OF SMARTER DISTRIBUTION GRIDS

Deliverable 10.5

Exploitation and Roadmap

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Abbreviations

ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
API	Application Programming Interface
ASM	Active System Management
BUC	Business Use Case
CBA	Cost Benefit Analysis
CC	Chance Constraint
CM	Congestion management
CVaR	Conditional Value-at-Risk
DdSE	Data-driven State Estimator
DdVC	Data-driven Voltage Control
DER	Distributed Energy Resource
DN	Distribution Network
DNI	Distribution Network Incidents
DSO	Distribution Service Operator
EENS	Expected Energy Not Served
END	Energy Not Distributed
EU	European Union
EV	Electric Vehicle
FDLR	Flexible Dynamic Line Rating
FMO	Flexibility Market Operator
FNA	Flexibility Needs Assessment
FNA	Flexibility Needs Assessment
FNA-OPF	Flexibility Needs Assessment-Optimal Power Flow
FSP	Flexibility Service Provider
GDPR	General Data Protection Regulation
HEMS	Home energy management system
HV	High Voltage

KER	Key Exploitable Result
KPI	Key Performance Indicator
LFM	Local Flexibility Markets
LV	Low Voltage
MO	Market Operator
MPC	Model Predictive Controller
MV	Medium Voltage
NRA	National Regulatory Authority
OBR	Optimal Bid Recommender
OF	Optimization Functions
OHL	Overhead Lines
P2P	Peer-to-Peer
PCI	Phase Connectivity Information
PV	Photovoltaics
RES	Renewable Energy Source
SCADA	Supervisory Control and Data Acquisition
SLR	Static Line Rating
SO	System Operator
SRA	Scalability & Replicability Analysis
SWOT	Strengths, Weaknesses, Opportunities, Threats
TSO	Transmission Service Operator
UMEI	Universal Market Enabling Interface
USP	Unique selling point
VC	Voltage control
WF	Wind Farms

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Summary

This report provides an overview of the EUniversal project by presenting its developed tools and achieved results. It highlights the lessons learned and offers insights and recommendations derived from them. The primary objective of the EUniversal project was to facilitate the implementation of a flexibility market by addressing and mitigating key challenges. The project consolidates the various challenges faced by flexibility markets into four core pillars, each focusing on specific solutions.

One set of challenges addressed by EUniversal is associated with the need for effective communication among different stakeholders in flexibility markets. To address this, the project developed the UMEI (Universal Market Enabling Interface). Another set of challenges pertains to the adaptation of grid planning and operation by Distribution System Operators (DSOs) to incorporate flexibility products as grid assets and interact with the new market environment involving different actors. The EUniversal DSO-toolbox, comprising 10 different tools, was established to assist DSOs in overcoming technical issues in this regard. The third set of challenges focused on Flexible Service Provider (FSP) engagement, which was addressed within the FSP pillar. This pillar provided solutions for aggregation and consumer engagement. The fourth set of challenges recognizes the varied ways in which flexibility markets can be designed due to the current lack of standards and norms resulting from their low market maturity. It emphasizes the importance of ensuring that the design of flexibility markets facilitates the procurement of flexibility.

The tools and solutions developed in these pillars underwent testing in three different demonstrators in Germany, Portugal, and Poland. Additionally, supporting tools and methodologies were provided to quantify flexibility and test various flexibility procurement mechanisms. Chapter 2 of this report elaborates on 19 key exploitable results developed throughout the project and it zooms in on the results of the demonstrators. In Chapter 3, lessons learned for each individual pillars are examined, followed by an overview of recommendations derived from these learnings.

The report concludes that all pillars are interconnected, often addressing similar problems from different perspectives. Solutions from one pillar often require support from another. In summary, the EUniversal project addressed six key overarching topics across its four pillars: Standardized communication setup, Consumer engagement, Data transfer in relation to stakeholders' responsibilities, Needs and products, planning (operation and network investment), external coordination. Chapter 3.5 offers recommendations for each of these overarching topics and discusses what further steps are needed to continuously make progress on removing barriers for flexibility markets. The report concludes with an overview of the exploitation strategy and Intellectual Property (IP) and knowledge management for all key exploitable results.

1 EUniversal project introduction

1.1 Context and challenges

The European Union (EU) finds itself at a pivotal juncture in its journey towards a sustainable and low-carbon energy landscape. Over the past few decades, the EU has recognized the imperative need to transition away from fossil fuels and mitigate the adverse impacts of climate change. This transformation, commonly referred to as the EU's energy transition, encompasses a complex web of policies, regulations, technological advancements, and socio-economic shifts aimed at reshaping the energy sector while ensuring environmental protection and energy security.

One of the cornerstones of the EU's energy transition is the **increasing penetration of renewable energy sources** (RES). Solar, wind, hydroelectric, and biomass energies have gained prominence as cleaner alternatives to fossil fuels. With these, the EU has set ambitious targets for the share of renewables in its energy consumption, a goal that entails not only scaling up the production of renewable energy but also addressing the intricate challenges posed by the integration of distributed energy resources (DERs).

Next to a focus on renewable energy production, a second cornerstone of the EU's energy transition is the **electrification of demand** (mostly mobility and heating). This implies the introduction of new loads on the grid (electric vehicles, heat pumps, electric cooking…) which speed up the occupation of the remaining distribution grid capacity. There are, therefore, not only changes in the way electricity is produced, but also in the way it is consumed.

One of the primary challenges is the **intermittency and variability of renewable energy generation**. Unlike centralized power plants that can be controlled and dispatched as needed to meet demand, DERs are subject to fluctuations in weather conditions and consumer behavior. This unpredictability poses challenges to grid stability and necessitates innovative solutions. Additional loads on the grid lead to **capacity constraints**, requiring investments in grid upgrades and the adoption of advanced monitoring and control mechanisms. Additionally, DERS and increasing loads cause issues related to voltage regulation, power quality, and grid congestion. Furthermore, the grid was originally designed as a **centralized system**, with a one-way flow of electricity from large power plants to consumers. Given the variability in renewable energy generation, it is now also imperative that demand follows generation. Underpinning this approach, it is envisioned that citizens need to become key players in the energy transition, benefiting from the technologies, from new services and tools, from the **possibility of actively participating in the markets**, and from a cost-effective energy system.

For the distribution grid operator, this implies that the context in which the DSO is operating is changing significantly, while its core responsibilities and requirements remain. As a result, distribution grids will need to rely more on **flexibility** and smart-grid functionalities to safely host more renewable energy sources, to integrate new loads and to adjust demand profiles to the available capacity in the distribution grids, moving away from the general principle where 'generation followed demand'. Flexibility[1] is defined as the modification of generation injection and/or consumption patterns, on an individual or aggregated level, often in reaction to an external signal, in order to provide a service within the energy system or maintain stable grid operation. The smart use of flexibility could help to reduce or to defer distribution network capacity investments, to reduce the curtailment of renewable energy resources and outage times, reduce technical losses, and increase distributed generation hosting capacity.

While in the past, a lot of work has been done to capture flexibility in transmission grids, there is still a significant amount of locked flexibility potential in the distribution grid. The European Commission recognizes the importance of **unlocking this flexibility** and establishes a regulatory basis in its Clean Energy Package. Market-based solutions for flexibility procurement are to be sought, giving non-discriminatory access for all system users to provide flexibility and to promote efficient use of resources and services. (Art. 32 Directive (2019/944)) However, until today, flexibility markets still face numerous challenges. The EUniversal project is funded by the European H2020 program to focus on effectively overcoming some of the key challenges linked to opening flexibility markets.

The objective of this report is to summarize the entire EUniversal project by showcasing its developed tools and achieved results, by highlighting the lessons learned and deriving learnings and recommendations from them. Finally, the report will also elaborate upon the next steps to ensure the EUniversal project is further exploited in the future. The figure below (Figure 1-1) gives an overview of all the chapters and their content in this deliverable. We start the report with section 1.1 in which an overview of the context and challenges is given. In what follows in section 1.2, we zoom into the solution framework that EUniversal developed to overcome different challenges linked to flexibility markets. To test and demonstrate the different solutions developed throughout the project, the EUniversal project set up 3 demonstrators in 3 different countries. We present these in section 1.3. Each of these demonstrators has a separate market design which we present in section 1.4. In Chapter 2 we present all the developed tools in more detail. We start in section 2.1 by zooming into each individual key exploitable result (KER) of the project. For each of these KERs, we do a SWOT analysis which is presented in section 2.2. The goal of this SWOT analysis is on the one hand to learn more about the tools and to give recommendations for their future development and implementation. On the other hand, the SWOT serves to understand what important points for the business and exploitation plan are that need to be worked out further. Finally, in section 2.3, we showcase what the result of implementing all these tools in the three demonstrators is, and we present the summary of their results. From these results and the SWOT analysis, we zoom in on everything that we learned during the development of the tools, and the implementation of the tools and the markets in the different demonstrators. For each of the pillars, we discuss in detail our findings in section 3.1-3.4 and we conclude this chapter with

[1] https://cdn.eurelectric.org/media/2395/flexibility_in_the_energy_transition_-_a_tool_for_electricity_dsos-2018-2018-oth-0002-01-e-h-F857DD9F.pdf

a summary of all our recommendations in section 3.5. Finally, to ensure that our tools are further used and exploited beyond the EUniversal project, in chapter 4 we develop a business and exploitation strategy for each KER and we discuss the IP and knowledge strategy.

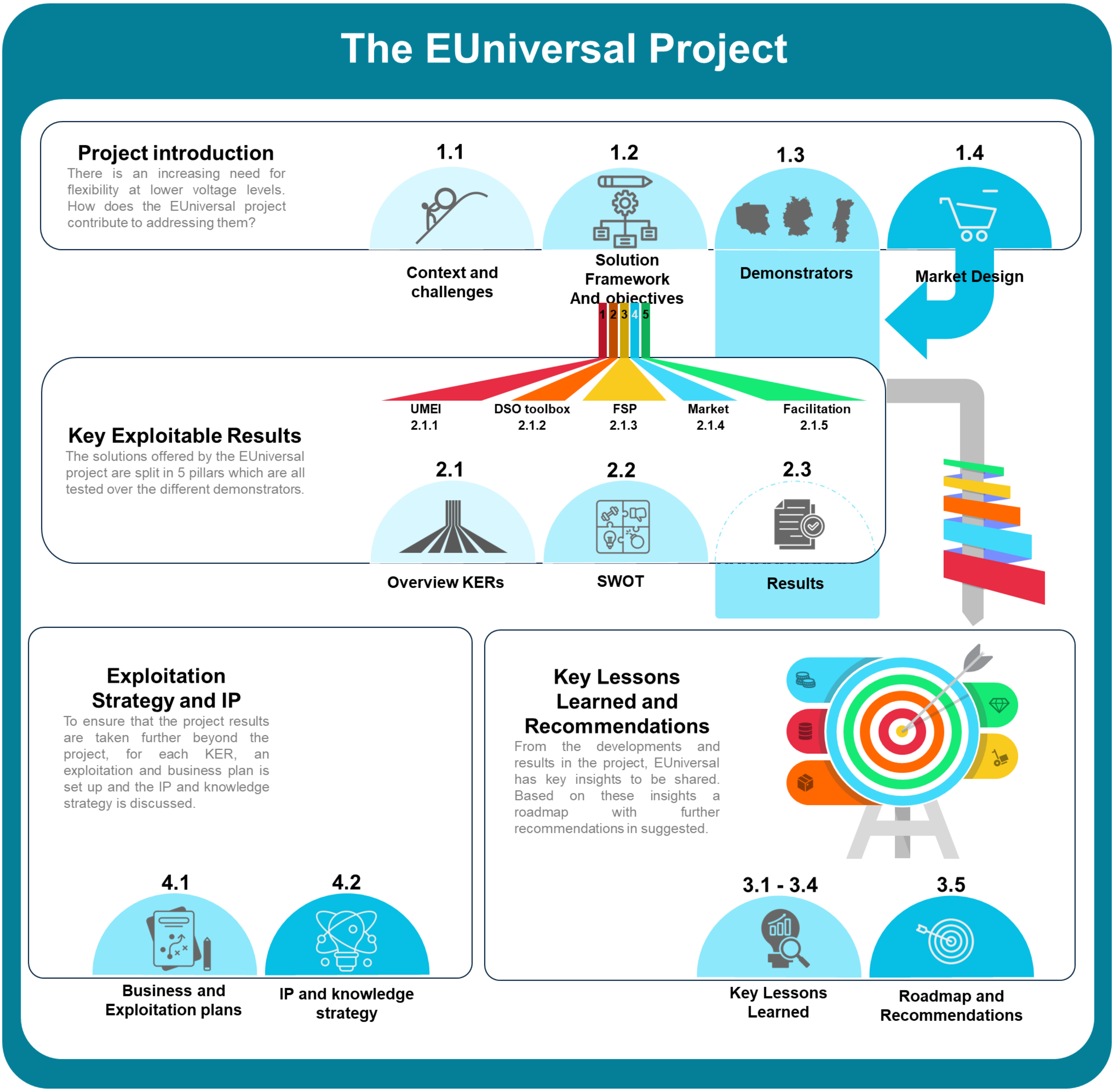


Figure 1-1: project overview

Note that this final deliverable is merging insights from all project deliverables in one document and we refer to them by their deliverable number. An overview of all public deliverables at the time of writing can be found below, and all documents can be found on the EUniversal website: https://euniversal.eu/download-center/ (Table 1-1).

Table 1-1: overview public EUniversal deliverables

	Public deliverables EUniversal
D1.1	Characterisation of current network regulation and market rules that will shape future markets
D1.2	Observatory of research and demonstration initiatives on future electricity grids and markets
D1.3	Challenges and opportunities for electricity grids and markets
D2.1	Grid flexibility services definition
D2.2	Business Use Cases to unlock flexibility service provision
D2.6	UMEI API management and documentation
D3.1	Flexibility Toolbox
D3.3	System-level assessment framework for the quantification of available flexibility for enabling new grid services
D5.1	Identification of relevant market mechanisms for the procurement of flexibility needs and grid services
D5.2	Methodology for dynamic distribution grid tariffs
D5.3	Implications for flexibility services and market mechanisms in a peer-to-peer market setting
D5.4	Evaluation of market mechanisms challenges and opportunities
D8.1	Specifications and guidelines of tools for an Active LV grid for field testing
D8.2	Specifications of test scenarios within the German Demonstrator
D8.3	German Demonstrator — Demonstration of congestion management using market driven utilization of flexibility options in a LV grid. Demonstration results assessment and conclusions.
D9.4	Polish Demonstrator - Data collection, analysis and conclusions Demonstration results assessment and data collection report
D10.1	Business model canvas and comparison of CBA methodologies
D10.2	Methodology and scenarios for the EUniversal Scalability and Replicability Analysis
D10.3	Regulatory recommendations for flexibility options and markets
D10.4	Scalability and Replicability analysis of the EUniversal solution

1.2 EUniversal solution framework

The EUniversal project bundles the different challenges that flexibility markets face in four core pillars focusing each on a specific set of solutions. Figure 1-2 visualizes the linkages between the different pillars. In what follows, we explain each of the pillars in more detail.

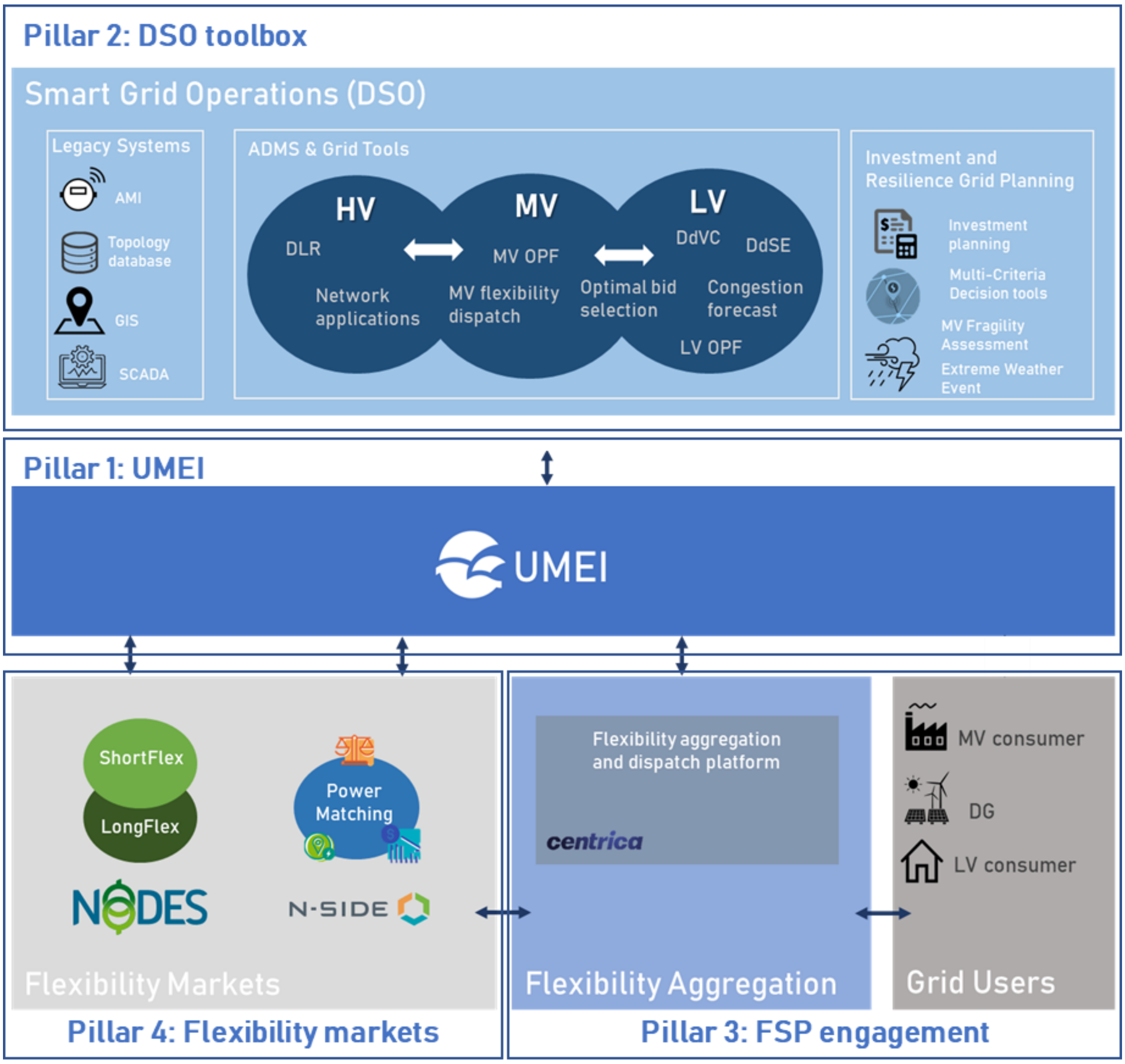


Figure 1-2: The EUniversal framework

Pillar 1: a Universal Market Enabling Interface (UMEI)

A marketplace is any place where at least two parties engage in an economic transaction. They need to be able to communicate both their needs (buyer) and offers (seller) to each other so that goods and/or services can be exchanged. As a result, one of the key challenges that flexibility markets face is linked to the fact that different types of stakeholders (SOs, FSPs, market operators and facilitating third parties) need to be able to communicate and interact with each other. This communication is also indispensable from the point of view of the DSO as activation of flexibility by other market parties could cause other issues in the distribution network (congestion or other operational problems, for instance due to double flexibility activation).

As flexibility markets are virtual markets for services, this implies that in practice each of these stakeholders need to implement additional layers of data management to ensure communication with a market platform. Given the current immaturity of flexibility markets, there is a large diversity in technologies and methods which implies that replicability of different communication solutions is limited. This increases risk of lock-in on one specific market platform which implies that buyers only have access to offers on, and that sellers can only offer to, one market platform. This decreases competition which is necessary for variation in offers and competitive prices and it could increase market power. Furthermore, it enlarges flexibility market entry costs.

EUniversal resolves this problem by developing the UMEI. As can be seen in Figure 1-2Figure , the UMEI links DSOs and market parties with flexibility market platforms, in coordination with other flexibility users. As such, the UMEI facilitates harmonized interaction between different market platforms, flexibility providers and (distribution) system operators. For simplicity, we also call the UMEI the data exchange system[2]. It allows stakeholders to focus more on their business processes and reduces implementation costs in the long-term. Furthermore, it reduces IT efforts and eases integrations of different DSO and FSP tools on the market. This approach allows distributed communication without the need for a central hub.

Technically, the UMEI consists of a common set of APIs (application programming interfaces), developed based on the existing APIs of the participating market platforms. An API is a way for two or more computer programs to communicate with each other. It is a type of software interface, offering a service to other pieces of software. APIs connect solutions and services without the need to know how these were implemented by each part. The interface and API specification are openly available for any company to access, implement and use, regardless of its location. You can find it via https://euniversal.eu/the-umei/. Any stakeholder can adopt or develop new APIs concerning new services while complying with the UMEI interface specification. As a result, all stakeholders, independent of their current data models and standards used in their systems, should be able to implement the UMEI. Being opensource, it promotes collaboration and extension to new functionalities. In addition, it enables direct data sharing between DSO-FSP and therefore also facilitates compliance with GDPR (General Data Protection Regulation). The UMEI is discussed in more detail in section 2.1 and 3.1

[2] APIs are a way to build a messaging system on top of the existing company data management. Through openly available APIs, different companies don't have to build a messaging system from scratch.

Pillar 2: the DSO toolbox

Before DSOs can benefit from flexibility markets, grid planning and operation need to be adapted to incorporate the flexibility products as grid assets and to interact with the new market environment with the involvement of different actors. DSOs face various technical issues in doing so:

1. Firstly, there is currently a lack of coordination of flexibility management between LV, MV and HV distribution networks. LV and MV flexibility can be aggregated to help solve local grid constraints and constraints in the upstream networks. However, it will be necessary to coordinate its mobilization and avoid creating additional grid constraints.
2. Secondly, the integration of generation and flexible loads in low voltage distribution grids, requires improved network observability to detect grid constraints and enable mobilization of flexible resources. However, LV networks are poorly characterized and monitored. While smart metering presents as an important source of information, the low deployment in some countries or difficulties in accessing smart meter data represent significant challenges for future upgrades in LV network grids.
3. Secondly, low voltage distribution grids face serious observability issues. The DSO's original network management based on "network follows demand" did not require many control and supervision systems. As a result, DSOs do not always know what is happening in their network. Given the high variability and increased unpredictability of RES, combined with new load patterns of demand, observability is increasingly needed.
4. DSOs need to be capable of predicting their flexibility needs. This implies forecasting the future network state. in order to procure flexibility through flexibility markets. This implies forecasting the future network state, considering representative and accurate historical information from LV consumers, MV/LV substations and distributed generation plants. As the granularity of information increases, particularly for LV consumers, alternative forecasting methods to load forecasting may need to be considered, to reduce the network state forecasting error.
5. Finally, the more frequent occurrence of extreme weather event requires a new approach to network planning and operation, focused in increasing the system robustness and resources to mitigate the impact of such events. This implies adopting new resilience metrics to evaluate network planning options, but also exploit flexibility of loads, energy storage and generation connected to distribution grids.

All these challenges have an impact on network operation and planning methodologies, and on the question of how flexibility should be integrated in these operation and planning strategies of DSOs. The EUniversal project therefore offers solutions in the shape of a DSO toolbox, which demonstrates novel operation and planning strategies while integrating distributed flexibility sources along with new market-based services, specifically designed for distribution networks. The EUniversal DSO-toolbox offers over 10 different tools to support DSOs in tackling challenges related to network state observability and constraints forecasting, flexibility needs assessment and flexibility bid selection/validation, multi-level voltage control of flexibility resources, and resilience enhancement. In section 2.1, we will zoom in on all the individual tools and we will explain how they work together to solve different DSO challenges. In section 3.2 we zoom in on the learnings from the DSO toolbox.

Pillar 3: FSP engagement

A proper functioning flexibility market requires the presence of both buyers and sellers. FSPs are entities that possess resources that can offer flexibility to the DSO. FSPs, however, still face numerous barriers to enter in flexibility markets and to offer their flexibility to the DSO. Specifically, owners of small volumes of flexibility face difficulties as, usually, a minimum amount of flexibility is required before being allowed on the market. Aggregating multiple small volumes of flexibility offers of multiple smaller FSPs is seen as a viable solution. Yet it represents numerous technical, economic, and regulatory challenges due to the large heterogeneity in residential and industrial assets that can be present in an FSP portfolio and the grid zones where aggregation is indeed allowed. Furthermore, the aggregation algorithm also focusses on providing new DSO services such as congestion management and voltage control as these services are still very innovative and not being provided traditionally. In addition, for FSPs to offer a sufficiently large volume of flexibility at lower voltage levels of the distribution grid they need to engage a sufficiently large number of end-users. End-user participation is also indispensable to achieve a sufficiently large level of market liquidity which is required to avoid gaming and market power, to have competitive offers and prices, and to cover all DSO needs. Nevertheless, achieving end-user engagement is not easy due to a distrust in electricity markets (as a consequence of the latest energy crisis), a lack of awareness, missing smart control and/or measuring equipment, low economic incentives… Finally, there are different technologies that can provide flexibility to the DSO. Since local flexibility markets are still at a very early stage, DSOs may not be familiar enough with all newly developed flexibility options. Indeed, it is not always clear which technologies are most suitable to provide which services, especially when considering different times scales and locations, which may lead to the risk of not granting access for some technologies to provide specific flexibility services.

To ensure that a large-scale participation of consumers in flexibility markets is possible, it is important that conditions for offering flexibility are improved and that the above challenges are tackled. In Pillar 3 (see section 3.3), the EUniversal project zooms in on 2 solutions and 1 set of recommendations to further facilitate non-discriminatory market access for all system users.

- First, the EUniversal project proposes an aggregation algorithm to aggregate small volumes of flexibility located in the LV and MV grid at the end-user's premises to provide services for DSOs. This algorithm focuses on aggregating different types of residential assets (such as heat pumps, PV, EVs) and is therefore explicitly searching solutions for new assets that are increasingly being adopted by end-consumers.
- When it comes to consumer engagement, the EUniversal project experienced the challenges of low market liquidity firsthand. It is only fair to say that, despite numerous consumer engagement actions, we did not manage to reach a high number of market participants. Yet, instead of covering this up, the EUniversal project devotes an entire deliverable (D11.5) to market engagement to summarize the actions taken and to explain why they were (not) considered as being effective. In pillar 3, we summarize recommendations for future flexibility markets that should be considered to increase consumer engagement.
- Finally, the EUniversal project develops a flexibility toolbox to help FSPs to select the most optimal technologies, considering its location and timing, to offer a specific service. The toolbox can help DSOs to ensure technology-neutrality in their product definitions to ensure non-discriminatory market access for all FSPs.

Pillar 4: flexibility markets

All previous pillars aim to facilitate the implementation of flexibility markets. However, flexibility markets themselves can be designed in many ways as there is currently a lack of standards and norms due to their low market maturity. It is therefore important to ensure that the flexibility market design itself facilitates the flexibility procurement.

- For instance, local flexibility markets need to be integrated into the sequence of other existing (wholesale and balancing) markets.
- Furthermore, flexibility markets can have an independent flexibility market operator who could take up certain roles in the market process.
- In addition, when clearing the market, the bids selected to solve the DSO needs should not cause additional grid constraints.
- Flexibility products design should comply with DSO requirements, but without imposing disincentivizing constraints to FSPs.
- Flexibility markets need also efficient and fair flexibility validation and settlement procedures that provide fair compensation to the FSP, rewarding reliability but without disincentivizing flexibility provision.
- Furthermore, it should be discussed whether flexibility markets for active power have different or similar market designs as flexibility markets for reactive power.
- ...

Apart from these design choices, there are other relevant choices such as the coordination between TSOs and DSOs, role division of different market activities between different market parties, aggregation, competition between market platforms for the same needs. On top of all these choices, there are also decisions to be made on other flexibility mechanisms such as distribution grid tariffs, and a coordinated design of them all so that different mechanisms do not conflict with each other.

Within the EUniversal project, these and other market challenges are dealt with in different ways:

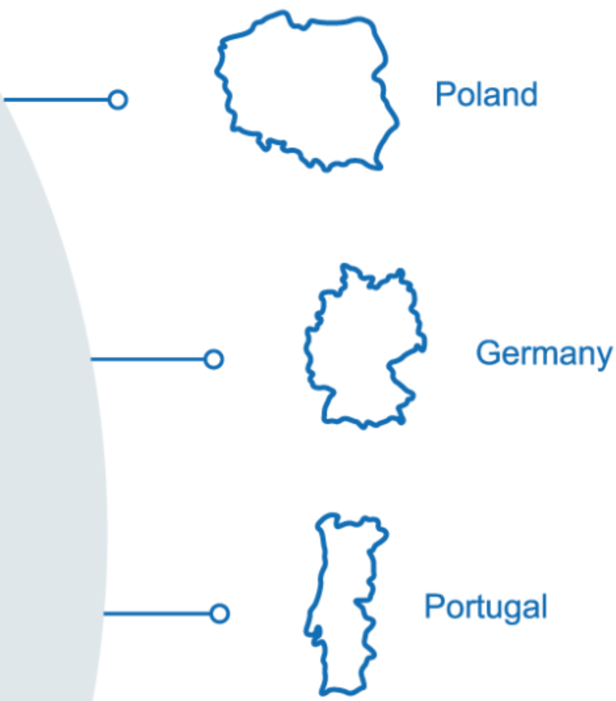
- Firstly, relevant market design choices were discussed with the demonstrators to set up their local flexibility markets. The market designs implemented in the demonstrators are discussed in more detail in section 0.
- Secondly, broad workshops were organized along the project to discuss market design topics that went beyond the scope of the demonstrators. As such, different flexibility market design implementation options were discussed from a multi-stakeholder perspective.
- Thirdly, separate deliverables examined additional mechanisms to acquire grid services. D5.1, for instance, examined the complementarity of different flexibility mechanisms such as Dynamic or non-firm access and connection agreements, dynamic network tariffs, local flexibility markets, bilateral contracts, cost-based remuneration and obligations. Afterwards, D5.2 deep dived into the discussion on different dynamic distribution grid tariffs, and D5.3 zoomed into P2P flexibility markets and their potential contribution to DSO flexibility needs.

In pillar 4 (section 3.4), we discuss all the market challenges in more detail, and we make recommendations based on the demonstrators and the conceptual research done during the project.

Facilitating work

Apart from these four core pillars, the EUniversal project also foresaw a facilitating pillar with supporting research and work. This work helped the EUniversal project with the development of business models, exploitation, and dissemination strategies. Furthermore, to ensure the findings of the project go beyond the lifetime of the project, it was important to also examine the scalability and replicability of the results. In addition, flexibility needed to be quantified at system level and policy recommendations needed to be gathered based on the project findings. In the KER-overview we describe the key exploitable results that result from this in more detail. Yet, it is to be underlined that most of the efforts of this facilitating work help to further comprehend and shape the project results and recommendations are summarized in the deliverable.

1.3 EUniversal Demonstrators

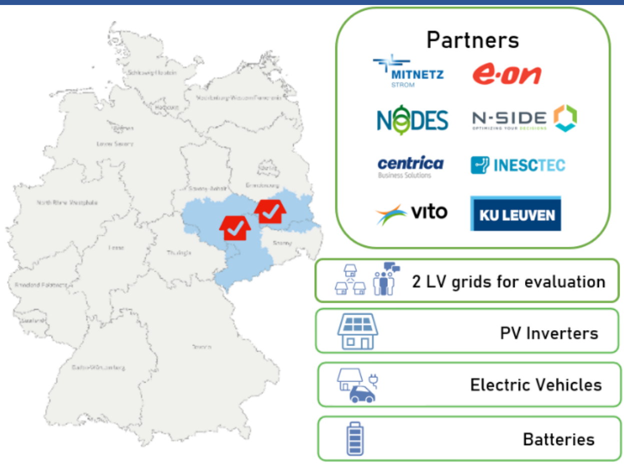


The EUniversal framework was tested in 3 different demonstrators, located in Portugal, Germany, and Poland, and all project solutions could be validated in practice. The selection of the demonstrators was done to cover a broad range of distribution grid topologies, to test solutions in different regulatory environments and to validate the UMEI as a universal interface for data exchange between multiple market stakeholders.

For each of the demonstrators, we describe its context, challenges and objectives, and the tools and processes related to pillar 2 that were tested. After this general description, we describe their markets set-up.

German demonstrator

Challenges and objectives

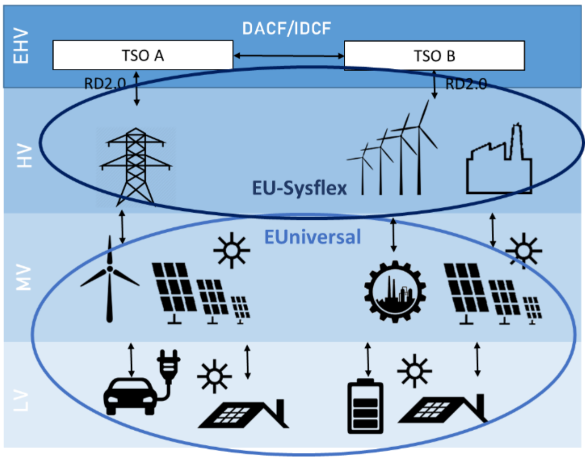


The German demonstrator is located in the East of Germany in South Brandenburg, South Saxony-Anhalt and in West and South of Saxony. The covered grid region was 30.804 km², with a line length of about 73.000 km and about 180 HV-MV substations. Over 2,2 million inhabitants are connected to this grid area, covering both urban and rural areas. Along with the energy transition, there is an increasing amount of renewable generation installed in the area (up to 10.8 GW) and a rising number of heat pumps and EVs. At the connection point in the LV-grid area, congestion and voltage problems are becoming more frequent, even though today, the issues are still limited. Today, there is relatively little knowledge on how to acquire services for these future grid needs at LV level. The German demonstrator therefore focusses on procuring flexibility in the LV grid, which has a radial structure. While doing so, the demonstrator must consider the German context. Therefore, the demo tried to fit the flexibility solutions with the already establish mandatory schedule-based congestion management process “Redispatch 2.0” for generation units in the HV grid. In addition, the DSO operates in a country with a very low penetration of smart meters. Considering the increasing congestion and voltage issues, this is a serious concern as LV grids are not monitored at all or only to a limited extent. This low observability leads to challenges when solving these future network needs. The key objectives of the German demonstrator were therefore to:

- **Increase observability of the LV grid**, given the fact that low-voltage grids are not monitored at all (or only to a limited extent)
- Implement a **simplified Redispatch 2.0** based concept with small generation plants and ensure that the developed solutions comply with the legal Redispatch 2.0 framework.
- Enable flexibility provision to the **LV/MV connection point**.
- Test and validate the **UMEI** to bring flexibility to the flexibility market to **solve future congestion and voltage issues**.

Regulatory Framework

Regarding the **regulatory framework**, it is to be highlighted that Germany has not an encouraging framework for market-based flexibility. In particular, there is a concern that there is too much strategic bidding on flexibility markets and that coordination between numerous assets and market participants is challenging. As a result, during the last legal change in the so-called German 'Easter Package (2022)', market flexibility is only considered as an alternative measure with unquantified benefits. The result of this is that, at the time the demonstration took place, there were not sufficient regulatory incentives to increase consumer engagement, which led to low market liquidity. The framework for Redispatch 2.0 is regulated through the grid expansion acceleration act 2.0 (NABEG 2.0) and the corresponding changes in the German Energy law (EnWG). It is a mandatory congestion management framework which is in place since October 2021. It is necessary, in the medium term, to solve the congestions caused by carrying energy over longer distances, from the North with high levels of renewables, to the South where there are large industrial centers. Generators larger than 100 kW are obliged to participate. To increase the efficiency of the congestions management and to leverage all potentials, the future participation of the demand side and of smaller plants of MV and LV seems worthwhile. In a previous project (EU-SysFlex, GA no. 773505), the German demonstrator mostly looked at the impact of flexibility on the high voltage level. In EUniversal, the goal of the German demonstrator is to examine the flexibility potential in the LV for the MV level with the aim to create a possible extension to the EU-SysFlex approach and the redispatch scheme.



In order to achieve all German demonstrator's objectives, the German demonstrator examines the **entire value chain** of using market-based flexibility to solve network congestions. This implies focusing first on the smart grid tools from the DSO-toolbox (pillar 2) to identify existing and future congestions (LV Congestion Forecasting, LV Flexibility needs Assessment Tool, Data-driven State Estimation), and then selecting the best available bids on the flexibility market (Optimal Bid Recommender). Figure 1-3 provides an overview of all the different tools used. All these tools are discussed in more detail in section 2.1. Within the German demo, all tools were tested with real measurements and grid topologies, and the technical feasibility of aggregation and flexibility retrieval could be demonstrated with the results discussed in section 2.2.

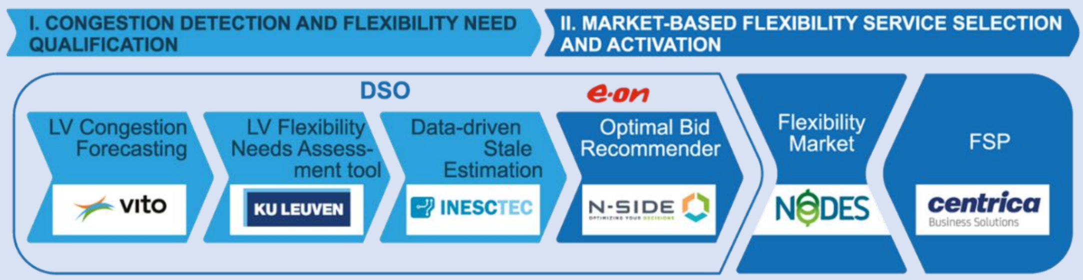
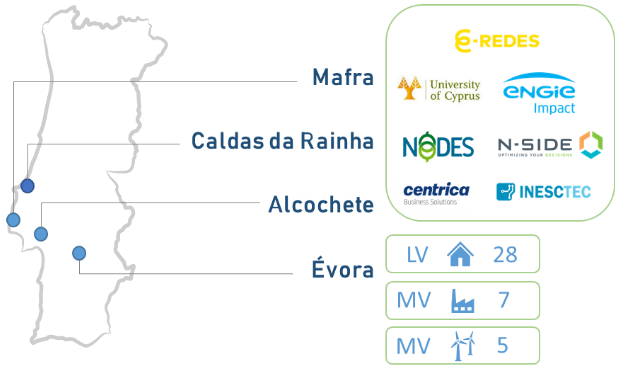


Figure 1-3: Simplified overview of the smart grid tools and market environment as tested in the German Demonstrator

Portuguese demonstrator

Challenges and objectives



The Portuguese demonstrator is located in different regions within the country, ensuring coverage of different contexts. Mafra and Caldas provide a more urban context, the Evora district is a more suburban region, while Alcochete is located near Lisbon. The MV and LV grids considered have a radial structure and cover a mixture of different users, ranging from residential to more commercial consumers, and even renewable energy producers at MV levels (wind turbines). Specific challenges that the areas will face in the future are linked to the feed-in of RES during sunshine hours which leads to voltage increases in the LV grid above the permissible values. On the other hand, additional loads due to, for example, EV charging, may lead to voltage drops below the minimum permissible limit. Furthermore, the network may suffer from imbalance issues due to high loads in some phases. In addition, the MV grid may also suffer from challenges linked to overload of transformers and conductors, feedback effects and voltage increases. Although these problems seldom occur, the goal of the demonstrator was to examine how different DSO tools and flexibility markets can offer solutions for them in the near future. One of the unique points of the Portuguese demonstrator is that it focuses on the implementation of a flexibility market in which two market platforms (NODES and N-SIDE, see explanation in section 0) are tested in parallel, although in separate grids.

- Consider both **short-term flexibility** to solve identified grid problems, and **medium- and long-term flexibility** for grid planning purposes.
- Using flexibility during **planned maintenance** actions in MV grid.
- Test the **functioning of two flexibility market platforms** combined in one flexibility market.
- Test and validate the **UMEI** to provide flexibility to the flexibility market to **solve future congestion and voltage issues**.

Regulatory Framework

The most recent **regulatory framework**[3] in Portugal considers the participation of customers in flexibility markets. Some changes were introduced to the legal regime, which have a direct relationship with the EUniversal Project:

1. Network planning using flexibility services.

2. Active participation of consumers in production and in markets.

The latter focuses on the new active role of consumers acting individually, collectively or through energy communities, to move from more passive consumers to active agents who produce electricity for self-consumption, sharing or storing for future use, and offering their surplus or even flexibility services to aggregators. To this end, this new legal regime increases, through the creation of the aggregator role, the removal of barriers to participating in electricity markets. In this context, the obligation to provide supply contracts at dynamic prices is considered, allowing the adjustment of the consumption profile at the differentiated price between periods, promoting the provision of implicit flexibility services. Aware of the need for customers to evolve towards a more participatory market, together with the need for more rational use of resources, both physical and financial, the Portuguese DSO E-Redes has already started a proactive path in the study of investment solutions in networks where the flexibility component is already seen as a solution for mitigating constraints in the HV and MV network. A review of the regulation was out for public consultation during the EUniversal project duration where E-REDES provided feedback based on their professional experience and some lessons learned from EUniversal project.

In order to achieve all demonstrator's objectives, the Portuguese demonstrator also looks at the **entire value chain** when using market-based flexibility to solve network congestions. In particular, the Portuguese demo developed one framework with two different market designs from two different market platforms. Firstly, it starts with proper data collection and forecasting of the MV and LV day-ahead network status. Then it computes the day-ahead network control plan and the MV and LV flexibility needs. In the next steps, it goes to the different market platforms, selecting flexibility offers from the NODES market platform, or sending flexibility needs to N-SIDE flexibility market (flexibility areas and needs). Finally, it validates flexibility bid selection and updates the DSO operations plan.

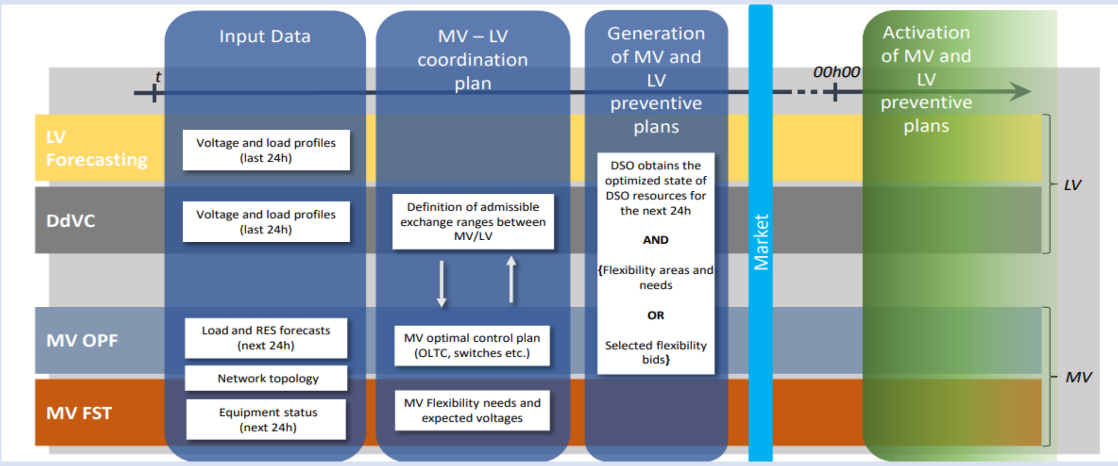


Figure 1-4: Framework of the Portuguese demonstrator

[3] Regulamento n.º 818/2023 do Acesso às Redes e às Interligações do Setor Elétrico https://diariodarepublica.pt/dr/detalhe/regulamento/818-2023-216251914

Polish demonstrator

Challenges and objectives

Grid region	Płock	Kalisz	Gdańsk
Customers with PV	59	13	11
Total installed PV [kW]	368	50	109
Energy meters connected	98	42	114

The Polish demonstrator is located in different locations in the North and Central part of Poland. Plock, Kalisz and Gdansk, presented in the figure on the left provide the LV network for the demo. Different types of grid users are represented (residentials, SMEs, wind-, solar- and biogas generators). The first location, in Plock, is primarily single-family houses and estates of terrace houses equipped with PV panels and heat pumps connected to the grid. In the second two locations, Kalisz and Gdansk, the grid is in a rural area and mostly has a radial grid structure. The MV grid used in the demo is in the North, in Wladyslawowo and contains both radial and meshed elements. However, it is the DSOs strategy to develop the MV network as a meshed network, which is sometimes hard. Furthermore, the Polish demo also covers the entire ENERGA-OPERATOR's HV distribution network which is a meshed network. In the demonstration area, about a third of the customers already has a smart meter, and 90% of the MV/LV substations are equipped with balancing meters. The HV and MV networks are managed by SCADA systems that operate remote-controlled switches and use data from fault current indicators. Nevertheless, even though over the last years, there is significant progress in the number of renewable generation units and in the digitalization of the grids, the Polish electricity system is still a very centrally managed system with ageing infrastructure and low flexibility.

As a result, the Polish demo faces very specific **challenges**. In the autumn/winter period, there are periods of intense wind which increases the generation of numerous wind farms located in the North of Poland. Storms and large wind phenomena cause massive network failures, especially during periods of low demand loads (for instance during Christmas and Easter). As a result, at all voltage levels, grids suffer from being overloaded due to over-generation from renewable energy sources. In addition, new renewable energy installations find it hard to connect to the grid due to increasingly limited network capacity. A specificity of the Polish demonstrator was testing DLR capabilities to increase network flexibility. To resolve the challenges, the objectives of the Polish demonstrator were the following:

- **Maintain voltage levels** within required levels even in presence of large generation of renewables.
- **Increase flexibility of the HV and MV** grids to ensure the possibility of connecting greater number of renewable sources
- Test **DLR functionality** for the HV network.
- Test and validate the **UMEI** to provide flexibility to the flexibility market to **solve future congestion and voltage issues**.

Regulatory Framework

During the demonstration, the **regulatory framework** in Poland related to flexibility markets was not further developed. There were no regulations that allowed the introduction of flexibility incentives to encourage customers to engage in flexibility services. As a result, in Poland, there is only a balancing market and no other market platforms. This resulted in only a low availability of flexibility in the power system.

At the end of the project, in July 2023, the existing Polish energy law was updated. The amendment provides an introduction of dynamic tariffs since July 2024. Prosumers will be allowed to voluntarily select dynamic tariffs and opt for net billing, feeding energy into the grid at hourly prices, and not monthly prices as is currently the case.

The electricity price tariffs currently in force are based on fixed prices for the purchase of 1 kWh of electricity. Any price changes during the day may only result from the zone tariff selected by the consumer, in which the energy price is lower at certain hours than at other times. We are talking, for example, about the G12 tariff. In both zones, night and day, this is a fixed price.

The implementation of dynamic tariffs in Polish law is a response to the need to fulfill EU obligations. The amendment to the regulations assumes the obligation to introduce a dynamic tariff for operators with over 200,000 customers. Customers will also have the right to receive information on the benefits and risks associated with such contracts. Not everyone will have to use dynamic tariffs. The condition for concluding an agreement with a dynamic electricity price is that the electricity seller obtains the consent of the end user.

It is expected that such a legal amendment will increase prosumers' interest in flexibility services.

To achieve all the demonstrator's objectives, the Polish demonstrator looks at a broad set of tools and mechanisms over all its voltage levels. On the LV level, it has installed a smart secondary MV/LV substation to provide autonomous management of the connected LV network and to supervise the flexibility services. This allows monitoring & control of PV and enhanced observability of the LV network based on data from the smart energy meters. Furthermore, the demonstrator tests an Advanced Management System (AMS) to control smart grid devices and equipment installed in balancing areas. Wind farms, biogas plants and Li-ion Storage are used for creating and offering flexibility services on the MV level. On top of this, congestion management and voltage control will be offered by means of market-based flexibility.

Finally, in a high voltage network, the Polish demonstrator uses the Dynamic Line Rating (DLR) as the tool for mobilizing the flexibility of the HV lines and thus minimizing curtailment of RES caused by insufficient HV allowable line capacity. Large energy producers such as wind farms, connected to the HV network, can benefit from weather-dependent HV line allowable capacity which in favourable weather conditions is usually bigger than in steady state conditions (Static Line Rating). As such, large energy producers such as wind farms can benefit from larger line capacity even if their expected production is larger than the power limit defined in the connection agreement.

Figure 1-5 summarizes these tools and mechanisms.

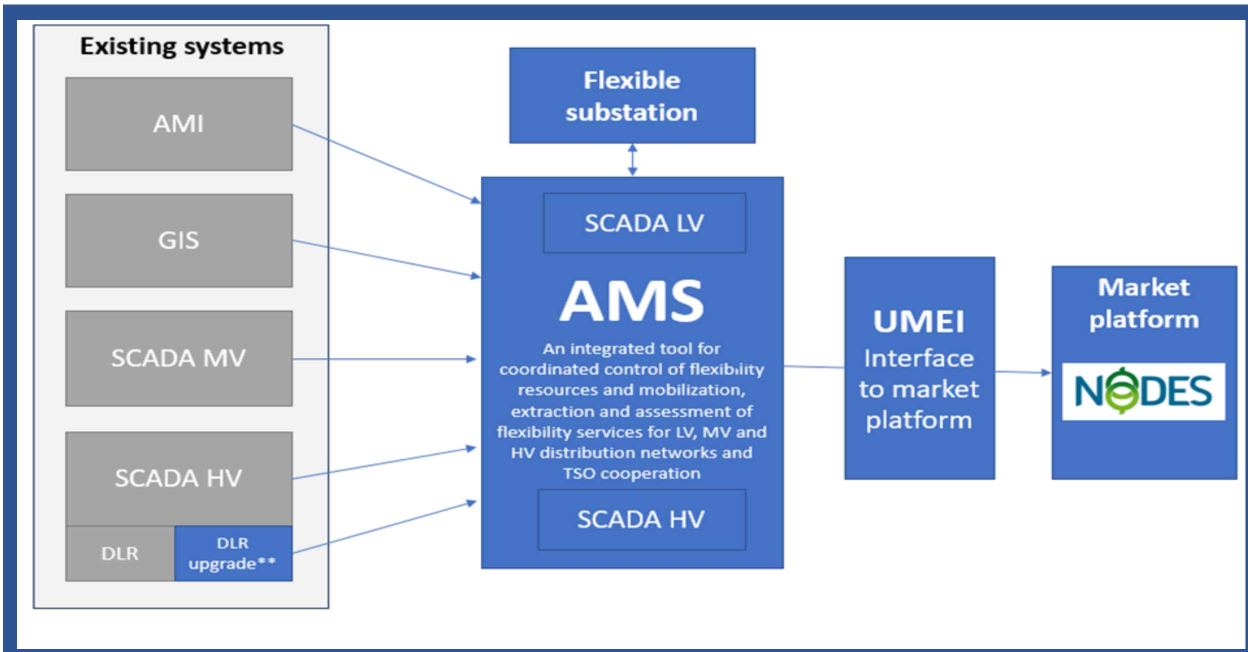


Figure 1-5: Framework of the Polish demonstrator

Each of the demonstrators tested a separate set of Business Use Cases (BUCs) with different processes/activities based on different needs. Some focused on the congestions management, others on voltage control. Some focused on long-term flexibility, while others focus on short-term flexibility. Some focused on the delivery of flexibility through Dynamic Line Rating or bilateral contracts, while the rest focused on delivery of flexibility through dynamic contracts. The differences in BUCs implied different interactions between the stakeholders involved and different information requirements. All of this led to differences in requirements regarding the market designs, needed technologies, or functional specifications for the development of the UMEI to ensure that it fits all stakeholders' needs in all different scenarios. The different BUCs are described in detail in D2.2 and summarized in Annex 1: Overview EUniversal Business Use Cases.

1.4 Market design of the demonstrators

As discussed in pillar 4, DSOs have different options to acquire flexibility. These mechanisms are discussed and analyzed in more detail throughout the project. The focus of the demonstrators was, however, mostly on local flexibility markets, testing the UMEI and its APIs to ensure the correct functioning of the market. Multiple market platforms and market designs exist to establish local flexibility markets to access and use local flexibility for grid services. Therefore, in the EUniversal project two different market platforms were used to compare different market approaches and assess the use of the UMEI as a universal interface for data exchange between multiple markets. Both market platforms are summarized below and described in more detail in D2.2.

The NODES™ market platform is an open and independent marketplace that covers all market-relevant processes related to registration and prequalification, trading and post-trading (i.e. validation and settlement) ensuring neutral and transparent market operations. NODES™ market operates requiring minimum data and information of the stakeholders to comply with common GDPR and data security standards. Thanks to NODES™, integrated market design flexibility can be procured and offered across all grid levels. NODES™ market offers short-term and long-term products, namely ShortFlex™ and LongFlex™, allowing customers to select the optimal flexibility solution for each grid problem. Validation and settlement performed by NODES™ monitors the correct activation and physical delivery of the contracted flexibility. NODES™ continuous market clearing applies pay-as-bid. As such, the market is cleared continuously when corresponding orders match.

The N-SIDE market platform is operated in two distinct ways in the EUniversal project: as a local flexibility market platform or as an optimal bid recommender (OBR), a tool for SOs (described in more detail in KER 03).

In both cases, a closed-gate auction will be run, matching available orders and resulting in an optimal selection of flexibility bids. This optimal selection is the one that maximizes social welfare and which also has one of the lowest procurement costs achievable for the DSO. For the clearing, both pay-as-clear (uniform pricing) and pay-as-bid pricing can be used.

Through this auction-based mechanism, the N-SIDE Local Flexibility Market Platform eases the link between FSPs/aggregators and DSO. Moreover, the market platform does not need detailed grid information; the flexibility is defined by area. The DSO specifies network constraints for the areas and the FSP specifies asset constraints.

On the other hand, the OBR is a tool that runs at the SOs premises. Thanks to this setup it can be run when needed, which allows for modularity and ensures that no unnecessary operations are performed.

It should be noted that the market designs of these market platforms are therefore substantially different. This is summarized in Figure 1-6 below:

NODES	Market platform comparison	N-SIDE
Continuous market	Market model	Auction-based market
Market participants submit bids to activate an offer or to signal their buy/sell interest. The market clears continuously when corresponding orders match	Bidding process Matching process	Market participants bid blindly of other offers until a given time. Then, the platform clears the market and decides on the trades
Supported, optional	Grid awareness	Supported, optional
Easy, closer to many daily economic interactions	Ease to understand	Harder without economic background
Not guaranteed. Market participants determine the price they are willing to pay or to receive	Economic optimality	Proved mathematically
Supported	UMEI compatibility	Supported

Figure 1-6: Comparison of Nodes and N-side market platforms

Even though both market platforms are significantly different, they are both compatible with the UMEI which is a major EUniversal achievement.

D2.2 provides a detailed description of each of the BUCs selected by the demonstrators. Each BUC describes different phases (registration and prequalification, bidding and selection, delivery and monitoring, and settlement). In the Polish demo, in the DLR BUC, slightly different phases are used (namely the operational activities and the registration and prequalifcaiton are different). In the BUCs, it is among others described how its roles interact. To achieve this, the EUniversal project set up a role model valid for all demonstrators. A role model provides a common definition of roles and domains employed in a given domain. Current role models (such as HERM – Harmonised Electricity Role Model) formed a good starting base, yet were highly focussing on transmission networks. The EUniversal project therefore adapted the role model described in HERM and added some roles, focussing more on distribution networks and ensuring that specific responsibilities related to flexibility markets were covered. A detailed description can be found in D2.2. Figure 1-7 provides a summary of the solutions tested in the different demonstrators. In total, 10 BUCs have been tested over three demonstrators. The figure shows the complementarity among the different BUCs. All flexibility markets, apart from the Polish one, had the DSO as the only buyer of flexibilty. In the Polish DLR case, the producer was the buyer of flexibility and the DSO was the seller, which happened when the producer had more RES generation than originally allowed in its connection agreement. The DSO could, in that case, verify whether the grid cable had the capacity to allow more RES. Furthermore, in the Polish demonstrator bilateral contracts were used to offer corrective voltage control through flexstation solutions. In addition, it can be seen that all demonstrators ambitioned to test both active and reactive power products to find solutions for corrective congestion management and voltage control. The German and the Polish demonstrator focussed on the short-term procurement of flexibility (day-ahead and intraday), while the Portuguese demonstrator also looked at long-term procurement of flexibility (weeks and years-ahead). In doing so, the Portuguese demonstrator did not only look for corrective services, but also for predictive ones. Products are traded in portfolios of variable size for 15 minutes segments (Trading Time Unit) in the German and Polish demonstrator, and for 30 or 60 minutes in the Portuguese demonstrator, and are described using volume, regulation direction, price and assigned grid node. Bids can be submitted for one or multiple trading time units.

Mechanism	Service	Buyer	Auction type	Product	Timeline	Aggregation	Demo	Platform: NODES	Platform: N-SIDE
Flexibility market	Corrective Congestion management and voltage control	DSO only	Continuous market	AP	Day-ahead intraday	Yes	DE AP	✓	
						No	PL AP	✓	
	Corrective and Predictive Congestion management and voltage control	DSO only	Continuous market (NODES) Call market (N-SIDE)	AP	Day(s)-ahead Weeks-ahead	Yes	PT 3	✓	✓
					Day()s-ahead Years-ahead		PT 4	✓	✓
	Corrective Congestion management	DSO only	Continuous market (NODES) Call market (N-SIDE)	AP	Day(s)-ahead	Yes	PT 1	✓	✓
	Corrective Voltage control						PT 2	✓	✓
	Corrective Congestion management via flexibility of the line capacity	Producer		> RES generation than connection agreement limit	Day-ahead	No	PL DLR	✓	
Bilateral contract	Corrective Voltage Control			Flexstation solutions			PL FS		

Figure 1-7: Products and services in the different demo BUCs

All demonstrators used NODES market platform, whilethe Portuguese demonstrator also used the N-SIDE market platform for comparison purpuses and to prove that the UMEI is indeed a standard supported by more than 1 market platform. The German demonstrator makes use of the N-SIDE OBR tool to help the DSO to select the best available option. This is due to the fact that, even though performing a grid-aware market clearing would bring major cost-efectiveness and network safety, it was impossible in the German demonstrator due to regulatory reasons. Furthermore, the Polish demonstrator did not allow for aggregation, implying that there was no aggregator present in their demonstrator. This results in the following set up for the different demonstrators (Figure 1-8):

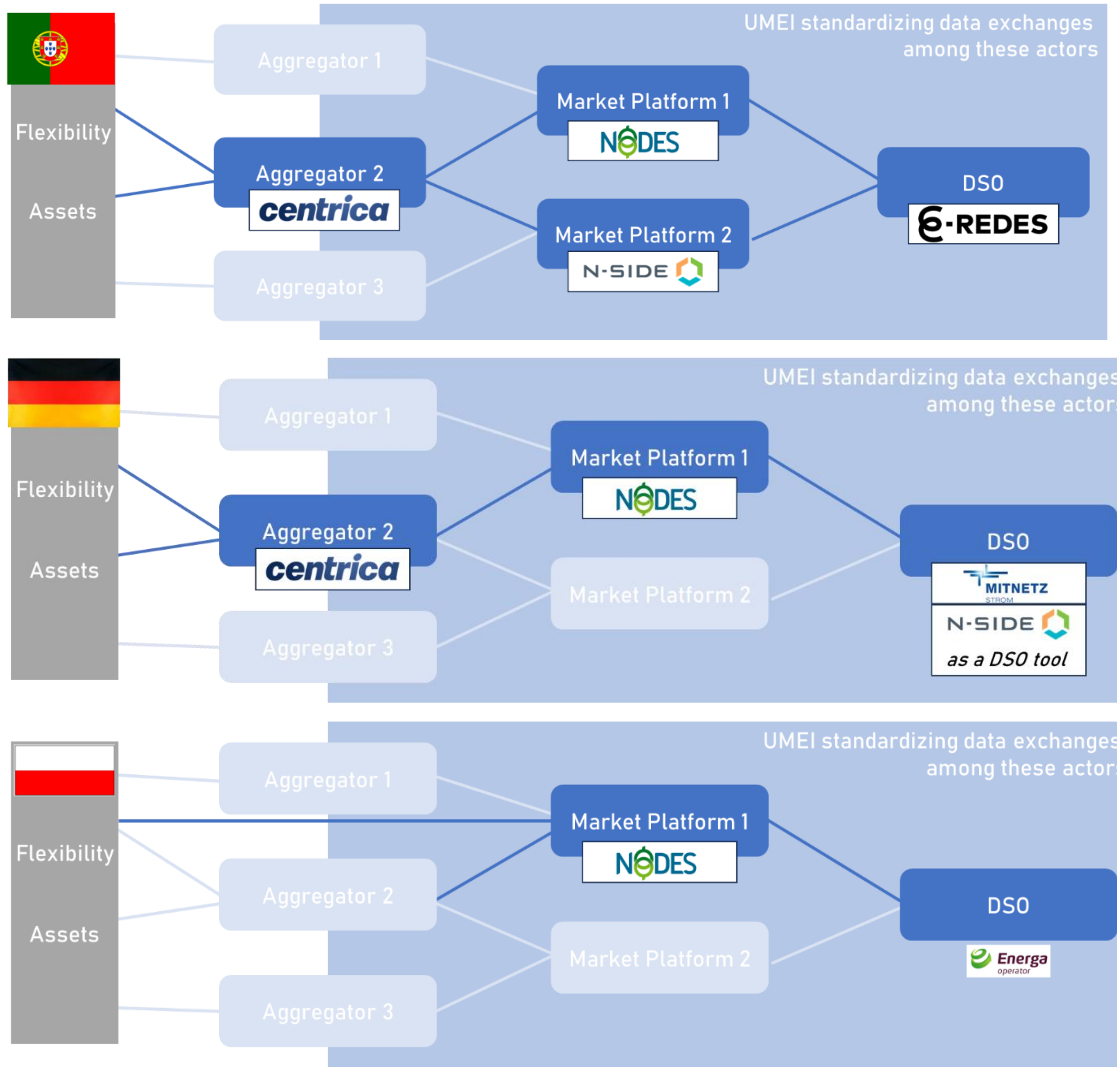


Figure 1-8: Market design demonstrators

Flexibility activation is done manually in all demonstrators, meaning that the FMO sends an activiation signal to the FSP which then can still activate assets manually or automatically. Depending on the market platform used, a continuous market (NODES) or a call market (closed-gate auction – N-SIDE) is applied. The flexibility provider is remunerated based on the flexibility activated according to a pay-as-bid pricing scheme (in case of the NODES platforms) or a pay-as bid or pay-as-clear pricing scheme (in case of the N-SIDE platform).

Other elements of the market design are discussed in more detail in pillar 4 where we zoom in on the differences among the demonstrators.

2 EUniversal achievements and results

In this chapter, we will start showcasing the different tools and methodologies that have been developed, tested, and implemented during the project. In section 2.1, we start with an overview of the key exploitable results (KER). The interested reader can, however, look in the appendix where each partner filled in a template with a more elaborated explanation of its tools. In section 2.2, we summarize the demonstrator results. Finally, in section 2.3, we analyse the different KERs and demonstrator results, and discuss strengths, weaknesses, opportunities, and threats that we endured and discovered throughout the project. This SWOT analysis will give first insights in the key lessons learned which will be discussed in detail in chapter 3.

2.1 Key Exploitable Results

EUniversal project results include 19 Key Exploitable Results (KERs) of all the different partners. Figure 2-1 presents a summary of all KERs grouped per project pillars. In this chapter, we present one-page descriptions of every KER. A detailed description of every KER, obtained through interviews with the involved partners, can be found in Annex 3 Completed KER templates from all partners. In Figure 2-2 we describe how the KERs in the DSO toolbox are used in the different demonstrators. In what follows, we describe each Key Exploitable result in more detail. Each description of the KERs contains a statement about the problem, the solution, the Unique Selling Points (USP), value and expected impact.

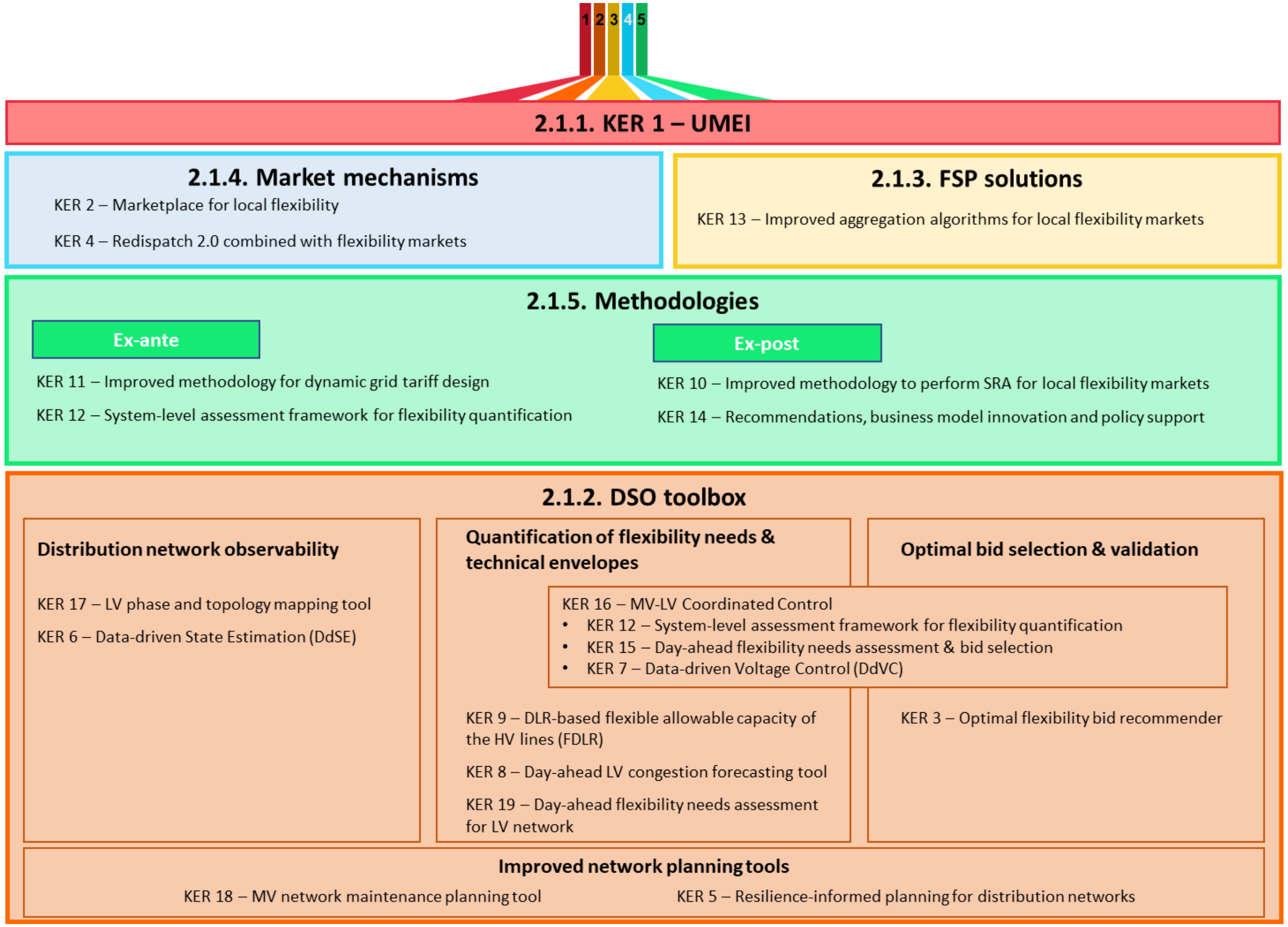


Figure 2-1: Key Exploitable Results

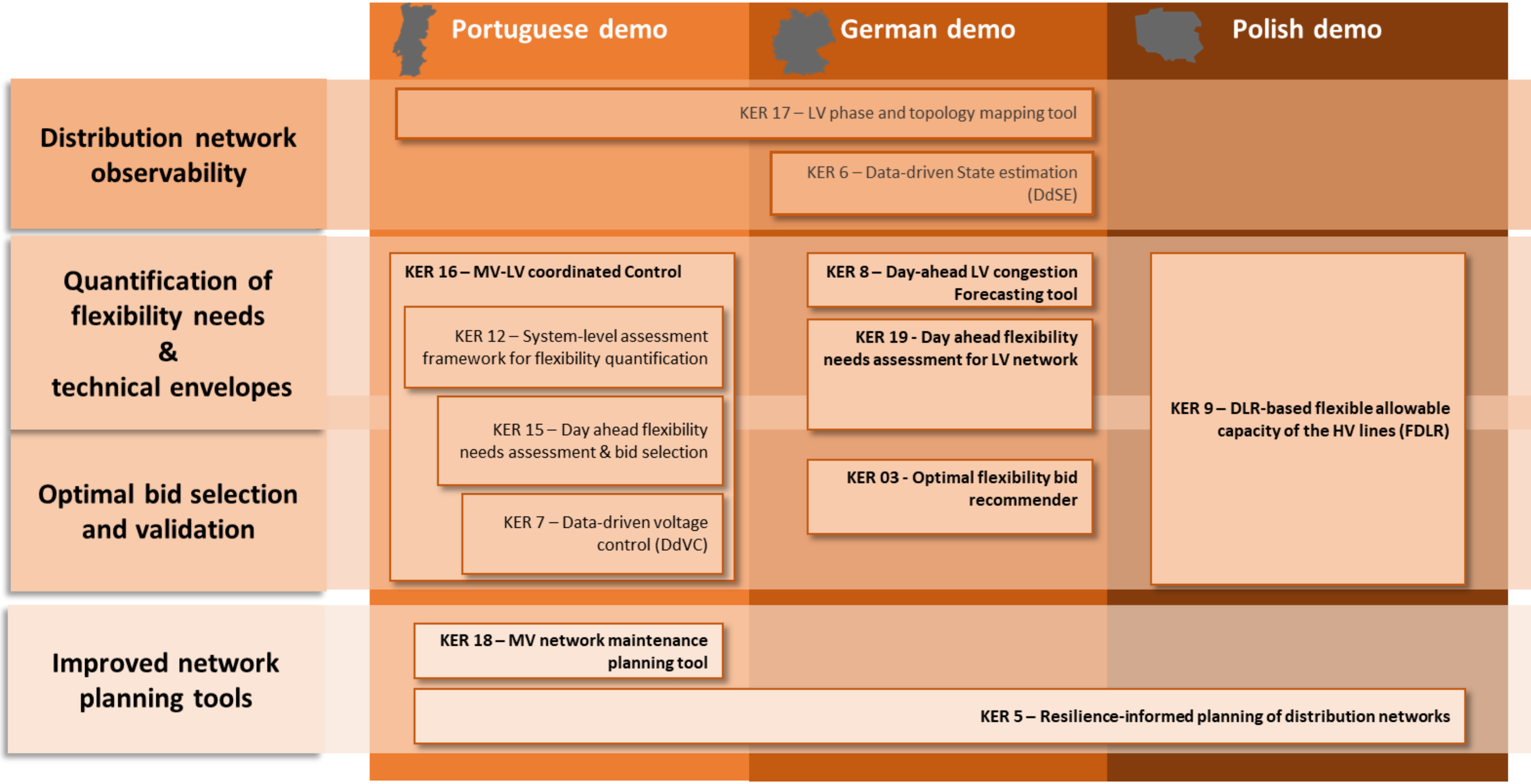


Figure 2-2: KERs in the different demonstrators- DSO Toolbox

KER 1

Pillar 1 UMEI: Universal Market Enabling Interface

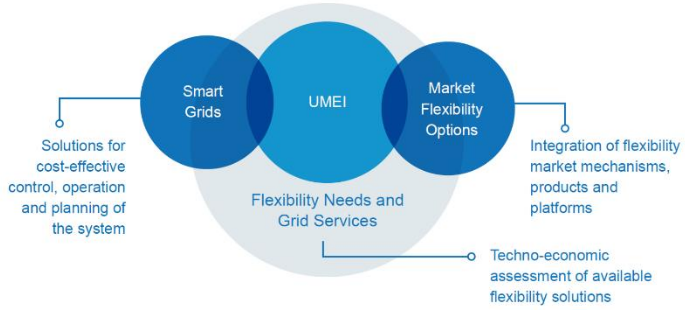
Partners: E-REDES, NODES, N-SIDE, Centrica

Problem

Given the increased need for flexibility, pilots and test projects are being set up to test local flexibility markets. The current market immaturity and regulatory unclarities result in many different solutions and a lot of diversity in market implementations. This diversity limits the adaptability and the usability of different solutions, and implies that system operators that aim to set up local flexibility markets would need to comply with the different market platform specifications. Each time a DSO wants to start setting up a new flexibility market with another market operator, it would need to start from scratch to integrate all systems with its internal environment. This creates a lock-in in one specific market platform and increases barriers for DSOs to benefit from multiple market platforms. In addition, other stakeholder costs increase since the would have to implement different communication/interaction processes for each individual market platform by adding an additional layer of data management to adapt communication to the specific requirements of each market platform.

Solution

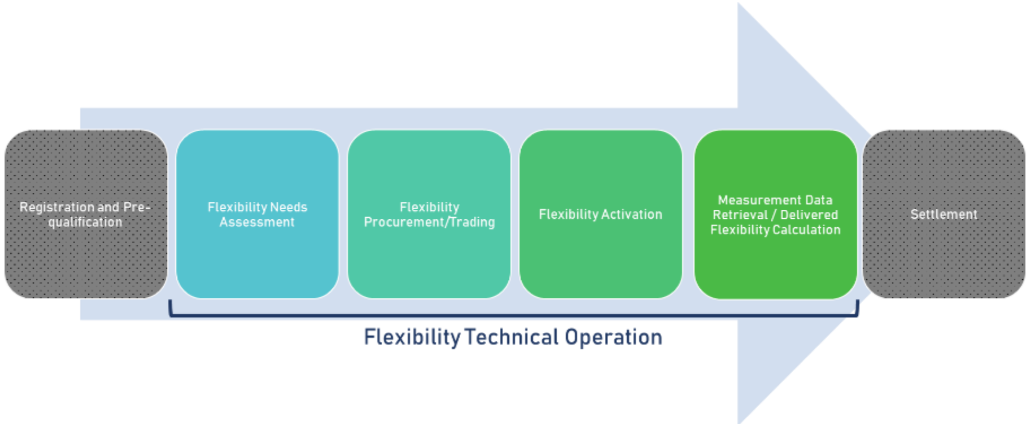
Due to the current market immaturity and the lack of standardization, there was no other similar decentralized solution. Most stakeholders build further upon their current systems in the best feasible way. The UMEI solves this by creating an interface that helps bringing different stakeholders together and demonstrates that it is possible to ensure direct interactions between DSOs and other market players. More specifically, the UMEI is a standardized interface that allows all stakeholders to interact with each other. It is a conceptual architecture design and implementation of a standard, agnostic, adaptable, and modular combination of different APIs to link DSOs and market parties with flexibility market platforms, in coordination with other flexibility users. This approach allows distributed communication without the need for a central hub.



Flexibility Zones	Portfolio	Baseline	Market	Order	Trade	Meter Reading
Flexibility Zones	**Manage Portfolios**	**Managing portfolio baselines**	**List All Markets**	**Manage Market Orders**	**List Market Trades**	**Manage Meter Readings**
Used by DSOs to define specific flexibility areas, composed by a set of portfolios	Used by FSPs to submit and manage portfolio on the market.	Used by FSPs to manage baselines on the market platform.	Used by market participants to retrieve the available markets.	Used by the DSOs and FSPs to execute orders' related operations in the market platform.	Used by market participants to retrieve the market trades.	Used by the DSOs to manage metering data submission both to the FMO and the FSP.

It therefore creates a common way for market actors to interact with the flexibility markets and amongst themselves, without the need of mediator components, such as data hubs or platforms, to procure system services for the distribution grid operation. This new implementation allows for quick uptake. The UMEI consists of publicly available APIs, allowing any stakeholder to adopt them or to develop new APIs concerning new services while complying with the UMEI interface specification. An application programming interface (API) is a way for two or more computer programs to communicate with each other. It is a type of software interface, offering a service to other pieces of software. APIs connect solutions and services without the need to know how these were implemented by each part. In Figure in the introduction, we already depicted how the UMEI's setup connects different stakeholders by linking the different pillars. The figure above describes the different UMEI functionalities that have been developed in the EUniversal project: flexibility zones, portfolio management, baseline calculation, market access, order management, market trades and meter readings.

The market process supported by the UMEI are visualized in the figure below. Apart from the registration, prequalification and settlement, all processes are covered.



USP

UMEI is adaptable and is not a rigid standard that obliges every market platform to take over the specifications of the UMEI. The demonstrated capability of UMEI of working with multiple market platforms allows stakeholders to offer and procure flexibility from multiple platforms. DSOs are not locked to one specific flexibility provider and/or market platform. Switching between platforms does not require new developments, giving DSOs more freedom to choose. In addition, UMEI is open-source and publicly available, both through the project website and Github.

Value and impact	Customer
Open end-to-end communication interface	DSO, FSP
Available set of components for interfacing with market actors	FMO
New incentive and revenue opportunities due to easier flexibility market access.	End Consumers
Support to innovative business models due to its decentralized nature.	Service Companies
Ensure a cost-effective and fast energy transition	Society
Customization possible towards different needs	Energy system
In support of market framework for flexibility, in which all consumer groups can participate	EU/national policy

Pillar 4 Flexibility Market

Partners: NODES and N-SIDE

KER 2

Problem

Load patterns have changed due to digitalization, RES and electrification. Grid problems became more frequent and spatially more granular. Market-based flexibility enables DSOs to use local and regional small-scale flexibility from the LV and MV grid to solve grid problems and to prevent the propagation of the congestion into different grid levels. However, FSPs still face numerous barriers to offer their flexibility. European standards and network codes are required to overcome the existing barriers (the lack of smart meters, minimum flexibility bid size, identification, and remuneration) and to create guidelines for the provision of market-based flexibility.

In EUniversal two market platforms have been tested, i.e. NODES and N-side. The market platform of NODES allows system operators to pick the optimal solution for their specific grid problem. NODES market platform performs the matching considering volume, location and price, while creating a level playing field for all types of assets and covering all functional requirements of the three phases: Registration and prequalification, Trading and Validation and Settlement. The registration and prequalification are done with minimum data requirements and according to GDPR standards. N-SIDE's market platform uses an auction-based mechanism to select optimal bids to solve issues in the DSO's grid. An advanced market clearing process, based on state-of-the-art optimization models and algorithms, concentrates the liquidity of the market with a closed-gate mechanism, before clearing it by maximizing the social welfare while respecting the asset and network constraints. Both platforms have their individual strengths and are described in the annex and in the introduction in chapter 1.

Impact

The market platforms help to optimize the use of the available grid capacity due to the effective use of available flexibility assets. This can lead to:

- Prevention of unnecessary curtailment of renewables;
- Reduction of grid expansion costs;
- Reduction of the electricity bill of end-users
- Reduction of the reaction time in case of congestions;
- Respecting local and regional grid limitations
- Bridging bottlenecks in the energy supply chain.

	Value	Customer
NODES	Distributed flexibility of any size to SOs for grid management.	DSOs, TSOs
NODES	Asset owners can monetize flexibility by selling energy in the flexibility market to help SOs manage grid constraints.	FSPs, Aggregators, BRPs
N-SIDE	Market clearing through a welfare maximizing algorithm respecting network constraints.	DSOs, TSOs, FSPs, Aggregators
N-SIDE	Dynamic flexibility areas to handle network constraints modularly	

EUniversal UMEI

KER 3

Pillar 2	Optimal bid recommender (ORB)	Partners: N-SIDE

Problem

Minimizing the cost of the flexibility that will be provided to the system is one of the main challenges in this topic. A market clearing process consists of a grid-aware optimization problem that finds the best combination of flexibility demand and offer orders (i.e. the combination that solves all congestions at the lowest cost). When this is done at Market platform level, the drawback is that the System Operator (SO) must share data about his grid with an external organization (market platform) which can be a sensitive topic. Furthermore, it is also plausible that there are multiple flexibility platforms operated in parallel, increasing the market liquidity. Yet, the drawback is that if each platform optimizes the flexibility on its own, without considering flexibility offered on other platforms, it is impossible to reach a global optimum. However, to perform a global optimization considering sell bids from multiple market platforms could be more complex.

Solution

To tackle these challenges, N-SIDE created the optimal bid recommender (OBR). This tool is a clearing engine that can be installed directly on the SO's servers and that can be used as a tool to help select the best possible selection set of flexibility bids. Instead of having the flexibility market platforms (FMO) performing the clearing, it is the DSO that runs an optimization algorithm (within the OBR). The OBR tool can use both the data fetched from multiple market platforms that operate in parallel, and the DSO grid-data. In this configuration the DSO can keep full control of both their data and actions. This solution can profit from serve different market platforms. Currently, it is a market-based solution, but it could be adapted to redispatch solutions with different types of contracting (smart energy contracts...). This approach would combine both the security of a direct control solution and a market solution.

USP

The OBR ensures effective use of available resources even if shared across multiple market platforms while keeping full control of the data. In the German demo the OBR is part of Mitnetz' cascading approach to their toolchain. In this approach the DSO has direct control, showing the flexibility of the tool.

Value	Customer
Data privacy: The OBR can run on the SO servers, meaning there is no need to share data (such as grid topology) with external actors. The actual contracting and FSP management is done directly by the SO.	DSO/TSO
Optimization of flexibility offered through multiple platforms	
Ensuring grid stability: the SO can input its most up to date grid topology and forecast, ensuring that the flexibility offered will solve congestions.	

EUniversal
UMEI

KER 4

Pillar 2 Flexibility for Redispatch 2.0

Partners: MITNETZ, E.ON, CENTRICA, NODES

Problem

Since more congestions are predicted due to the increased share of renewable energy sources with intermittent production, there is a need for alternatives to manage congestion. Therefore, a more effective use of local available flexibility from the LV grid is needed. Specifically, in the German demonstrator, the approach of combining market-based flexibility procurement with Redispatch 2.0 is a promising approach to implement an effective mitigation of congestions across all grid levels. However, the regulatory framework for flexibility markets is under development and insights from the demo could be used to support its adjustments.

Solution

This KER tests the feasibility of combining the cost-based approach (Redispatch 2.0) with the market-based approach. Several tools were developed and interconnected to correctly assess the state of the grid and the flexibility needed in terms of quantity, time and location in the LV grid. Mitnetz, as DSO, will then evaluate the existing offers (submitted by Centrica as FSP) on the market in addition to the assets available according to Redispatch 2.0 and select the offer that most effectively solves the grid constraint at the best price. Note that this tool is different from KER 12 (System-level assessment framework for flexibility quantification) because the approach of KER 12 solves all voltage levels in a single mathematical problem. This would not work everywhere since different system operators can have different resources at different levels. Therefore, this KER opted for a cascading method, iterating from the LV to the HV, and back.

USP

Flexibility markets are a complementary tool to cost-based redispatch for grid constraints. They use existing and available assets to reduce or prevent unnecessary grid investments.

Flexibility can also be an interim solution while the grid can be reinforced when there is a repeated issue in the same location. Regulation incentivises CAPEX, new investment in lines, rather than OPEX solutions like flexibility.

Value	Customer
Access to added available flexibility	DSOs, FSPs
Effective complementary solution to Redispatch 2.0	DSOs, FSPs
Incentive for adaptive behaviour of customer	FSPs, utilities, residentials
New business model creation, enabling more parties to offer flexibility	FSPs, aggregators, utilities
Transparency & neutrality for flexibility procurement	DSOs, FSPs
Visibility and accessibility of distributed assets	DSOs

Pillar 2	Resilience tool	Partners: UCY, INESC TEC	KER 5

Problem

As weather patterns grow more extreme and frequent, the impact they have, and the resulting damages they cause on power systems increases. E.g., in 2018, Hurricane Leslie caused more than 15 thousand homes in Portugal to lose power and roads across the country were severely damaged, which increased the response time to repair the power supply losses. The existing methodologies used to plan distribution networks focus primarily upon reliability of the networks over extended periods of time. This approach focuses on the routinely planned maintenance necessary to keep the network operating for decades at a time. It does not, however, consider the impact of individual events that have the potential to cripple the network in a matter of hours or days. As a result, it is imperative that system resilience becomes an integral component of planning methodologies to ensure that ST impacts are accounted for with as much importance as LT degradation is currently.

Solution

A framework and a methodology were developed in parallel within this KER to address this existing limitation. The former is an optimal investment planning framework for MV distribution grids that has two separate tools: (1) a hazard scenario generator and (2) an optimizer. The hazard scenario generator was developed from network fragility curves and accounts for the vulnerability of the individual network assets to natural hazards. These scenarios are then compiled, along with the potential investment options, within the optimizer to develop optimal investment portfolios that balance system reliability with resilience. The latter is a reliability evaluation methodology that determines load loss from a state evaluation process. This is accomplished via a time-dependent understanding of the existing flexibility and its energy limitations within the system. The method uses the assets proposed by the planning tool (the resilience planning framework) to evaluate the system reliability under anticipated regular events.

USP

By providing DSOs with the ability to select their preferred level of risk (risk averse, risk neutral, or partial-risk), this tool enables them to adequately plan their investment strategy for network reinforcement and flexibility enhancement assets. For example, in the Portuguese Demo, for an investment of €6 million, the tool improves the system performance against windstorms with expected energy not served by 36.79% and the conditional value-at-risk of energy not served by 28.29% from the base case (without any asset upgrade) for the scenarios considered. Moreover, with the same asset options, the popular reliability indices such as SAIDI and SAIFI improved by 27.14% and 25.49%, respectively.

Value	Customer
Risk-based resilient investment planning: helps DSOs to stick within the allocated budget	DSOs, Power system planners, NRAs
Improved distribution network resilience	All customers, DSOs
System performance: using the best assets based on risk-driven resilience metrics	DSOs, NRAs
Decrease natural hazard events impact on power systems	Society, policy makers

KER 6

Pillar 2 Data Driven State Estimator

Partners: INESC TEC

Problem

DSOs currently have limited monitoring capabilities for LV networks. Combining this issue with the increase in DERs and EVs, DSOs face a number of growing challenges such as voltage/congestion issues and quantification of flexibility needs. The greatest challenge, however, is the lack of visibility of these problems as a result of the limited monitoring capacity. Without knowledge of the problems in real-time, DSOs are unable to adequately address them in a timely fashion. Unfortunately, the installation of real-time communication meters across an entire system is not economically viable in a short-term setting.

Solution

By using the existing smart meters within a LV network, the Data-driven State Estimator (DdSE) provides real-time estimation of voltage and active power across the entire network, even without full network observability. It accomplishes this by combining historical data and real-time measurements provided by the existing smart meters within the network. This allows the DdSE to create estimated consumption profiles for each metering point without the need of topological or electrical network information, while quantifying the uncertainty of each estimate. The DdSE goes even further by integrating weather measurements and forecasts into the meter profile estimates. This provides real-time results with improved accuracy for LV networks with high DER integration.

USP

The DdSE leverages historical data from existing smart meters, real-time measurements, weather forecasts, and other measurements to provide real-time state estimation in LV grids. Compared to existing approaches, the DdSE provides more accurate estimates without the need of full network observability, topology, or electrical characteristics.

The KER goes even further by providing conditional uncertainty for each estimate in the form of quantiles. These enable the operator to have improved awareness of the significance of the information alongside potential network issues identified through probabilistic alarms.

Additionally, the integration of weather data and forecasts further improves the estimate accuracy for LV systems that have a high integration of renewable resources, like PV panels.

Value	Customer
Improved knowledge of voltage violation occurrences	DSOs
Enables flexibility use to solve voltage problems	DSOs
Enables flexibility exchange without compromising volage limits	DSOs
Enhance overall reliability and efficiency of LV	Society
Real-time estimations w/o substituting equipment that do not communicate in real time	Society, DSO, consumer

KER 7

Pillar 2 — Data Driven Voltage Control

Partners: INESC TEC

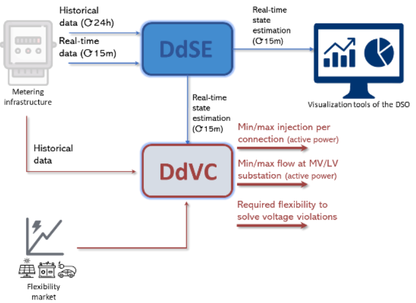
Problem

Voltage control at LV grid is one of the challenges to be addressed to ensure quality of power supply, when dealing with large scale integration of distribution energy source and new loads as electric vehicles and heat pumps. This would enhance the overall quality of service for consumers and minimize curtailment of distributed generation due to over voltages. However, accurate forecast and identification of voltage issues is difficult these days as conventional flexibility management tools require a complete topological and electrical model of the grid, which is typically incorrect or inexistent in LV systems.

Solution

Considering the limitation of existing methods, the DdVC (Data-driven Voltage Control), based exclusively on the historical data of the installed smart meters, can quantify flexibility needs, flexibility ranges and select optimal bid offers when applicable. The DdVC provides exploitable results for effective voltage control in LV networks. It calculates sensitivity factors, offers preventive and real-time capabilities, determines flexibility perimeters and ranges, selects flexibility bid offers, and conducts system state analysis. These results enable accurate voltage control, proactive violation detection, optimized flexibility utilization, and informed decision-making for improved LV network performance.

USP



The selling point of the DdVC is its data-driven approach tailored specifically for LV networks. It stands out by utilizing the existing smart metering and measuring infrastructure, eliminating the need for additional measurement equipment. This approach ensures cost-effectiveness and operational efficiency by leveraging the available infrastructure without requiring additional installations. Furthermore, the DdVC implements a privacy-preserving strategy, ensuring the confidentiality and protection of sensitive data collected from smart meters.

Value	Customer
Enables the use of flexibility to solve voltage issues	DSOs
Enables flexibility exchanges without compromising voltage limits.	DSOs
Market clearing tool: select the most cost-efficient solution to solve violations	DSOs
Enhance service for customers	Customers
Optimize utilization of RES by controlling voltage issues.	Society
Minimize operational network costs	DSOs

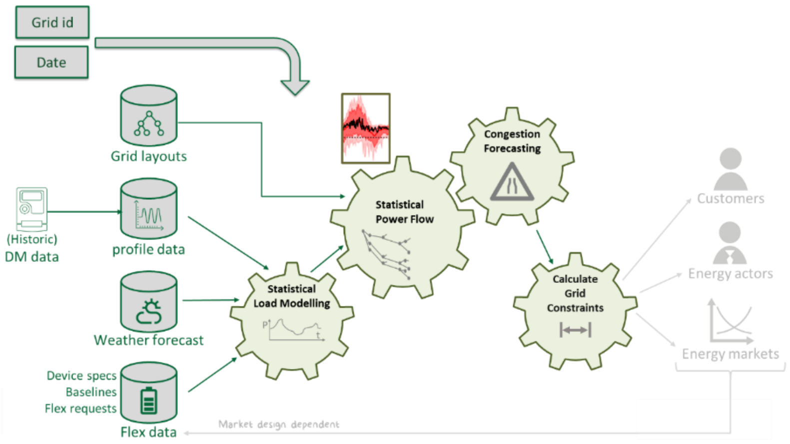
Pillar 2 Day-ahead LV congestion forecast

Partners: VITO

KER 8

Problem

DSOs have a very low level of observability in their LV network. Indeed, parts of the LV network are (almost) not measured nor monitored automatically, and as a result, it is hard to forecast what is likely to happen on the networks. Nevertheless, having a better view on LV networks is necessary for DSOs to being able to manage their assets better. The latter would lead to improved assets use and eventually lower costs for society. Furthermore, for flexibility markets to work properly, DSOs need to know where the congestion risks are, and thus, the needs for congestion management in their LV networks. Currently, the lack of measurements in LV grids makes it hard to estimate congestion risks, making it hard to further improve distribution grid management.



Solution

The LV congestion forecasting tool aims at calculating the risks for congestion on a LV distribution feeder for a forecasted day. These congestions are overvoltages, undervoltages or overcurrents anywhere within the feeder, or overloading of the MV/LV transformers. The tool does not deterministically calculate congestions, as for this calculation the necessary input would be impossible to acquire (e.g. deterministic forecasts of single connection consumption are not available), but merely outputs a congestion risk based on the statistically possible LV feeder states during the forecasted period. The congestion risks are defined as the probability a particular congestion may take place, and is based on a predefined risk threshold that is calculated per node and per time step. The calculations within the tool are based on historical, and (if available) recent grid and connection profile measurements, as well as weather forecasts. The tool assumes that the grid lay-out is known. However, the phase-connectivity of the single-phase connections is assumed to be unknown by the DSOs.

USP

The tool provides the congestion risk on a particular LV network, even when there are little to no measurements available on the given network. The only prerequisite of the tool is that the network topology must be known, since all other unknowns are covered through exploiting statistical methods to assess the congestion risk.

Value	Customer
Improved distribution grid management	DSO, society
Safe activation of flexibile assets on the LV network for ancillary services	DSO
LV congestion forecast, given sparse measurement data	DSO

Pillar 2 Flexible dynamic line rating (FDLR)

Partners: ENERGA

KER 9

Problem

RES energy producers have a connection agreement with the DSO in which a power limit is defined. In case the forecasted renewable power generation exceeds the defined power limit, RES will be curtailed. For most wind farms (WF), contractual connection capacity is lower than the installed capacity. This means that these WFs in windy conditions can deliver more power than agreed in the connection agreement. However, it is dependent on the HV line's allowable capacity in the given weather condition, which results from the safety of the line operation. The safety of the line implies that in every span, the distance to the earth should be kept within normative limits. The allowable line capacity can be calculated based on the traditional method called static line rating (SLR) where it is generally fixed depending on the season of the year, but it can also be done based on DLR (dynamic line rating). Using the traditional method implies that there is more curtailment of renewable energy, but also that new RES generators are waiting to be connected to the grid while the network is being reinforced.

Solution

The DLR-based flexible allowable capacity of the HV lines (FDLR) allows to provide flexibility to RES generators that have more forecasted renewable power generation than the defined power limit. As such, RES generators could buy flexibility services on the flexibility market from the DSO. DLR values are usually larger than SLR, leading to a better lines' capacity estimation and usage. As a result, FDLR can be used for operational planning by considering the changing capacity of the line due to thermal conditions. It can look at the full line capacity utilization and as such have a more efficient load dispatching, avoiding the so-called 'bottleneck' which provides safety for the overhead lines (OHL) operation. FDLR utilizes weather-based dynamic line rating (DLR) which is nowadays the only measure to cope with increased power transmission demand, especially in the situations when network infrastructure upgrading (for example restringing) is hardly possible. DLR is calculated based on the measured or forecasted weather conditions along the line (ambient temperature, wind speed, wind direction, and solar irradiance, and line parameters).

USP

The selling point of the tool is the high accuracy of the calculated results and low cost, especially when deployed for multiple lines. In practical deployment, when DLR values are used for short-term load flow and congestion analysis, the very accurate thermal model of the HV lines in the steady state is used. Presently the calculation accuracy of the wire location over the ground is better than +/-10 cm, as proved in the field installations. Accuracy of the wire location over the ground is very important for the safety of the HV line operation in terms of keeping the normative distance to the ground. There are very few companies that offer a similar solution.

Value	Customer
More accurate calculation of the wire location over ground	DSOs / TSOs
Adapted (higher) line capacity available for RES	RES producers
Less RES curtailment	Society

KER 10

Pillar 5 Improved SRA method

Partners: Comillas

Problem

Given that local flexibility markets are at an early development and implementation stage, there are many open research questions related to their design and implementation (e.g. flexibility product definition, clearing methods, DSO need determination, etc.). Answers to these questions are needed for policy makers and regulators to better understand the value of flexibility for policy and regulatory design as well as to evaluate investment plans, submitted by DSOs, integrating flexibility. Insights on these topics can ensure more efficient development of distribution grids and integration of DER thanks to proper designs of flexibility markets, can lower network costs and can ensure more efficient grid connections. Furthermore, they can ensure the availability of new knowledge on local market design for stakeholders and ensure data-driven conclusions that can support regulatory developments related to flexibility.

Solution

The improved SRA (scalability and replicability analysis) methodology and associated modelling tools aim to provide data-driven information on some of these open issues such as when and where flexibility is most useful or what the required conditions for it to be useful are. The methodology performs a simulation-based quantitative SRA of use cases related to applying local flexibility markets to prevent or alleviate distribution grid constraints. The aim of this type of SRA is to assess the impact on a certain number of Key Performance Indicators (KPIs) (e.g. grid constraints avoided, flexibility costs, etc.) of changes in several factors or boundary conditions relevant to upscaling and replication, i.e. grid characteristics (impedances, voltage levels, topology), existing grid users (load/generation profiles), and FSP characteristics (type, technology, flexibility availability, costs, location). These factors drive, on the one hand, the amount and type of flexibility needs by the DSO and, on the other hand, the capability and cost of the FSPs to solve them. Within EUniversal, new modelling capabilities have been developed for the methodology to enable a more efficient use of flexibility and the analysis of additional use cases. More specifically, the developments being made are: implement the full set of SRA tools within the same environment using Python language, joint use of active and reactive power, calculation of sensitivity factors for congestions based on a coupled AC power flow (DC power transfer distribution factors were used in previous implementations), comparison of market-clearing by a MO vs. DSO determined flexibility activations (involving different grid-modelling approaches), and solving congestions and voltage problems jointly.

USP

A key strength of this tool is its ability to combine modelling, regulatory and power systems expertise into a single methodology to evaluate the performance of use cases on local flexibility markets under different scales and contexts. The new developments include a result analysis and visualization module which supports the interpretation of results and decision-making based on them.

Value	Customer
Valuation of flexibility under different grid conditions	DSO
Testing of alternative market formulations	MO, platforms
Deeper knowledge on the value of flexibility	FSPs
Knowledge on flexibility	Engineering master and PhD students

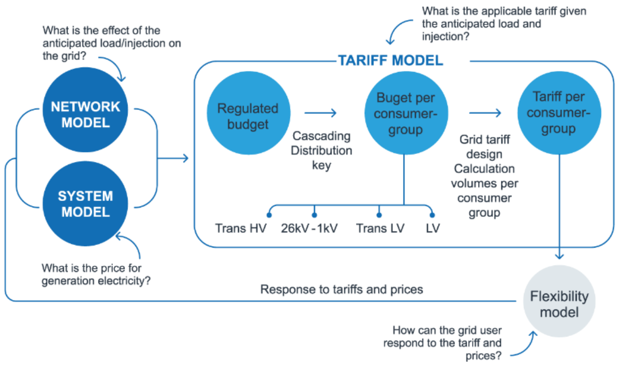
KER 11

Pillar 5 Method for dynamic grid tariff design

Partners: VITO

Problem

Higher flexibility needs require giving triggers to FSPs to offer flexibility at the right place and at the right time. To achieve this, well adapted grid tariffs are needed. However, it is hard to determine which tariffs are appropriate given the fact that there are many unknown and uncertain factors. There is a need for more transparency in the tariff design process and the criteria used to set tariffs. Grid tariffs need to be designed in such a way that they improve the efficient use of the grid and incentivize consumers to reduce grid congestion by shifting their peak consumption away from the peak demand periods. Properly designed tariffs could encourage consumers to step into demand response programs and could stimulate innovation.



Solution

This methodology helps DSOs, TSO, regulators, etc. to set up appropriate tariffs in an environment with many unknown and uncertain factors. It is a comprehensive methodology for the design of tariffs that can mitigate both short- and long-term congestions. It consists, firstly, of a qualitative analysis that incorporates a conceptual framework of establishing grid tariff designs which includes the different design dimensions, provides a review of dynamic tariff design methodologies and best practices, and studies the congestion needs that have to be addressed. Secondly, it consists of a quantitative analysis using a simulation environment consisting of different sub-models: a system model which represents the electricity system in clustered fashion, a network model which represents the distribution network, the tariff model which defines the selected tariffs, and the flexibility model which represents the (residential) demand on the level of individual consumers.

USP

VITO designed a comprehensive methodology which can be used to define and evaluate the impact of an alternative design of several electricity pricing components on the consumer, society and the electricity grid. By using the methodology developed, DSOs and TSOs are enabled to design dynamic grid tariffs which can provide an implicit flexibility signal to the residential consumer to adapt its behaviour in function of the grid state. Hence, by applying the methodology, implicit tariff signals could lead to reduced grid operation costs.

Value	Customer
Knowledge on tariffs and prices	DSOs, TSOs, NRA, policy makers
Methodology to assess LV flex for management of LV grid constraints	DSO, FSP
Method to design proper incentives for adaptive behaviour of consumers	DSO, FSP, consumers

KER 12

Pillar 5 Framework for flexibility quantification

Partners: ENGIE Impact, INESC TEC

Problem

DSOs may procure flexibility services, rather than reinforcing the grid, since this might be more timely and costly. However, the questions of when and how to organize such Flexibility Markets are still an open debate. We are not aware of such preliminary quantification exercises. These initiatives were not transparent on the framework used to assess future needs in flexibility, to characterize them or to define an appropriate LFM to procure required services.

Solution

For this reason, this KER performed optimal power flow simulations, in view of getting quantified and realistic insights on the available flexibility of distributed generation and flexible loads like water heaters, air conditioning, space heating equipment and EV chargers, and their impact on operational planning of the electricity network under different conditions. In particular, it was aimed to quantify the congestion and voltage issues that are expected to appear in a distribution grid characterized by increasing shares of intermittent RES generation and flexible loads. This was done by means of a methodology to assess the available flexibility in a distribution grid, and their impact on operational planning of the electricity network under different conditions. Based on simulations of a detailed electricity distribution grid, this methodology contributes to this discussion in two ways. First, it aims at characterizing the issues (mainly congestions and under- or over-voltages): when, how often, how long and where are issues happening. Second, it provides insights about the solutions and the interaction of assets located at different places in the grid (LV/MV in particular). The proposed methodology consists of a techno-economic optimization framework for the definition of flexibility products. The main characteristics of the product that can be identified are the type, location, capacity and duration of the flexibility. The model is an intraday optimization, that identifies congestion or voltage problems according to the nature of the network. It will run on an intraday basis to determine the optimal control that needs to be applied for the following day. The value of the KER is in the methodology to define the flexibility that can solve the congestions identified by an optimal power flow analysis.

USP

ENGIE Impact is able to combine modelling, regulatory and power systems expertise into a single methodology to evaluate the performance of use cases on local flexibility markets under different conditions (penetration of RES and EV charging stations). ENGIE Impact owns the required tool (multi-period optimal power flow on a distribution network). Some of the use cases are:

- Network configurations under different scenarios of RES and EV penetration.
- evolution of the network for the next 10+ coming years (2030, period to be considered for establishing the market)

Value	Customer
Characterization of network issues (when, where…)	DSO, FSP
Quantification of available flexibility and its impact	
Insights in how to design local flexibility markets	DSO, NRA, Policy
Helping define geographical scope of LFM	

EUniversal
UMEI

KER 13

Pillar 3 Aggregation algorithms for local flexibility

Partners: Centrica, EON, E-REDES, NODES, N-SIDE

Problem

With the current regulation, there is a minimum quantity that participants need to be able to bid into energy markets before they can participate. Therefore, small volumes of flexibility cannot participate into the market without aggregation. This is a significant entry barrier. A solution is to aggregate multiple small-scale flexible assets to allow them to offer together a larger volume of (aggregated) flexibility. However, this leads to a portfolio with different residential and industrial, small- and large-scale assets combined which each face economic, technical and regulatory challenges needing to be accounted for during aggregation.

Solution

To aggregate resources optimally, Centrica designed an algorithm to aggregate small volumes of flexibility located in LV and MV grids to provide services for distribution system operators (DSO). This small volume of flexibility is located at end-user's premises. Centrica, as flexibility service provider (FSP), will aggregate the available flexibility from different flexible assets, such as batteries, electrical water heaters, or electric vehicles. This aggregation will be done not only to reduce the impact of uncertainty related to the energy consumption and behaviour of individual end-users, but also to meet the minimum flexibility required to participate in the market. In the EUniversal project, the aggregated available flexibility will be estimated and offered to flexibility market operators (FMO) via UMEI API. Depending on the market design and type market, the aggregated flexibility will be selected either by an FMO or a DSO afterwards to solve the grid constraint. The objective is to understand the DSO market better with different types of flexible assets. Previously, only batteries were considered, and during EUniversal hot water tanks and EVs were added.

USP

This aggregated flexibility will reduce the investment of the SO in grid expansion, potential curtailment of renewable energy assets or even prevent a black-out event. This algorithm will also help end-users to maximize their benefit from installing flexible assets and minimize their energy cost. It can model different types of flexible assets and calculate their available flexibility at each time step, aggregate it and offer it to the market while respecting end-users' comfort level. The algorithm consists of different parts: modelling of assets, optimization (min customer costs, or other OF) to calculate optimal bidding, constraints, (comfort level, max power that can be injected in grid…), and considerations for data driven methods of controlling the assets. Due to the lack of data, they will have a simpler MPC (model predictive controller).

Value	Customer
Enabling the participation of LV / MV customers	End-users, FSP
Solving the grid issues using aggregated flexibility	DSO
Participation in local flexibility market	FMO, DSO, FSP
Reduction of energy cost and greenhouse gases	Society, consumers
Reduce unnecessary grid investments	DSO, Society
Reduce market liquidity or supply issues	Society, DSO, policy

KER 14

Pillar 5 Business models and policy

Partners: Vlerick, E-DSO

Problem

There is a need to create knowledge and regulatory recommendations regarding the implementation of flexibility mechanisms in terms of regulation and business models. There are many tools available to implement flexibility, national and European regulations are not harmonized, and the trade-offs between the different options are not straight forward.

Solution

This KER consists of 1) regulatory recommendations and 2) Business model innovation and CBA methodologies. Regulatory recommendations are presented in 'D10.3 Regulatory recommendations for flexibility options and markets.' The deliverable shows how different flexibility mechanisms can be combined and discusses why regulatory sandboxes and market power remedies can be important for the optimal implementation of the mechanisms. Six flexibility tools are defined: flexible access and connection agreements, dynamic network tariffs, local flexibility markets, bilateral contracts, cost-based mechanisms and obligations. Business models are compared in 'D10.1 business model canvas and comparison of CBA methodologies. The deliverable analyses, first, the business models of the EUniversal demos before examining distribution planning methodologies in Europe. The business models are built using Osterwalder's business model canvas. Second, the deliverable describes the evaluation of distribution planning methodologies in Europe, with a focus on the trade-off between flexibility and network investments.

USP

Often, regulatory analysis is presented in reports on a country per country basis, making it difficult to evaluate the trade-offs in different flexibility or planning methodologies.

In the results mentioned above, a series of interviews and workshops with experts led to abstractions of the main building blocks behind the different tools used across Europe. This leads to a summarized bird's-eye view of the different flexibility tools available.

Value	Customer
Regulatory recommendations on implementation options of different flexibility tools	1/regulators, 2/stakeholders (DSOs, Flexibility service providers, market operators,…), 3/students and academics, 4/ public bodies
Flexibility market business models for different use cases tested in the project are outlined.	
Evaluation of distribution planning methodologies in Europe	
Comparison of sandbox methodologies	
Mitigation of rising network costs	

KER 15

Pillar 2 Day-ahead flexibility needs assessment

Partners: INESC-TEC, E-REDES, ENGIE Impact

Problem

Operating distribution networks with flexibility requires efficient tools capable of defining cost-effective day-ahead operation plans for DSO assets and flexibility. DSO requires tools to support the following steps:

a) Foreseeing grid issues, such as congestion and voltage problems and estimate flexibility needs. It is important that DSOs can enable the activation of a group of resources within a specific zone or by combining resources across multiple zones, to facilitate aggregation and enhance flexibility provision.
b) Selecting appropriate flexibility bids in response to forecasted issues (e.g. congestion and voltage problems).

Without fulfilling these needs, it is hard for DSOs to tackle grid challenges proactively to ensure a more efficient operation of their networks, to enhance grid efficiency, increase renewable energy penetration and demand response, and to ensure economic efficiency.

Solution

MV_FST is a computational tool designed to address and provide the flexibility within MV electric grids when grid issues are anticipated. The tool utilizes two distinct methodologies (a and b) to compute flexibility. The combination of these two methodologies allows MV_FST to accurately compute and offer the required flexibility in MV electric grids.

a) **Grid segmentation procedure**: This approach involves identifying zones within the grid based on sensitivity coefficients. These zones offer flexibility to effectively resolve foreseen grid issues like congestion management and voltage control.
b) **Optimization of flexibility bids**: This method focuses on selecting the optimal flexibility bids through a cost minimization process. By considering sensitivity coefficients, the tool selects the most suitable flexibility bids to solve the congestion and voltage constraints.

USP

Methodology a) segments the MV electric grid into distinct zones, enabling precise identification and communication of flexibility needs for each zone. This methodology ensures effective resolution of foreseen voltage and/or current issues on a zone-by-zone basis by computing the required flexibility of the grid buses. Furthermore, methodology a) identifies the optimal combination of grid zones that collectively provide the necessary flexibility to overcome grid limitations. By considering tuples of grid zones, the methodology ensures a holistic and coordinated approach to addressing grid challenges.

In methodology b) DSOs can leverage this feature to select the optimal bids that align with grid requirements and constraints. The utilization of this feature improves grid management and operational decision-making for DSOs.

Value	Customer
Enables the quantification of flexibility needs in MV networks through zones	DSOs/Aggregator
Enables the quantification of flexibility needs in MV networks through combination of zones.	DSOs/Aggregator
Computationally efficient for running in close to real-time	DSOs/Aggregators/Commercial market parties

KER 16

Pillar 2 MV and LV coordinated control

Partners: INESC TEC, ENGIE Impact, E-REDES

Problem

A great majority of flexibility resources will be connected at the LV network. They can help solve local problems in LV networks or can be aggregated to help solve grid constraints at the MV networks. This interaction requires a better coordination between the operation of MV and LV networks and in future AMDS tools developed for MV and LV network management.

Solution

The MV and LV coordinated control methodology enables DSO procurement of day-ahead market-based flexibility services for congestion management and voltage control. An iterative procedure is adopted for enabling LV flexible resources to help solving technical constraints in the MV network, while ensuring that no further technical problems result from flexibility provision. It involves the coordination of different tools developed within the project that forecast the network status and expected MV and LV network constraints (voltage violations and congestions), estimates the flexibility needs in both MV and LV networks and defines the optimal selection of bids, if necessary. Besides ensuring the safe mobilization of aggregated LV resources for MV operation support, it also considers that MV network optimization would also solve some of the restrictions detected in LV networks. It also enables the selection of flexibility bids considering the impact of flexibility mobilization in both LV and MV network. This framework is compatible with different market designs, both continuous or auction based, with day-ahead and/or intraday activity.

USP

It is a management framework enabling DSO procurement of day-ahead and/or intraday market-based flexibility services for congestion management and voltage control for both MV and LV networks. To date, ADMS applications are mainly focused in MV and HV networks. LV network applications are mainly focused on Outage Management and fault location. This framework effectively coordinates different tools designed specifically for LV networks and MV networks.

It is compatible with different market designs. The framework has been tested and adapted to the NODES and N-side market designs. From the N-side design, where the clearing is done on the platform, privacy is maintained while network limits are communicated and respected. From NODES the bid selection is done from the DSO side with full network knowledge.

Value	Customer
Promotes coordinated control between MV and LV networks	DSO
Define operating envelopes at the MV/LV substation	DSO
Better market & grid integration	DSO
Unlocking local flexibility (demand side flexibility) potential	FSP

KER 17

Pillar 2 — LV Phase and Topology Mapping tool

Partners: INESC-TEC, KUL

Problem

By having a better view on the LV networks, DSOs are able to manage their assets better, leading to improved asset use and eventually lower costs for society. However, currently, there is a lack of metering equipment meaning that either crew field interventions are need, or more investments are needed in additional metering equipment (which takes time and is expensive). One specific part of the required information is phase connectivity identification (PCI), enabling better knowledge of system conditions. This is valuable for operation and planning of an active distribution network due to improved distribution network (DN) topology information leading to (1) Improved grid asset utilization, (2) Flexibility activation for congestion/voltage unbalance mitigation, (3) Providing network awareness for charging of EVs, operating heat pumps, DER, storage etc. (4) Higher renewable integration & improved forecasting, (5) Formation of active DN, (6) Accurate unbalanced power flow studies and OPF calculations crucial for operational and planning of DNs, (7) Detecting topology changes due to DN reconfiguration, and (8) More accurate digital twin formation for evaluating in time ahead and real time. Phase connectivity information is therefore crucial for DN operation and resource planning. In absence of this, either manual phase connectivity identification (PCI) is performed or using expensive hardware which often requires sensor placement at the reference point and in the premises of single-phase consumer. Both these methods are intrusive and expensive.

Solution

In our work, we utilized historical voltage time series information for PCI. Voltage magnitude is measured by most smart meters and other measurement devices either already existing or economical to be installed. Further, for highly accurate phase identification, our PCI methodology does not require the distribution network to be fully observable. Thus, the proposed methodology would imply significant savings for the system operators. For instance, in the UK there are 11 million distribution network feeders. Performing PCI for these feeders would cost multiple millions if not billions of euros. The LV phase and topology mapping tool performs the phase identification of the LV consumers and estimates the topology and electrical characteristics of the LV distribution networks, avoiding the need for human intervention to characterize the LV network. Two different algorithms were also developed by INESC TEC and KUL considering different data availability scenarios. INESC TEC scenarios consider that most of the LV consumers are equipped with smart meters, while KUL ones consider lower levels of observability in the distribution network.

USP

It is a data-driven tool designed for LV networks which doesn't require the installation of additional measurement equipment or field crew mobilization, since it takes advantage of existing information such as smart metering and other existing measuring infrastructure.

Value	Customer
Enables the identification of phases and characterization of network topology and electrical characteristics without intervention in the field.	DSO

KER 18

Pillar 2 — MV network maintenance planning tool

Partners: INESC TEC, E-REDES

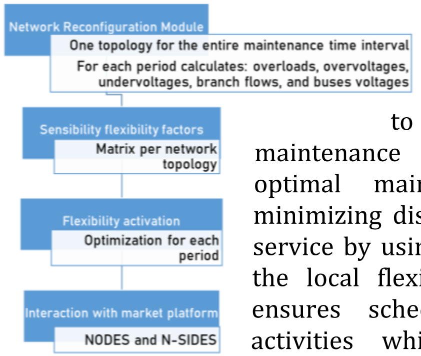
Problem

Maintenance can cause comfort issues to the end-customers, flexibility can mitigate the discomfort of maintenaince for consumers. Individuals and businesses need to have reliable access to electricity, reducing the inconveniences caused by unexpected outages. By utilizing local flexibility markets, maintenance can be scheduled during periods that are less expensive, such as avoiding costly Sunday mornings when maintenance crew costs are higher. The challenge is to plan this in an efficient way to ensure the minimization of both cost DSO costs, and increase the network reliability (which is good for overall economic growth and competitiveness).

Solution

The MV network maintenance planning tool is a decision support tool to help network operators to plan network reconfiguration actions required to ensure service to a maximum number of consumers and taking into consideration the participation of flexible resources through voltage and congestion management services. The tool identifies alternative network topologies for a configurable time frame (e.g. a set of days) selected by the operator, considering the network area out of service due to maintenance. Then if technical problems are identified, the flexibility needs are quantified. The possible alternatives of periods for maintenance are then ranked according to pre-defined KPIs (cost, interruption time interval, amount of flexibility mobilized, number of switching actions, etc.).

USP



The selling point of the MV network maintenance planning tool is its ability to support network operator maintenance planning, recommending optimal maintenance actions while minimizing disruptions to end customer service by using the flexibility offered in the local flexibility markets. This tool ensures scheduling the maintenance activities while reducing costs and maximizing the availability and reliability of the network for customers.

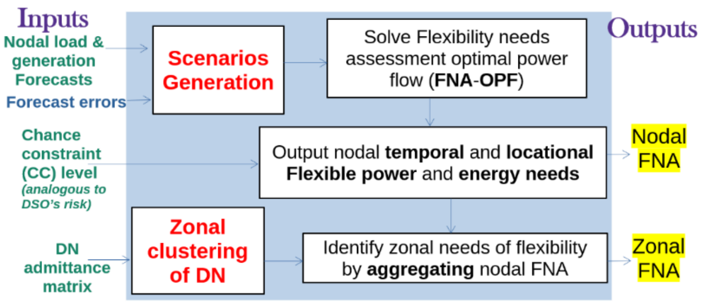
Value	Customer
Network topology optimization	DSO
Identification of network congestions	DSO
Use medium to long-term flex. in NODES and N-SIDE	DSO
Support network operator maintenance planning	DSO
Improved network reliability and availability	Society
Reduced downtime contributes to economic growth	Society

Pillar 2 | **Low Voltage Flexibility Needs Assessment** | **Partners: KUL**

KER 19

Problem

Flexibility needs assessment (FNA) refers to the amount of flexibility the DSO needs to plan or procure from the flexibility market to avoid probable Distribution Network Incidents (DNI). There is a need to quantify flexibility needs for a distribution network in order to avoid probable congestion incidents. DNIs in low voltage grids are often local problems in which flexible resources in the proximity may be enough to avoid these incidents.



The probable DNI are captured using uncertainty modeling and scenarios generated with Monte Carlo techniques that emulate the different events which could happen. The scenario generation utilizes the nodal load and generation forecast along with historical forecast errors. A flexibility needs assessment-optimal power flow (FNA-OPF) problem is solved for each of the scenarios. The robust FNA, considering the worst-case scenario, if used for flexibility procurement would lead to substantial over-procurement. In order to avoid this, a risk-based index, e.g. a chance constraint (CC), is introduced. Higher values of the CC would indicate greater risk the DSO might have to encounter by facing unresolved DNIs.

Solution

USP

Time ahead temporal and locational quantification of the flexibility needed to avoid probable distribution network congestion or power quality deterioration incidents. Customizing the above feature for different grid topologies, with different levels of observability is hard to do in traditional power system analysis. Current software companies are not flexible enough to adapt to new needs.

Value	Customer
Forecasting of LV network congestion	SO, MO, software co.
Quantification of locational and temporal flexibility needs	DSO
Improved network operation	DSO

2.2 Demonstrator results

All the Key Exploitable Results and tools presented below are tested in the three EUniversal demonstrators. In what follows, we summarize the key results per demonstrator.

2.2.1 German demonstrator

The German EUniversal demonstrator had the following objectives: (1) Achieving enhanced observability of the chosen LV grids; (2) Providing flexibility over the UMEI to the flexibility market; (3) Integrating the flexibilities into a scheduler-based congestion management; (4) Enabling the provision of flexibilities to the LV/MV connection point. To validate the achievement of these objectives, not only individual functional components, but process steps and tools were tested as well. In addition, also testing the entire flexibility value chain under realistic circumstances were part of demonstrator.

During the demonstrator tests, mitigation measures had to be implemented. Firstly, the transmission capabilities of the lines were adapted to 50% of their nominal capacity, as well as a narrower voltage band level [0.95 pu, 1.05pu] than the one allowed by standardization [0.90pu, 1.1pu], was assumed. This is because MITNETZ's low-voltage grids are very stable and currently do not exhibit a great likelihood of congestion. This virtual adjustment was made to be able to test the flexibility chain regularly.

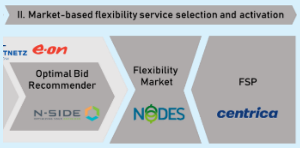
Furthermore, and more importantly, due to the difficulties in acquiring and equipping customers, it was no longer possible to complement all tests just with flexibilities out of the foreseen network areas. To cope with this, the evaluation in the demo grids tests were separated into two focus parts. One part of the tests focused on the connection of the DSO smart grid tools with the market. These tests are carried out within the specified LV network area, using the measurements and equipment available within that network. A second part of the tests, focussing on the aggregation and activation of assets, was carried out using real assets that are outside of the specified LV network in a laboratory environment. This separation made it possible to run the German demo with real measurements and topologies, even if the virtual portfolio of the FSP also contained off-grid assets. At the same time, the technical feasibility of flexibility retrieval could also be demonstrated. This means that the entire range of functions has been tested. Technically, no further steps are necessary for merging the two parts. However, higher market liquidity must be achieved, e.g. through the removal of prevailing regulatory barriers and incentive creation.

The tests of the **Data-driven State Estimator**, being the first part in the flexibility tool chain, showed that this tool is highly reliable in providing estimations that closely match the actual values, with an achieved mean absolute error of 3.2 V, corresponding to a Mean Absolute Percentage Error of 0.2%, achieved over a measurement period of 10 days.

Evaluation of the **congestion forecasting**, being the second part in the flexibility value tool chain, showed that the congestions are detected. The congestion forecasting is based on historic offtake profiles. The pool of profiles that was available within this project contained about 90 yearly profiles. With this relatively low number, only a relatively low average continuous ranked probability score (this is a metric to assess probabilistic forecasts) could be achieved. It must be noted, however, that with a larger pool of historic profiles, it is expected that more accurate forecasts could be achievable.

Within the German demo market setup, the congestion forecast also produces maximum and minimum allowable limits for the activation of flexibility on the LV network, ie. the so-called **headroom**. These limits make sure that no congestion occurs within the LV network after flexibility activation, i.e., all congestions on the LV network are a priori avoided by making sure that only grid-safe flexibility bids will be selected from the market clearing.

In parallel, a **Flexibility Needs Assessment** (FNA) is done to evaluate the level of flexibility required by the DSO to minimize the likelihood of congestions. The test results indicated a good performance of the tool with a small underestimation of the flexibility needs occurring in temporal and locational terms while covering the most flexibility needs.



Finally, a **market-based procurement process** was successfully set up with the DSO (MITNETZ STROM) as a buyer, using the **UMEI** as standard communication interface, to connect to NODES market platform.

Activation of the flexibility was shown by using a system consisting of battery, hybrid inverter, metering and home energy management system (HEMS). The HEMS acts as a control channel and communicates the set points with the DERs. Figure 2-3 shows an example of the control of the inverter in two phases.

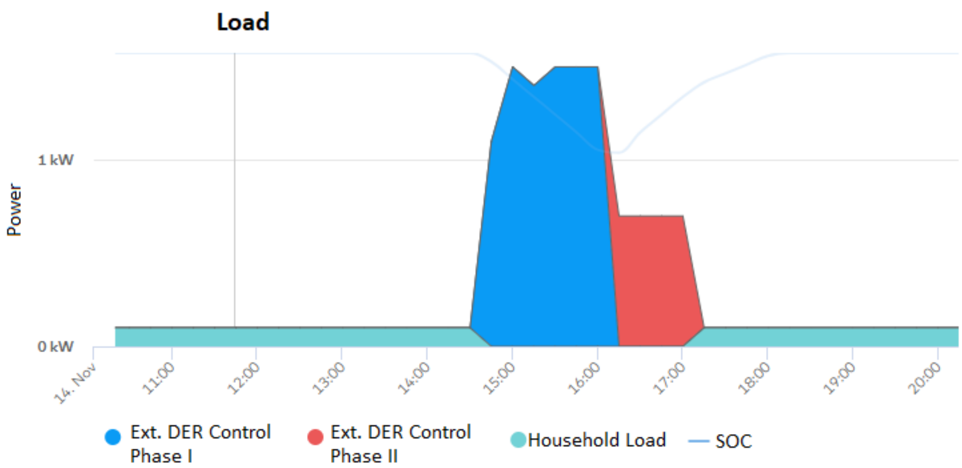


Figure 2-3: Control of Load via HEMS

The major problem was that there were still no common standards for controlling systems externally from the grid side. Settings had to be made individually for each device. The compatibility of inverters with third-party HEMS is limited. Combined with the low customer participation, a test could therefore only be carried out with a few systems.

What has the German demonstrator learned?

The functional principle of the developed flexibility value chain has been successfully demonstrated. With the used algorithms it is possible to predict probability of congestion and assess the temporal and locational flexibility needs in the LV grid. In addition, it is possible to estimate the headroom for the upstream grid level. In Germany the rollout of smart meters is at a very early stage still. To further improve the forecasts, smart meter data must be available on a larger scale.

At the same time, the results indicate that LV network specifics ask for a deviation from established solutions used for higher voltage levels. Especially more probabilistic approaches, which are still largely unknown, and a certain degree of uncertainty must be accepted. This implies also that DSOs and policy makers should foresee a back-up option for emergency control after the market phase.

The demonstration showed, using NODES' market platform, that local flexibility markets can be used to complement congestion management for DSOs. The UMEI helps by creating an approach for a simple connection. However, standardization and incentives for end customers still need to be significantly increased to ensure sufficient market liquidity. Finally, a connection and coordination scheme with other wholesale markets still needs to be established.

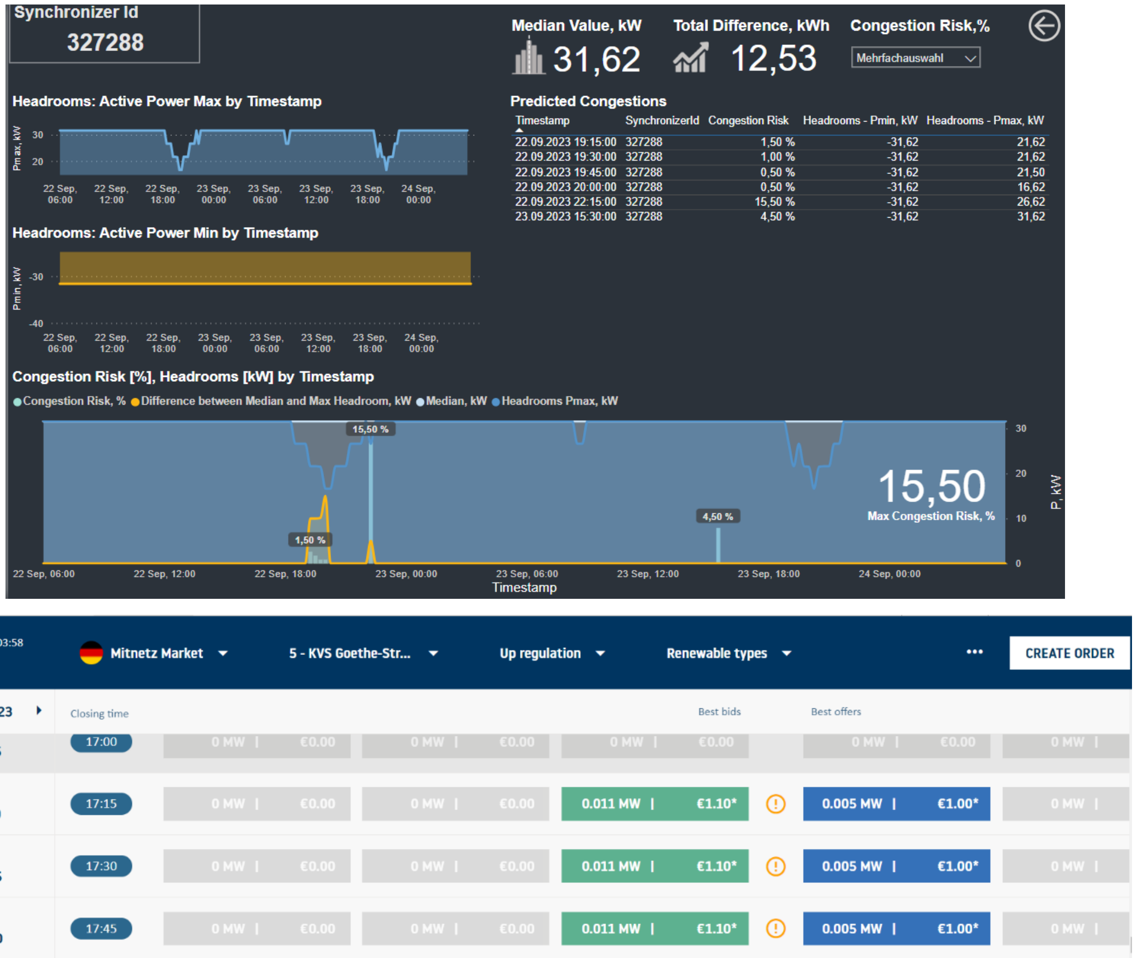


Figure 2-4: Predicted congestion September 22 2023 and created market requests on NODES market[4]

[4] Retrieved from www.nodesmarket.com

2.2.2 Portuguese demonstrator

The main objective of the Portuguese DEMO was the demonstration of flexibility procurement to solve grid constraints, supporting operation and medium/long-term investment planning. Four operational objectives can be derived: (1) Demonstrate day-ahead congestion management and integrated voltage Control in MV and LV grids (2) Contracting flexibility services to avoid voltage and/or congestion issues during planned maintenance action in MV grids (3) Congestion Management for medium /long-term grid planning through market mechanisms (4) Demonstrate integrated and interoperable operation between DSO toolbox, Market and Aggregators Platforms through UMEI. To achieve such ambitious goals, a strong collaboration between the different actors of the demo framework (see Figure 2-5) was implemented, ensuring seamless integration between all blocks of the architecture. Both NODES and N-SIDE market platforms have been tested in parallel. The NODES platform includes ShortFlex and LongFlex markets (specific NODES terminology) with continuous trading of flexibility across distinct timeframes. The most cost-efficient solution is selected and validated by the DSO to solve the predicted grid congestion. N-SIDE's Local Flexibility Market platform aims to help solve grid problems by offering an auction-based mechanism that facilitates the matching of the DSO's expressed needs with the FSPs/aggregators' offers through an algorithm that maximizes the social welfare. The algorithm considers the flexibility offers which the FSPs can provide based on the asset location concerning the congestion. It yields the dispatch solution considering a pay-as-clear remuneration mechanism. The relationship between both MV and LV clients and the market is assured by an aggregator, Centrica, which operates on both platforms.

The DSO toolbox implemented forecasted grid constraints and quantified the flexibility needs to solve them, assuring the coordination between LV and MV grids. Engie developed MV multi-temporal OPF to define the grid assets control plan. If needed the MV flexibility scheduling from INESC TEC determines MV flexibility needs or selects the bids (depending on market platform assigned). A data-driven approach was successfully tested for LV grids, considering smart metering historical data, namely LV forecast and DdVC (Data-driven Voltage Control).

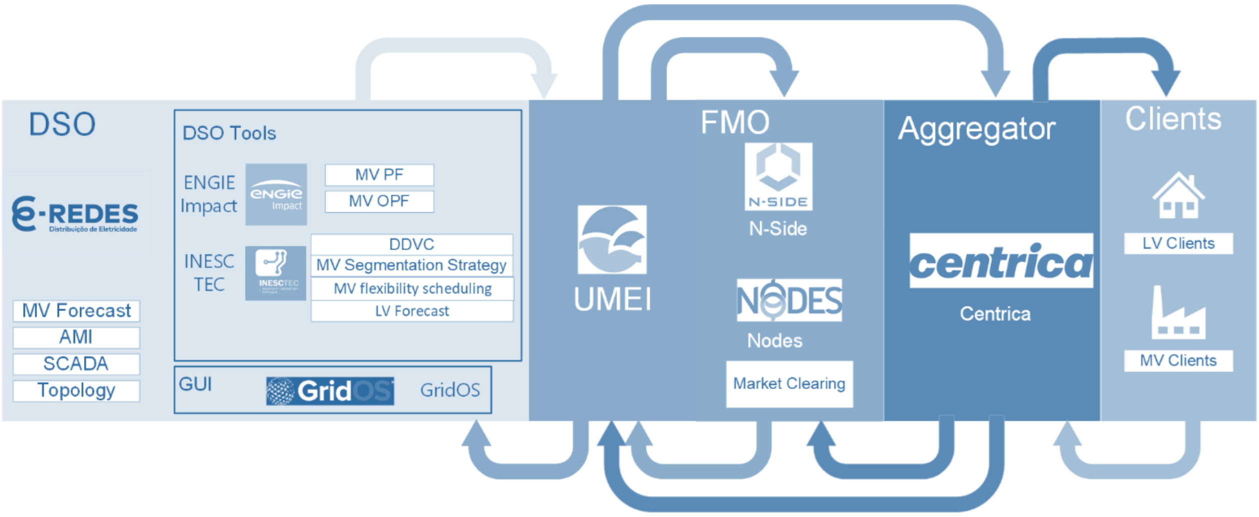


Figure 2-5: general workflow Portuguese demonstrator.

To enable the operation of two distinct Flexibility market platforms different timelines were tested.

Case with N-Side market platform

When using N-side market platform, the tools first determine the necessary flexibility to solve the expected grid constraints without knowing the selling bids. The needs are presented by the market platform, to allow aggregators to submit their offers considering the network areas and hours where grid constraints are expected. Its implementation required N-SIDE platform to implement the concept proposed of the **semi-dynamic flex zones**, adapting its market clearing process, to include the areas defined and the grid technical limits. **Demonstration shows that this approach allows aggregation of bids per area even in LV networks and market clearing considering abstract grid knowledge and avoiding further constraints**. However, in a market with low liquidity, due to reduced number of participants, the areas may not include a significant number of bids, or even remain without bids. **This approach is therefore only representative in network areas with a higher number of participants.** Issues such as the risk of market manipulation when compared to other market designs need to be further assessed.

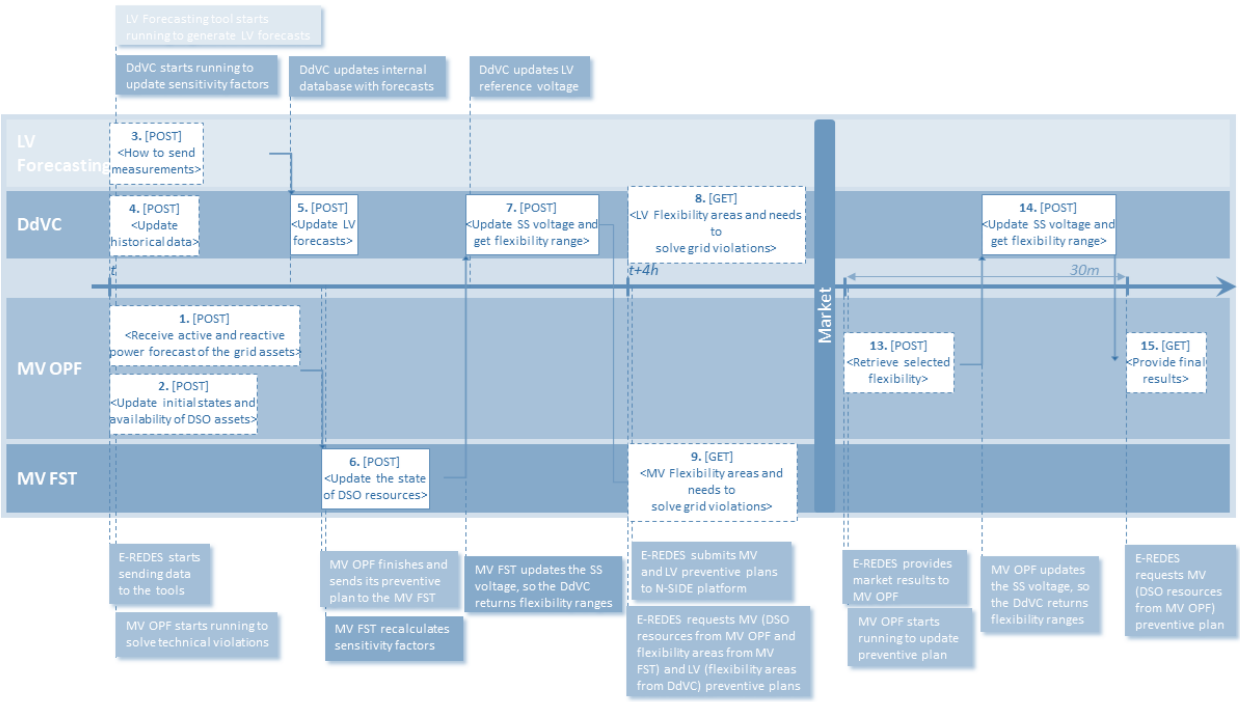


Figure 2-6: Timeline of the interaction between the different tools till the final MV and LV preventive plans to submit to N-SIDE platform.

Case with NODES market platform

When using Nodes market platform, flexibility offers are first presented and then selected by the DSO to solve the expected grid constraints. NODES, as independent market operator, provides the central environment for market-based procurement of flexibility ensuring correct and transparent transactions between buyers and sellers. Using NODES integrated market design, flexibility can be offered bottom-up and bought top-down allowing for an efficient use of the available flexibility resources across all grid levels. Due to limited market liquidity, at this point in time, NODES only applies a continuous market clearing via pay-as-bid. The flexibility offers are then selected by the DSO considering its location, volume and price that has been submitted to the market platform by the flexibility providers through the UMEI. The DSO tools then selected the bids per node that minimize the cost of operation for the next day. In this approach aggregation is only allowed then for LV consumers connected to the same MV/LV substation to provide support to the upstream MV network. This approach provides to DSO a more transparent process, giving full control over flexibility offers selection. In a grid where the number of participants is small, the optimization problem tractability is manageable. However, as the number of participants increase, the optimization problem needs to adopt adequate strategies to produce viable solutions, as the ones demonstrated within the pilot, namely MV flexibility scheduling and DdVC that use a linear model based in current and voltage sensitivity matrixes.

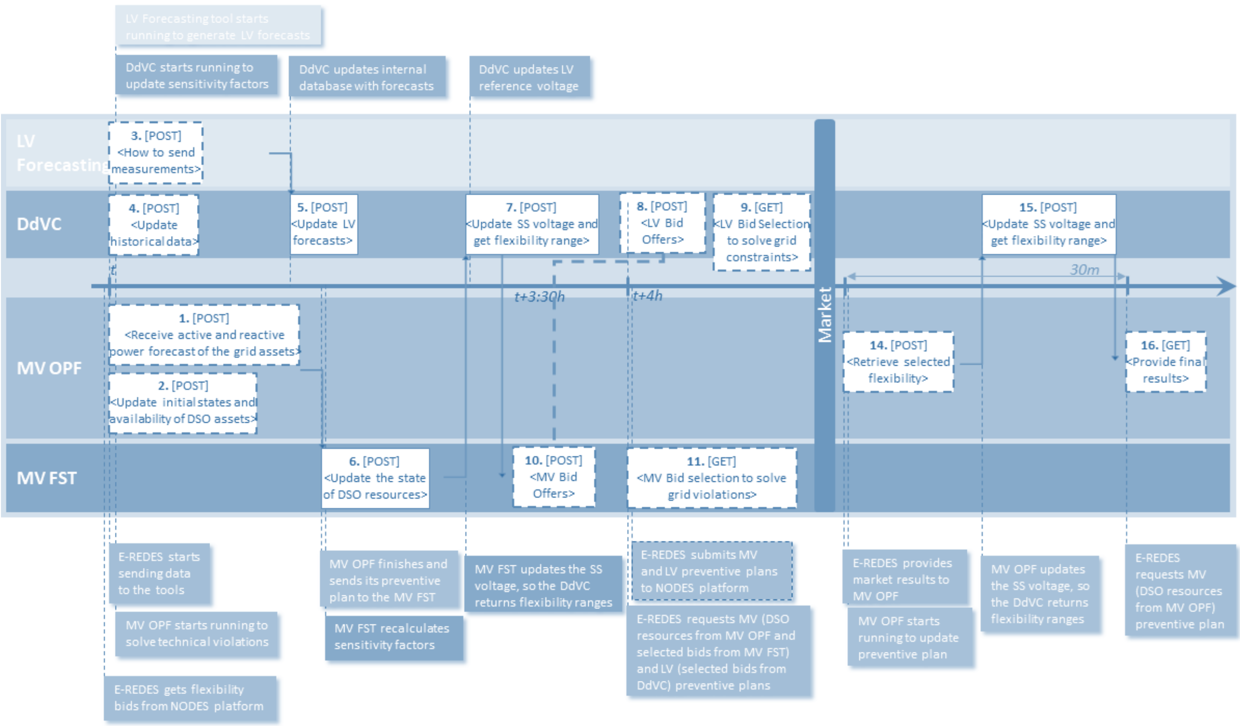


Figure 2-7: Timeline of the interaction between the different tools till the final MV and LV flexibility bids selection to submit to NODES platform.

BUC3 – Flexibility to support planned maintenance

The main objective of BUC 3 was to demonstrate the participation of market-based flexibility services for the support of maintenance activities. Planning network maintenance activities requires an analysis of the network reconfiguration capabilities and contingency plans. This often implies scheduling the work during weekends or off-peak hours when the maintenance crew's costs are higher. A new approach to maintenance planning was evaluated in the demo, showing that the participation of flexibility offered in local flexible markets may allow to move field work during periods where the maintenance crew prices are lower, in weekdays, reducing load curtailment requirements. To do so, the DSO with the MV maintenance planning tool defines a viable set of alternative periods to perform maintenance, identifying the network reconfiguration solution that minimizes the Energy Not Distributed (END) and the flexibility needs for each period. The flexibility needs were then submitted to NODES LongFlex market and finally selected by the DSO for the maintenance period. This approach allowed for considering more realistic load profiles, based in historical data, and consequently of more accurate network reconfiguration plan.

Two different maintenance works were tested, namely: maintenance of MV switch at the HV/MV substation of Évora MV network and the maintenance of an overhead MV line switch of Mafra MV network. A maximum of 2,2 MWh requested by the DSO at a maximum flex bid of 1343 €/MW for the maintenance of the MV line switch.

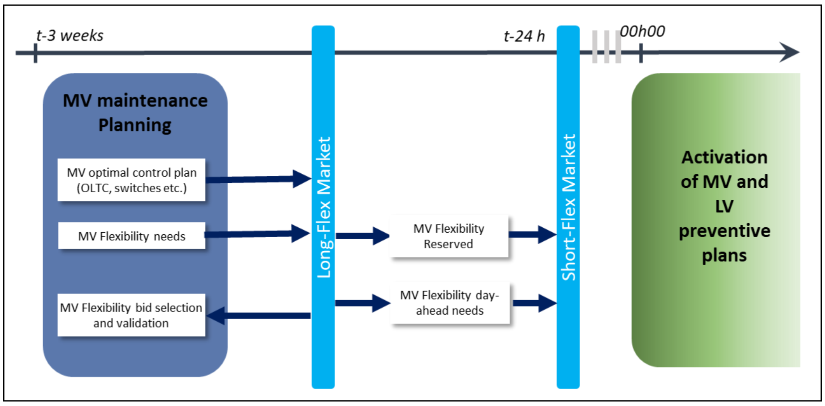


Figure 2-8: Coordination between long-term and short-term flexibility markets for flexibility procurement.

As expected from the demo results, flexibility reservation had higher bidding prices for longer maintenance actions, leading to higher END. The offers selected are reserved and renegotiated in the Short-flex market, allowing the DSO to procure the most economical flexibility bids.

Figure 2-9: Example of Flexibility request submitted by the DSO on the 13/11/2023 in NODES Long-Flex platform.

BUC4 – Long-term planning with flexibility

Flexibility products can be considered as an alternative asset to grid reinforcement. The mobilization of flexibility in NODES long-term flexibility market, as foreseen in BUC4 was tested for Évora and Alcochete MV networks. Following the methodology represented in Figure 2-9, first the base scenario was determined for the planning horizon and identified the main constraints. The conventional grid reinforcement solution to solve the constraints considered was to replace a section of the overhead line to increase its capacity. In alternative to grid reinforcement, the flexibility needed to solve congestion and voltage constraints were determined.

The maximum cost for flexibility determined was based on the energy losses reduction cost resulting from the increase of line capacity. This was determined in alternative of the total cost of investment, considering that the implementation of Flexibility Market Platform and related infrastructure was not quantified in this project. The long-term flexibility needs were submitted in the market for the month of November. A maximum participation of 42h per year were requested for both MV networks, with a maximum request of 155kW during one hour in Évora network.

Long-term flexibility procurement was successfully demonstrated. However, pilot networks are well sized and operate with a secure capacity margin. Flexibility participation will benefit networks with higher risk of congestion and with a higher number of market participants. The limited number of Flexibility providers also limited the results obtained.

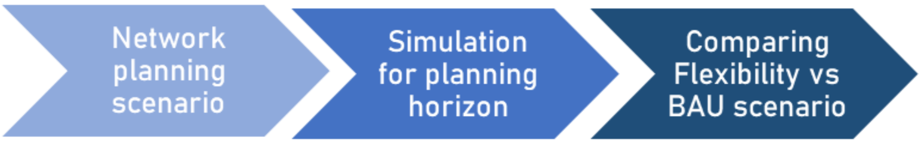


Figure 2-10: Methodology for the identification of long-term flexibility needs

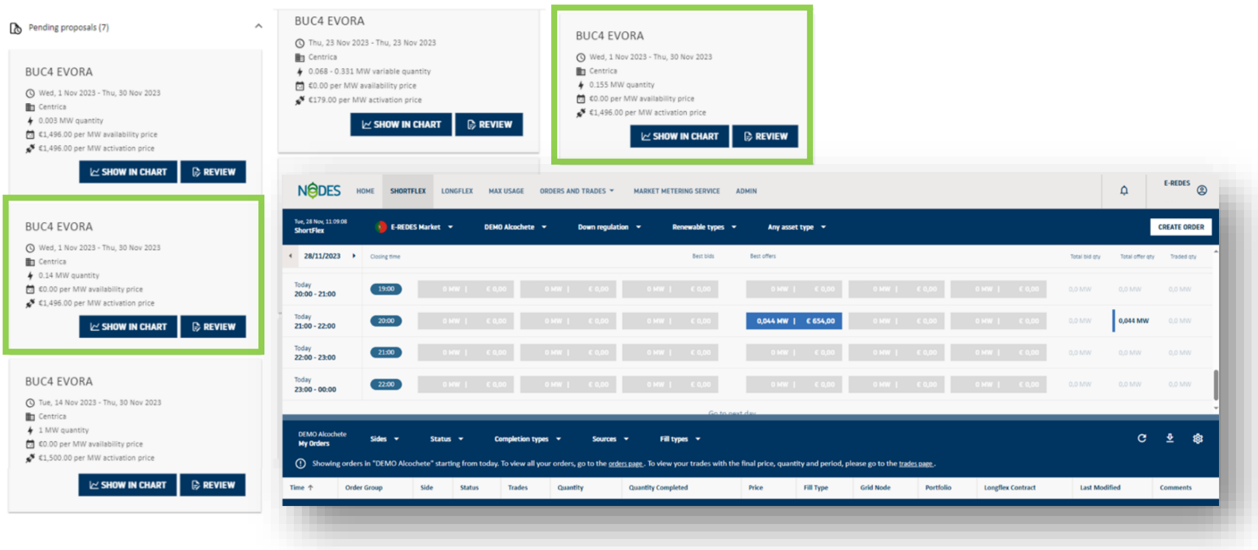


Figure 2-11: Long-term flexibility bids received for Évora Network and bids automatic transition from Long-flex to Short-term flex in Alcochete network.

What has the Portuguese demonstrator learned?

The Portuguese demonstrator established very ambitious goals, involving the demonstration of new DSO tools developed within the project, two Flexibility Market Platforms, one Aggregation Platform connected through the UMEI. **Demonstration was implemented in different regions of the country, involving 5 MV networks and 9 LV networks that supply approximately 200 MV/LV substations and 1189 LV consumers,** from which 40 accepted to participate in the project. This resulted in the **processing of a high volume of data performed by the data exchange platform and tools, enabling both the functional validation of the use cases and the identification of the challenges related with their replicability**. Different challenges needed to be overcome along the project, starting from the pilot architecture specification and data requirements identification, discussion of GDPR issues and preparing the guidelines to share sensitive smart metering data, implementation and deployment of tools and finally integrated testing of all demo components. Some specific conclusions can then be derived:

- The UMEI was successfully demonstrated, enabling communication and data exchange between DSO, Flexibility Markets and Flexibility Aggregation Platform. The APIs specification development benefit from collaboration of the different platforms involved, incorporating their internal specifications and experience from other projects.
- Pilot implementation involved the deployment of a data exchange platform interlinking internal DSO systems, as AMI, SCADA and MV load and generation forecast, that provide the input data for the DSO toolbox. At the same time, it also ensures the interaction with external platforms, through the UMEI. All data exchange processes are GDPR compliant. Daily collection of smart metering and MV consumer metering data is a time-consuming process that need to be considered in the specification of the final tool and market interaction timeline. Tools need to be able to deal with incomplete datasets while ensuring the quality of results, such as forecasts and day-ahead network operation planning and flexibility needs estimation. Longer demonstration period would be needed to derive more relevant conclusions on the impact of forecast errors in the flexibility mobilization solution.
- Two different timelines for the short-term flexibility procurement were successfully demonstrated. Timeline definition depended on the computation time of data inputs and DSO tools and market processing. Replicability will probably require adjusting to market size, participants and network area involved. Although a longer demonstration period with higher number of participants would allow to derive more solid conclusions on the results obtained, all the steps were tested both individually and integrated, leading finally to the activation of selected bids.
- The data-driven approach implemented to improve LV network observability and control, based on the LV voltage forecast and Data-Driven Voltage Control (DdVC) tools was successfully demonstrated. This approach is based on smart metering data with the potential to reduce monitoring requirements, without requirement full characterization of network. This is a competitive advantage against some commercial solutions offered today in the market for LV networks. However, further developments should include the integration of other sources of data, to enable its implementation when smart metering infrastructures are not fully deployed.
- Consumer engagement is key for future large-scale demonstration of the framework developed and tested in the PT demo.

2.2.3 Polish demonstrator

The objectives of the Polish EUniversal demonstrator were: to facilitate the delivery of flexibility services utilizing the MV network infrastructure; to ascertain the flexibility available in the transmission capacity of HV lines using the Dynamic Line Rating (DLR) to reduce curtailment of big Wind Farm; and to validate the concept of improving the observability and preparedness of the LV substation for its role in providing flexibility services. To achieve this, 3 BUCs were tested and are discussed below: BUC PL AP Congestion Management & Voltage Control with market-based active/reactive power flexibility; BUC PL DLR Congestion management using permissible line capacity based on Dynamic Line Rating (DLR) system; BUC PL FS Voltage Control with the use of flexstation solutions.

BUC PL AP/RP

Congestion Management & Voltage Control with market-based active/reactive power flexibility

The demonstration area covered two wind Farms, Biogas Power Plant, a few industrial customers, and the Flexibility Service Provider. The testing of the functionality of this BUC was split into the following tests:

- Network state forecasting based on load and weather forecasts
- Congestion detection and flexibility needs identification
- Market-based flexibility procurement on NODES market platform via the UMEI

The verification of the network state forecasting based on load and weather forecasts was done by checking on the graph the obtained results for selected measurement points. The forecasted values were within technically reasonable limits.

The power flow (PF) module was used to detect the overloads. Calculated (forecasted) power flows are compared with the rated data of individual elements of the network, such as cable/overhead lines, and transformers. Congestion detection and the demand for flexibility services are based on the forecasted generation and load values in the power network, determined by the previously described methods.

Market-based flexibility procurement on NODES market platform via the UMEI used in the Polish Demonstrator ensured correct and transparent transactions between buyers and sellers. Using NODES integrated market design, shown in Figure 2-12 flexibility in the test condition was offered, allowing for an efficient use of the available flexibility resources across all grid levels.

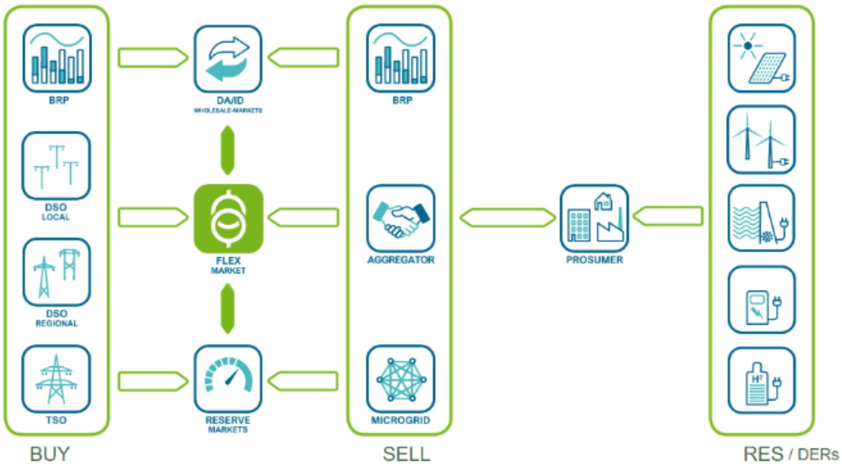


Figure 2-12: NODES integrated market design

The screenshots (Figure 2-13) below show an example of the power increase service purchase transaction seen from the FSP on the NODES platform and the DSO in the AMS system.

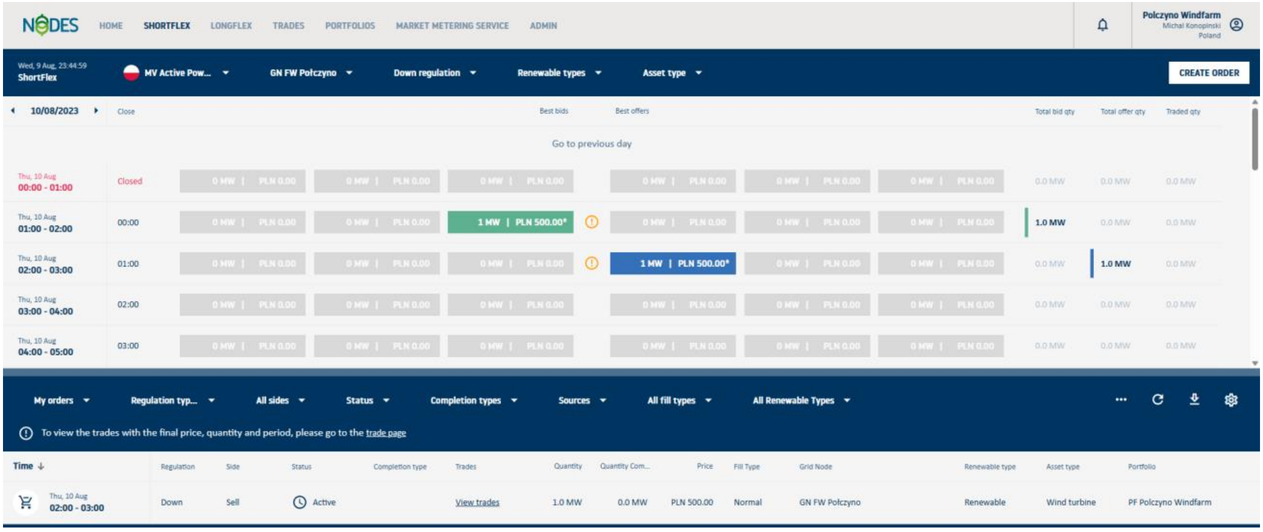


Figure 2-13: Screenshot NODES market interface

BUC PL DLR

Congestion management using permissible line capacity based on Dynamic Line Rating (DLR) system

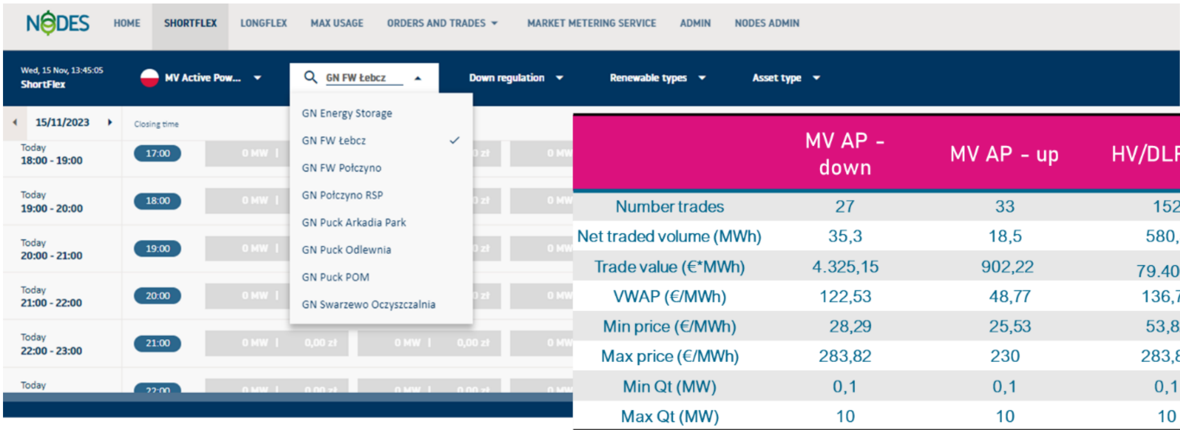
Tests were conducted in mid-summer 2023 and involved ENERGA, the seller of the flexibility services, wind farm (WF) Kukinia, and WF Karścino, acting as the buyer. During the test run the duties of the buyer were simulated, but real needs and the testing environment were arranged including real weather condition forecasts and expected (calculated) power flow. Two scenarios involving distinct network topologies and varied power flow directions were considered.

The process of handling the wind farm producer's notification of the intention to produce energy on contractual terms was supported by the NODES service platform used as part of the EUniversal project. The Universal Market Enabling Interface (UMEI) was used to test its applicability regarding information exchange and flexibility trading in local flexibility markets (MV markets for Active and Reactive Power and HV market for DLR) with different market settings.

The use of DLR to allow more injection of wind farms showed effectiveness when the wind farms, taking advantage of good wind conditions, operate at a power close to the rated power, and at the same time the transmission line conductors are cooled more intensively than in calm (warm) weather where the absence of wind is cooling the lines less. Determining the dynamic load capacity of lines to manage transmission constraints and provide flexibility services allowed for achieving benefits such as preventing network overloads, especially lines, improving the quality of energy supply, or limiting or postponing network investments.

The BUC-related KPI assesses the RES-generated energy above the connection agreement value. The value calculated based on the test results showed an 8% increase in the total yearly production above the connection agreement value only due to the power line flexibility management. Figure 2-14 contains the list of the transactions on the NODES platform related with the flexibility services buy/sell order and Figure 2-15 gives an overview of this BUC together with the previously discussed AP BUC. It can therefore be concluded that a good way to optimally use the HV lines and to obtain flexibility is to utilise the permissible line capacity calculated on the basis of current or forecasted weather conditions.

Figure 2-14: Tested transactions in the HV/DLR market on the NODES market platform



	MV AP - down	MV AP - up	HV/DLR AP
Number trades	27	33	152
Net traded volume (MWh)	35,3	18,5	580,5
Trade value (€*MWh)	4.325,15	902,22	79.400,37
VWAP (€/MWh)	122,53	48,77	136,78
Min price (€/MWh)	28,29	25,53	53,82
Max price (€/MWh)	283,82	230	283,82
Min Qt (MW)	0,1	0,1	0,1
Max Qt (MW)	10	10	10

Figure 2-15: Overview trades Poland BUC AP and DLR

BUC PL FS

Voltage Control with the use of FlexStation solutions

The main goal of the test is to evaluate how LV at the client premises can be controlled with the use of an MV/LV transformer with an OLTC to mitigate voltage issues and maximize PV generation by preventing the switch-off of the PV installation caused by inverters' overvoltage protection.

Voltage control using OLTC was deployed in three installations of secondary substations implemented as part of the EUniversal project. Since the very beginning, the algorithm was in the mode "live".

Energy meter measurements were continuously collected in the test database by communication software installed on a central dedicated server in the DMZ of the Distribution System Operator (DSO) technological network via a data concentrator located at the substation.

Figure 2-16 shows the operation of the voltage regulation system at one of the Flex Station (MV/LV Linia) on September 17 (Sunday). The regulation is correct (red line), and the voltage is within the dead zone (green lines). The tap changer operates in the range from tap 1 to tap 4, i.e., in the area of lowering the voltage by 14 V. Lack of OLTC regulation with permanently setting it on tap 5 (= the middle position which was used only for test purposes to experience what would happen when there was no voltage control and OLTC device) resulted in voltage exceedances in the hours from 10 a.m. to 3 p.m. by about 10 V, resulting in prosumer inverters being turned off.

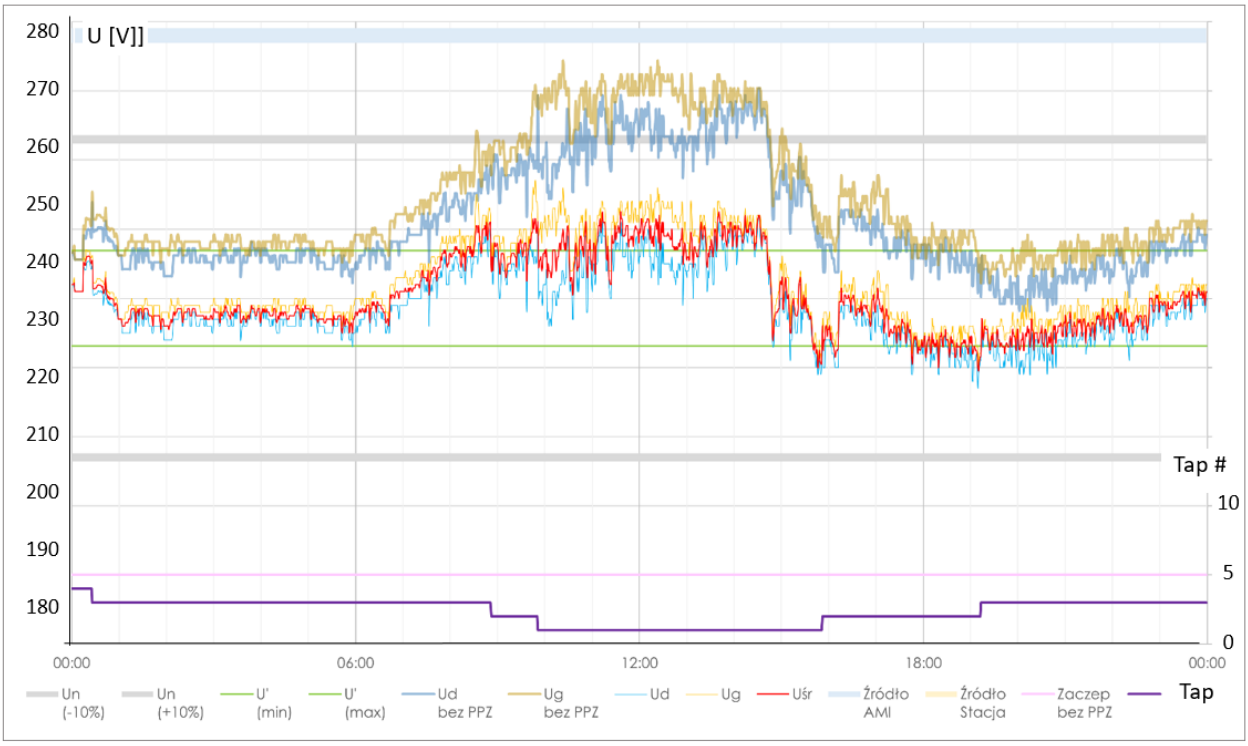


Figure 2-16: Voltage waveforms FS Linia

Voltage control using OLTC of the MV/LV transformer correctly regulates the voltage in the network, responding to changes in generation and loads. The operation of the algorithm based on voltage measurements deep in the network plays a key role here.

Measurements from AMI meters are an effective source of voltage for the control algorithm with a one-minute resolution, despite observed interruptions in PLC communication.

The presented test results and KPIs calculated indicate that power control using OLTC based on the voltage measurement in the depth of the LV network, mostly at the POC of the PV, protects against power limit violation and thus provides the possibility of uninterrupted operation of the PV installation with no power limitations and without the need to manage reactive power. It can therefore be concluded that joint voltage control in the MV/LV and the HV/MV substations based on the value and flow direction of the active power in the MV level, better fulfil the voltage maintenance requirement.

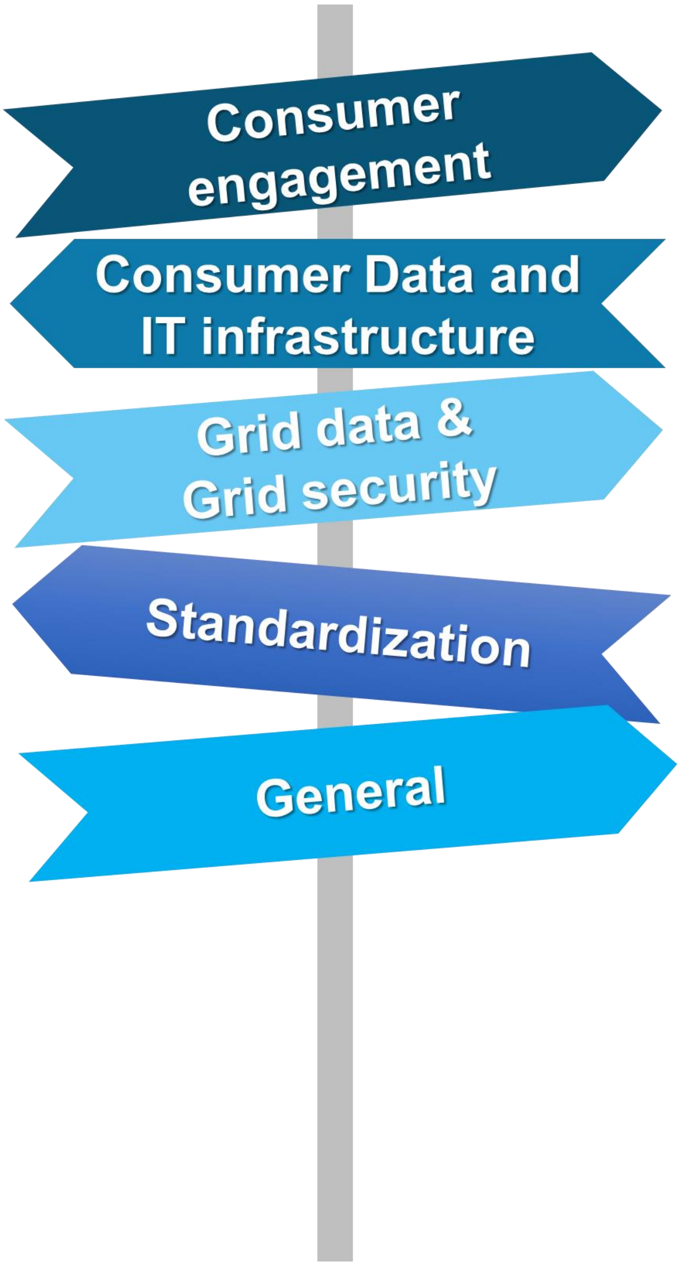
2.3 SWOT

As part of the business and exploitation plan, each KER also developed a SWOT analysis to better understand its strengths and opportunities to be exploited, in addition to weaknesses and threats to be addressed.

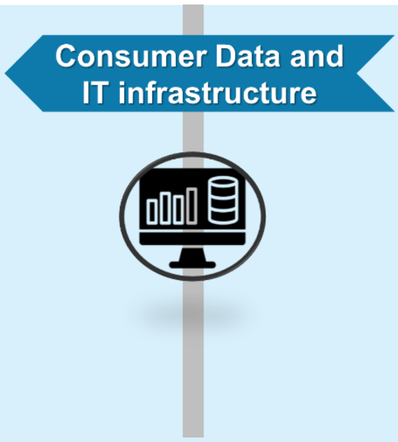
Insights from this analysis lead to the key lessons learned (KLL) discussed in the next chapter. For the interested reader, all the separate SWOT analyses are summarized per KER in Annex 3 Completed KER templates from all partners. In what follows, we analyze all SWOTs combined. The insights from this analysis are taken further in the KLL and the exploitation plans.

Below, all SWOT-insights are discussed in 6 topics: consumer engagement, consumer data and IT infrastructure, grid data and grid security, standardization, and more broader and general topics.

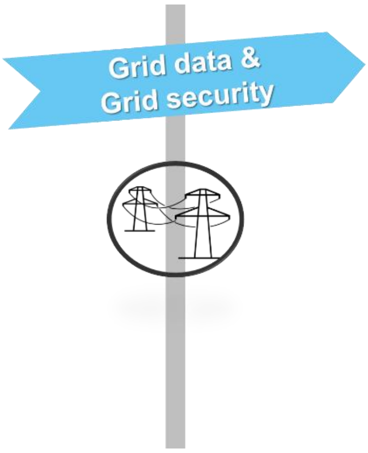
At the end of this section, all SWOT-insights are summarized in a table where the general challenges that need to be overcome are summarized, and the EUniversal solutions are indicated.



First, a key topic that comes back over most KERs, is the topic of **consumer engagement**. Some call it a threat or weakness, some call it an opportunity by suggesting ways to improve consumer engagement. Yet, the key message is clear: consumer engagement is indispensable to ensure the required amount of market liquidity. This is both necessary for pilot and demonstration projects to test new tools and market designs, as well as for real-life implementation of flexibility markets. As a result, consumer engagement is not only pointed out as an issue in the FSP and market pillar, but also in the DSO-toolbox pillar. Opportunities to increase consumer engagement lay in incentivizing FSPs so that offering flexibility becomes interesting for them, but also in further encouraging investments in renewable and flexible assets (such as heat pumps) that give LV-consumers more means to actively participate in markets. Furthermore, taking care of market participation in regulatory development is highlighted as important. While the fact that Europe is pushing for more consumer engagement is seen as a major opportunity, it seems that at national level, regulation is not always sufficiently encouraging and only slowly implemented. In addition, market-based regulation is not always in line with other non-market-based mechanisms (such as redispatch 2.0 in Germany). Country-specific applications can hamper implementation to different countries. Furthermore, the fact that future trends and political impacts are hard to foresee is indicated as an additional threat. From the perspective of the consumer, it is necessary that end-user comfort level is not decreased. Some of the EUniversal KERs ensure this (for instance the aggregation algorithm ensures effective and efficient use of FSP resources while considering end-user comfort level). The OBR is also optimizing flexibility resources to increase market liquidity. Yet, further smart control and automation are necessary to take flexibility markets to the next level.



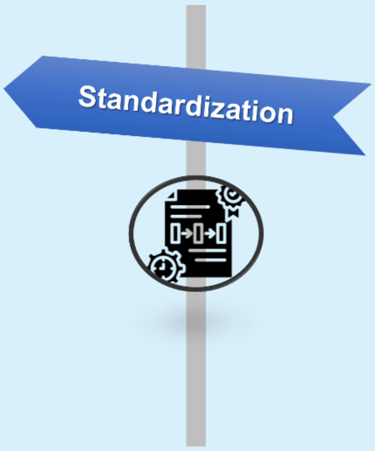
Highly linked to this is the topic of **data and measurements**. Here, a distinction is made between consumer data, and grid data. When it comes to **consumer data**, in member states where there is a lack of smart meters operated by the grid operator, lack of data was highlighted as a severe hurdle as they decrease observability and standardized control. Closely linked to this issue is the reduced number of sub-metering and control equipment deployed at households for remotely monitoring and controlling consumers flexible resources currently. Also, the lack of standardized communication and data exchange represents one of the main barriers for the integration of flexibility from LV consumers. In this respect, IT infrastructure was judged to be rather basic, and its improvement would be a major opportunity. However, advanced development of smart meters was also indicated to empower the development of flexibility tools. In addition, from the DSO perspective, all demos had to set up a mediation infrastructure within their internal DSO environment to receive and collect customer and technical data (from smart meters and from other sources). Today, DSOs do not have a system which can automatically integrate these data (consumer meter reading, baseline data…). If flexibility markets are to be deployed in the very short run, all DSOs would need to do this, or smaller DSOs would need to find external partners who can support them in doing so. For flexibility markets in general, especially for smaller DSOs who do not have the means to set up such mediation infrastructure, this could be a significant barrier. In the long run, this could be solved by ASM (automated system management) systems. For the EUniversal project, it is nevertheless a strength as the project DSOs set up these systems today already. Furthermore, in order to have a transparent flexibility market, some consumer data needed to be shared with external partners (injection and offtake profiles, baseline data…). Yet, GDPR makes this very hard and time consuming. Furthermore, from a market perspective, it is to be noted that the project only tested congestion management and voltage control markets. In practice, data infrastructure, consumer data, etc. are not only used on, for instance, a congestion market but also on other markets or platforms. Coordination is therefore important, and this is a topic not examined within the EUniversal project.



When it comes to **grid data**, it is to be highlighted that grid observability is often very low, especially in lower voltage grids. While this is a big weakness, the EUniversal project identified it as an opportunity and a strength of EUniversal as it aims to develop solutions that require only limited data. For predictability of flexibility needs and to ensure that flexibility activation is not causing additional grid constraints, grid data are important to increase observability. However, especially at LV-level, grid observability is often limited. In the DSO-toolbox, several tools were presented and tested throughout the project to contribute to solutions for this issue. Solutions were sought and found in reducing the needs for additional measurement equipment, and in improving forecasts (for instance by testing the network topology optimizer, by looking in different timeframes to forecasted grid uses, integrating additional weather data, or by improving forecasts under conditions of numerous unknowns…). Furthermore, methodologies and tools were further improved to be customized to different grid environments and operational context. Moreover, some of the KERs ensured that there was no dependency anymore on full knowledge of grid and network conditions/topology or decreased the need of human intervention in phase identification. While these are indisputable key strengths, mostly of the DSO-toolbox pillar, further work is still needed for some tools as identified weaknesses are for instance the increased reliance on historical data, which could have suffered from potential errors.

Furthermore, it should not be forgotten that in the end, the most important point remains **grid-security**. Through reinforcing flexibility markets and by further developing tools in the DSO-toolbox, the EUniversal project contributes to increasing DSOs' possibilities for congestion management and voltage control to have a solution until grid reinforcements become necessary or completed. This is therefore frequently highlighted as a strength. The fact that current regulation requires DSOs to operate networks in a more dynamic way, utilizing flexibility, increases opportunities for many tool developers to assist DSOs in doing so. In this regard, many KER owners indicated that DSOs are open to the use of decision support tools, certainly when they improve their operational efficiency. DSOs recognize the importance of network observability in all grids and are accustomed to data driven applications as support tools. This is important as further development of their tools and methodologies is dependent upon stakeholder awareness, acceptance and collaboration. Nevertheless, it is indicated that some potential customers still lack knowledge and awareness about the need and opportunities that these tools can offer. Furthermore, some KERs highlight as a strength that they managed to reduce computational burden, even though many DSO tools and calculations are still computationally very intensive. Often complex tools are required, with mathematical optimizations that decrease transparency and interpretability for other stakeholders. Although increasing transparency was not a key goal of the project, the EUniversal project did manage to increase transparency indirectly by facilitating complex calculations. Finally, given the complex calculations, there is also a concern that this might increase challenges when markets are being scaled up. Especially for highly data-driven tools that are based on historical data, this remains a challenge.

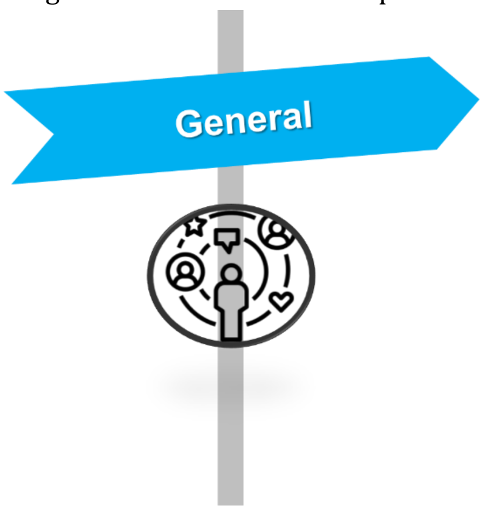
Given this complexity and their responsibility of ensuring grid-security, DSOs have a strong preference to remain in full control of their grid data. The EUniversal project devoted, through discussions on market mechanisms and tools development, a lot of attention to this issue. An additional strength of some of the tools is therefore that they allow for market-based solutions without sharing detailed network information, thus enabling compliance with legal and data protection obligations without losing the advantages in pricing and efficiency (if liquidity is high enough). Other KERs focus on further improving long-term efficient solutions for, for instance, grid congestions that include demand side response.



As the EUniversal project aimed to increase replicability of flexibility markets in different environments by setting up a standardized interface, **standardization** was a major topic of discussion throughout the project. It was, therefore, also ensured that the tools were interoperable. Most of the tools make use of commercial software such as Python which are accessible to many stakeholders, and which ensure further maintenance of the platforms on which the tools are based. Yet, for some KERs, it was indicated that this also reduced the modelling environment flexibility, while for other KERs it was indicated that this increased adaptability of the tools. Tool adaptability is important as there is a lot of heterogeneity in the grid, regulation and local context. Most tools highlight the strength of being modular so they can easily be adapted to different markets, different natural hazards, different grids etc, increasing its adaptability to new and existing systems and technologies, and facilitating adding new functionalities. Yet, on the other hand, looking at for instance the UMEI, it should be noted that open standards could also allow for free manipulation which could be a severe threat. While standardization was something EUniversal aimed to contribute at, the lack of it in interfaces, regulation and technology, was also indicated as a major weakness and threat as it made the implementation process of the demos and the testing of the tools more complicated. When implementing applications at the FSP side, they always had to adapt. Adapting client's old technologies is difficult and costly, and moreover inefficient. Finally, the lack of standardization in regulation and immature market and local specifications of flexibility services leads to a wide range of options that may not be universally applicable. The need of standardization must be balanced with the freedom for innovation in immature markets, and similarly, overregulation of products and services can also be a threat.

The data challenges are closely linked to the need for more **transparency** in flexibility markets. One of the points of discussion was the clearing of the market. Up to today, there is currently still a lot of input needed from the DSO as they need complex calculations to clear the market decreasing transparency (for instance the calculation of the headrooms in the OBR tool).

Throughout the development of all the KERs, a frequent challenge is the fact that the complex and fast-moving environment require a **combination of expertise from modelling, regulation and power systems**. Often, specialized knowledge and experience is required. While the EUniversal consortium provided the required expertise, a weakness to implement all the KERs in the future is the current lack of trained work forces for implementation. In addition, knowledge needs to be built up and some concepts need to be further proven and implemented outside the current testing environment, especially if they will serve as guide for future regulations. Furthermore, a more general concern of most KER owners was that the current market recession reduces innovation and investment into energy markets. In this sense, an identified opportunity was that some KERs do not require significant financial investments from DSOs. Finally, a key strength of the project was that different international stakeholders, even competitors, worked together to find standardized agreements for the UMEI and other tools within the project. This is indispensable if we want to strive for a harmonized EU-market.



	Economic and market	Regulatory	Technical
Consumer engagement	• Flexibility incentives and investment incentives in renewable and flexible assets are not sufficiently present • Appropriate budget and resources allocation for consumer engagement processes is missing	• Slow implementation of CEP in national regulation and link with non-market-based mechanisms • GDPR constraints make consumer engagement difficult in energy projects	• Lack of smart control, standardization and automation increase required efforts and decrease comfort • Lack of knowledge of flexibility concept and low potential benefits for consumers • Optimization of flexibility resources without reducing comfort
Consumer Data & IT infrastructure	• Coordination between different markets is missing	• GDPR makes it hard to share data with external partners	• Lack of smart meters • Lack of remote control and standardized interfaces • Possibility of creating an intermediate system in the DSO-environment even without an ASM system
Grid Data & IT infrastructure (Grid security)	• Delaying needs for grid reinforcement investments • Not all tools require significant financial investments • Proven that a market-based solutions without sharing detailed network information is possible	• Regulation favors grid investments, but CEP encourages use of flexibility • Market regulation makes sharing of grid topology with FSPs hard • Even though not all data are easy to share, the UMEI proves that it is possible to exchange data through a distributed approach of data handling.	• Complex calculations increase challenges when scaling up markets. • Increased transparency thanks to facilitation of complex calculations • Grid observability is indispensable, yet EUniversal proposes different solutions to increased observability and predictability.
Standardization and adaptability	• Immature markets still in need of innovation: risk of overregulation of products and services • Ensuring different market platforms can interact with the same stakeholders in the same region	• Lack of standardization in interfaces, technologies or regulation complicates implementation of flexibility markets.	• Interoperability between tools • The UMEI facilitated communication and interaction between multiple involved stakeholders
General	• Combination of expertise from modelling, regulation and power systems required to implement flexibility markets and present in the project • Stakeholders with different interests and even competitors worked together during the project • Long run trained work forces • Market recession could reduce innovation and investments in energy markets		

3 Key Lessons Learned

3.1 Pillar 1: UMEI

To set up and run a local flexibility market, different types of stakeholders (SOs, FSPs, market operators and facilitating third parties[5]) must be brought together. They all need to be able to communicate and interact with each other to understand each other's needs and offers. Without a facilitating interface such as the UMEI, stakeholders would have to implement different communication/interaction processes for each market platform. DSOs and aggregators would need to add an additional layer of data management to adapt communication to the specific requirements of each market platform.

In the absence of rules and standards, technology providers have developed all kinds of solutions to offer to the industry. The result of this is that there is a large diversity of technologies and tools being implemented limiting the interoperability of solutions of different technology providers. This enforces stakeholders to start from scratch most times and to build further on their own communication / interaction systems. The lack of this standardization creates a large barrier due to the additional costs for the implementation of flexibility markets, and increases the risk of a lock-in on one specific market platform.

As demonstrated throughout the EUniversal project, the UMEI offers a solution for this challenge. While implementing and developing the UMEI, the EUniversal project gained relevant insights shared below.

[5] Asset owners, relevant customers…

KLL1: One single communication and interaction channel

One key learning of the EUniversal project is that it is possible to set up one common interface that facilitates interactions between market platforms and different stakeholders. For the first time, this project managed to create a tool that overcomes the system barriers from each stakeholder`s system and communication model. The SWOT highlighted this as a key strength of the EUniversal project. To prove that it is indeed a common interface, in the demos, the UMEI was demonstrated in two different ways. On the one hand, in the Portuguese demo, it was possible for the Portuguese DSO to integrate with two FMOs with the same technical implementation of the UMEI APIs. This is a key achievement of the project as both FMOs (NODES and N-SIDE) have substantially different market designs. On the other hand, the German and the Polish demo succeeded in reusing the common UMEI specifications to implement the data exchange with NODES market platform.

This core achievement of the EUniversal project facilitates DSOs to access flexibility, and FSPs to offer flexibility. The fact that it is proven possible to create one communication channel, is one important facilitating step in the **opening of flexibility markets**. In D10.4, it was proven that the business model for flexibility, thanks to the availability of a common standard such as the UMEI, contained important replicable business model components which increases the potential to implement and replicate local flexibility markets in other regions. Without the UMEI providing a standard communication interface for specific operations, both DSOs and FSPs would be obliged to integrate separately with every market platform system. Considering the development effort, this could disincentivize DSOs to consider flexibility markets as a possible tool for grid management and discourage FSPs to register their assets to offer flexibility.

One channel

- Stakeholders appreciated the ease of communication with multiple stakeholders through one single channel. An appropriate communication model between DSOs, TSOs and other market parties needs to be established that takes into account the flexibility requirements and responsibilities of the parties. Uncoordinated or even conflicting use of flexibility services must be prevented.

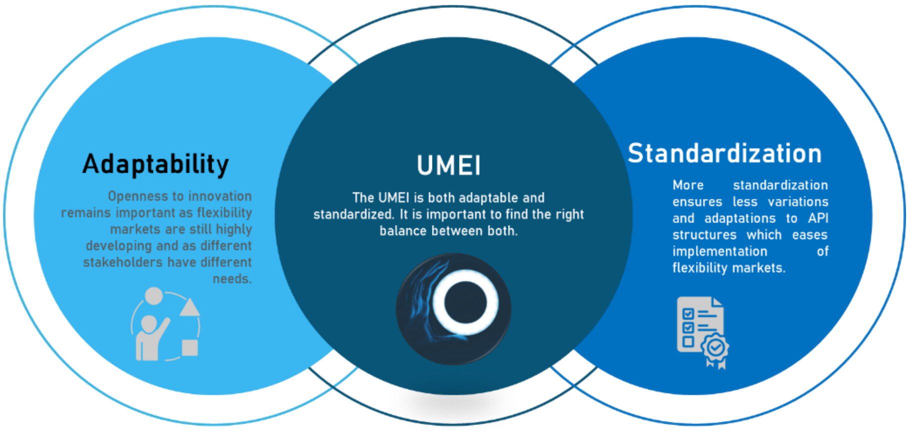
EUniversal Recommendation

- EUniversal therefore recommends proceeding with the UMEI to further facilitate access to flexibility markets by taking away communication barriers between different stakeholders.
- Furthermore, it is important to ensure the API compatibility with more than 2 market platforms and ultimately, to define a standard communication model for flexibility trading.
- Finally, it is important to remove the other barriers for the UMEI as discussed below.

KLL2: UMEI standardization versus adaptability

The single-channel UMEI approach allows distributed communication without the need for a central hub. To manage this, clear rules and routines for stakeholders to exchange data and flexibility services with the DSO must be established. Within the EUniversal project, due to the lack of an existing regulatory framework and standardization, it was the market platforms who, contributing majorly to the set of APIs used in the UMEI, defined these rules and routines.

Defining these rules appeared to be a time consuming and challenging task, especially for stakeholders who already had systems in place (FMO, FSP). In particular, the latter were required to adapt their systems toward the new 'UMEI'-specifications. To give one example, the UMEI is developed in such a way that multiple market platforms can be integrated with it. In the project, NODES as the market platform being used in all three demonstrators provided the underlying basis for the UMEI. N-SIDE as the second market in the Portuguese demo had to ensure compatibility with the UMEI. This implied that both NODES and N-side had to align their specifications to enable the common interface. Yet, both market platforms are competing. Their individual specifications shape their business model and characterize their unique selling points and competitive advantages. As a result, for now only the procurement phase was part of the UMEI. Guidelines on market standardization could facilitate specifications for other market phases (such as the prequalification phase), however, given the current immaturity of the markets it is equally important to ensure their openness to innovation.



Given the current lack of standardization, there is a large diversity in systems, tools, protocols and so on. The EUniversal project therefore decided to suggest standardization where possible, but also keeping the UMEI **adaptable**. As a result, the EUniversal project left space for different implementation ways and only closed options where needed. This leads to numerous benefits in the sense that different stakeholders (SOs/FSPs/Aggregators) can easily integrate with several flexibility market platforms and thus access the different products and services. To showcase this, the EUniversal project implemented the UMEI in three different countries, and different DSOs used various sets of tools/strategies to quantify flexibility needs and validate market results when interacting with market platforms. The Portuguese demonstrator demonstrated the applicability of the UMEI which enabled trading on multiple market platforms, with different market approaches. The fact that the UMEI can be used in different markets, with different products, makes it a good basis for a reliable and future-proof solution for emerging flexibility markets. This way, the aim is to establish UMEI as the primary solution for standardized messaging in future flexibility market implementations, providing a reliable foundation for the development of adaptable and efficient market operations. As such, UMEI fosters the integration of more flexibility market platforms and the development of flexibility markets.

However, the flexibility of the UMEI also leads to the disadvantage that, despite having a common framework, more work is needed to adapt to different business requirements from different stakeholders, such as FMOs and FSPs. Even though the UMEI was aimed to be worked out in a standard way, the implementation can have different variations at the level of the market platform and the DSOs. The way flexibility needs are expressed, and results are retrieved from the market can differ significantly. Each market platform can make its own implementation of the UMEI. All of this is an important bottleneck for the further development and implementation of the UMEI. All the variations that are allowed and plausible within the UMEI namely need translation into additional APIs which leads to additional work. **API standardization** would therefore be of high added value for the further development of these type of initiatives, yet more market standardization is needed to achieve this. For instance, to connect to an API, stakeholders need to be authenticated. Currently, authentication mechanisms are to be decided by the party implementing the UMEI. During the project OAuth 2.0 and Token-based authentication were used. Yet, without standardization, other projects could use another authentication. Other examples that would benefit from standardization are for instance the API payload that would further improve communication standardization. In the project, a list of best practices for API design was defined in D10.4. Given the fact that the UMEI allows a certain percentage of freedom for implementation, some users might not follow all best practices. Yet, even in that case, the UMEI is evaluated to still present a good level of compliance with the best practices for API design. Categories where the UMEI scores lower in terms of best practices for API design are usually considered as least relevant rules for API design. The UMEI is therefore evaluated to be understandable and reusable, while remaining adaptable.

Standardization versus adaptability

- Clear rules and routines need to be set up for stakeholders to exchange data and flexibility services with the DSOs. This can be facilitated through standardization of APIs. Yet, as long as this is not yet in place, it is important to remain adaptable.

EUniversal Recommendation

- In the short run, the EUniversal project believes that it is important to ensure that the UMEI is flexible and adaptable to different markets. This is necessary due to the fact that currently, there is no common market framework.
- If the API-structure of all the stakeholders and systems is standardized, the UMEI can be standardized too, while at this point in time, the UMEI needs to be adapted to differences among the platforms and their products. Therefore, as the UMEI consists of a set of APIs, it is important that there is a European API standard. This will further facilitate the implementation of the UMEI in different environments.
- In order to facilitate this API-standardization, market standards need to be defined as these determine API standards. In the long-term, in order to achieve a more standard version of the UMEI, it is therefore recommended that more market standardization comes in place so that the UMEI can be adapted to the standardized requirements. (E.g. How do we define explicit flexibility needs? How do we retrieve results from the market?...). These standards can be defined in the grid codes, such as the newly developed network code on demand side flexibility.
- Creating standards requires a lot of research, agreement of standard functions/communication schemes, development expertise and more than 2 parties defining the standard. During the project, it was experienced that given the current immaturity of the markets, it is not easy to come to agreements on required standards.
- Flexibility market solutions for DSOs are still relatively at the beginning of their developments and are yet not a practicable and economic solution in most countries, (e.g., Germany). Should flexibility markets for DSOs become established as a default approach, this would also increase the need for European standardization of asset and flexibility to be able to create an interface (e.g. via UMEI) that are applicable across Europe and that would enhance competition between market platforms. However, it is to be noted that in case that regulation opts to go for alternative market solutions such as mediation platforms for flexibility, which is the opposite of what the UMEI is doing, this would put an end at the UMEI-story. Nevertheless, the success of the UMEI development was in part explained by the fact that many DSOs and stakeholders were motivated and engaged to make this solution work due to the fact that it entailed clear benefits for them.

KLL3: Interoperability and easy implementation

The UMEI also creates a strong foundation for the interoperability of different stakeholders and their tools in flexibility markets and it ensures easy implementation of the interface for future stakeholders.

Regarding **interoperability**, the tools for the DSO were implemented in the DSO cloud environment. A project data lake and backend platform were setup in order to implement the processes for exchange of data through the UMEI. This meant that interoperability between the DSOs internal tools and the market platforms was assured through the UMEI, without the need of further compatibility with communication standards.

Secondly, one of the key assets of the UMEI is the fact that it is publicly available as it is open source. The UMEI is kept as simple as possible aiming at incentivizing the use and further developments beyond the EUniversal project. This **easy implementation** is important for DSOs, especially the smaller ones who have less ICT capabilities. UMEI implementation at DSO side is facilitated in the EUniversal project as the APIs are mostly hosted by the FMO, while some specific fall under the responsibility of the FSP, like for metering data.

Two remarks need to be added to the benefit that the UMEI can be easily implemented:

- Firstly, for now, there remains a small part of internal development needed at the DSO side as they currently don't have systems available to receive data and to manage flexibility (consumer and technical data). In the future, this is likely to be solved by means of the implementation of Active System management (ASM) by DSOs. Yet, it is to be pointed out that in case flexibility markets are to be rolled-out at a faster rate, DSOs would need some intermediate development between their corporate systems and the market. The DSOs in the EUniversal project demonstrated that it is feasible to do so, yet smaller DSOs might benefit from a third-party IT team to support them.
- Secondly, it should be noted that, this easy implementation only counts for FSPs and DSOs. Market platforms, on the other hand, have already set up specifications to implement a flexibility market. As different market platforms are in competition with each other, individual specifications of the platforms could be competitive advantages and unique selling points of the platforms. Although open for adaptations, in general the idea is to end up with one set of specifications which all stakeholders follow to ensure that switching between different market platforms is possible. For the market platforms, this could imply a loss of their competitive and unique features, and it implies that adaptation and development costs are needed from the market platform side. Within the EUniversal project, the fact that these stakeholders worked together, is highlighted as core strength.

Interoperability and easy implementation

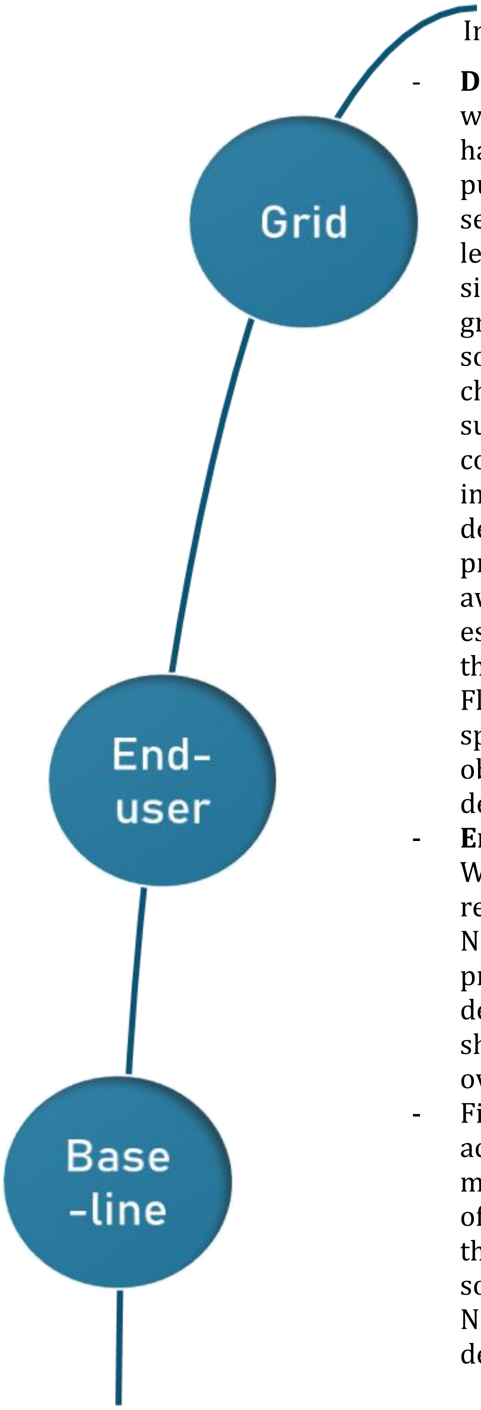
- The EUniversal project therefore recommends continuing enabling the easy implementation of the UMEI. However, to ensure this continuation of the UMEI, some work still remains.

EUniversal Recommendation

- First of all, the UMEI needs to be maintained to ensure its viability in the long-run. To do so, clear ownership of the UMEI beyond the project is important.
- Users should follow the API specification presented in the Github. Although minor adaptations may be introduced in each case, these are to be avoided in order to ease the implementation process.

KLL4: Data transfer

Another important innovation was achieved in the field of **data transfer**. The UMEI shows that even though not all data are easy to share, it is possible to exchange them. To do so, the UMEI uses a distributed approach with respect to data handling. This implies that the data exchanged must be kept at the origin and/or the destination, without the need of a mediation system where the data are stored. As this leads to numerous benefits (transparency, less security concerns…), this is highlighted as a key strength in the SWOT analysis.



In the EUniversal project, we distinguish 3 types of data:

- **Data on grid representation / awareness**. These are needed to evaluate whether a specific FSP bid can answer a DSO need without causing additional harm to the grid. The challenge with these data is that grid data are not publicly shared by the DSO, yet they are needed to make a proper FSP bid selection. In addition, different market platforms require different levels/granularity of grid representation/awareness. This could cause significant data sharing challenges as DSOs typically do not publicly share grid topology information. Depending on the market platform used, different solutions were proposed in the project: on the NODES platform, the DSO can choose the level of granularity to display the grid according to his need. As such NODES market works with minimum data requirements while ensuring common data security and GDPR. Registered assets will be assigned to the indicated grid nodes. On the N-Side platform, the clearing does not use detailed grid information. The concept of dynamic flexibility areas is proposed to allow efficient selection of bids without detailed grid topology awareness. The development of **dynamic flexibility areas**[6] enabled the establishment of a data-sharing process with market platforms, allowing them to select bids without requiring detailed grid topology awareness. Flexibility areas were a way to preselect those FSPs capable of solving a specific DSO need without causing trouble to the grid. The DSO would objectively verify whether they were suited or not. This is discussed in more detail in pillar 2.
- **End-user data**. These data are required for registration and settlement. Within the EUniversal project, no data of end-users were shared because registration and settlement were not considered during the project. Nevertheless, data privacy remains an important requirement. The protection of data privacy is therefore a major and key factor in the development of the data-sharing processes. The assurance that DSOs can share data with market platforms and aggregators while maintaining control over sensitive information is critical.
- Finally, **data for baselining**. These data are required for validation of the actual delivery of the contracted flexibility. So far, no standardized baseline methodology per asset exists, complicating the validation and determination of revenue in case of partial delivery. For the market platforms, currently, there are no restrictions on baseline calculation methodology as long as a solid data profile is submitted according to the specific market requirements. Note that during the project, verification and settlement was not part of the demonstrators.

[6] Flexibility areas are clusters of aggregated grid nodes. E.g. a flexibility area could be an LV Feeder. All Flex assets belonging to the feeder are part of the flex zone. Therefore, topology of the feeder doesn't need to be shared just the nodes belonging to the zone.

Data transfer

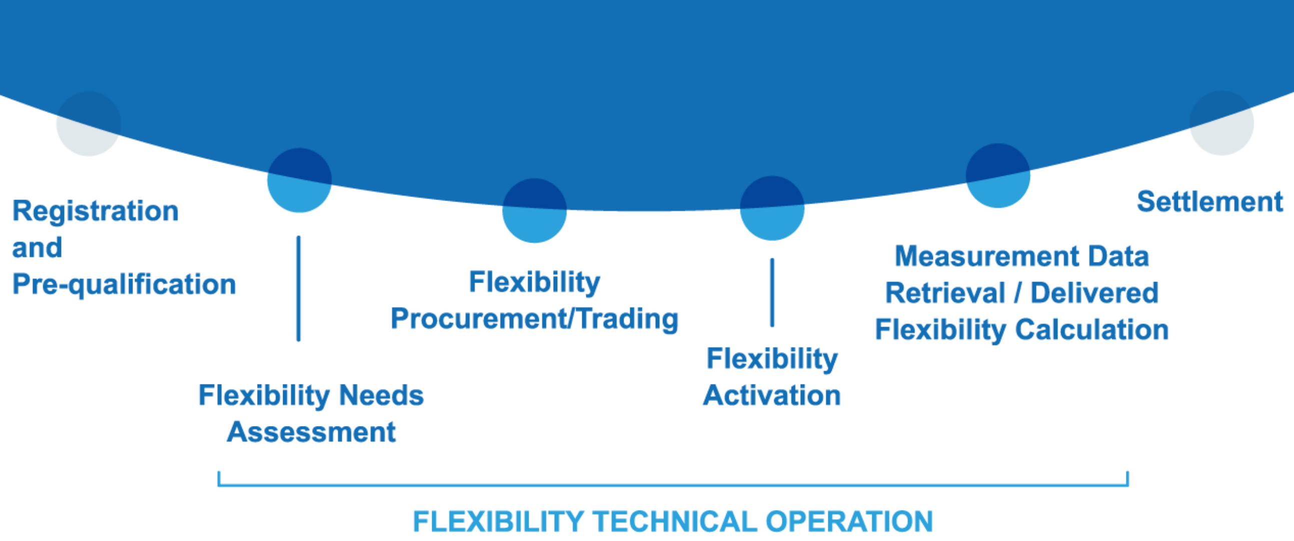
- Finding solutions to share data in a correct way is indispensable for the further exploitation and development of the UMEI.

EUniversal Recommendation

- Data protection and IT security concerns must be taken into account in the grid as well as for end-users. This should also be taken into account regarding future developments and possible standardization.
- The UMEI offers creative solutions for data transfer (thanks to its distributed approach of data handling and its dynamic flexibility areas) without opening doors for security issues. It is recommended to take further the basic data transfers principles of the UMEI to further ensure data security.

KLL5: UMEI further developments

The UMEI, as implemented in the EUniversal project, is a first basic implementation. To expand its implementation and exploit it all over Europe, further development is needed. First, the UMEI consists of a specific number of flexibility process groups. Each of these groups is composed of a set of APIs. Market entities can choose which functional groups they need to implement. The current version of UMEI is a standardized API that covers the most frequently used operations in a Flexibility market (daily operations that market participants would need in the trading phase, including validation phase aspects). The UMEI is therefore only tested for active trading in three different demos with different use cases. The UMEI is thus ready to be used for the trading part, while functions for registration and prequalification as well as validation and settlement still need to be developed. However, further testing and development is still recommended. The APIs are already implemented in the PT DEMO Data Exchange Platform (DEP). In addition, parties are able to communicate with NODES and N-SIDE market platforms using the APIs defined in the UMEI.



Nevertheless, there are also elements that were, due to time constraints, not implemented within the timeframe of the project and that need further development in the future, including DSO-TSO coordination.

- In the Portuguese demo, the utilization of the UMEI for communication in BUC3 (Planned Maintenance) and BUC4 (Long-term Planning) was deemed unfeasible due to the inadequate cost-benefit ratio of implementing such a solution. The implementation efforts (in terms of cost of man hours) were significant since the algorithms for both BUC were different. In the future, the process of using flexibility for planning purposes will be more cost-efficient because it will be more frequent. Currently, the DSO has about 50 planned maintenance tasks each day, and if they could use flexibility to avoid curtailment, this would be a significant improvement. Planned maintenance is therefore an important use case to further exploit. Yet, within the timeline of the project, the limited number of actual tests that would be conducted did not justify the significant effort and resources required for automatic implementation through the UMEI.
- Another identified problem was the need of the DSO to receive disaggregated bids to be able to run the voltage control tool (See DSO-toolbox in section 3.2). The UMEI allows for both disaggregated and aggregated bids to be exchanged. For this to be possible, the FSP needs to submit the bids in a disaggregated format (or aggregated to the point of interest in the grid) to the FMO and it should be ensured that the DSO also receives insights in these data.
- For the German demo, all market functions used in the trading phase could be implemented with the UMEI. However, information from other phases such as prequalification were missing and had to be implemented manually or by the APIs of NODES market platform. The manual implementation of these phases posed an extra effort during the demo. An extension of the UMEI to all market phases promises increased benefits. In the medium term, the question also arises what role flexibility markets will play for which parts of grid services and whether the data model should be adapted to existing processes and models such as those already used in the scheduled based congestion management “Redispatch 2.0”. A combination of both approaches seems to be beneficial.

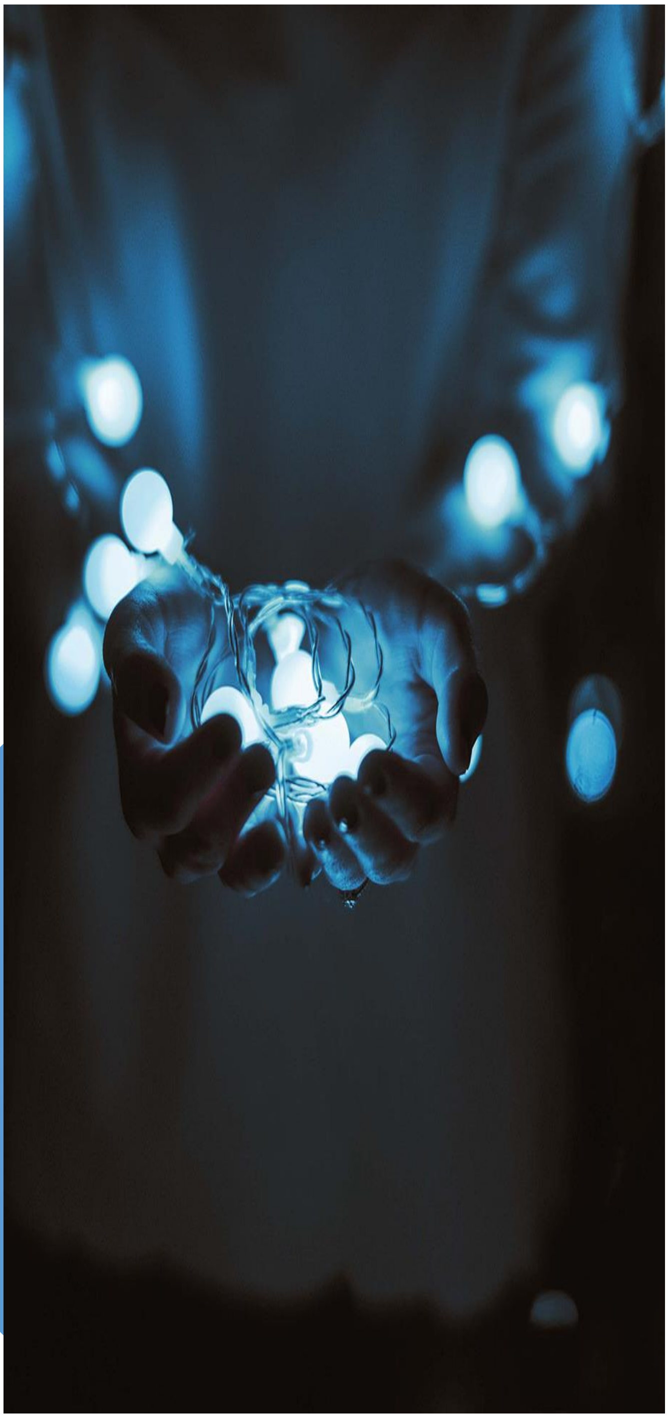
UMEI further developments

- The EUniversal project set up a first basic structure for the UMEI. Yet, there are still many ideas to develop it further which should be proceded in the future.

EUniversal Recommendation

- As indicated, the UMEI now covers the key trading market operations. It is a first version which covers the key basis steps to operate any type of platform. Therefore, currently the UMEI is only implemented for the procurement phase. However, if the UMEI becomes a widely accepted API standard for flexibility markets, all operations market participants can do must be covered by the API standard (for example also pre-trading activities such as pre-qualification and registration). These steps are, however, harder to implement in the UMEI due to agreements that are needed regarding standardization of these phases.
- Furthermore, development of more process groups for the UMEI, TSO-DSO coordination, Flexibility Register synchronization are needed.
- In addition, there might be country specific elements such as the German redispatch that should be accounted for.

KLL6: UMEI internal and external communication



To allow the UMEI to become the new standard, **awareness creation beyond the project** is needed at different levels. We are still studying and identifying when and how flexibility markets should ideally be implemented. In the first place, it is indispensable that stakeholders understand the need for flexibility markets. Without flexibility needs and demand, there is no urgency to implement the UMEI. Since not all countries have entirely opened their markets for flexibility at distribution level, it is important that this is further encouraged and facilitated. Once there is a clear demand to set up flexibility markets, stakeholders need to be informed about the existence of the UMEI as this will take away flexibility market implementation barriers. Yet, throughout the EUniversal project, it became apparent that convincing the right people about the UMEI is not always a simple matter. Stakeholders in a company that are occupied with the practical implementation of flexibility markets and the data and communication challenges, see clear benefits of the UMEI. However, the people taking decisions on continuing with the UMEI were not always easily convinced since it requires a proper understanding of the UMEI. There is therefore a continuous need to describe the UMEI in a simple, non-technical way. Further steps are needed to understand the architecture and functionalities of the UMEI. It is important to come up with a way of disseminating the UMEI idea and the concept of an API. This is important as decision makers do not use the same terminology as the IT people in a company.

UMEI internal and external communication

- The UMEI is still a very new concept and it is important to discuss and communicate it with many people, both internally and externally.

EUniversal Recommendation

- A document with a non-technical description on the working of the UMEI and the API is set up to further facilitate the dissemination of the UMEI. This will help to further explain what the UMEI is, and it will ensure a smoother transition from the UMEI towards new partners.
- Once communication documents are available, the further dissemination of the results will be important to increase further awareness. It will be presented in sessions where experts are (for instance CIRED, BRIDGE). We will also be present in other forums to understand what other stakeholders' concerns are

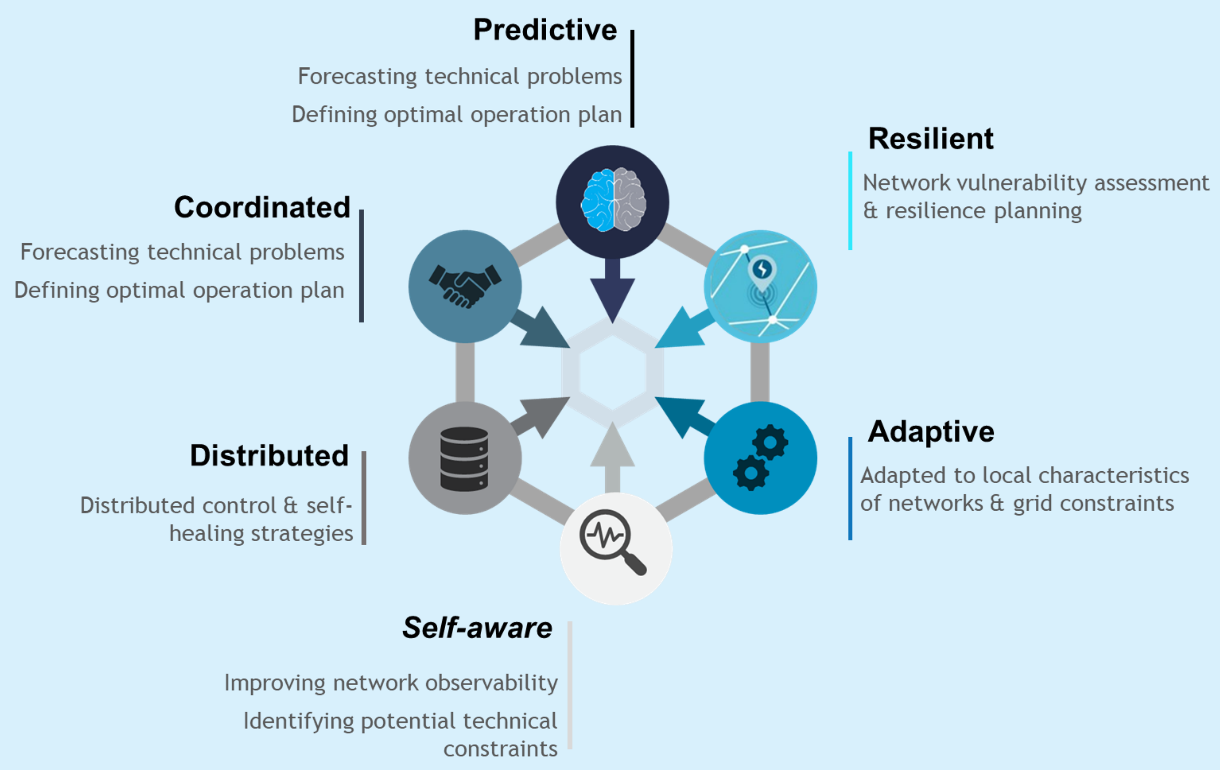
3.2 Pillar 2: DSO Toolbox

Increasing flexibility of distribution system is key to enable further integration of renewable based generation while ensuring secure and efficient operation. EU Electricity Directive 2019/944 established specific rules to increase flexibility and promote coordination, incentivizing system operators to become neutral market facilitators and procure market-based flexibility services. Taking advantage of DER flexibility will help DSOs to manage daily congestion and voltage grid constrains, defer network reinforcement investments, increase network security during maintenance and improve its reliability and resilience.

However, before DSOs can benefit from flexibility, they need to adapt their grid planning and operation strategies and tools to interact with the new market ecosystem and accommodate flexibility services has an alternative grid asset. One of the main changes is towards promoting a more predictive operation, since flexibility procurement requires forecasting technical problems and estimating short-term and long-term flexibility needs.

From a technology perspective and excluding regulatory issues, to integrate flexibility as a new grid asset, DSO havened first to overcome two main challenges to overcome: improving observability of the network and promoting a more coordinated and predictive operation of HV, MV and LV networks. Observability of the network will allow for accurate forecast of grid status and extended monitoring capabilities towards LV networks, while improved coordination and control mechanisms will allow for efficient management of DSO assets and flexible resources connected to the different voltage levels, while enabling interaction with TSO and new system actors such as aggregators and market platforms.

EUniversal has developed and demonstrated a new generation of tools for future distribution networks that enable effective integration of innovative flexibility market-based services and improve network resilience. The tools developed implement a **predictive and coordinated management**, **extend network observability** from HV substations to the LV consumers, distribute control capabilities, while adapted to **the local characteristics of MV and LV networks**.



3.2.1 Improving distribution network observability and self-awareness

The integration of flexibility within planning and operation of distribution networks, requires improving network observability and self-awareness, meaning the capability to characterize network loads, generation and other DER as well as network status, concerning voltages, currents, energy losses and reliability.

While HV and MV networks have already a good monitoring and control capacity, LV networks monitoring is typically limited to the MV/LV substation. Also, poor network characterization (topology, cables characteristics, consumer phase connection) doesn't allow to identify nor predict technical problems in the LV network, neither ensure that the activation of LV flexibility will not have a negative impact causing additional technical constraints.

EUniversal has developed a set of tools to improve the observability of distribution network, from HV to LV networks, namely:

- At the HV level, improved monitoring enables dynamic management of HV line capacity.
- At the MV level, accurate load and generation forecasting is key to forecast grid constraints.
- At the LV level, a set of data-driven tools are used to map and characterize network topology, forecast voltages problems and lines congestions, and monitor the network status in real time.

KLL1: Dynamic Line Rating for improving HV line capacity management

Dynamic line rating (DLR) is a modern method to evaluate the maximum allowable HV line power transfer according to the forecasted weather conditions, preventing violation of the safety of the line exploitation. The HV line, whose capacity is calculated with DLR methodology, can be considered as the flexible network infrastructure asset, that can be procured as a market-base flexibility service by those using the lines.

Today, RES energy producers have a connection agreement (CA) with the DSO, establishing a given power injection limit. In case the power delivered exceeds this limit, the plant is curtailed. However, with DLR and under favourable weather condition, the RES plant can deliver more power than initially agreed in the CA. As such, RES generators could buy flexibility services on the flexibility market from the DSO to reduce curtailment.

DLR can be used for operational planning by considering the full-line flexibility of the transmission and distribution network. It can look at the full line capacity utilization and as such have a more efficient load dispatching, avoiding the so-called 'bottleneck' which provides safety for the OHL lines operation.

As the flexibility service (short-term) is offered based on DLR, the only requirement is a locally accurate weather forecast (usually considering a geographical resolution of 7,5 x 7,5 km squares) where the HV lines that participate in the transmission of power from RES are located. Line admissible capacity forecast is determined by a line thermal model and its accuracy depends on the accuracy of the weather forecast.

Test results obtained within the EUniversal demo in Poland proved the high potential of the DLR-based flexibility services. In some cases, the RES power exceeding the CA limit, for example in the highly RES-saturated generation area, can be supplied without curtailment, compared to using a traditional static line rating (SLR) method.

Dynamic Management of network capacity

EUniversal has shown that deploying flexibility services based on DLR increases opportunities of RES integration and decreases RES curtailment

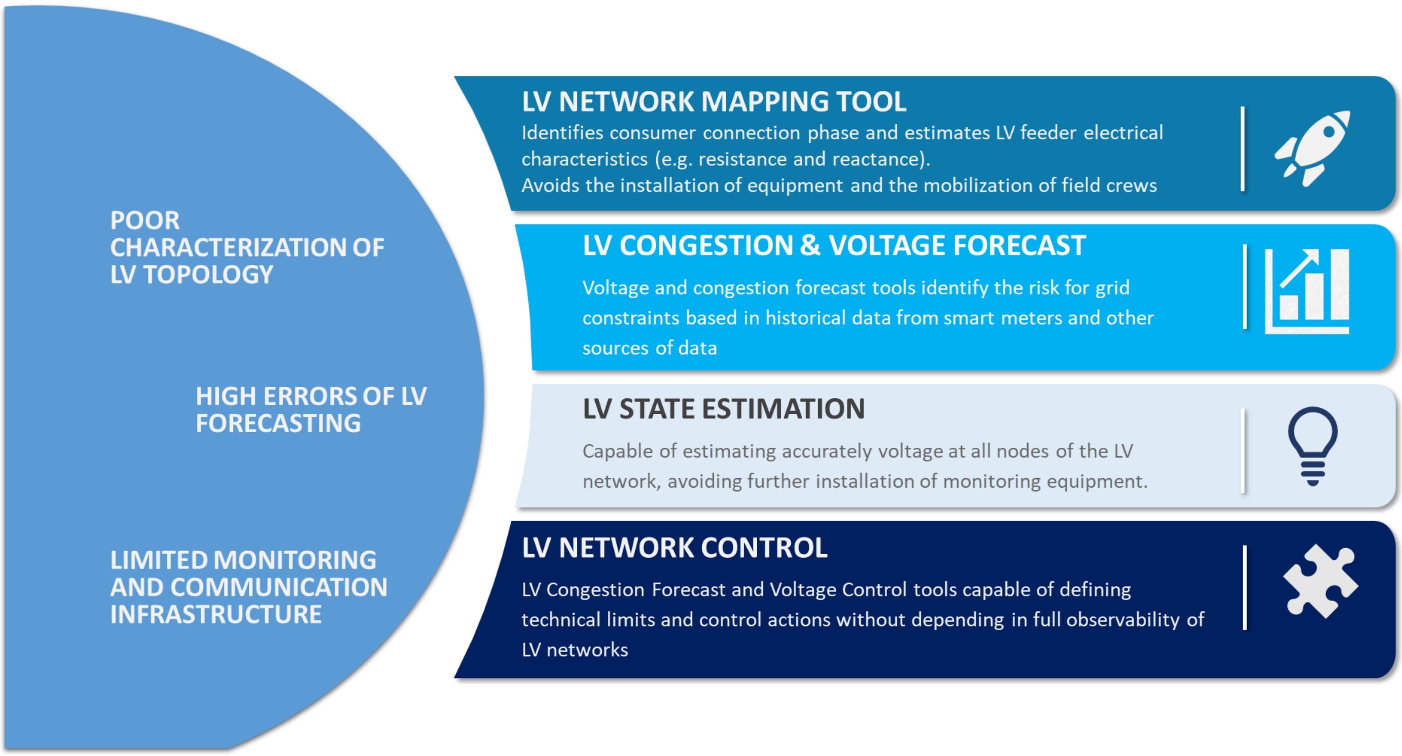
EUniversal Recommendation

DSOs should make extensive use of the DLR method to monitor and forecast the admissible line load, thereby fortifying the framework for flexibility services, while allowing dynamic management of grid capacity

KLL2: Relevance of smart metering data for LV network observability

Network observability requires mapping of the LV network topology and its electric characteristics and monitoring of relevant parameters. This is critical, particularly for LV networks, considering that their topology and feeder characteristics are typically poorly characterized, and their monitoring and control capabilities limited.

EUniversal has developed data-driven tools to improve LV network observability and self-awareness considering smart metering data and other sources of data.



Smart meter data, together with data from other DSO systems, have a huge potential for improving network observability and may avoid further investment in network monitoring equipment. For example, MV and LV load diagrams provided by smart meters are key for both planning and operation, enabling more accurate long-term (years ahead) and short-term (days to hours ahead) load forecasts.

Voltage measurements or alarms collected by the smart meters help identify constraints at the LV network without the need of investing in additional voltage sensors.

However, communication infrastructure limitations do not allow to massively collect data in real-time from smart meters and ensure the correct collection of data for billing purposes. The communication infrastructure deployed today may not be able to handle the additional volume of information required for real-time monitoring, consequently compromising both operation and billing tasks. Also, in some countries, the DSO is not responsible for the smart metering infrastructure and data management, imposing some restrictions on real-time use of this source of data.

LV Network Observability

Improving the capability of forecasting and detecting problems in LV networks is key for enabling the use of flexibility

EUniversal Recommendation

- It is recommended that DSOs further exploit options to improve observability in their grid, particularly for LV networks. These solutions do not only rely on investing in monitoring equipment but should take advantage of existing historical data from different sources, particularly smart metering. Using this data is key for the development of accurate load and voltage forecast tools, that in turn will lead to accurate estimation of flexibility needs.
- Development of favorable regulatory framework for the use of smart metering data by the DSO, including load and voltage is recommended, considering the relevance of this data for an efficient and secure operation while enabling active participation of LV consumers in market and operation.

KLL3: Developing and testing trustworthy data-driven tools for network monitoring and control

EUniversal successfully demonstrated a set of data-driven tools for forecast, monitoring and control, taking advantage of different sources of data, while avoiding heavy investments in LV network monitoring equipment and communication infrastructures. However, when developing and testing data driven tools, it is important to ensure the availability of representative datasets and pilot LV networks that are fully characterized, allowing algorithm training processes and validation.

The data that are needed to test these tools fall in two categories:

- Measurement data: Measurements are, on one hand, obtained from dedicated measurement set-ups, for example those installed at the MV/LV substation to measure the current flows at the feeder heads, or those installed at specific network nodes to measure the grid voltage. On the other hand, measurements can be collected from smart meters installed within the households. Usually, in this case only offtake and injection are collected, and the network voltage and current measurements are not always available.
- Grid data: Information on the network lay-out, the length and types of the cables used, and their associated impedances are a second type of data required for the development of the LV networks.

Different issues may arise when collecting the required data sets:

- Privacy concerns related to measurement data obtained from smart meters are prevalent, since GDPR restrictions apply to the data generated by smart meters. This means that, in many cases, the DSO cannot use smart meter data, or very strong restrictions on the use of this data are applied.
- Correctness of grid data and compliance with the 'actual' situation: a large part of the LV network is formed by underground cables and was installed a long time ago. It is therefore not clear everywhere how the households are exactly connected to the network. Also, information of network reconfiguration is not always accurately recorded in the digital representation of the LV network.

To avoid both issues, developers of network tools may resort to using synthetic datasets (for example based on publicly available test networks) for the developing and testing. The downside of using such synthetic datasets is that all types of measurement errors are most probably not captured by such datasets, leading to underperforming tools in the 'real world'.

The EUniversal demo set-up gives the opportunity to validate and test the developed tools within a realistic environment. However, ensuring availability and access to the different sources of data was complex and raised both technical and non-technical issues. It's then recommended that these issues are identified in an early stage of the project when defining the demo sites.

Trustworthy data-driven tools

EUniversal demos enabled testing and validating data-driven tools within a realistic setting. However, data collection wasn't trivial raising both technical and non-technical issues .

EUniversal Recommendation

- Demonstration of tools have proven the potential of a data-driven approach to avoid heavy investments in LV network monitoring equipment and communication infrastructures, taking advantage of smart metering or other historical information available to forecast grid status, identify potential constraints, improve (quasi)real-time monitoring capabilities and define corrective control actions.
- Having representative datasets based on real historical data are key for development and validation of tools, while avoiding data privacy issues.
- Identification of demo location and its implementation should take into consideration the availability of network characterization and measurement data.
- Overcoming data privacy issues requires a solid data management strategy defined in the first stages of the project.

3.2.2 Predictive & coordinated distribution network toolchain for flexibility market interaction

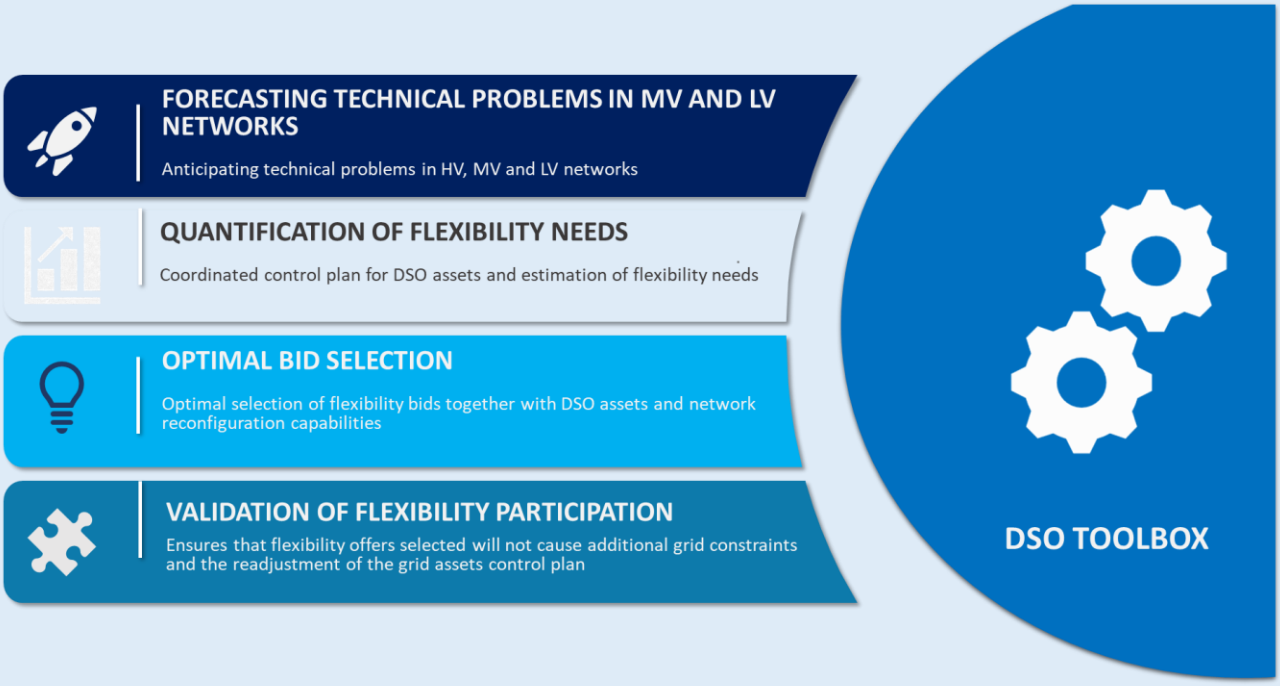
Short-term flexibility procurement for congestion and voltage control supports DSO in the dynamic management of distribution grids. This is required to deal with the increased complexity and uncertainty associated with renewable energy resources and flexible loads, such as EV.

Flexibility procurement may involve more than one interaction between the DSO and flexibility market platforms. For example, it might be comprised of needs assessment, clearing, or activation. The DSO tools required will depend on the market design, namely on the implemented regulatory framework (services and products available), used Flexibility Market Platform (and its market processes involved), and finally existing DSO systems.

Distribution network operation is typically conducted in real-time. Overvoltage and congestions are solved after being detected, based on the information provided by SCADA systems. To meet increased system complexity, current DMS solutions are however evolving from corrective to predictive management, integrating load and RES forecasting to define optimal operation plans for the network assets. However, these solutions typically do not integrate coordinated operation between different voltage levels, neither are compatible with market procurement activities. Also, the existing ADMS tools typically do not model flexibility services as they focus on providing one single solution (in the EUniversal project, we took a step-by-step approach).

The EUniversal DSO toolbox was defined for technology agnostic flexibility service mobilization and for compatibility with different market designs and platforms. The toolbox was developed considering flexibility market procurement process and data exchange (with exception of registration and pre-qualification process).

The developed tools exploit the interaction with two distinct market designs and platforms, namely N-SIDE and NODES Flexibility market platforms, while also proposing innovative solutions for sharing relevant information without needing to share commercially sensitive information. This includes, for example, the identification of the network nodes that can technically help to solve constraints and the definition of limits (or envelopes) for flexibility dispatch.



KLL4: Forecasting technical problems in MV and LV networks

Implementing a predictive operation strategy requires accurate forecast to identify potential grid constraints and define the most adequate control actions, for example DSO assets control or activation of flexibility sources. Three types of forecasts were exploited within EUniversal project:

- Day-ahead load and generation forecast, namely net load at the MV/LV substation, and renewable energy generation forecast. Forecast is based on historical metering data and can use other sources of data, such as meteorological information.
- Daily voltage forecast for LV nodes, based on the historical data from the smart meters. This approach provides a direct forecast of voltage magnitude, enabling the detection of voltage limit violation within LV networks.
- Daily congestion forecast for MV/LV substation, based on historical data and other sources such as incomplete topology or typical load profiles.

The identification of potential grid constraints in MV networks was based on load flow studies considering the load and generation forecast for the MV consumers and producers. The following conclusions were derived from the implementation and demonstration activities:

- The accuracy of grid constraint forecast depends on the accuracy of load forecasts.
- Computing MV forecast requires alignment of the process of daily collection of metering data with the forecast application.
- The time the forecasts are available will condition the market processes timeline, for example for flexibility needs submission or flexibility offer selection. While for pilot demonstration this may not represent a big challenge, it will when scaling it up to the entire distribution network.

For LV networks, load forecast was avoided, considering the potential gross errors associated with the forecast of individual load profiles for each consumer. As the granularity of load increases, so does the error. Also, the approach proposed for directly estimating voltage and transformer loading avoids the need for power-flow based tools.

Grid Constraint Forecasting

Implementing a predictive operation strategy requires accurate forecast to identify potential grid constraints and define the most adequate control actions

EUniversal Recommendation

- The implementation of predictive management requires a thorough quantification of the technical and economic impact of MV forecast errors in the identification of flexibility needs and service mobilization
- Large scale deployment of such tools will require robust and efficient MV metering data ingestion and forecast processes, enabling further use by other tools and day-ahead market interaction
- For LV networks, voltage and congestion forecast directly allow to identify grid constraints reducing the error when compared to tools base in LV net load forecasts

KLL5: Ensuring coordinated use of DSO optimal asset control and flexible resources

Network operation aims to ensure reliability and quality of supply, meaning that the network should operate within adequate voltage and current limits, while in case of faults, the system should be able to restore the service to the maximum number of consumers in a short period of time. To do so, DSO operates network assets, namely OLTC, capacitor banks and change network topology. However, such assets might not be able to solve the existing grid constraints, particularly if they occur downstream MV feeders or even in LV networks.

DER providing flexibility connected to the LV and MV grids and aggregated might help to solve the technical constraints locally or in higher voltage levels. In addition, the flexibility activated for higher voltage levels should not cause technical problems in lower voltage networks.

EUniversal developed a framework enabling the coordinated control between MV and LV networks, which has the following assumptions:

- DSO assets are used first to solve grid constraints, before estimating flexibility needs;
- Grid constraints are first solved in higher voltage levels;
- Technical envelopes are determined, allowing for aggregation of LV resources to support MV network operation without causing additional constraints.

The need for these internal coordination mechanisms will become more important as networks operate closer to their operation limits and as more flexibility capacity becomes available.

Technical envelopes can be defined as the limits for flexibility activation upwards and downwards, that ensure operation within acceptable technical limits (voltage and current)

Coordinating grid & flexible resources

DSO toolbox enables coordinated control between MV and LV networks and between grid assets and flexible resources, towards more economic efficient grid operation

EUniversal Recommendation

- Enabling joint planning of MV and LV resources will need to be considered as the grids operate closer to their technical limits
- Fostering data sharing between MV and LV operation centers and tools will help promote such coordination
- Defining technical envelopes in the boundaries between voltage levels provide a simplified solution for coordinated operation planning

KLL6: Defining technical envelopes for network and market operation

The participation of LV consumers in system services (e.g., balancing services, or MV congestion management) can have a negative impact on the LV network operation. To enable safe aggregation of LV resources, the DSO toolbox defines technical envelopes to constraint the flexibility activation to safe values.

MV/LV substation headroom capacity

- Maximum and minimum allowed limits of flexibility activation at the MV/LV substation to avoid that LV flexibility creates additional problems in the LV networks.
- LV congestion forecast determines how much headroom, in [kW], is available for use by the flexible devices at the MV/LV transformer and LV feeders

LV nodes technical envelopes

Data driven Voltage Control tool defines for each LV node the maximum and minimum limit in [kW] for the activation of flexibility at the LV network.

To account for the possible congestion risks posed by the flexible assets, a worst-case congestion risk was taken as a starting point. This worst-case congestion assumes that the flexible devices are always on. This worst-case flexibility forecast is then further on used to calculate the headroom capacity available on the feeder, and the transformer.

Therefore, the flexibility of LV grid bids can be freely selected in the flexibility markets if it is inside the technical envelopes, guaranteeing that no LV grid congestions can happen. However, as a consequence of focusing on the worst case, part of the available flexibility is a priori discarded. It must be noted here that the headroom limits are not restricting any source of flexibility but put limits on what a group of flexible resources can maximally consume/produce.

To reliably calculate the technical envelopes, the DSO must be aware of the flexible assets, i.e., where they are connected, what type of flexibility they offer and how large the flexibility source is (in terms of kW).

Tests within the German demo of EUniversal have shown that in a day where the network is heavily loaded, the **technical envelopes can reach up to 70% of the offered flexibility**. However, it was also shown that in most cases, these limits are much larger, restricting the flexibility only during the network peak-load (or peak injection) times.

Within the Portuguese demo, **the identification of individual limits per LV node** are shared with N-SIDE market platform, together with the dynamic flexibility areas. This **allows sharing relevant information for clearing, without the need for detailed grid modelling**.

Flexibility technical envelopes

Defining technical envelopes as constraint within the flexibility market operation will limit offers but ensure coordinated and safer grid operation

EUniversal Recommendation

- EUniversal has shown that by imposing technical envelopes as constraint within the flexibility market operation, is a possible solution to ensure a coordinated operation between the different voltage levels of the network for flexibility assets connected at the LV side.
- All information concerning the flexible assets must be known by the DSO to enable a reliable calculation of the envelopes.
- A possible limitation is that a part of the available flexibility is a priori restricted from the flexibility market by such technical envelopes.

KLL7: Dynamic flexibility areas identification for efficient procurement of flexibility

Allowing aggregation is quite relevant to ensure adequacy to flexibility products, facilitating the participation of LV flexibility resources. However, voltage and congestion constraints are local problems, meaning that the contribution of the flexible resources depends on the node where the resources are connected and the quantity they can provide.

The adoption of predictive network management allows to forecast grid constraints, identifying the areas where flexibility will be needed for the next day and the resources that can effectively help solve these constraints, enabling their aggregation from the LV feeder towards substation level.

When assessing flexibility needs for solving technical constraints, EUniversal proposed the concept of **dynamic flexibility areas**, which identifies those nodes that can solve the technical constraint(s) and group them into zones according to their effectiveness in solving the network constraints.

This concept also **enables more effective DER aggregation within the LV and MV feeders, avoiding the need of DSOs sharing network information with the market platforms to ensure technically viable flexibility bids selection**.

The concept has been implemented and tested in the Portuguese demo. The DSO tools provide the flexibility areas and technical envelopes to N-SIDE Flexibility Market platform, through UMEI. Each area includes a group of flexibility providers and the total quantity per area that can solve the constraint. This information is also shared with the Aggregators that formulate their offers according to the areas. After bid submission, the market is cleared, ensuring mobilization of the resources that can effectively solve the constraint.

Dynamic flexibility areas

Effective aggregation strategies for distribution networks will depend on the nature and location of grid constraints

EUniversal Recommendation

- DSO toolbox demonstrated with the dynamic flexibility areas concept, the viability of sharing relevant data with external market platforms and aggregators, without sharing sensitive network data.
- Dynamic flexibility areas model is more relevant has the number of market participant increases, having different alternatives to solve grid constraints.
- The abstraction provided by the areas enables the implementation of linear model, independent of network models.

3.2.3 Distribution network planning with flexibility

Medium to long-term flexibility, either delivered by distributed energy resources or end consumers, can be exploited as a competing solution to the conventional distribution network expansion planning approaches. Long-term planning is typically based on network reinforcement investments, involving the installation of new cables, transformers, fast reconfiguration devices, amongst others, to avoid lines congestion and ensure that voltage levels are within admissible limits.

As a cost-effective planning option, the EUniversal showed that flexibility services can mitigate the risk of congestion and voltage constraints in normal and contingency situations, as shown by the results provided by the optimal resiliency-based investment planning tool and the long-term reliability assessment tool.

However, in addition to voltage and congestion management, flexible resources such as distributed energy sources and energy storage systems may also support DSO in improving network robustness against frequent extreme events and avoid curtailment of critical loads.

In recent years, frequent natural disasters like windstorms, earthquakes, and floods have inflicted substantial damage on the country's economy. This damage is particularly evident due to their negative impact on critical infrastructures, such as power networks. Among these, distribution networks have been the hardest hit by these natural disasters. To tackle this issue, we must devise plans for distribution networks that enhance their resilience.

Regarding resilience, EUniversal has proposed a set of tools to improve operational and long-term grid resilience, providing decision support in long term investments to increase the robustness of the grid towards these extreme events, and for operation planning (next days or hours) under these extreme events.

KLL8: Maintenance planning with flexibility

Maintenance planning is typically conducted by isolating the maintenance area and reconfiguring the network to minimize the energy not supplied during the maintenance period. DSO usually plans network maintenance actions some weeks in advance, coordinating the works in different networks and managing the field crews. The plan results from the analysis of different types of information: availability of field crews, management of different interventions in the network, load and generation conditions, regulatory periods for performing service interruptions and network reconfiguration capabilities.

To avoid load curtailment, maintenance actions are in some cases planned for the weekends, which increases the maintenance costs from paying maintenance personnel. However, with the flexible resources installed along the network increasing, along with the emerging flexibility markets, maintenance operation planning can take advantage of flexibility services for a better network performance.

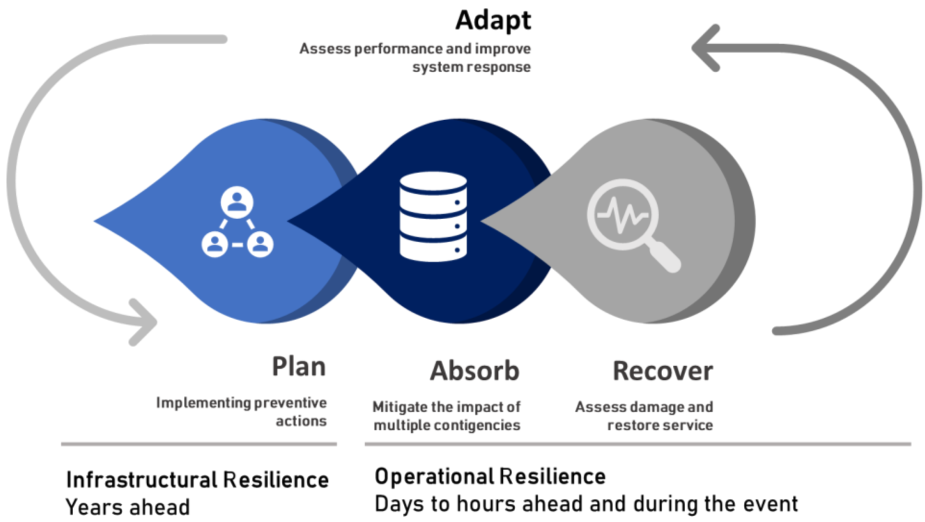
EUniversal evaluated and tested the benefit of considering flexibility provision for distribution network maintenance planning. Considering different maintenance works, the use of flexibility for network operation support under maintenance was demonstrated in two real MV networks. The results have shown that maintenance can be done during periods when, without procuring flexibility, it would have not been possible to energize all the nodes without violating network technical constraints. This effectively shifts maintenance activities from high-cost periods to even regular working hours, reducing maintenance-related costs while minimizing the impacts on the end customers.

Flexibility for grid maintenance support

EUniversal has demonstrated the benefit of considering flexibility provision during maintenance actions

EUniversal Recommendation

- Voltage and congestion support flexibility products are able to provide support during maintenance actions
- Flexibility provision together with proper network reconfiguration planning increases the number of cost-effective periods to perform maintenance, while minimizing the impacts on the end customers



KLL9: Participation of flexibility to improve operational resilience

Resilience-oriented operation planning aims to provide an integrated decision aid tool to support network operators in defining preventive control strategies to mitigate the impact of the events leading to multiple contingencies, while supporting network service restoration. Mitigating the impact of such severe events and improving the restoration phase while reducing the energy not served are the main pillars of the self-healing procedure in distribution network operational planning. This is achieved by combining network automation with the flexibility of distributed energy resources and grid forming energy storage, providing controlled islanding services.

Improving the operational resilience of the medium voltage (MV) distribution networks through the integration of flexibility encounters several significant challenges, namely:

- One major obstacle is the lack of historical data on extreme events, which is essential for understanding the potential risks and impacts on the network operational planning problem. Without sufficient data, it becomes difficult to accurately model different extreme events and their impact on the network.
- Ensuring the adequacy of the emergency control strategies, considering the complexity of the network operation under multiple contingencies. Solutions should be automatically supported by advanced automation.
- Considering DER flexibility provision during contingencies combines inverter advanced grid support capabilities with demand response from other resources. These requires specific modelling strategies, to enable the operation under different islanded systems.

The methodology developed was tested for a typical MV grid considering the occurrence of severe windstorms, affecting mainly overhead lines. The participation of grid-scale energy storage and other flexible resources was compared to a base case considering only network reconfiguration. Results show that, when allowing controlled islanding with grid storage, the average ENS is reduced by around 44% and the percentage of clients experiencing full load curtailment is reduced by 35%.

Islanding flexibility services

EUniversal has developed controlled islanding strategies for mitigating impact of extreme weather events

EUniversal Recommendation

- Deployment of distributed energy storage and increased network automation may facilitate the development of controlled islanding services
- The participation of flexible resources and network reconfiguration capabilities will help mitigate the impact of grid contingencies

KLL10: Distribution network planning for improved resilience

Currently, the prevailing power system planning methodology focuses on reliability metrics. These metrics include the System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Loss of Load Expectation, and Expected Energy Not Served. To conduct this analysis, input data utilized are network information, fault data (comprising frequency, duration, and location), maintenance and repair data (including their frequency and duration), historical outage duration, and frequency. Furthermore, this analysis is carried out by considering a predetermined list of contingencies, such as single outages and a few multiple outages that could arise from the loss of generators and transmission links. This is commonly referred to as N-1 to N-k analysis, and these events are typically classified as low-impact, high-probability (LIHP) events.

The conventional approach to distribution network planning, may not be well-suited for improving resilience against natural hazards. This is because, in addition to network data, a key input for resilience-driven planning is the hazard model. This involves the modeling of natural hazards such as windstorms or earthquakes, which can affect the power system's performance. Creating various hazard scenarios to simulate these natural events is essential for accurately assessing resilience. However, a significant challenge in hazard modeling lies in the scarcity of high-quality historical data on extreme events.

Considering that reliability metrics are based on longer time horizons, which may not be suitable for resilience analysis, a shift towards event-focused, risk-based resilience metrics is undertaken. Using risk metrics, specifically Conditional Value-at-Risk (CVaR) and Expected Energy Not Served (EENS), an optimal investment planning tool was developed. This tool assists in deriving optimal asset portfolios, which encompass overhead lines, underground lines, and energy storage systems. To support this planning model, a stochastic hazard scenario generation tool is introduced, based on a fragility modeling. This tool has the capability to generate multi-spatial and multi-temporal hazard scenarios that mimic both known and unknown extreme events while quantifying their impact.

The resilience-driven planning framework developed within EUniversal was tested on a real Portuguese distribution network. The results demonstrate that resilience-driven planning can significantly enhance the ability to withstand natural hazards, such as windstorms, by meeting a larger portion of the demand. In a specific risk-strategy with equal priority to EENS and CVaR, it was observed that resilience-driven planning reduces the EENS and CVaR of demand loss by approximately 37% and 29% when compared to the base case (without planning). Furthermore, this planning solution also enhances reliability metrics, such as SAIDI, SAIFI, and expected demand loss, by approximately 30%.

Improving network resilience

EUniversal has demonstrated that planning various network assets with a focus on resilience and utilizing risk-based metrics significantly enhances network resilience

EUniversal Recommendation

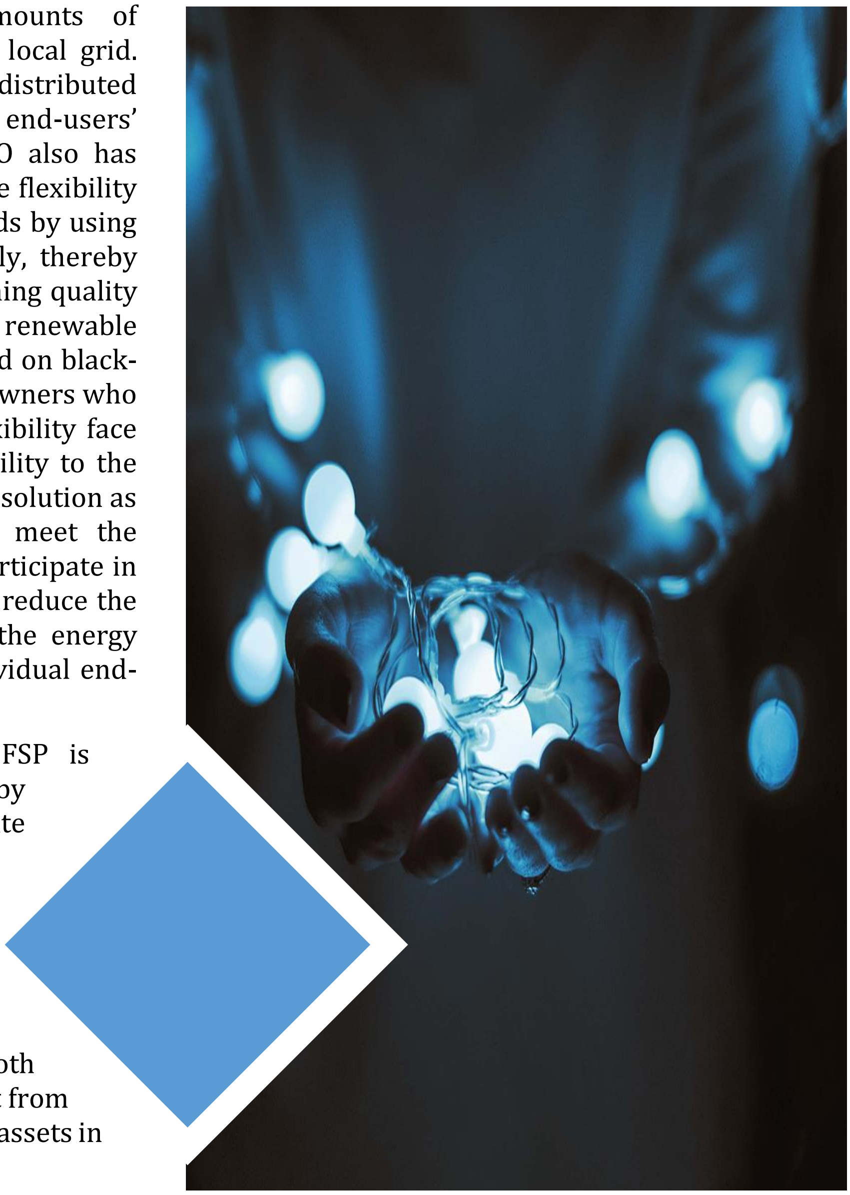
- EUniversal recommends that Distribution System Operators (DSOs) should adopt resilience-driven planning methodologies, especially for networks that face continuous exposure to natural hazards.
- It has been observed that the assets planned for resilience, even under normal conditions, also contribute to the improvement of network reliability.
- It is also advisable to establish and standardize a hazard-dependent contingency procedure for network planning.

3.3 Pillar 3: Flexibility enabling technologies and solutions.

The aim of EUniversal is to foster the provision of flexibility services to cover the needs of DSOs (and TSOs). Pillar 3 contributes to this goal by ensuring the conditions for flexibility offering by the FSP are improved and by looking on how to reduce the barriers for large-scale participation of consumers. Three topics are scrutinized in this pillar: we first investigate the improved aggregation algorithm developed within the project; secondly, we discuss end-user engagement and motivation in the market; and thirdly, we zoom into the flexibility toolbox developed within the project.

3.3.1 Improved aggregation algorithms for local flexibility markets

DSOs will need increasing amounts of flexibility to solve issues in their local grid. With the emergence of more distributed energy resources (DERs) at the end-users' side, it is important that the DSO also has access to these flexible assets. More flexibility will help DSOs to manage their grids by using the existing grid capacity optimally, thereby reducing total costs while maintaining quality of service, potential curtailment of renewable energy assets or even the likelihood on black-out events. Up to today, however, owners who only possess small volumes of flexibility face many barriers to offer their flexibility to the DSO. Aggregation is one part of the solution as it helps individual end-users to meet the minimum flexibility required to participate in the market. In addition, it helps to reduce the impact of uncertainty related to the energy consumption and behavior of individual end-users.



In EUniversal project, Centrica FSP is addressing the above challenges by developing an algorithm to aggregate small volumes of flexibility located in the LV and MV grid at end-user's premises. This aggregation aims to provide services for DSOs. The algorithm solves an optimization problem to offer optimal bids in terms of both volume and price. These bids result from the aggregation of different flexible assets in the DSO flexibility market.

In the past, similar algorithms have existed (see for instance the Cornwall Local Energy Market which focused on both DSO and TSO flexibility markets[7]). However, more and more DERs are being connected to the network, leading to increasing numbers of various types of DERs in LV and MV grids. In the EUniversal project the algorithm was expanded to consider different types of residential flexible assets. In addition to residential batteries (a focus of the Cornwall project), it now considers assets like electric water heaters, EVs, and PV systems.

This algorithm consists of different parts: modeling of assets, optimization (aimed at minimizing customer costs or other objectives) to calculate optimal bidding, the imposition of constraints, (e.g., comfort levels, maximum power injection into the grid), and finally disaggregation step to control the assets and deliver the flexibility to DSO. It should be mentioned that one noteworthy feature of this algorithm is its modularity and high adaptability. If there are changes in flexible technology like upgrades in heat pumps… adjustments would primarily involve updating the asset descriptions and not the core of the aggregation algorithm. Without access to this algorithm and the expertise of a knowledgeable FSP, customers may be unable to meet the minimum requirements and navigate the complexities of the market.

Furthermore, in EUniversal project, the algorithm was extended to different services for the DSO, including voltage control. This expansion necessitated increased data exchange between FSP and other market participants. The optimal bids generated by the algorithm are subsequently submitted to the market via UMEI.

KLL1: Optimization of flexibility resources coming from different types of assets

In the first place, the EUniversal project demonstrated an improved aggregation algorithm, which effectively optimized[8] the use of different combinations of flexibility resources available in LV and MV grid. These resources include electric water heaters, batteries, EVs, and PV systems. This optimization was particularly beneficial during periods of low market liquidity, allowing for the more efficient utilization of the distribution grid's existing capacity through expanded combinations of flexibility resources.

In the SWOT analysis, this was indicated as a strength of the project because the efficient use of resources is crucial for the further development of flexibility markets.

The results indicate that by incorporating a wider range of flexible assets, FSP can aggregate a larger quantity of flexibility from end-users and offer it to DSO flexible markets. Therefore, more potential benefits can be achieved via these markets to both DSO and FSP.

Aggregation of different types of assets

- To aggregate flexibility from DERs, it is increasingly important to integrate a growing number of smart assets that allow remote control by FSP.

EUniversal Recommendation

- Without the capability to aggregate an increasing large diversity of DERs, the aggregation of flexibility and delivery of the promised value of flexibility to DSO can be challenging or impossible for FSPs. Aggregation algorithms should therefore account for this.

[7] https://www.cornwallislesofscillygrowthprogramme.org.uk/projects/local-energy-market/

[8] The variables for optimizations are optimal schedule parameters of the flexible assets, such as turning on or off the water heater, curtail the PV production, charging or discharging the battery.

KLL2: Customer engagement is indispensable, also in pilots and demonstrations

During the development and implementation of this algorithm, customer engagement in the demonstrations was notably low. This had several consequences for the algorithm's testing. Firstly, the low level of customer engagement resulted in a less innovative aggregation algorithm. Even though the algorithm was developed properly, it could have benefited from testing on a larger number of customers. Due to the lack of customer participation, the disaggregation algorithm was designed in a simpler manner. Secondly, not all functionalities of the algorithm could be deployed in the demonstrations due to limited data exchange. In fact, the aggregation level was restricted to the household level, whereas it is typically done at the feeder level. Therefore, to obtain meaningful results that demonstrate the benefits of aggregation for SOs, a higher number of customer engagements is required. Higher rates of customer participation are therefore essential for the further development of market tools, but also to increase market liquidity to ensure sufficient flexibility offers are available to the DSO in a price competitive manner. This topic is therefore discussed as a second sub-pillar in this pillar (see further below).

Customer engagement

- It is essential to aggregate flexibility with a higher number of customers, as this leads to the creation of a larger portfolio. A larger portfolio helps FSPs reduce the uncertainty coming from behavior of different assets and end-users. It also provides more freedom to FSPs for disaggregation of accepted flexibility.

EUniversal Recommendation

- Given the importance of this challenge for flexibility markets, as well as pilot and demonstration projects as a whole, we discuss the recommendations to increase customer engagement in more detail further in the document.

KLL3: Disaggregated bid information required for participation into congestion management and voltage control markets

In addition, we gained meaningful and valuable knowledge regarding congestion management and voltage control markets with active power. Specifically, via simulation results, we were able to quantify the benefits and opportunities for FSPs to participate in each market. We noticed that adding more types of flexible assets increases the capacity of available flexibility in the demonstrator. This implies that FSPs have more capacity to bid into the market. On the other hand, since voltage and congestion are local problems, aggregation needs to take into consideration the location and proximity to the grid constraint. For instance, in the DSO toolbox, we developed a tool for voltage control that identifies the flexible resources that can help solve grid constraints and the minimum quantity required (flexibility areas). Based on this information, the aggregator can propose aggregated bids and the DSO or market platform can select the most economical and technically efficient bids. Otherwise, disaggregated bids per MV or LV node are required by the tools to select the available bids. In this case, Therefore, an extra data flow should be implemented in UMEI to transfer disaggregated bids from FSP to DSO, allowing DSOs to run its tool and then select the optimal bids or perform final validation after market clearing.

Participation in CM and VC markets

- The EUniversal project demonstrates that the improved aggregation algorithm provides more options for smaller FSPs to join flexibility markets.

EUniversal Recommendation

- Further developments in the aggregation algorithm would open up flexibility markets even more for smaller FSPs. Additional research and developments are therefore to be encouraged, for instance with respective to voltage control delivery via reactive power. Currently, the EUniversal project only tested the voltage control BUC via active power. It is important to further improve the algorithm and to engage in further testing that will also allow such services to be delivered with reactive power.
- Another recommendation can be provided regarding the exchange of data between FSP and DSO. As mentioned before, for the voltage control BUC, the DSO is requiring the disaggregated data. For this to be possible, the FSP needs to submit the bids in a disaggregated format (or aggregated to the point of interest in the grid) to the FMO and that visibility should be given to the DSO.

KLL4: A standardized communication set-up

In order to offer flexibility, FSPs typically need to establish a communication channel with the FMO to submit the bids and receive the market clearing information. In a typical business-as-usual situation, each market and each FMO has its own unique features. Therefore, to communicate with different FMOs and participate in different markets, an FSP must develop different communication implementations.

However, in the EUniversal project, the UMEI was developed to address this challenge for FSPs. The UMEI provides a solution that enables FSPs to communicate with different FMOs and access various markets using a single implementation.

This project taught us how to create a unified communication channel that can connect FSP with different FMOs effectively.

Standardized communication set-up

- The UMEI is a true facilitation for FSPs as they don't have to establish separate communication channels with different market platforms to submit bids and receive market clearing information.

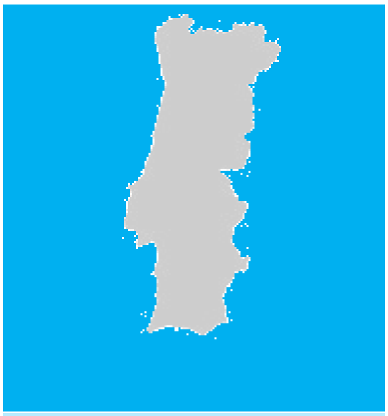
EUniversal Recommendation

- From the perspective of the FSPs, it is of added value to proceed with a solution such as the UMEI. To continue with the UMEI, all recommendations previously given to further boost the UMEI remain valid. On top of that, for the FSP, it is important to add an additional data flow to the UMEI so that information on disaggregated bis can be exchanged to the DSO, especially for the case of voltage control.

3.3.2 End-user motivation/engagement in the market

End-user engagement is essential to gather end-user flexibility through local flexibility markets. This end-user engagement is, in the short run, required to further develop the markets and test the necessary tools. In the long run, it is also necessary to ensure sufficient market liquidity beyond the testing phase. Within the EUniversal project, consumer engagement appeared to be a significant barrier as discussed in deliverable 11.5. Customer participation during the project was low due to a variety of reasons. The energy crisis and more expensive energy bills increased consumer mistrust and made them unwilling to give their time/support to the energy sector in general. As a result, end-user engagement in the demonstrator was low. While information sessions could be a good way to take away this concern, during the covid crisis the restrictions made it hard to set up information sessions to involve end-users. The different demos therefore had different implementation strategies based on their country specific energy contexts (see D11.5).

The **German demonstrator** had to start from scratch to engage customers. The lack of standard interfaces connecting to the Home Energy Management System (HEMS) was a considerable technical challenge as it limited the number of customers compatible with the project pilot testing. In addition, due to mentioned challenges and despite the mitigation measures implemented (research on the motivations of customers to participate in the pilot, door to door visits, newspaper calls etc.) the rate of customer engagement remained very low.



The **Portuguese demonstrator**, on the other hand, had a head start as they could count on customers from a previous H2020 project, the Integrid project. These customers already had received infrastructure in their premises, such as flexible assets and HEMS from this project. However, the customer engagement still took plenty of time (involving a call center to follow up on the customer interest and participation requirements) and, in the end, not all the end-users accepted to be a part of EUniversal trials as there was no additional incentive for them to do so.

Finally, the **Polish demonstrator** also struggled to engage customers in pilot activities. As described in D11.5, despite organizing a face-to-face informational Town Hall in Mława in collaboration with the Mayor, sending individual letters inviting customers or following up with online meetings etc. initial customer interest was not translated into final participation in the Polish pilot. Although engagement efforts proved to improve relationships and trust between the EUniversal project and customers, this was not enough to fully engage customers in the pilot. As previously described, the energy crisis, COVID-19 restriction, GDPR constraints and the policy context in Poland made it hard to get customers to participate. The lack of financial incentives was detected as a large barrier to complete the engagement process as many customers appreciated the information shared, and were interested in the project, but they were not willing to give away time and support without compensation in return.

The project ended up having low participation rates in the demonstrations, despite numerous actions to increase engagement (see D11.5). In what follows, we share some lessons learned from this process and we make some recommendations that could resolve similar our issues in the future.

KLL5: Consumer engagement should be coordinated by a stakeholder used to deal with end-consumers

First, in the EUniversal project, the DSO was responsible for customer engagement. It had to contact all the consumers, providing them with home and energy solutions, and arrange data and other administrative steps. The DSO was therefore the main responsible entity to share the data of the end-users with the different partners in the project. It appeared that this data sharing was a significant challenge for DSOs, who are usually not responsible for behind the meter activities. Reaching agreements between the DSOs and FSPs to share, for instance, data sets, took many months, which delayed the demo implementation and testing. As highlighted in the SWOT analysis, GDPR regulation posed significant struggles in this regard as it made it hard to share data with external partners. Nevertheless, the DSO is usually also not the first contact entity of end-consumers, since it is not responsible for behind the meter activities. Therefore, an aggregator, supplier or retailer would probably be in a better place to promote customers engagement.

Consumer engagement coordination

- Most DSOs do not have the right expertise and knowledge in-house to be the single-point of contact for consumers.

EUniversal Recommendation

- New pilot or demonstration projects should ensure having an energy supplier/cooperative and/or aggregator on board who will oversee the interaction with end-users. DSOs often do not have the needed professional structure and set-up to deal directly with end-users. Furthermore, in case the right partners can coordinate the consumer engagement processes, they could also provide more financial benefits to the end-users to be involved in the flexibility markets (such as the FSP). An issue with this approach is that there is a likelihood that there are multiple retailers in a specific region and that not all consumers in a certain grid area have the same retailer.
- When following this recommendation, it is important to take into account that potentially more stakeholders need to be involved in the consumer engagement process as expertise in different fields (social, economic, technical, organization or regulatory) might be required.
- Furthermore, previously, European projects already gained experience with regard to MV-flexibility. At LV, however, data sharing between partners is much more regulated (GDPR) and ideally, such points should be tackled already in the proposal phase.
- Furthermore, to share experience among different EU-projects, it might be beneficial to set up guidelines to work with end-consumers. EUniversal has attempted to structure a guideline from the lessons learned from EUniversal pilots' engagement processes, and shared experiences with other projects (BRIDGE) (see D11.5) but further research and testing of these approaches is needed. For instance, in the German demo, it was discovered that local newspapers did a better job in engaging consumers than personal letters.
- Another solution to avoid the challenging GDPR requirements is to broaden the scope of regulatory sandboxes for pilot projects. Regulatory sandboxes are also beneficial to test new regulation beforehand. Currently, the demonstrators needed to test within the existing framework, implying that the new regulation has not necessarily been tested properly.

KLL6: Proper incentives are important to convince consumers to join

In general, the lack of customer engagement in the EUniversal project was highly linked to a lack of monetary incentives. Furthermore, consumers are looking for long-term benefits, and are not only interested in benefits during the project. Nevertheless, from the PT-demo experience, it was learned that incentives given in previous projects to consumers (for instance in the shape of free assets to the participating consumers), were not perceived as incentives to keep them engaged in new projects.

Incentives

- Consumers do not join flexibility markets if they don't receive clear economic incentives to do so.

EUniversal Recommendation

- One cannot expect consumers to behave actively without receiving clear benefits. It is therefore recommended to ensure that consumers have clear economic incentives to join flexibility markets, whether this is in real-life, or in demonstration or pilot projects.
- Furthermore, an important recommendation about the provision of testing infrastructure to customers in the context of a (European) project is that when infrastructure is provided to end-users free-of-charge, some agreement should be made with them in terms of the commitment to participate in other projects for at least e.g. the next 5 years.

KLL7: Automation and standards are important to facilitate implementation

The lack of IT infrastructure for remotely reading sub-meter data and remotely controlling the flexible assets (by the FSP or the DSO) asked for additional investments at the consumer premises. Moreover, in PT demo, the flexibility available from MV-customers needed to be activated manually due to lack of remote-control infrastructures. The manual activation can bring some challenges as the presence of the person on the premises is needed to activate the flexibility in case it is requested.

Furthermore, most customers highly value their comfort. Automation and implementation of digital tools should therefore be encouraged to ease the burden of providing data to make consumers life easier. For instance, home management systems can facilitate energy arrangements. However, it should be ensured that all processes still occur in a transparent way so that consumers can still be informed in case they wish to be. Consumers still like the idea of being responsible for their own energy management/decisions.

Also, from the perspective of the DSO, automation would imply fewer manual interventions and a more time-efficient set up of all the tools at the customer side. The SWOT-analysis therefore emphasized the importance of ensuring low-efforts for all stakeholders through smart control and automation.

In addition, regarding the set-up at the customers households, it is important to ensure that there are more standard interfaces. Now, the demos always had to develop different set-ups at different customer sites, since no set-up works for all customers.

Automation

Automation and standardization have a large potential to increase engagement and to facilitate implementation of new pilots. On one hand, these processes ease the burden of customers that would like to be "active actors" in the energy market to provide data etc. On the other hand, automation and standardization can enable the provision of more structured and clearer information to customers so that it is easier for them to understand the energy market and make informed decisions.

EUniversal Recommendation

- Encourage standardization in consumer appliances.
- Ensure interfaces of customer meters and management systems are standardized to facilitate reading by both consumers and external partners.
- Enable automation of data exchange and other administrative and organizational tasks.

KLL8: Ensure that both economic and human resources are allocated to customer engagement

Engaging consumers takes time and effort. No consumer engagement process can succeed without a planned strategy, designed ad hoc to context-specific needs. Engaging consumers in the energy market can be particularly challenging due to the dynamism of the sector and the lack of shared knowledge of this complex topic with the general public. Although efforts are being made to educate and inform customers about the energy sector dynamics, until knowledge gaps are overcome, more resources for engagement should be allocated to ensure continuous communication and information flows to find the type of benefits and motivations (economic, social, technical or political) that might attract customers to further involve themselves in new energy projects.

Resources

There is a lack of awareness regarding energy with the broader public. Engaging consumers therefore takes time and resources.

EUniversal Recommendation

- Make sure to commit sufficient resources to increase consumer awareness and to engage consumers.

Aligned with these consumer lessons learned from EUniversal, more project specific challenges and recommendations on the EUniversal demonstrator engagement activities have been described in D11.5. An overview of the recommended steps to increase consumer engagement is provided in Figure 3-1. First of all, stakeholder identification and mapping are necessary to understand who are the stakeholders that need to be involved. Second, it should be verified what you want to reach with these stakeholders. Should they be informed about flexibility markets, should they be consulted, involved or do you want to collaborate with them? Based on this, the most appropriate communication approach to raise their interest and to reach your objective should be selected. Step 4 then can be used to select additional tools for engagement to further raise awareness. These tools will need to be adapted to the needs, knowledge, and willingness of the stakeholders to participate in the activities proposed. Overall, continuous monitoring and evaluation is needed to assess if the objectives of the engagement process are reached.

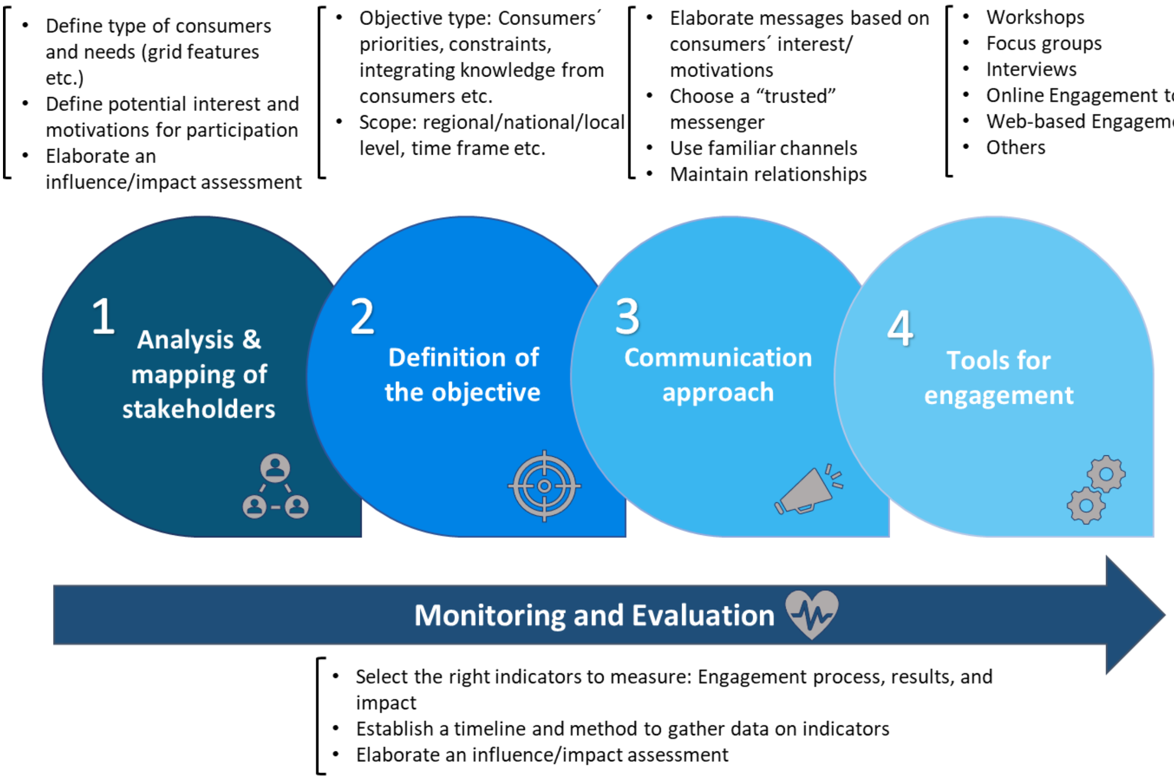


Figure 3-1: EUniversal Social awareness and engagement guidelines (D11.5)

3.3.3 Flexibility toolbox

As part of the EUniversal project a “flexibility toolbox” was developed. This toolbox ensures that DSOs across Europe can quickly and easily identify the most suitable technologies given a particular location and flexibility needs. The aim of the toolbox is to assess the usefulness of technologies and services that can bring flexibility to the DSOs. The toolbox considers the most promising flexibility-providing technologies providing the characteristics and suitability of these technologies[9]. The mapped technologies are grouped according to their technical attributes: flexibility in the short, medium, or long term; and installation at customer, distribution and transmission level. As a result, the toolbox contains the main attributes of each technology and systems, for different locations and flexibility needs. The toolbox is therefore also relevant for the FSP as it helps FSPs to optimally select the technology and the location of the technologies. See Table 3-1 for a summarized overview of the toolbox.

The development of the toolbox was necessary as DSOs must evolve their role as a neutral market facilitator, tendering services to market parties to meet its flexibility needs. Since local flexibility markets are still at a very early stage and DSOs may not be familiar enough with all newly developed flexibility options, there is a steep learning curve for DSOs but also for market players who wish to offer flexibility services. There is a need to gather information on the state-of-the-art in all different technologies that could potentially deliver flexibility and to anticipate expected technology developments in order to match the flexibility needs of the DSO with the capabilities of different technologies. Furthermore, a flexibility toolbox would be beneficial from the point of view of the DSO and FSP to estimate the flexibility potential in a certain DSO area. This is difficult as, in literature and practice, the characteristics of flexibility service providing technologies are available, however, there does not exist a mechanism to compare them and identify their suitability based on the DSO need. Moreover, there was no mechanism through which the suitability of various flexibility enabling technologies can be explored considering the time scale and location. There was therefore also a need to group the technologies according to the timescale (how fast they respond to the need of scale) and location of their installation.

Table 3-1: Flexibility toolbox D3.1

Name of Solution	Service provision					Deployment location			
	Flexibility at short term	Flexibility at medium term	Flexibility at long term	Reactive power	Active power	Transmission grid	Distribution grid	Commercial & Industrial	Residential consumers
CAES	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🔴
LAES	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🔴
LHS	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢
SHS	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢
PHS	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
TCS	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Power to Hydrogen	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴
Supercapacitors	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	🔴
Lead-acid Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢
Li-Ion Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢
Li-Polymer Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢
Li-S Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴
Metal-air Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴
Na-S Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴
Vanadium Redox Batteries	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴
DLR	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🔴	🔴
Residential DR – TCL's	🟢	🟢	🔴	🔴	🟢	🔴	🟢	🟢	🟢
Residential DR /Shiftable loads	🟢	🔴	🔴	🔴	🟢	🔴	🟢	🟢	🟢
Industrial loads	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴
Microgrids	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🟢	🟢
Smart charging	🟢	🔴	🔴	🔴	🟢	🔴	🟢	🟢	🟢
Distr. network flexible assets and control	🟢	🔴	🔴	🟢	🔴	🔴	🟢	🔴	🔴
Renewable self-consumption solutions	🟢	🔴	🔴	🟢	🟢		🟢	🟢	🟢
Active power control of RES	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🔴	🔴

[9] Including 1) energy storage (mechanical, electrochemical, electrical, power-to-heat, power-to-gas); 2) digital solutions and technologies enabling demand response; 3) flexible thermal generation, 4) smart charging and other ancillary services provided by EVs, and 5) active power control of RES

KLL9: Usage of the flexibility toolbox

The usage of the toolbox can take many shapes. We list them below:

DSOs need to set up products that are as technology-neutrally defined as possible. Technology-neutrality will enlarge the flexibility offers at the disposal of the DSO to answer their needs. For DSOs, it is therefore important to be able to verify if their products are indeed technology neutral, which they can only do if they have an overview of all technologies that can deliver a service for their needs. The toolbox can help them to verify this by checking which technologies can deliver the defined product.

In the case that in the first step it is decided that products are not technology-neutral enough, the toolbox can provide key inputs for the definition of flexibility services and products regarding the tendering procedures, and prequalification criteria that could be used in order to have a technology-neutral approach to flexibility procurement at DSO level.

The fact that the toolbox centralizes all information together is also beneficial as it provides a quick overview in a system where rapid technology development causes data to be quickly outdated. It is in that case indispensable that the toolbox is constantly updated, and a mechanism should be put in place to keep it topical. This is, however, not yet arranged today and ideally an entity is put in charge to maintain this. In addition to the rapid changes, there is also a lack of recent, verifiable data for some technologies.

The toolbox also reminds DSOs and other stakeholders that there are sometimes many possible solutions to their problems. This is important as many of the flexibility toolbox solutions are not yet widely deployed on the market. Additional research, development, deployment, and pilot projects are needed in order to fully support the market readiness of some technologies. Yet, until then, it remains important to keep an eye on them.

Finally, the toolbox only focusses on the evaluation of whether flexibility solutions are technically capable of providing flexibility. Yet, in practice, outdated regulation and policy decisions in some EU Member States might make their usage limited. Implementation of the Clean Energy for All Europeans package should eliminate some of these barriers, although implementation speeds will likely vary across the EU. This means that there will still be significant barriers to entry for some flexibility technologies in the years to come. Having an overview of all technologies also reminds other stakeholders on the work that still needs to be done to ensure all technologies can access flexibility markets. The toolbox could therefore support the following actions:

- The regulatory framework should enable the development of a full range of possible flexibility resources, while also ensuring that it is robust enough to deliver the best outcomes for stakeholders and the system as a whole. The toolbox can be used to verify whether the regulatory framework is technology neutral.
- National Regulatory Authorities should ensure that no options are prematurely ruled out. All flexibility solutions that benefit the grid, including storage and demand side response, should be treated in a non-discriminatory manner when procured by network operators. Regulatory incentives should avoid any bias towards specific technologies that deliver flexibility. The toolbox can allow NRAs to verify whether all options are accounted for.

- The relevant regulatory framework should be non-discriminatory and should not hinder or unduly disincentives DSOs from facilitating the development of flexibility. By comparing in the toolbox what is technically possible, with what is possible in the regulatory framework, gaps can be identified and solved.

Usage toolbox

EUniversal developed a flexibility toolbox and gives suggestions on how to use it. However, it is also important to further develop and maintain the toolbox.

EUniversal Recommendation

- To take this toolbox to the next level, a digital and automated toolbox should be created with the capability of specification and configuration based on the requirements from the DSOs. The toolbox will be able to prescribe 1) suitable technology, 2) sizing, and 3) location, based on the input data from DSO network status and needs. Based on the findings from the toolbox, DSOs can consider which applications can be deployed to reinforce existing grid-based systems.
- The toolbox could be implemented as a regularly updated state-of-the-art database, able to portray the different options given the available technical features but also their economic viability from the electricity market point of view. Since a high level of accuracy would be difficult to maintain for a toolbox, it should at least provide a preliminary assessment of the most suitable option to be adopted, according to previously selected standards.
- On the other hand, the efficient use of flexibility resources may change in accordance with national or regional differences. This will likely require working with regulators to jointly agree on the framework and return implications while considering the expected improvement of system performance.

3.4 Pillar 4: Markets

Within the context of the energy transition, the changing energy mix (more renewables) and consumption patterns (electrification) leads to higher flexibility needs, both at transmission and distribution grids. To gain access to additional flexibility, flexibility at distribution level needs to be unlocked. However, today not all electricity markets are accessible to all (especially LV-) resource providers. This is due to the existence of different technical, economic, social and regulatory barriers. Therefore, within the Clean Energy Package, article 59(1) point (e) of the Electricity Market Regulation established the right for the European Commission to establish network codes that ensure non-discriminatory access of all types of resources to all electricity wholesale markets. This implies that different articles in the Electricity Market Regulation (2019/943) on demand response (aggregation (art 17), tasks of DSOs (art 31) and TSO (art 40), incentives for the use of flexibility (art 32), ownership of energy storage facilities by DSOs (art 36) and TSOs (art 54), and article 57 of the Electricity market directive (2019/944) on the cooperation between system operators) need to be covered through the new grid codes.

A framework guideline[10] to set up the network code has been established and will be finalized in the short run to a full grid code. The EUniversal project ends right at the end of this process and is therefore in an excellent position to give some final insights and recommendations.

Within the EUniversal project, three different DSO demonstrations were set up which tested a universal approach to interact with stakeholders on flexibility markets to gain access to flexibility. To do so, the demos developed and implemented a local flexibility market to test different use cases (D2.2, WP7, WP8 and WP9). This was supported by both qualitative research on different types of flexibility mechanisms (D5.1) and workshops on open market issues (D5.4), and quantitative research examining the optimal choice of distribution grid tariffs (D5.2) and the impact of P2P markets on DSO needs (D5.3).

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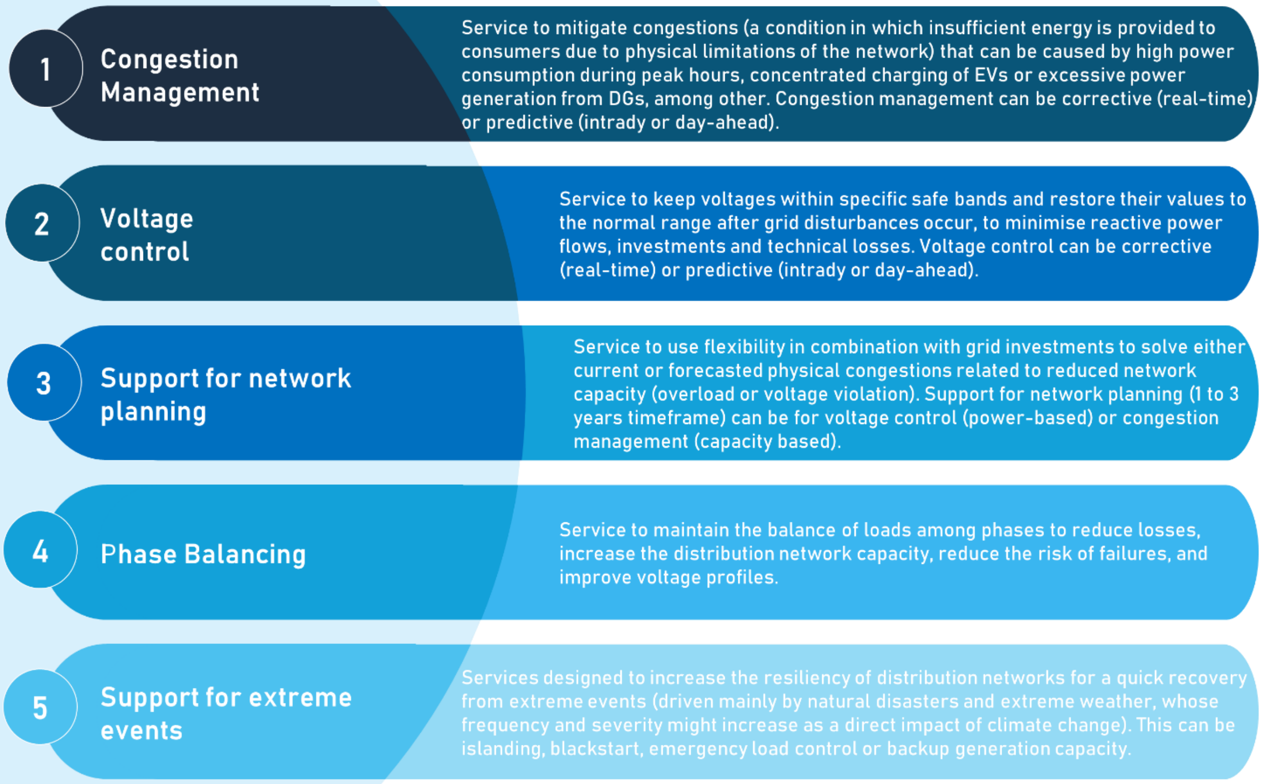
10 https://eudsoentity.eu/nl_BE/blog/open-consultations-7/public-consultation-on-the-network-code-demand-response-draft-57

KLL1: Flexibility needs and services

System operators experience different types of **flexibility needs**, in different time frames (real-time versus medium-long term) which need to be resolved**.** These needs are still relatively new and there are no commonly defined requirements yet. In order to proceed with flexibility markets and to ensure filling in all flexibility needs, flexibility services that can resolve them should be defined.

EUniversal contributes to filling this knowledge gap by defining the future flexibility services that can address the DSO flexibility needs identified in three different European Member States. In D2.1, all services are defined, considering different DSO needs in different timeframes. They are summarized in the figure below.



It should be noted that this set of definitions is one of a kind for many reasons. Most of these services are not yet commonly procured through flexibility markets in most European Member States. It was therefore challenging to define the required services for the different needs as the alignment among the demonstrators in the different countries was needed. A proper definition of these services is important to ensure that non-discriminatory, technologically agnostic and market-based procedures can be set-up to ensure cost-effectiveness. Furthermore, before the services could be defined properly, the demonstrators had to clearly identify and characterize their needs by specifying the type of events that occur in the distribution grids and by indicating the possible procedures that can help resolving those technical issues. Only when agreement on these needs was found, a proper specification of the flexibility services could take place. Given the wide heterogeneity in the distribution grid, coming to a common agreement on flexibility and needs was challenging.

Congestion management and voltage control were considered the most important services in all demos. While there were practical implementation ideas for congestion management, reactive power management has so far only been presented theoretically due to the high locality and the restricting status quo of technical connection conditions in the low voltage level. More specifically, the large majority of LV clients are usually not able to control reactive power which makes them unsuitable to participate in reactive power markets. Nevertheless, with the framework developed in KER12, we proved that in terms of needs and related products, voltage issues are going to appear earlier than congestion issues. Indeed, based on a reasonable range of scenarios, we found that congestion is not the most urgent issue to address. However, a product intended to solve a voltage problem will also impact the currents, which means that products could potentially be designed in such a way that both issues are addressed together, at least if regulation allows it.

Flexibility needs & services

- EUniversal defined future flexibility services needed to resolved flexibility needs of DSOs in three different European Member States.
- Given the wide heterogeneity in the distribution grid, finding alignment was challenging and time-consuming.

EUniversal Recommendation

- To define proper flexibility products, a transparent, non-discriminatory, technology-agnostic definition of flexibility services needs to be defined and established in the network codes. The EUniversal definitions could be used as a starting point to set up harmonized definitions of flexibility needs and services, as they already contain alignment between three Member States which differ quite a lot.

KLL2: Flexibility products

Following proper needs and flexibility services identification, all demonstrators characterized the requirements[11] to solve these flexibility needs (D2.1). The technical requirements in D2.1 define how flexibility could support the grid operation during distinct operational conditions. These requirements to fulfil a specific DSO need must be translated into **flexibility market products** that can be procured by the DSO at flexibility markets. Ideally, these products should be generic/standardized so that they are fully technology neutral and resource type independent. This would avoid blocking out certain FSPs and reduce complexity for the market clearing algorithms. Also, more generic products would be more beneficial for the UMEI implementation of the information exchange, reducing interoperability issues. However, “given

[11] Type, procurement timeframe, reservation and/or activation, mandatory (or not), mode of activation, expected duration of the response, full activation time, location / geographic scope, aggregation, minimum quantity, maximum quantity, deactivation period, minimum duration of delivery period, maximum duration of delivery period.

the heterogeneity of networks, the range of products may change depending on topography, population, industrial density and activity focus and the network itself.” (D5.1) This could easily lead to tailored products that reflect specific flexibility market needs by being more adapted to e.g., specific grid problems, promoting products innovation. In addition, tailored products properly designed can still be technology neutral. Simulations in KER12 showed a significant decrease of RES curtailment when considering more technologies, highlighting the importance of including a maximum of technologies. Technology neutrality allows for higher participation rates which decreases flexibility costs.

As a result, EUniversal agrees that product standardization would be more beneficial. Yet, in the short run, generic products are more challenging to satisfy required services and needs of DSOs. Product definitions must consider the technical and operational framework conditions and on-site circumstances to meet the requirements of the system operators. Furthermore, the products to be defined should be measurable and, since they have a major impact on the security of supply, they should include penalties in case of non-performance. The EUniversal partners therefore also indicated in the SWOT analysis that more standardization of flexibility products is needed while avoiding overregulation and discrimination of products and services. Flexibility markets are still new and in need of innovation. In addition, KER12 proved that the way products and flexibility markets are designed, also depends on the relative importance of PV and Wind assets. As a matter of fact, wind-dominated systems are characterized by issues that last longer than in PV-dominated systems, since wind generation is more constant and may be present or absent over longer periods. This raises the need to coordinate measures through time.

Therefore, the demonstrators within the project designed their own individual products, fixing at least four product attributes: the minimum and maximum quantity, the minimum and maximum duration of a delivery time interval, the activation price and locational information. However, the implementation of these attribute values, as well as the values of other attributes, might be different among the EUniversal demos due to differences in their needs and tested use cases. The discussion on the importance of the different attributes is elaborated in D5.4. It is important to emphasize that different stakeholders might have different perspectives on the importance of some attributes (e.g., divisibility is important for the DSO, but less relevant for an aggregator).

Flexibility products

- Deciding upon the demonstrator product attributes and how they should be filled-in, was not a straightforward task as there are still many unknowns in today’s immature flexibility markets.

EUniversal Recommendation

- Full product standardization for DSOs should not be pushed for in the short run. Partially standardized products, fixing certain product attributes, might be more feasible in order not to block further innovation and to ensure that specific local conditions are considered.
- Alternatively, defining a standard list of product attributes at European level, could also ensure further harmonization of different products, without restricting products.
- Leave sufficient time for implementation of any standardization decisions.
- Aim for standardization of low hanging fruit first – high/medium voltage level products

KLL3: Market and non-market based mechanisms

Different **mechanisms** exist to ensure DSOs can acquire flexibility to address different grid needs, both **market and non-market based**. Non-market-based mechanisms can be technical solutions, but they can also be regulated mechanisms such as cost-based remuneration or obligations. Non-market-based solutions are, according to Directive 2019/944, only to be chosen if economic efficiency cannot be guaranteed.

The focus of EUniversal was on market-based solutions. In practice, before market-based solutions can be implemented, the right conditions need to be met. We discuss these in Table 3-2. The EUniversal project aimed to further facilitate the fulfillment of these conditions in two ways which are also summarized in Table 3-2:

- On the one hand, the EUniversal project offers solutions for ensuring these conditions are met;
- On the other hand, the EUniversal project experienced challenges such as low market liquidity in the demonstrators when in case not all these conditions were fulfilled (see more details in Table 3-2). As this also happens in practice, the EUniversal project transparently discusses these challenges to contribute to further projects and the further development of flexibility markets. We do so by summarizing lessons learned from the project experiences and we offer recommendations to solve these challenges in the future.

The minimum conditions to establish flexibility markets are discussed in more detail throughout this entire document. The table below gives a short overview of the necessary conditions and indicates in which pillar learnings and solutions are being discussed. In the context of the EUniversal project, it should, however, be pointed out that the demonstrators only replicated markets and that the conclusions are therefore not based on real market conditions.

In practice, and especially in the short run, these minimum conditions are not yet all present. Given the current liquidity challenges, the EUniversal project also discussed whether flexibility should be used in the **long-run** for grid investment deferral, or whether flexibility is mostly a good solution in the **short-run** while the grid is being reinforced. The EUniversal project found that investments in the distribution grid will always be needed alongside flexibility, and that flexibility requirements should be designed in such a way that flexibility delivery is reliable. Regarding the different **procurement time horizons**, the Portuguese demonstrator tested both short-run and long-run solutions. It took advantage of flexibility in the medium and long-term network planning. In the MV network, operational maintenance planning was used in the Mafra and Évora networks. A total of 2,4 MWh flexibility was requested by the DSO during November for a period of 6 hours (LongFlex). For the Evora and Alcochete network, grid investment planning with flexibility was implemented which respectively “led” to a 1-year and 2-year deferral in grid investments. For this use case, a total of 7,5 MWh was requested by the DSO using Long flex, during all business days in November.

Table 3-2: Conditions for market-based flexibility solutions and related EUniversal solutions

Condition	Explanation	Pillar	EUniversal solution
High market liquidity	A first key condition is that a high market liquidity is indispensable, especially during rare situations. This is something that is very hard to realize with day ahead/intraday markets alone, especially when there are competing offers for flexibility for balancing purposes. (D2.1) Within the demonstrators, reaching sufficient market liquidity posed a real challenge.	**3**	D11.5 discusses solutions to increase consumer engagement
Flexibility incentives	In the SWOT analysis, it was indicated that before market liquidity could be ensured, it is indispensable that flexibility providers receive proper incentives either to offer their flexibility, or to invest in renewable and flexible assets. It should therefore be noted that before market liquidity can be increased, there might be other conditions that need to be fulfilled.	**4**	D5.2 discusses dynamic grid tariffs and D5.3 discusses P2P markets
Smart meter infrastructure and automation	Another key condition for flexibility markets is highlighted in the German demo, stating that the smart meter infrastructure in Germany is not developed enough to enable efficient flexibility use. The lack of smart meter rollout (in the EUniversal project in Germany, but it also relates to other countries) is a major hurdle in implementing smart grid solutions.	**3**	The EUniversal project cannot assure smart meter roll-out or standardization, yet in this report, we give recommendations to be accounted for.
Standardization in behind the meter assets	In addition, there are missing standards in the home energy management or other behind-the-meter systems. This implies that it is not always straightforward to capture flexibility. It is therefore necessary that operational solutions and standardized interfaces are in place to make flexibility markets work more efficiently. Flexibility markets are in need of more standards for communication systems and information exchange.	**3**	
Predictability of network needs	Another important condition for flexibility markets is that congestion problems and voltage issues need to be predictable. In the German demo, it was pointed out that the developed tools for congestion detection offer possibilities to identify system shortages ahead of time. The quality of the forecasts increases with the quality of the input data. Greater observability and standardized control channels are needed to enable better forecasting and ensure grid resilience as the number of heat pumps, EVs, and PVs increase.	**2**	EUniversal has developed multiple tools to tackle this issue.
Coordination between stakeholders	D5.1 also emphasizes that flexibility markets currently still face numerous other challenges as they require more complex coordination between different stakeholders, as there is currently no consensus on the market design option(s) that should be considered.	**1**	The UMEI facilitates communication and interaction between stakeholders
Cost-effective solution	Furthermore, flexibility markets are to be used if market-based flexibility is the most cost-effective solution. There is no consistent evaluation scheme for differentiating when market and non-market system services are beneficial. From a business point of view, flexibility markets are currently in a worse regulatory position than conventional grid expansion. Market entry barriers and the regulatory framework, however, limit the market liquidity and the competitive development of prices for flexibility, and reducing the possibility for DSOs to purchase cost-efficient flexibility services on the market.	**4**	Flex market implementation costs are decreasing thanks to innovations such as the UMEI, and the benefits from using flex markets will increase.

Nevertheless, even if the right conditions are in place for market-based mechanisms, non-market-based solutions should not be ignored as they form an indispensable part of the DSO flexibility mechanisms. In Germany, a national congestion management mechanism, Redispatch 2.0, is in place to resolve congestion due to high renewable energy production. The mechanism changes the planning of power-generating plants to ensure grid issues are avoided. It is a mandatory cost-based mechanism with which all system operators need to comply. Therefore, even though EUniversal's focus is on market-based mechanisms, we also tested the combination of market and non-market-based mechanisms in the German demo by testing the effective use of locally available flexibility from the LV grid combined with the existing German cost-based **Redispatch 2.0 mechanism**. The market solutions found should be able to be integrated into already established mechanisms. Otherwise, the operational effort will increase significantly and the energy system, which is already becoming more complex, will face further hurdles. The German demo showed that a combination of mandatory solutions like the German Redispatch 2.0 process and market-based solutions for individual system services seems possible but is complex and requires further research.

Furthermore, there are also other mechanisms to acquire flexibility (see

Figure 3-2). D5.1 made an evaluation of the different mechanisms[12] that can be applied to acquire products for congestion management and voltage control, the two main services tested in the EUniversal demonstrators. An important conclusion of the analysis was that not all mechanisms can be adopted to procure any product depending. The choice of mechanism is related to the product characteristics and boundary conditions that define the system operators' need. Moreover, the coexistence of different mechanisms may lead to a non-efficient acquisition of the system service products. Hence, acquisition mechanisms should be designed considering their mutual impacts to emphasize their respective strengths and to reduce their weaknesses. Moreover, given the heterogeneity of distribution grids, and depending on other contextual elements, some mechanisms for acquiring grid services might be more effective than others. As a result, it is likely that a combination of flexibility tools, covering both mandatory and voluntary offering of flexibility services and short-term and long-term sourcing of flexibility, might arise in the coming years. Some mechanisms might even not be appropriate as a stand-alone in specific situations (for example a flexibility market in case of low market liquidity). A qualitative analysis of the compatibility between flexibility tools can be found in EUniversal D5.1 in which all market mechanisms are considered in different contexts[13]. It was concluded that all analyzed mechanisms could work for congestion management, while voltage control is forced to fall back on mechanisms that explicitly consider the local characteristics of the service (such as bilateral contracts, and obligatory mechanisms). D5.1 details all possible combinations in more detail.

Within the EUniversal project, we also examined and analyzed other flexibility acquisition mechanisms. Besides the direct provision of flexibility, D5.2 of EUniversal also shed light on the implicit delivery of flexibility through economic incentives. **Dynamic grid tariffs** were tested on a grid model provided by the

[12] Evaluating which mechanism is most appropriate, was done based on different attributes that describe DSO needs (attributes related to grid needs (e.g., contracting timeframe, frequency of the need, the volume of the problem), the affected grid area (e.g., grid topology, voltage level, the volume of available flexibility), and the potential FSPs in the area (e.g., size, FSP nominal voltage, number of expected FSP participants, and resources types of FSP)). In addition, the mechanisms were further assessed by means of regulatory principles to verify their economic efficiency, transparency, reliability, customer engagement, equity and implementation concerns.

[13] The proposed set of context attributes includes aspects related to the grid needs (e.g., contracting timeframe, frequency of the need, the volume of the problem), to the affected grid area (e.g., grid topology, voltage level, the volume of available flexibility), and the potential FSPs in the area (e.g., size, FSP nominal voltage, number of expected FSP participants, and resource types of FSP).

German demonstrator (DSO Mitnetz Strom) to examine the reductions in congestions due to different types of implemented grid tariffs. Such simulations are indispensable as more and more member states are moving from volumetric tariff charges towards more capacity-based tariff designs and time-varying tariffs. This trend is enlarging customer engagement and aims to increase cost-reflectivity and flexibility availability. In total, 5 different tariff designs were tested with different levels of granularity (real-time, 15-minute basis, hourly basis…) and were compared to a reference scenario where the consumers only received a fixed individual capacity tariff signal. For the more granular tariff designs, a quantitative assessment was made of the entailed impact on the grid operation (in function of relieving grid congestion, redispatch needs and cost recovery) as well as on the end-consumer (viewed in function of the invoice impact). From the perspective of the end-consumer, providing implicit flexibility could lead to considerable cost reductions if the tariff is more granular and if the consumer has sufficient means to respond to the price signals. From the perspective of the grid operator, overall, all selected grid tariff designs that gave incentives to flexibility, helped to relieve distribution grid constraints while specific redispatch needs were considered. The analysis showed that the original capacity tariff, which was applied to all individual consumers, helped to reduce the highest peaks that were present in the network. These peaks determine the investment needs of the grid operator and it is therefore beneficial to reduce them. Yet, higher levels of granularity in the distribution grid tariff, would further help reduce congestion risks. This is because they give more opportunities to shift loads over time, increasing the possibilities to further reduce the remaining peaks. In addition, they increase the responsiveness to the redispatch signal as well. An attention point in that case would be, from the grid operator perspective, the aspect of cost recovery as consumers could adapt their behaviour towards lower tariff periods. The latter could impact whether grid operators manage to recuperate their costs. Some precaution is therefore needed, for instance for the event-based tariffs design, to ensure DSOs can recovered all costs. Nevertheless, even though higher granularity increases the potential to mitigate grid congestions, the reflection was made that simplicity for consumers should also be considered. It is important that they understand how to behave in the most efficient way. Furthermore, predictability of grid congestion should also be taken into account, as without proper forecasts, it is not possible to give the correct economic signals to consumers.

Figure 3-2: Alternative mechanisms to flexibility markets

As the proper combination of different mechanisms seems to be indispensable in the future, and as the decentralized markets, such as P2P markets, are emerging, D5.3 analyzed the innovative **combination of the local flexibility market with a bilateral grid-aware P2P decentralised trade mechanism**. This is an important analysis as emerging concepts like P2P trading can also have a direct effect on the grid operation which must be accounted for. Four different scenarios were tested: a local flexibility market with no P2P trading (Sc0) acting as a benchmark case, a P2P market without DSO intervention (Sc1) considering a fully uncontrolled/unchecked P2P trading environment, a P2P market with DSO-disallowed trades (Sc2), and a P2P market with DSO-(dis)incentivized trades (Sc3). This implies that we tested the standard P2P trades, which are basically financial agreements without any explicit impact on the grid, and P2P trades with DSO intervention to account for grid impact. The analysis has shown that, under Sc1, on the positive extreme, the P2P trading can naturally result in bilateral energy trades between peers that can be in line with the needs of the grid, hence, resolving the existing congestions and leading to a reduction of flexibility procurement costs in the local flexibility market. On the negative extreme, however, the P2P mechanism may result in bilateral P2P trades that further exacerbate the congestions available in the grid, or even create new ones, requiring additional costly procurement of flexibility to resolve all caused congestions. Between those two extremes, the P2P trading can partly resolve and/or create new congestions (even concurrently). As such, given the case-dependence and uncertainty of these results, and to ensure grid safety, D5.3 explored mechanisms in which the DSO can provide inputs/supervisions to the P2P trading when the grid is under heavy loading conditions following two scenarios (Sc2 and Sc3): in Sc2, the DSO can introduce ex-ante blockers on some P2P trades that are deemed non-grid-safe, while in Sc3, the DSO can introduce financial incentives and penalties to, respectively, encourage or discourage trades that are deemed advantageous or disadvantageous to grid operation (i.e., incentivizing trades that lead to reduced congestion and penalizing trades that exacerbate congestions). The results have shown that, under Sc3, even though the incentives and disincentives tend to impact the P2P trades in such a way that is beneficial to the grid, the computation of the adequate monetary incentives and disincentives is practically challenging, and their associated costs may outweigh the potential benefits in reducing flexibility procurement costs. In addition to the regulatory barriers that can face Sc3 due to introduced market distortions, inadequate incentives/penalty values may even lead to more grid-unsafe trades. On the other hand, Sc2 can provide a practical way to safeguard the grid as shown in D5.3. The Sc2 results have, indeed, shown how the DSO can still allow (largely free) P2P trading while limiting its effects on the grid through blocking some trades, especially in heavy-loaded conditions. These results are case dependent and Sc2 can face regulatory and fairness challenges. Hence, the results incentivize conducting similar analyses for the P2P and grid settings considered in practice to enable an informed choice of the best grid-safe P2P market mechanism to be implemented. In summary, there is no one-size-fits-all answer as the characteristics of the network, the level of available flexibility providers in the system, as well as the incentivization schemes that are deployed, determine whether both mechanisms can co-exist. A regular P2P market without DSO intervention could solve some congestions but had the risk that it could cause other additional congestions. In case the DSO intervenes by explicitly (dis)incentivizing trades, the potential to solve congestions increases significantly. However, it comes at the price of being more complicated: incentives and disincentives must be calculated appropriately, which is, as discussed previously, not always easy given the lack of observability in the distribution grid. Furthermore, the cost of the incentives could outweigh the benefits and there might be legal barriers to set incentives. For instance, the DSO is not always allowed to give economic incentives.

In summary, the EUniversal project showcases many analyses on different flexibility procurement mechanisms. Insights are furthermore also derived from the demonstrators themselves. The German demonstrator has shown that various prevailing barriers, e.g. limited smart meter roll-out, the lack of standardization of technical devices, the regulatory framework and a growing resignation among the German citizens, heavily impacts the willingness and the ability to offer flexibility services for grid management. Consequently, unless these barriers are removed, the available flexibility in the LV and MV grid remains unused, obliging DSOs to rely on the existing and costly solutions like grid expansion and mandatory redispatch for specific assets to solve grid constraints. Expect for the limited smart meter roll-out, the German case also applies to the Portuguese demonstrator.

From the Polish demonstrator, it could be seen that, in certain situations, forced by technical conditions, with a small number of customers able to provide services, bilateral contracts may be a solution. In the case of DLR BUC, the buyers of flexibility services are wind farm energy producers who would like to supply more energy in a given period than specified in the connection agreement. After submitting a purchase offer to the DSO on the market platform, the DSO uses the DLR technique to check whether the 110 kV network allows it at a given time. If the technical feasibility is positively evaluated, the answer is given by specifying the value of the permissible hourly power (i.e. hourly energy), time interval and price. The transaction is to be done on the market platform. However, due to the 110kV network ownership monopoly there is no competition and the potential buyer of the flexibility has limited possibilities to negotiate.

(Non-)market-based mechanisms

- Even though focusing on flexibility markets, the EUniversal project also examined other flexibility mechanisms. This is indispensable as there no solution can act as a stand-alone-solution. It is important that a proper combination of mechanisms is put in place.

EUniversal Recommendation

- Flexibility markets can only take place if the right market and economic conditions are in place. Sufficient market liquidity is needed, and flexibility needs to be the most cost-efficient and effective solution.
- Furthermore, the right technical conditions also need to be in place: Smart and standardized control and measurement with standardized interfaces is indispensable, and observability of the network and/or predictability of flexibility needs should be sufficiently high.
- There might be sub-conditions that determine whether the key market conditions can be achieved. For instance, incentives for FSPs to provide flexibility are needed to increase market liquidity, which is a necessary condition for the successful implementation of flexibility markets.
- Flexibility markets are not a stand-alone solution as there are still many challenges to be solved. Different mechanisms exist to obtain flexibility and a dedicated design of mechanisms should be implemented to combine strengths and reduce weaknesses. The EUniversal project provides a sneak-peak sheet to assess strengths and weaknesses of different mechanisms and it indicates which mechanisms can be combined. It should be ensured that different mechanisms do not contain contradicting measures or actions.
- Flexibility markets can both be used to procure short-term and long-term flexibility. Yet, it should be noted that investments are assumed to be always needed alongside flexibility.
- Grid tariffs can help to relieve grid congestions. The more granular grid tariffs offer more congestion reduction options. However, it comes with an increased challenge to set the height of grid tariffs appropriately to ensure full cost recovery for the DSO, while keeping tariff simple enough for consumers to understand.
- Compared to other incentive systems such as time-variable network charges, market-based solutions can respond more accurately to potential congestion in the network without introducing, through tariffs, discriminations among users connect to different grid areas. Local solutions can be provided by defining market environments that potentially lead to economically favorable solutions. However, liquidity and potential risks such as gaming must be kept in mind.
- Different flexibility mechanisms can co-exist, but how they should work together depends on the characteristics of the network, the grid flow status , the level of available flexibility providers in the system, as well as the incentivization schemes that are deployed. It is therefore important that regulation does not force a one-size-fits-all solution or combination of solutions. In particular, looking at P2P market design, it is indispensable to consider network constraints before it can co-exist with other flexibility markets. Furthermore, when different mechanisms are combined, their mutual impact should be considered as it might be different from their individual effects.

KLL4: Coordination between markets and system operators

From the EUniversal and other projects, it becomes clear that there are multiple design options for flexibility markets. Different flexibility platforms have emerged to facilitate the procurement of flexibility services. These platforms have to adapt to regulatory differences in the countries they operate, fix certain market parameters themselves depending on the type of products (for instance in the case of industry-led standardization) and/or they can work with flexible parameterization options that DSOs can choose from when setting up the market. Different platforms can also aim to resolve different needs. Some can focus on localized procurement of congestion management services for the DSO, while others enable exchange of standardized balancing and congestion management products between TSOs and aggregators[14]. As a result, different countries and DSOs are implementing their own solutions, placing different accents on flexibility market designs. This implies that, in the future, it could appear that flexibility is procured from different markets running in parallel, or multiple system operators could be procuring flexibility to solve similar or opposite needs. Contradictory needs could, for instance, occur between TSOs and DSOs as they each aim to resolve issues at different levels. A local solution to a local problem, could cause issues at higher levels (for instance balancing issues). However, despite being very complex, two platforms could also operate in the same local region, with one focusing on resolving an issue A, which could cause indirectly an issue B for the DSOs on the other platform. Therefore, relevant design considerations in future flexibility markets are competition and cooperation among different flexibility market platforms, TSO-DSO coordination, and the issue of counterbalancing.

Competition between different market platforms could occur in the future when multiple independent market operators develop flexibility markets in the same network areas. The EUniversal project concludes that this may be acceptable (taking into account pros and cons as discussed in D5.4) if certain key conditions are met. Overall, competition between multiple platforms should only be allowed if safe network operation remains guaranteed. This implies that DSOs utilize the necessary tools for grid state analyses to prevent the creation of grid constraints through activation of flexibility. Furthermore, despite the existence of various market platforms the activation of flexibility of a same asset should only be allowed if the asset type, selected time slots and the required flexibility do not affect the delivery obligations resulting from double activation. However, the co-existence of multiple market platforms in one area may reduce the market liquidity and hence the efficiency of each market. Ultimately, adequate mechanisms are required to prevent strategic bidding of market participants across different market platforms. The co-existence of more than one market platform in the same area can therefore turn out to be very complex. From the challenges that the EUniversal project endured (market liquidity, standardization), it can be derived that in the short run not all conditions are fulfilled to have competition between different market platforms in the same grid area.

While the EUniversal project is focusing on DSO flexibility markets, there are also flexibility markets where both DSOs and TSOs are buyers among the emerging markets being developed across Europe. Information sharing and other interactions between DSOs and TSOs are identified as important and should be ensured through proper **TSO-DSO coordination**. Linked to this is also the discussion on who should be

14 https://eepublicdownloads.azureedge.net/clean-documents/SOC%20documents/SOC%20Reports/210957_entso-e_report_neutral_design_flexibility_platforms_04.pdf

responsible for **counterbalancing**. When the DSO activates flexibility, this might create imbalances at system level, especially in case of large volumes of flexibility activated when the DSO flexibility market takes place uncoordinated after the TSO balancing market. When volumes traded on flexibility markets increase, this could become a significant issue (even though this is currently not yet the case in small demonstration and pilot projects). In the EUniversal project, flexibility needs were determined based on the state estimation (see also pillar 2 for further explanation). If private customer systems (e.g. batteries, charging stations…) become more a part of TSO balancing markets, and if congestion markets are cleared without coordination, there will be larger unwanted interactions. The difference of TSO balancing markets and DSO flexibility markets for congestion management or voltage control is especially apparent within the locality. While TSOs can theoretically draw from a large pool of suppliers, line congestion or voltage control are of a more local nature. In this regard, an appropriate coordination and accountability system still needs to be defined. A more detailed consideration in further research projects is recommended.

The EUniversal project also discussed the importance of **coordination with other markets and data systems**. Today, this is not yet a serious concern due to the limited amount of competing flexibility markets. Yet, in the future, this coordination might become indispensable as data are often also shared with other systems and other markets. In the SWOT analysis of the EUniversal project, it is therefore highlighted that coordination should be looked at from a broader perspective than only one flexibility market. Multiple markets, stakeholders, data systems and infrastructure should be coordinated properly.

Coordination between markets and system operators

- Today's flexibility markets are still rather small and do not frequently occur. The impact of one platform on another, or of one system operator's need on another, is therefore rather small or non-existing. It is, however, important to be prepared for a future where flexibility markets gain momentum, and where these issues do need to be resolved.

EUniversal Recommendation

- In the short-run, conditions to allow competition between multiple market platforms in the same grid areas, do not seem to be fulfilled. To ensure this is possible in the long-run, it is recommended that challenges linked to standardization and market liquidity are solved.
- Given the current small-scale implementation of flexibility markets, counterbalancing issues are rather limited. For future purposes, counterbalancing issues and solutions do need to receive more attention and research to overcome future challenges.
- TSO-DSO coordination needs to be further defined in terms of coordination between and accountability of systems that take into account the local nature of DSO flexibility markets.
- Coordination should go further than coordination between stakeholders and markets, it should also entail coordination between data, infrastructure, interfaces…

KLL5: Integration of the flexibility market in the sequence of existing markets

Flexibility markets are only one type of market which needs to be fit somewhere in the existing sequence of energy and balancing markets. During the EUniversal project, we also investigated how to properly align the EUniversal flexibility markets with existing markets. This was identified as an essential element for flexibility markets to succeed. On the other hand, it was also a challenging topic as today there are still significant differences in the current markets of the three demonstrators. Only in the future, following trends of TERRE, PICASSO, MARI and FCR cooperation, all EU countries are expected to evolve towards a target model in which the balancing capacity market goes ahead of the DA wholesale market. Given the differences in the current markets in the three demonstrator countries, specific timings of the flexibility markets could not be generalized within the EUniversal project but were discussed specifically per demonstrator. Nevertheless, as a general conclusion, there was a strong preference for a market sequence where the flexibility market takes place after the wholesale market. This is because then DSOs can rely on the DA wholesale market outcome to make an appropriate prediction of the network congestion. In addition, it would allow the DSO to acquire flexibility closer to the delivery time, reducing the likelihood of needing non-market based remedial actions or overestimating DSO flexibility needs. Furthermore, there would be a lower chance of activating bids in later markets that could cause additional DSO congestion which was not anticipated. The disadvantage of placing the flexibility market after the other market is, however, that there would be no priority access for flexibility for the DSO (with a risk of decreased flexibility availability for the DSO). It is also less attractive for some FSPs as late closing times of flexibility markets might lock out flexibility services with long start-up times.

Integration of flexibility markets in the sequence of existing markets

- The Euniversal project identified a proper fit of flexibility markets in the existing sequence of energy and balancing markets as essential to ensure flexibility markets can be rolled-out on a larger scale.

EUniversal Recommendation

- It is recommended that local flexibility markets take place after the closure of the wholesale market. This is necessary to ensure DSOs can forecast their congestion needs more accurately, taking into account the results of the DA wholesale market.

KLL6: New roles in flexibility markets

Within the EUniversal project, the role of the flexibility market operator is covered by an **independent market operator (NODES and N-SIDE)**. An FMO is described as a neutral party that transparently provides a central service between buyers and sellers to facilitate the communication and coordination of all processes related to the procurement of capacity and/or energy bids, i.e., grid or asset registration, on its marketplace, matching of bids, validation (through market monitoring) and settlement. Beyond the EUniversal project, there are, however, also emerging market platforms that do not always consider a third party as flexibility market operator (in that case, the DSO could for instance be the FMO).

The EUniversal project argues that having a neutral FMO compared to the FSO being the market operator **improves neutrality** and therefore **reduces conflicts of interest** for balancing and redispatch. It also **improves transparency** in bid matching and communication and **coordination between market players (FSP, DSO, FMO)**. Furthermore, it increases the possibility of having multiple system operators as buyers, and it **increases competition** as it **facilitates market access** for customers. Finally, due to the **specific knowledge** of the market operator, an independent FMO can offer **improved clearing algorithms**, **data security** and **encryption possibilities** which other, less neutral market operators might not have in-house.

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Independent market operators therefore lead to clearer benefits. However, in order to ensure these benefits can take place, there is a **higher need for interface management** between the DSO and the flexibility market, and higher coordination efforts are required for reasons explained under KLL4: that is coordination between multiple stakeholders, between multiple system operators and between data systems is important to run the market efficiently, to ensure all stakeholders understand and respond to each other needs, and to ensure that there are no conflicting actions. Today, many flexibility platforms are being set up or already exist to ensure independent market operators can work properly. However, there are still numerous issues related to **data security and GDPR** that become more and more **complex** when multiple actors are involved. The involvement of an independent market operator namely implies an additional party to join the market, which adds an additional layer of complexity and cost to an already complex environment. Finally, a key challenge of having a third-party market operator, is the question on **how the responsibilities and activities related to market operation should be divided among different actors**. The later is a key challenge that we observe with regard to existing market designs in general.

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The EUniversal project devoted quite some time to the later question. When a third party operates the market, it is important that the activities and responsibilities of the different actors are clearly divided so that there is no overlap between the activities of the two parties. In theory, a role cannot be shared between different actors. However, the conclusion is that there is no black and white answer as a strict separation of the different roles and activities is difficult as many activities exist and as responsibilities are often shared between multiple parties. During the EUniversal project, the most important market activities were categorized in three key market phases (see Figure 3-3: registration and prequalification phase, procurement phase, delivery and monitoring phase) and discussed. There were four parties whose activities had to be divided: the DSO, the DSO as Data operator, the FMO, and the FSP/aggregator. It was concluded that there is quite a lot of agreement in the registration and prequalification phase, as well as in the delivery and monitoring phase. In the latter, activation signals are sent by the FSP/aggregator and the calculation of the amount of flexibility delivered and the remuneration is also performed by the FSP/aggregator. Metering data is provided by the DSO (taking up the role of the meter data operator). In the prequalification and registration phase, the different activities are divided among multiple parties (FMO, DSO, FSP/aggregator). Only the set-up of the product and grid prequalification requirements are the sole responsibility of the DSO. The role division of the other activities in this phase is set by arrangements made during the demonstrator operations and therefore differ depending on the project context.

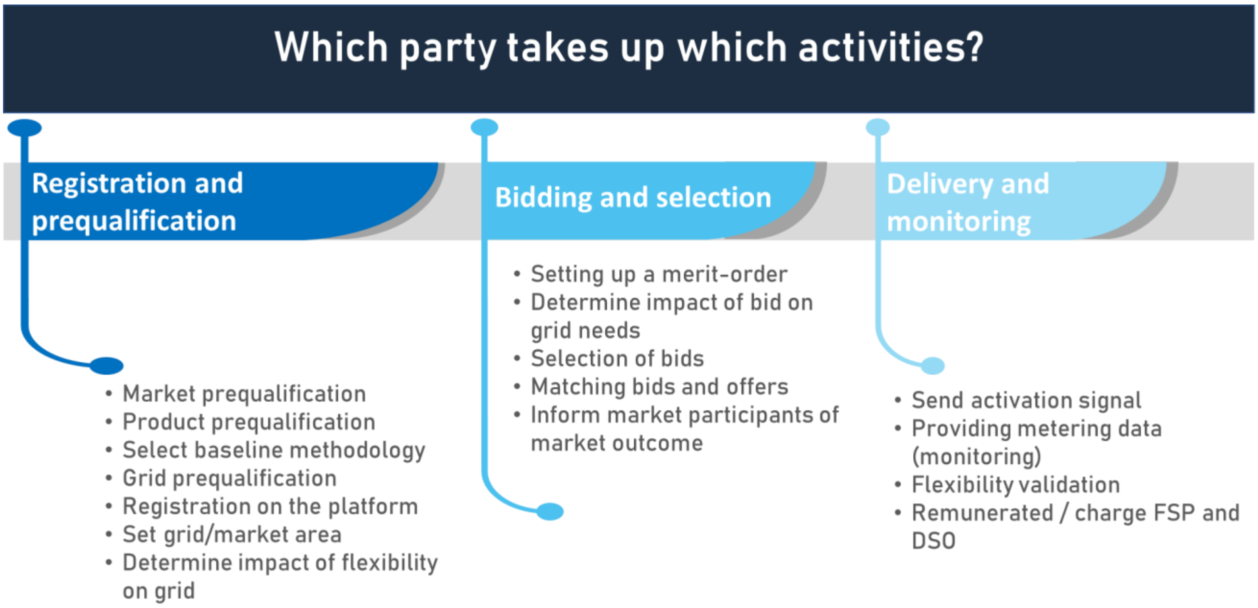


Figure 3-3: Market phases and market activation in the EUniversal project

Activities in the bidding and selection (procurement phase) were identified as the most disputable market phase. This is because there are conflicting needs of different parties. Namely, from a market point of view, rules for selecting and validating bids should be clearly defined and made transparent to market parties. Therefore, in order to validate compliance with grid constraints, it is necessary to have sufficient network information to select the appropriate bids for congestion management and voltage control. In case an independent market operator is responsible for clearing the market, he needs to have access to specific data such as customer data or local network information. This network information is, however, not always (publicly) available to all market parties but is often only visible to the DSO. This is because, from a system point of view, it is the DSO who is responsible for system security, and he therefore prefers to have control on the selected bids and data. The DSO needs to be able to validate that the procured flexibility complies with the distribution grid constraints while ensuring network security, as well as determine the contribution of flexibilities towards the need. Therefore, it is possible or even necessary, in some cases, that the DSO is also involved in the selection of flexibility to be procured. This is also indicated in EUniversal D5.1, where it is pointed out that the DSO should be in charge of the optimization process in the cases in which, to achieve the most efficient results, the market-clearing depends on comprehensive grid data that cannot be shared outside of the DSO boundaries for regulatory reasons. Therefore, for the purpose of the EUniversal project, we introduce the terminology of "bid selection" in contrast with the traditional market clearing. More details about this phase can be found in D5.1.

To answer the question on whether network representation had to be taken care of in the market or outside the market (by the DSO), the EUniversal project ranked bid selection options on a scale from selecting bids in the market to selecting bids outside the market. Bids can be ordered through an economic merit order in which FSP bids are ordered based on prices. While this is very transparent and simple to calculate for all market participants, it has the disadvantage of not accounting for dynamic constraints. It also does not consider the impact of flexibility on the distribution grid and is therefore not appropriate for congestion and voltage management. Bid selection techniques that are therefore potentially more complicated, even though it might decrease the transparency for the market participants, are therefore preferred by DSOs as they can consider multiple constraints (both FSP and network related). There are three types of bid selection options here. We discuss them below and summarize them in Figure 3-4.

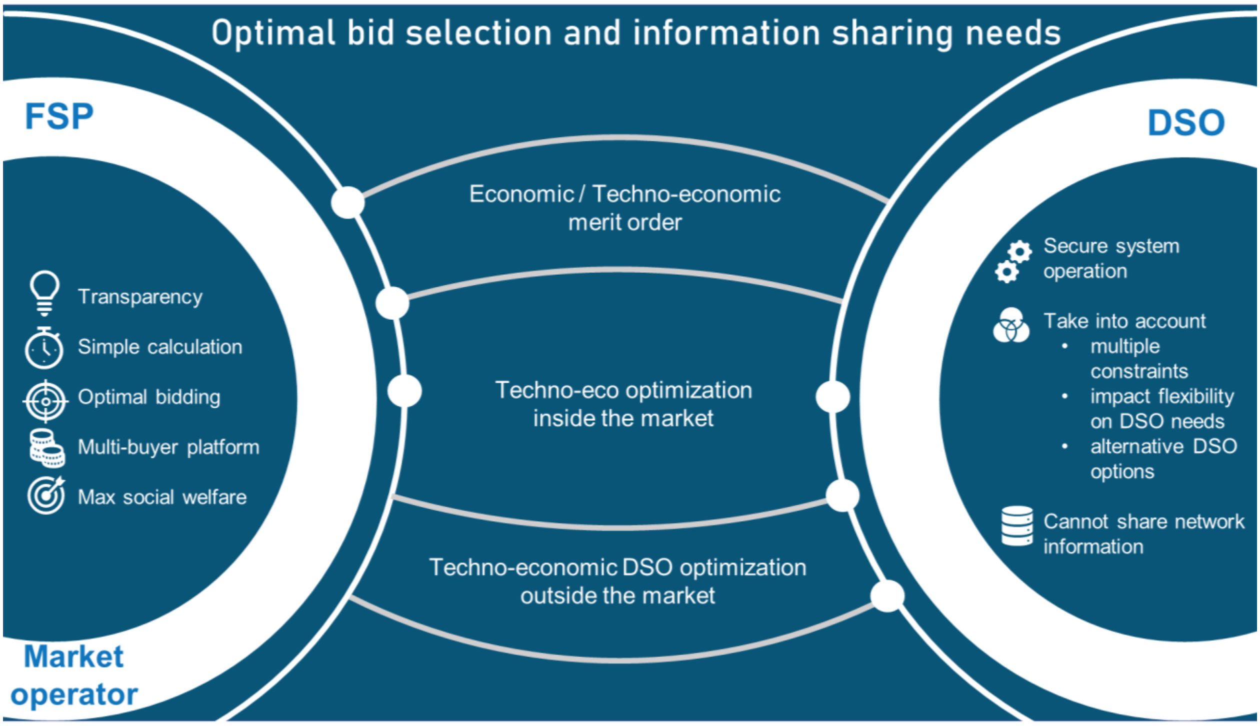


Figure 3-4: Optimal bid selection and information sharing needs

- Option 1: On the one hand, it can be a **techno-economic merit** order where next to price information, also additional technical information is considered.
- Option 2: On the other hand, the additional information can also be used as an input for a more **advanced clearing algorithm** used by the market operator. The algorithm then does the matching in the market based on the available information. The benefits of these first two options are that a neutral market player does the matching, considering the welfare of all market parties. However, the market platform would need information to consider technical or grid constraints. Yet, the DSO is the final party responsible for system security, and it is a risk for it to share crucial network information. In addition, some data cannot be shared due to legal reasons or are hard to share in the case of meshed networks where grid sensitivities are harder to determine.
- Option 3: The latter is the reason why the German demo opted to go for an **internal optimization tool** to select the final bids outside the market (option 3). Also, the DSO might have additional information linked to construction sites, other technical solutions, maintenance plans, etc., which only they could account for themselves. Therefore, at the end of the bid selection scale, it is also possible that the DSO does an internal optimization by considering the necessary information and, as such, selects the bids itself outside the market.

The market platforms themselves also facilitated this discussion by adapting their platforms to the needs of both the DSO and the FSP. With respect to the implementation of the second option, in the Portuguese demonstrator, the two market platforms were used in parallel making direct comparison possible. NODES shared bids with the DSO and allowed the DSO to create a grid abstraction with grid nodes. Each FSP had to be registered in the respective grid node and their location was therefore defined per grid node. As such, the DSO could select and validate the flexibility bids while considering grid constraints and voltage levels. The market platform did not require grid topology. With these bids, the market operator did the market clearing on the market platform and the DSO was certain that the outcome would comply with its needs. N-SIDE, on the other hand, approached the issue differently by not using detailed grid information in the market clearing. They proposed the concept of dynamic flexibility areas to allow an efficient selection of bids without grid topology awareness (this is discussed in more detail in pillar 2). As a result, the market platform selects the bids without knowing their exact location. In the German demonstrator, the N-SIDE optimal bid recommender (option 3) was used to allow the DSO to select the optimal bids. Sequentially, the NODES market design ensured that the DSO was responsible for the bid selection (as discussed above). This ensured, also in the German demonstrator, a non-discriminatory and transparent market design without extended data sharing. Both platforms are summarized in Figure 1-6 .

The market platforms, therefore, made efforts to accommodate to DSO needs by ensuring grid constraints can be accounted for without requesting detailed grid information. As such, bid selection on the market is possible. Nevertheless, choosing between bid selection on the market or outside the market remains a choice between (a) taking into account more detailed constraints (including alternative DSO options) and without jeopardizing a secure system operation or sharing sensitive network data, and (b) between having a more transparent, simple to calculate bid selection. Which bid selection option is best depends on numerous factors, one of them being the network topology. For instance, radial grids do not contain closed loops, implying that the influence of individual FSPs on the grid is more easily determined than in meshed networks where network nodes are interconnected to one another. In case of meshed grids, bid selection option 3 (outside the market), or option 2 where the DSO can select and validate the bids, could therefore be better. In case of radial grid, bid selection option 1 and 2 are appropriate.

New roles in flexibility markets

- In summary, in the EUniversal project, the combination of actions in the UMEI pillar, the DSO-toolbox pillar and the market pillar, lead to the fact that it was possible to have a market-based solution without sharing detailed network information, thus enabling compliance with legal and data protection obligations without losing the advantages in pricing and efficiency (if liquidity is high enough).

EUniversal Recommendation

- EUniversal recommends having an independent market operator, yet more clarity is needed regarding role division between the market operator and existing parties.
- Data sharing conflicts of interest are a blocking element in having an independent market operator. Yet, EUniversal proves that market-based solutions for DSO services is also possible without sharing detailed network information. Solutions are developed and demonstrated in the market clearing itself (how the grid is defined), but also through facilitating tools (optimal flexibility recommender).
- Market-based solutions should take into account differences between meshed and radial grids, acknowledging that meshed grids might require more DSO involvement in grid selection.

KLL7: Baselining

Baselining is necessary for accurate validation of the volume of flexibility delivered and a proper continuation of the demos beyond the project. The baseline namely gives insights into the normal behaviour of a flexibility asset before it has activated its flexibility. As discussed in D5.1 there are different ways to determine a baseline. Within the EUniversal project, the demonstrators decided that FSPs need to submit the baseline for their portfolio to the market. If the FSP is responsible to provide the baseline he can choose the method that he wishes. This is at its own responsibility in the sense that if he is too far off with its estimates, penalties might apply. The FSP submits the baseline to the market platform each time. To avoid gaming due to the way the baseline is computed., the baseline should be calculated even if no offer from the bidder is accepted. Alternatively, baseline methodologies could be standardized over the whole flexibility market. As flexibility markets are still under development, EUniversal argues that it would be better not to harmonize the baseline methodologies too early in Europe. As such, the optimal method can be decided depending on the type of flexibility resources used, data availability, timing of baseline calculation (before or after the market clearing), timeframe of the market (day-head, intraday…) and flexibility service (congestion management, planned maintenance…).

Baselining based on forecasting from past behaviour may not always be the optimal approach because load variations may occur if the client expands its activity or decreases it for several reasons (ex.: new orders that must be fulfilled, absence of new orders, internal maintenance). Rewarding or penalizing the client based on past behaviour may lead to attrition. Learning from best-practices will be important in the short-run to understand which option to go for under specific conditions. In this regard, examples can be taken from balancing markets which are already more established. However, specifically for flexibility markets, additional criteria must be considered due to the local context of distribution grid services. Within the EUniversal project, four indispensable parameters were highlighted: the local characteristics of congestion management and voltage control, the product and asset types, data availability, and the timing of the baseline submission.

A final discussion related to baseline definitions zoomed into the question whether baselines should be defined on an aggregated level or not. Aggregation can take place at resource level (submeter), at smart meter level (behind the meter) and at feeder or substation level (multiple connection points). Baselines should capture local characteristics of DSO needs in as much detail as is necessary, yet on the other hand they should also be sufficiently aggregated to reduce the impact of uncertainty in the flexibility service provider's portfolio, especially during settlement.

Baselining

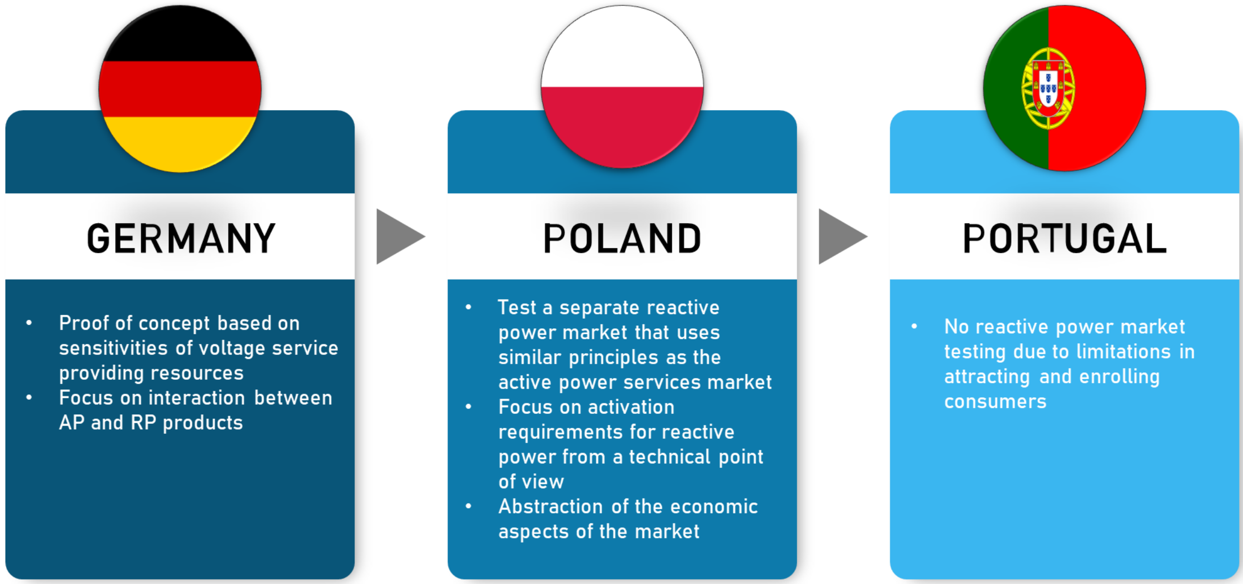
- It is important that the optimal baseline method can be decided upon depending on the type of flexibility resource used, data availability, timing of baseline calculation, the timeframe of the market and the flexibility service being provided.

EUniversal Recommendation

- We recommend not to harmonizing baseline methodologies too early across Europe.
- It is important to learn from best-practice in the short-term.
- Due to the local context of distribution grid services, it is indispensable that new criteria (not based on balancing markets) be considered. Within the EUniversal project, four indispensable parameters were highlighted: the local characteristics of congestion management and voltage control, the product and asset types, data availability, and the timing of the baseline submission.

KLL8: Reactive power markets

Within the EUniversal project, the demonstrators tested both active and reactive power business use cases. Reactive power is necessary for DSOs to maintain voltage in their grid within predefined limits. In the past and up to today, most of the time, technical solutions and mechanisms for voltage control have been used. For the three demonstrators, these technical solutions are summarized in D5.4. However, in the future, there will be a shift in resources that provide reactive power services as large power plants are becoming less available and new resources are more third-party owned. Reactive power requirements have always been mandated for TSOs, but today in regions where voltage issues occur due to higher levels of PV, the DSO is also in greater need of reactive power solutions.



Throughout the project, it became evident that knowledge on reactive power markets was limited and often deviated from active power markets. The EUniversal project therefore highlights that reactive power is different from active power due to different elements:

	Reactive power is dependent on the R/X ratio of the network, which implies that reactive power is less effective in low and medium voltage networks
	The impact of reactive power on certain voltage control needs (sensitivity factors) is dependent on the network operating point, which implies that market boundaries and sensitivity factors need to be constantly updated. As a result, the effectiveness of reactive power for voltage control might be limited, depending on where the need is located and what the current network state is.
	Besides that, there are two reasons why there is a strong link between reactive power and active power. First, the reactive power output of a resource is generally a function of its active power output, which is often referred to as the Q(P) characteristic. Second, in LV and MV networks, voltage control is embedded in congestion management and addressed with active and reactive power support interchangeably.

Therefore, in the demonstrators, active and reactive power are considered as separate products on the market platform.

Reactive power markets

- It is important to distinguish active and reactive power products separately on the market platform.

EUniversal Recommendation

- The technical connection conditions as well as the locality of the problem give little potential and possibilities for aggregation and for the implementation of reactive power markets in the low voltage level. The implementation of capacity markets for congestion management holds more potential and should be prioritized.
- There is currently a lack of knowledge on market-based reactive power procurement and more research and test projects are recommended in this field.

3.5 Recommendations

The EUniversal project proposes solutions for different challenges through 4 key pillars. Yet, as shown in the previous chapters, the pillars are interlinked and often resolve similar problems from different perspectives. To resolve a challenge, solutions from one pillar often also need to be supported by solutions from another one. It is as stated by Aristotle: "The whole is greater than the sum of its parts." Therefore, in this section, we bundle all the challenges, solutions and recommendations of the previous chapters together in six key topics and we indicate how different pillars contribute to the topic (see Figure 3-5).

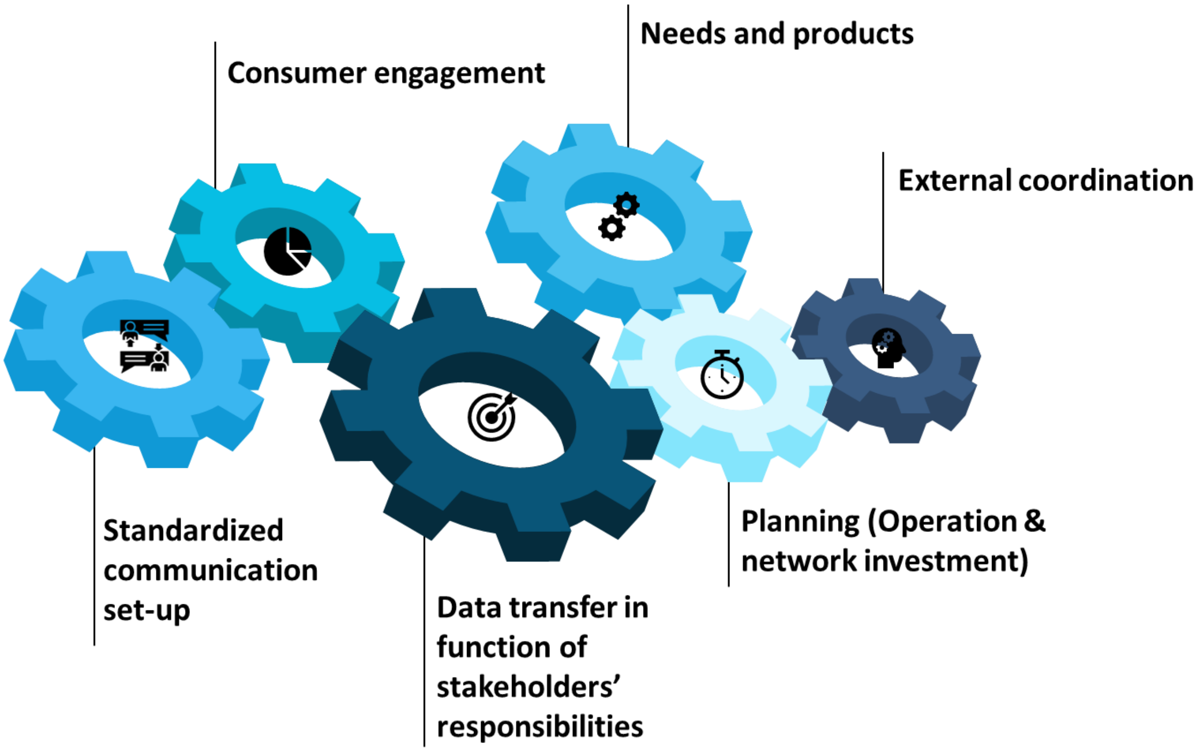


Figure 3-5: Key overarching topics to which EUniversal pillars contributes

The solutions to the challenges are spilt up into two categories. The first category contains solutions proposed by EUniversal. The second category contains recommendations for other stakeholders to help create solutions for remaining challenges. These recommendations can be linked to regulation, R&D, data measuring and processes, and economics. For each challenge, we indicate in which pillar the challenge is being discussed, and what type of solution is recommended.

Standardized communication set-up

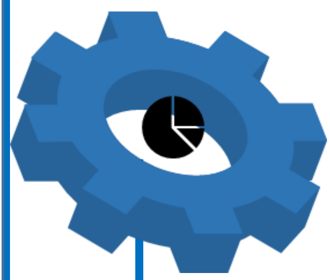
To set up and run a local flexibility market, different types of stakeholders need to be able to communicate and interact with each other, to properly understand each other's needs and offers. In the business-as-usual scenario, all individual stakeholders need to establish a separate communication channel with each market platform which increases costs, complicates the establishment of flexibility markets and ultimately impedes the access to DERs. Consequently, stakeholders are limited to one market platform and associated regions of market activity.

	Pillar	Category
Standardization		
The UMEI is a standardized communication set-up and facilitates communication and interaction between stakeholders. **It is recommended to proceed with this or a similar type of standardized opensource communication solution.**	1	EUniversal solution
The UMEI also decreases the fear of lock-in to one market platform. **To further ensure this, it is important that the UMEI or other communication set-up is API compatible with more than one market platform. Ideally, a standard communication model for flexibility trading is required to achieve this.** Within the project, the market platforms adjusted their specifications to the UMEI.	1, 4	EUniversal solution
The UMEI consists of a set of APIs and **it is important that there is a future European API standard**. This will further facilitate the implementation of the UMEI in different environments.	1	Regulation
To facilitate API-standardization, **market standards need to be defined**.	4	Regulation
The standardized communication set-up is especially important in case of the presence of an independent market operator. **EUniversal recommends having an independent market operator due to benefits linked to neutrality, transparency, and customer engagement.**	4	Regulation
Exploitation		
The easy implementation of the UMEI is facilitated by the EUniversal project by distributing the UMEI as an open-source interface on Github. **It is recommended that the European Commission further supports these open-source tools so that they can continuously be upgraded.**	1	Economic
In the short run, the EUniversal project believes that it is **important to ensure that the UMEI is flexible and adaptable to different markets**. This is necessary due to the fact that currently, there is no common market framework yet.	1	EUniversal solution

The UMEI covers all key trading market operations linked to flexibility procurement. However, if the UMEI becomes a widely accepted API standard for flexibility markets, **all market operations must be covered by the API standard** (for example also pre-trading activities such as pre-qualification and registration, as well as settlement).	1, 4	EUniversal solution

Interoperability

The UMEI creates a strong foundation for the interoperability of different stakeholders and their tools in flexibility markets and it ensures easy implementation of the interface for future stakeholders. The tools to ensure interoperability between the DSO's internal tools were implemented in the DSO cloud environment. A project data lake and backend platform has been set up to implement the processes for data exchange through the UMEI and to ensure compatibility with the tools from the DSO toolbox. This ensured interoperability between the DSO's internal tools and the market platforms through the UMEI, without the need of further compatibility with communication standards. **To further facilitate this, following the API specifications presented in Github is recommended, or a standardized API-structure is to be set-up.**	1, 2	EUniversal solution, regulation



Consumer engagement

Flexibility markets can only function properly if there are sufficient FSPs offering sufficient flexible resources present on the market to offer flexibility to the DSO. This is necessary to ensure competitive prices; to decrease the risk of market power, shortages and interruptions; and to guarantee that the flexibility needs of the DSOs can be resolved. To achieve this, consumer engagement is needed. Today, many consumers are still unaware about flexibility markets or do not have sufficient incentives to participate, they may have lost confidence in the energy sector (due to the energy crisis) and, often, they do not see the benefits of offering flexibility. In addition, those consumers that do want to access flexibility markets still face technological, operational, regulatory and economic barriers. Finally, most DSOs do not have the direct contact to the end-users to be the single point of contact for consumers and are yet also not incentivized by regulation to use flexibility markets. As a result, consumer engagement is rather low, and it was a significant barrier for the project.

Facilitation

	Pillar	Category
Throughout the project, it became evident that consumer engagement was low. It is therefore recommended and necessary that stakeholders who set up a flexibility market **commit sufficient resources to increase consumer awareness and to engage consumers**.	3	Economic, social
EUniversal has identified drivers and motivators as well as barriers for consumer engagement, providing a guideline to consider during end-consumer engagement processes. **It is recommended to take those into account when planning and allocating resources for engaging consumers in future flexibility markets.**	3	EUniversal solution
In the EUniversal demonstrators, the DSOs oversaw consumer engagement. Yet, they were not used to being in direct contact with consumers. **New pilot or demonstration projects should therefore ensure having an energy supplier/cooperative and/or aggregator on board who will oversee the interaction with end-users**. Potentially, additional stakeholders with expertise in different fields (social, economic, technical, or regulatory) might also be required.	3	Social
GDPR management becomes challenging in many EU energy projects, especially in new pilot or testing projects as time and resources are limited. Creating common guidelines on how to approach GDPR constraints and leverage EU projects´ experience would be most helpful. This could be developed by BRIDGE Regulation WG.		Regulation

Incentives

Consumers should get clear economic incentives to join flexibility markets, whether this is in real-life, or in demonstration or pilot projects. These may include a grid tariff reduction or taxation.	3	Economic, regulation
If in the context of a (European) project a testing infrastructure or other equipment is provided to end-users free-of-charge, attention should be given to ensure consumer engagement beyond the project. This is recommended as in the Portuguese demonstrator, end-users from previous projects were not necessarily more engaged than other end-users.	3	Economic, regulation

Aggregation

To be able to deliver flexibility to the DSO, **the capability to aggregate a growing number of (smaller) assets of different types that allow remote control by the FSP** will become increasingly important. **Aggregation algorithms should therefore account for this.**	3	EUniversal solution
The EUniversal project demonstrates that the improved aggregation algorithm provides increased opportunities for smaller FSPs to join flexibility markets. **Additional research and developments could be envisioned, for instance regarding the adaptation of the algorithm for the provision of voltage control by means of reactive power.**	3	R&D

IT and automation

Additional work is recommended in the field of **activating flexibility remotely**, as manual activation requires the involvement of end-users which is not the preferred option for most consumers.	2, 3	Technology
It is recommended to **encourage standardization in consumer appliances** as this facilitates the implementation of flexibility markets and remote control. This also implies that interfaces of customer meters and management systems are standardized to facilitate reading both by consumers and external partners.	2, 3	Technology, Regulation
Furthermore, it became evident that end-users highly value comfort and low-effort solutions. Therefore, **enabling automation of data exchange and other administrative and organizational tasks** would be an important enabler for FSPs to offer flexibility.	2, 3	Technology

Data transfer in function of stakeholders' responsibilities

In flexibility markets, stakeholders need access to different types of information. They need grid data to evaluate whether a specific FSP bid can answer a DSO need without causing additional constraints to the grid. Furthermore, FSPs like transparency to optimize their bidding strategy, and market operators need these insights for cost-effective market clearing. Second, they need end-user data for registration and settlement. In addition, data for baselining are needed for validation of activated flexibility. However, not all data are easy to share. For grid security reasons, DSOs can for instance not share data on grid representation, and GDPR makes sharing end-user data very cumbersome or impossible. Finally, in all data sharing activities, data protection and IT security concerns should be prioritized. It is therefore also important to determine which stakeholder takes up which responsibilities as this determines which data each stakeholder needs. Solutions for these challenges can be found in a number of sub-categories as discussed below.

Sharing arrangements

	Pillar	Category
A solution to avoid the challenging GDPR requirements in pilot and demonstration projects is to **do these pilots in the context of regulatory sandboxes**. In that case, the scope of regulatory sandboxes should be broadened, providing more flexibility regarding GDPR.	3	Regulation
At LV, data sharing between partners is much more regulated (GDPR) and ideally, **such points should already be tackled in the proposal phase**.	3	Organiz-ation

Data solutions

Finding solutions for proper data sharing is indispensable for proper functioning of flexibility markets. The UMEI offers creative solutions for data transfer without causing security issues thanks to its distributed approach with respect to data handling. **It is recommended to retain the basic data transfer principles of the UMEI to further ensure data security.**	1	EUniversal solution, data
A further development needed in the UMEI is the exchange of data between FSP and DSO with respect to disaggregated data for voltage control as this would further facilitate aggregation of bids. To facilitate this communication, a new data exchange function should be added to the UMEI.	1	EUniversal solution

Roles

EUniversal recommends having an independent market operator, yet more clarity is needed regarding role division between the market operator and existing parties.	4	Regulation
EUniversal identifies that the **procurement phase is the most disputable market phase and identifies different bid selection options**, ranging from selecting bids in the market to selecting bids outside the market. The former option allows taking into account detailed constraints (including alternative DSO options) without sharing sensitive network data, while the latter allows a more transparent, simple bid selection. Which bid selection option is best depends on numerous factors, one of them being the network topology. **In the case of meshed grids, bid selection options outside the market, or where the DSO can select and validate the bids, could therefore be better. In the case of a radial grid, other bid selection options could be more appropriate.**	4	Regulation
Data sharing conflicts of interest are a blocking element for having an independent market operator. Yet, **EUniversal proves that market-based solutions for DSO services are also possible without sharing detailed network information.** Solutions are developed and demonstrated in the market clearing itself (how the grid is defined: flexibility areas, grid abstraction with grid nodes), but also through facilitating tools (optimal flexibility recommender (OBR)). The market platforms offered solutions that ensured DSOs did not need to share detailed network information while the clearing could still take place on the market. One solution was to share with the market platform dynamic flexibility areas, that include the candidate FSPs to solve technical constraints and the limits that avoid additional technical problems. A second solution is to allow the DSO to select the final bids outside the market, considering their full knowledge of the network. Choosing between the two solutions will depend on flexibility market regulation and implementation model.	1, 2, 4	EUniversal solution

Needs and products

Due to increasing loads from electrification and higher levels of renewables, DSOs need cost-effective solutions for congestion management and voltage control. Flexibility of grid assets combined with DER flexibility allow for solving grid constraints and postponing grid investments. To do so, DSOs need to be able to monitor and predict grid issues, to properly quantify flexibility needs, and allow for cost-effective mobilization of technology-neutral flexibility that can be procured by the DSO via flexibility markets. Ideally, these products should be generic/standardized so that they are fully technology neutral. This would avoid blocking certain FSPs and decreases complexity for the market clearing algorithms.

Grid observability

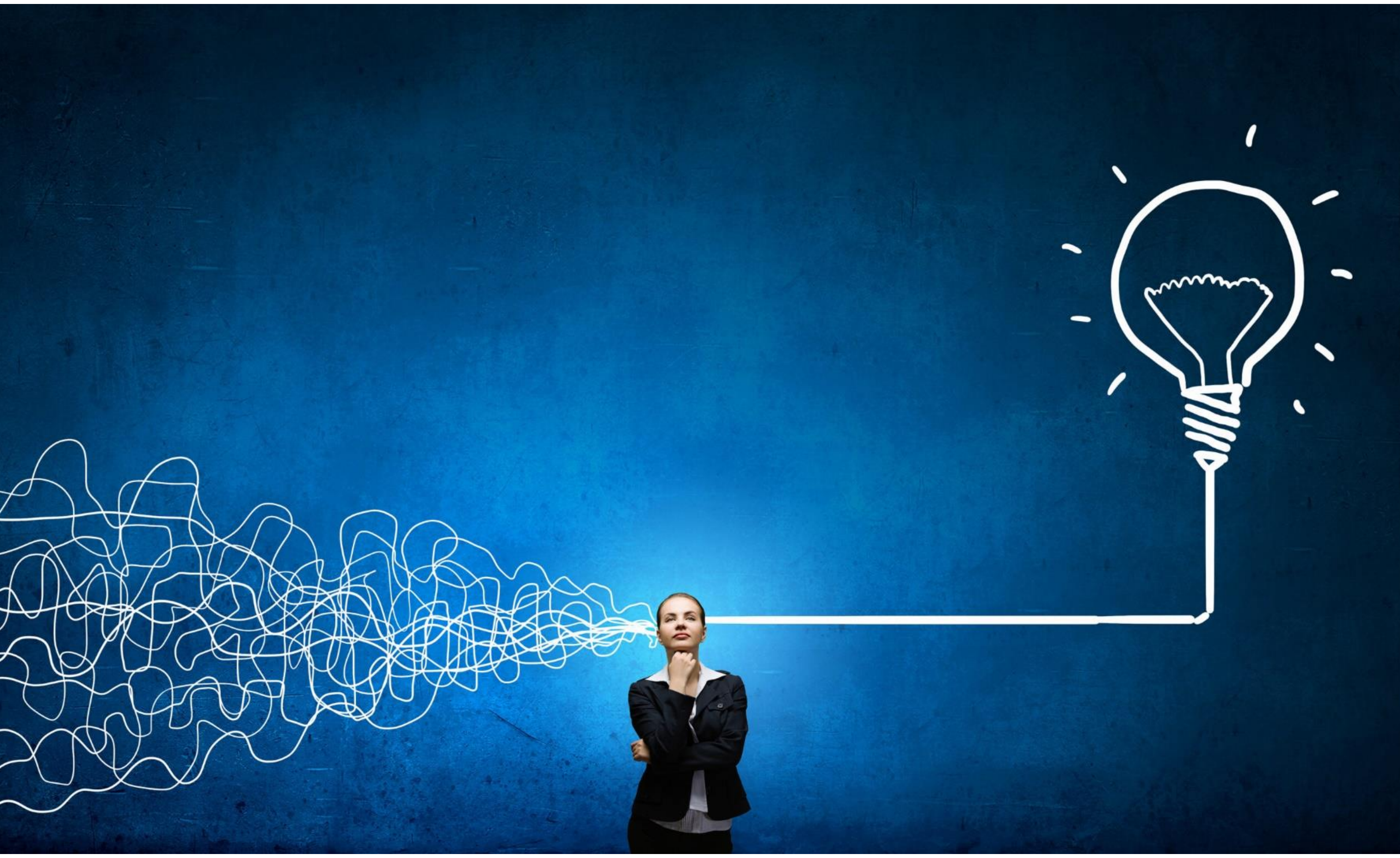
	Pillar	Category
EUniversal has developed a set of tools to improve observability of the distribution network, from HV to LV networks: • At the HV level improved monitoring enables dynamic management of HV line capacity. • At the MV level, accurate load and generation forecasting is key to forecast grid constraints. • At the LV level, a set of data driven tools are used to map and characterize network topology, forecast voltage and congestion and monitor network status in real time. **It is recommended that DSOs further exploit options to improve observability in their grid. These solutions do not only rely on investing in monitoring equipment but should take advantage of existing historical data from different sources (SCADA, AMI, network planning, etc). Using this data is key for the development of accurate load and voltage forecast tools, that in turn will lead to accurate estimation of flexibility needs.**	2	EUniversal solutions
The participation of LV flexible resources requires major improvements on LV network observability, which typically have low monitoring capabilities, poor characterization of grid topology and network characterization, phase connection. EUniversal proposes a data-driven approach to improve network observability, taking advantage of different types of data (e.g., smart metering, typical load profiles, power quality analyzers, ...). Tool demonstrations have proven the **potential of a data-driven approach to avoid heavy investments in LV network monitoring equipment and communication infrastructures, taking advantage of smart metering or other historical information available to forecast grid status, identify potential constraints, improve (quasi)real-time monitoring capabilities and define corrective control actions.**	2	EUniversal solutions
EUniversal has shown that deploying flexibility services based on DLR increases opportunities of RES integration and decreases RES curtailment, especially in areas with constrained grids. **EUniversal**	2	EUniversal solutions

therefore recommends that DSOs use DLR to monitor and forecast the admissible line load, thereby fortifying the framework for flexibility services.		
The EUniversal demos provide an important added value by enabling testing and validating the developed network tools within a realistic setting. The tools use data from distinct systems, requiring the development of transversal data collection processes **and may come with many (also non-technical) issues, such as enabling data transfer among different DSO systems (AMI, SCADA, pilot testing), IT security constraints to GDPR compliance. Moving towards more flexible and interoperable systems that also promote data integration and analytics will benefit DSOs in the future and facilitate new tools testing and integration.**	2	Data

Needs

System operators experience different types of flexibility needs, in different time frames (real-time versus medium-long term) which need to be resolved. These needs are still relatively new and there are no commonly defined requirements yet. To define proper flexibility products, a transparent, non-discriminatory, technology-agnostic definition of flexibility services needs to be defined and established in the network codes. **The EUniversal definitions could be used as a starting point to set up harmonized definitions of flexibility needs and services, as they were defined from the specifications proposed in the most relevant European projects and were aligned considering inputs of at least three Member States.**	4	Regulation
Full product standardization for DSOs should not be pushed for in the short run as there are still many unknowns in today's flexibility markets. Innovation should therefore be encouraged. Partially harmonized products, proposing certain (ranges of) values for certain product attributes, might be more feasible in order not to block further innovation and to ensure that specific local conditions are considered. It is important to leave sufficient time for further standardization. In addition, product specification for distribution network should be simple when compared with TSO services. Therefore, product specification should be compatible with LV flexible resources characteristics and with simplified characteristics.	4	Regulation
Alternatively, defining a standard list of product attributes at European level could also ensure further harmonization of different products, without restricting products or innovation. Product specification for distribution network should reflect DSO needs, resulting in simpler products when compared with TSO services. Also, product specification should be compatible with LV flexible resource characteristics. Reliability of LV flexibility through its aggregations, when having a relevant flexibility capacity available.	4	Regulation
It is recommended that the toolbox is used to verify whether flexibility products are technology-neutral, to ensure that all technologies that		

	can answer to DSO needs are indeed allowed and able to deliver flexibility.		
	The cost-effective mobilization of flexibility in distribution networks, needs to consider the local nature of grid constraints. Also, LV flexibility bidding and aggregation could benefit from previous knowledge of flexibility needs in a specific network area. **Adopting dynamic flexibility areas concept, proposed in EUniversal, defines flexibility aggregation areas that can solve technical constraints, within a determined envelope. This will help aggregators to provide more accurate flexibility bids and promote more effective use of flexibility resources.**	2	EUniversal solutions



Planning (Operation & network investment)

As discussed above, DSOs need flexibility. This flexibility can, however, be acquired through different types of mechanisms which can be both market and non-market based. The key challenge is that there is no one-size-fits-all flexibility mechanism and different mechanisms can be combined considering their respective strengths and weaknesses, the considered grid needs (see above) and the applicable timeframes. Proper coordination and planning are indispensable to choose complementary solutions to ensure cost-effective usage of the distribution grid. This planning is also important to not only solve grid issues in corrective mode, but to evolve towards more predictive grid management.

Combinations

	Pillar	Category
Flexibility markets can only take place if the right market and economic conditions are in place. Sufficient market liquidity is needed, and flexibility needs to be the most cost-efficient and effective solution. Furthermore, the right technical conditions also need to be in place: Smart and standardized control and measurement with standardized interfaces is important, and observability of the network and/or predictability of flexibility needs should be sufficiently high. **Throughout the EUniversal project, different suggestions are provided to ensure these conditions are in place.**	1, 2, 3, 4	EUniversal solution
Flexibility markets are therefore not a stand-alone solution as there are still many challenges to be solved. **Different mechanisms exist to obtain flexibility and a combination of different mechanisms could be implemented to combine strengths and reduce weaknesses.** The EUniversal project provides a sneak-peak sheet to assess strengths and weaknesses of different mechanisms and it indicates which mechanisms can complement each other. It should be ensured that different mechanisms do not contain contradicting measures or actions.	4	EUniversal solution, Regulation
Different flexibility mechanisms can co-exist, but how they should work together depends on the characteristics of the network, the grid flow status, the available flexibility in the system, as well as the incentivization schemes that are deployed. **It is therefore important that regulation does not force a one-size-fits-all solution or combination of solutions.**	**4**	Regulation

DSO solutions

EUniversal has proven that flexibility markets can be used to procure both short-term and long-term flexibility. **EUniversal proposed and tested a set of methodologies and tools for assessing both long-term and short-term flexibility needs assessment and optimal flexibility bid selection. Results obtained show that flexibility mitigates the risk of congestion and voltage constraints and avoids curtailment**	2	EUniversal solution

of renewable energy, postponing or being an alternative for grid reinforcement investments in network areas where investments are needed to reinforce the grid. While for short-term it can help avoid grid constraints, for long-term cost-benefit analysis between traditional grid reinforcement and flexibility should always be performed in the network planning exercise.		
Predictive & Coordinated network		
Actively integrating market-based flexibility for grid support requires the implementation of predictive operation, where network operators can forecast grid status and define the operation plan that avoids eventual constraints, including DSO assets and flexibility services. **EUniversal has successfully demonstrated a toolchain that enables day-ahead mobilization of flexibility services coordinated based on an optimal network operation plan**. The toolchain **includes a set of innovative tools combining more traditional network analysis tools such as OPF with linear network modelling and data-driven algorithms to ensure computationally and time efficient solving of complex problems.**	2	EUniversal solutions
Taking advantage of LV flexible resources are important to solve local problems at the LV network and depending on the volume available its aggregation might help solve constraints at the MV level. Also, LV problems might occur due to constraints in the MV and HV networks. **The toolchain developed within EUniversal proposes an iterative coordination scheme between MV and LV network tools** for the identification of flexibility needs and the selection of offers. This **ensures proper coordination between MV and LV network operation, through an optimal control plan including network assets and cost-effective use of flexibility**. However, this is only needed when a representative volume of flexibility can be aggregated at the MV to LV substation.	2	EUniversal solutions
Maintenance planning and support operation		
EUniversal has demonstrated that Flexibility can also be a cost-effective solution for distribution network maintenance planning, supporting operators in these actions by setting up flexibility markets weeks ahead. Accordingly**, these markets can be leveraged to fast-track maintenance actions by executing them in periods that would have otherwise been forbidden due to voltage/current constraints violations.** This effectively shifts maintenance activities from high-cost periods to even regular working hours, reducing maintenance-related costs while minimizing the impacts on the end customers.	2	EUniversal solution

Long-term network planning

EUniversal has demonstrated that planning various network assets with a focus on resilience and utilizing risk-based metrics significantly enhances network resilience. Furthermore, it has been observed that the assets planned for resilience, even under normal conditions, also contribute to the improvement of network reliability. **Therefore, EUniversal recommends that DSOs adopt resilience-driven planning methodologies, especially for networks that face continuous exposure to natural hazards. Additionally, it is advisable to establish and standardize a hazard-dependent contingency procedure for network planning.**	2	EUniversal solution

Active vs Reactive power flexibility

Distribution network constraints are mainly local problems, which give little potential and possibilities for aggregation. EUniversal has mainly exploited active power flexibility services to solve grid constraints at the MV and LV networks. Active power becomes more efficient for solving congestion and voltage constraints. However, it has higher impact for FSPs. **At the MV network, reactive power flexibility products could complement active power flexibility products in solving grid constraints, reducing load shedding or generation curtailment needs, while taking advantage of interconnection capacity to the grid.** There is currently a lack of knowledge on market-based reactive power procurement and **more research and test projects are recommended in this field**.	2, 3, 4	R&D
Specific issues of the DSO are to be solved with reactive power. The technical connection conditions as well as the locality of the problem **and for the implementation of reactive power markets in the low voltage level.** The implementation of capacity markets for congestion management holds more potential and should be prioritized.	4	R&D

External coordination

While it is indispensable to coordinate different flexibility options within the internal network operation of one DSO, it is important to highlight that the electricity system is a very interlinked system. On the one hand, the TSO is also acquiring flexibility connected to the distribution grid for its needs, which could lead to conflicting needs. On the other hand, in case the DSO procures flexibility through a flexibility market, it is important to this market that it is properly integrated in the sequence of existing energy and balancing markets. Coordination is therefore needed between these markets. The latter is even more important in case that there are multiple market platforms in one network area.

	Pillar	Category
TSO-DSO coordination needs to be further defined in terms of coordination between systems that consider the local nature of DSO flexibility markets.	4	Regulation
It is recommended that local flexibility markets take place after the closure of the wholesale market. This is necessary to ensure DSOs can forecast their congestion needs more accurately, taking into account the results of the DA wholesale market.	4	Regulation
In the short-run, conditions to allow competition between multiple market platforms in the same grid areas do not seem to be fulfilled. **To ensure this is possible in the long run, it is recommended that challenges linked to standardization and market liquidity are solved and that regulation takes these challenges into account.**	4	Regulation
Given the current small-scale implementation of flexibility markets, counterbalancing issues are rather limited. **For future purposes, counterbalancing issues and solutions do need to receive more attention and research is needed to overcome future challenges.**	4	Regulation

4 Exploitation strategy and IP and knowledge management

Given the achievements and developments of the EUniversal project, it was important for the EUniversal partners to think further about the usage and exploitation of all the different KERs beyond the project lifetime. To have a real impact on the energy transition and the implementation of local flexibility markets, it is indispensable that the results are further exploited after the project ending. To ensure this, the EUniversal project set, per KER, an exploitation strategy and business plan. This made each partner think about the next steps that are to be taken. In addition, discussions were opened regarding intellectual property (IP) and knowledge management strategy.

In this chapter, we discuss the exploitation strategy and IP and knowledge management strategy. However, before we start, we begin by explaining the methodology used to arrive at the different KER descriptions and exploitation plan. We believe this is important for future projects as many projects must think about how to exploit their results. Yet, most tool developers, are not necessarily experienced with business models and exploitation. The EUniversal project also experienced this barrier. To solve it, we set up templates that each partner had to fill in. We believe this methodology can also be useful for other projects and therefore describe our method and the template in section 4.1 Afterwards we zoom into the exploitation strategy and business plan in section 4.2 and in section 4.3 we discuss the IP and knowledge management strategy.

4.1 Methodology

Before one can set up a business and exploitation plan, a first step to be taken is the identification of the key exploitable results. The EUniversal project did this through the steps shown in Figure 4-1. Initially, the KER identification was preliminarily set out in the project proposal. the EUniversal project already started with the identification of KERs before submitting the EUniversal project: that is, during the proposal phase. We clearly identified current issues that stakeholders in flexibility markets were facing, and we defined solutions which we wanted to develop throughout the project to solve these open needs. In the proposal phase, we also ensured that the right partners were involved so that we had all the expertise on board to develop the solutions. Then, in step 2, while the project started, we continued keeping an eye on the market, the discussions surrounding flexibility markets, new regulations… to make sure that our solution developments continued to be in line with stakeholders need. This implied that in step 3, throughout the project it was sometimes needed to make adaptations in some tools. For instance, depending on how the demonstrators were implemented, EUniversal solutions were adapted. Around a year before the end of the project, all partners were asked to identify their key exploitable results based on their original objectives and based on project developments. In this way, an initial description of each KER was drafted. These KERs were then discussed for the first time during an EUniversal meeting in Germany (Halle) (step 5). All partners analyzed the KERs and verified whether there were duplicates, missing KERs or whether some KERs were not considered as innovative anymore (taking into account step 2, the technology watch). This ended up being an iterative process with all project partners. Based on their comments, a final list of KERs was identified. Some individual KERs were merged together into one KER. For instance, the project had two market platforms, and even though both of them were different, it was decided to discuss them together in one KER. Also, some KER were developed for different demonstrators but exercised similar functions. These were also merged into one KER, even though the underlaying tools per demonstrator might be different due to the differences in demonstrators.

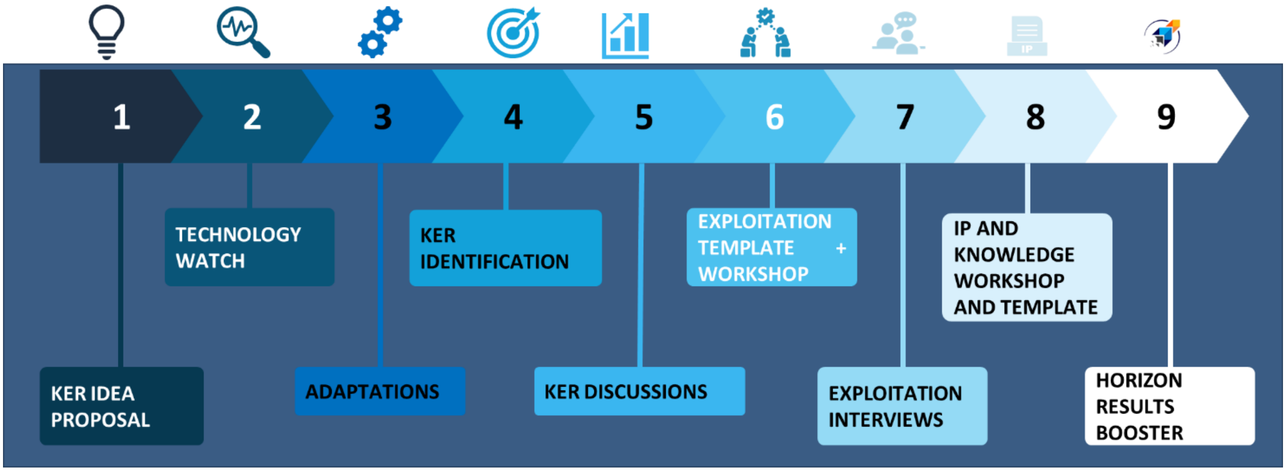


Figure 4-1 - Overview of the steps taken to determine exploitation and knowledge management strategy

After an initial list of KERs was drafted, we set up a template which all partners had to fill in (step 6). The template contained questions that guided the partners to describe their KER. A proper description, in which the needs which the KER resolves are described, is indispensable to end up with a good value proposition. This value proposition is a necessary starting base for the business and exploitation plan. Furthermore, the template covered the unique selling point of the KER and its expected impact on society, environment, economy… Then, before jumping into the business and exploitation strategy, the template asked partners to think about a SWOT-analysis for their KER. This is necessary to learn about their KER and as such to identify factors that have to be taking into account for further development/exploitation of their KER.

Next, the template contained questions related to their business model and exploitation strategy. Partners had to identify:

- Target group
- Total addressable market
- Market competitors
- Technology readiness level
- Market maturity
- Exploitation strategy
- Associated business model for the target group
- Exploitation assets and/or channels
- Revenue streams
- Implementation timeline
- Internal added value
- Background Intellectual property rights (IPR)
- Foreground IPR
- Joint Exploitation
- Further actions (exploitation)
- Further actions (development)

These questions were harder for the partners to complete as most of them did not have a business background. To resolve this, the EUniversal project created inspirational tables for each of the items above that contained example answers and options that could inspire them on how to fill in the different elements of their business model and exploitation strategy. This also ensured the usage of a harmonized language over all project partners.

For some partners, there were still a lot of open questions related to how to fill in their business plan and exploitation strategy. Especially questions related to cost and revenues were hard to complete given the fact that some products were just being developed or completed. Therefore, the last two questions were added to the template: further actions for exploitation and development. These questions required partners that were not sure about specific elements to think about the next steps that they had to take to exploit their results or to further develop their product based on the SWOT. The empty template can be found in Annex 2: Empty questionnaire.

To further guide the partners in filling in the template, the template was introduced during the consortium meeting in Gdansk in Poland during May 2023. There we explained how to complete the template and partners had the opportunity to ask questions. Once the templates were filled in, the task leaders reviewed their answered and individual online interviews were organized with each KER-owner to further discuss and complete their answers. Furthermore, an online workshop was done in September 2023 to further complete lessons learned that all partners had from the project.

During these processes, we noticed that the IP and knowledge management strategy remained a challenging topic. Therefore, two additional workshops were set up with partners to discuss this. In addition, there has been further development of the KER 1UMEI through the 'Horizon Results Booster'. This is a service provided by the European Commission, to help projects better define and take to market their main KERs.

4.2 Exploitations strategy and business plan

In this section, we analyse the individual partners business plan and exploitation strategy. To stay to the point in the main document, we will not discuss all the individual strategies of all the partners individually. All partners answers to the template can be found in appendix. Instead, below, we analyse the different plans and strategies. First, we present an overview of the types of KERs created over the project, we classify them into product, service, software, and knowledge. Second, we summarize the revenue streams that characterize the business model of the KERS. We find non-monetary value created in the form of policy recommendations and open-source software, as well as monetary value created in the form of grid services/cost savings, trading & aggregation, Software as a Service & licensing, consulting services, and trainings. Third, we present an overview of the exploitation horizon of the KERs ranging from immediate to 1 year, 3 years or 5 years. Fourth, we characterize the larger impact each KER has: social impact, scientific impact, political impact, commercial impact, or grid impact. However, before we start with the analysis of the business and exploitation plans of all the KERs, we start with the business model and exploitation plan of the UMEI. As the UMEI is the core product of the EUniversal project, we describe it in more detail.

4.2.1 UMEI exploitation strategy and business plan

In this section we present the UMEI's business model using a Lean Canvas methodology, and an exploitation roadmap. Parts of this sub-section were developed through the 'Horizon Results Booster' service provided by the European Commission.

Business Model

The UMEI, as an interface, is ready to be used in flexibility markets across Europe, allowing for different configurations and specifications. However, as mentioned earlier, the regulation is not yet adapted to allow market flexibility use for DSOs. This means that the market is not mature, and it is still in an introductory phase. The aim for the UMEI is to bring other DSOs, market operators and flexibility service providers on-board into the EUniversal flexibility model. A model where flexibility is used without a platform intermediator, enabling simple communication between stakeholders. Figure 4-2 presents a lean Canvas for the UMEI. The main concepts such as the problem description, the unique value proposition, the solution, the main customer segments, and financials are explained in this section.

The **problem** that the UMEI solves is that flexibility market players do not have a simple and economically feasible way to interact with each other regarding daily flexibility needs and availability. There is currently a lack of communication standards. As the market for local flexibility procurement is still in its emergent phase, various stakeholders have made numerous proposals which creates a lot of diversity. This diversity limits the adaptability and usability of different solutions, and it implies that system operators that aim to set up local flexibility

	markets would need to comply with each market platform's specifications. Each time a DSO wants to start setting up a new flexibility market with another market operator, they would need to start from scratch in integrating all systems with their internal environment. This creates a lock-in in one specific market platform and increases barriers for DSOs to benefit from multiple market platforms. In addition, without a facilitating interface such as the UMEI, stakeholders would have to implement different communication/interaction processes for each individual market platform. DSOs and aggregators would need to add an additional layer of data management to adapt communication to the specific requirements of each market platform. This represents an additional cost for the DSO.
	The **unique value proposition** of the UMEI is that it creates an interface that helps bring different stakeholders together, and demonstrate that it is possible to ensure direct interactions between DSOs and other market players. The interface is adaptable and it is not a rigid standard that obliges every market platform to take over the specifications of the UMEI. Furthermore, it allows stakeholders to offer and procure flexibility from multiple platforms as it is demonstrated that the UMEI works with multiple market platforms. DSOs are not locked to one specific flexibility provider and/or market platform. Switching between platforms gives them more freedom and it doesn't require new developments from their side. In addition, the UMEI is open-source and publicly available, both through the project website and Github. The UMEI is a quick to implement, cost-effective solution for DSOs, FSPs, and MOs.
	The **solution** proposed by the UMEI consists of publicly available APIs, allowing any stakeholder to adopt them or to develop new APIs concerning new services while complying with the UMEI interface specification. An application programming interface (API) is a way for two or more computer programs to communicate with each other. It is a type of software interface, offering a service to other pieces of software. APIs connect solutions and services without the need to know how these were implemented by each part. The UMEI is agnostic to market models and it is easily adaptable to changing regulation.
	The **customer segments** that the UMEI caters are other DSOs, FSPs, market operators, regulators and TSOs. At this point in the market, it is too early to 'sell' the UMEI as a commercial product. Rather, the aim is to communicate the UMEI so that stakeholders outside of EUniversal will start using it, and adding their point of view. Given that regulation is at this point both a barrier and an enabler to flexibility markets in distribution, regulators are included as the 'customer segment'. The idea with the UMEI is to create an industry standard that would then help guide regulation. It is a cooperative effort to shape the market, rather than a competitive commercial endeavour.
	In terms of **financials**, it is yet early to quantify the cost structure and revenue streams from using the UMEI. At this moment, there is a limited need for flexibility at a local distribution level, so the business case is not clear. However, given the EU's objectives in terms of growing to a more renewable energy system, and transport electrification, DSOs need to be ready for a system that will change significantly in the next few years. The **cost structure** concepts that need to be considered by stakeholders who wish to implement the UMEI are the people who will implement it, R&D costs to integrate it to a changing system, and lobbying and dissemination to arrive at an industry standard. The UMEI is simple to implement, and carries much lower costs, than the alternatives: reinforcing the network or curtailing renewable energy. The business case for the future is promising. In terms of **revenue streams** at this point the aim is to create an industry standard, therefore interested stakeholders look at EU funding through

	direct support, or through projects; adjustments to the regulated DSO revenue schemes; and incentives for consumers to provide flexibility.

Problem
Flexibility market players (DSO, FSP, market operators) do not have a simple and economically feasible and fast way to interact with each other regarding daily flexibility needs and availability. Current lack of communication standards.

Alternative Solutions
Proprietary solutions, mediation platforms.

Solution
UMEI : an open interface that enables direct communication between the flexibility market players.

Key Metrics
- Set up time and lower costs.
- Enable use of local flexibility.

Unique Value Proposition
The UMEI is open-source and publicly available on GitHub.

The interface doesn't require a mediator party.

It is easy and cost—effective to implement by DSOs.

It is agnostic to market models and easily adaptable regulation.

Unfair Advantage

N/A because the UMEI is not commercial.

Channels

- Github.
- Industry associations (eg. EDSO).
- BRIDGE
- Direct contact
- Industry events/ conferences
- Publications

Customer Segments

- DSOs
- FSPs
- Market Operators
- Regulators
- TSOs

Early adopters
- Project participants (E-Redes, Mitnetz, Energa, NODES, N-side, Centrica).

Cost Structure
People – managing team
R&D costs – future improvements
Lobbying and dissemination

Revenue Streams
EU funding through direct support.
EU funding through projects.
Adjusting regulated DSO remuneration schemes while creating incentives for customers.

PRODUCT | MARKET

Figure 4-2: UMEI Lean Canvas

Exploitation Roadmap

The main goal of the UMEI exploitation is to create a collaborative initiative towards establishing an industry standard. This subsection presents the exploitation roadmap as set out by the EUniversal partners. We divide the section into actions, roles, milestones, and vision.

The UMEI co-proprietors E-REDES, NODES, N-SIDE and CENTRICA intend to claim IPR on the co-developments made in the EUniversal project. Their intention is to keep open dialogue and collaboration with future parties that would be interested in using the UMEI. The partners believe that an industry-led standard can shape the market and contribute to the necessary changes in regulation in the years to come.

In terms of **Dissemination / Communication,** co-proprietors will disseminate and/or communicate the UMEI functionalities to other possible stakeholders, aiming at enlarging the community of UMEI users and involving the EC services, policy groups as well as associations and, eventually, standardization organizations.

While doing so, a co-proprietor will always give credit to the others as co-developers of the present version of the UMEI.

In terms of **governance, t**he collaborating partners will form a governance board to follow up on the development of the UMEI in the future.

Management of change requests: Co-proprietors will manage eventual requests on the git-hub.

Future development by co-proprietors: Each co-proprietor is free to enlarge the UMEI's functionalities, while respecting its main objectives, namely i) to promote the development of flexibility in the European region and ii) to be opensource and available to any stakeholders. The developing co-proprietor must inform the others of that intent. In the case of future development through a future EC-funded project, each co-proprietor will analyze the option of inviting other co-proprietors to also be partners in that project.

In terms of **costs,** there are very low maintenance and follow-up costs. Further development and use-cases of the UMEI would require additional funding, which the partners hope to obtain through either national or European innovation initiatives.

The overall **vision** in the long term would be that the UMEI forms the basis for organizing local flexibility markets in an easy, decentralized way. The partners would hope that an industry-led standard can shape the market and contribute to the necessary changes in regulation in the years to come.

4.2.2 Type of KER and value proposition

This section presents the types of KER that the EUniversal project has produced. The types of KER are classified into four categories:

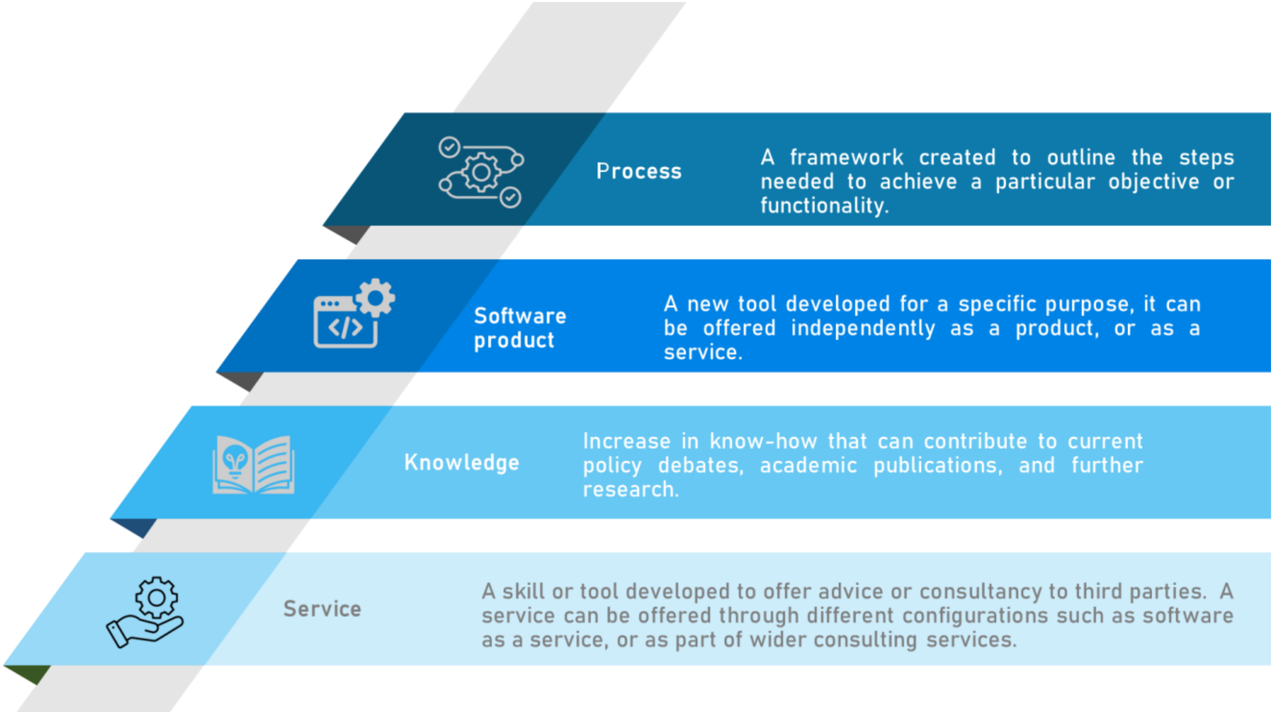


Table 4-1 presents the categorization of KERs per type. It is to be noted that all KERs generated knowledge, but here knowledge is ticked when a KER significantly adds to the current policy or academic debates. Furthermore, many solutions that the EUniversal project propose, are related to software developments. Given the current digitalisation of the energy sector, these solutions are in line with one the key trends of energy transition. Digitalisation will help to integrate more renewables in the energy system by increasing its flexibility. Yet, on the other hand, digitalisation also leads to additional challenges such as data sharing, lack of data and data privacy which need to be solved. These issues are all tackled throughout the project and are therefore clearly adding value to the current challenges that the energy sector is facing.

Table 4-1: Type of Key Exploitable Result

KER	Software Product	Process	Service	Knowledge
1 UMEI	✓	✓		✓
2 Flexibility Market	✓		✓	
3 Optimal bid recommender	✓		✓	
4 Flexibility for Redispatch 2.0	✓	✓		
5 Resilience tool	✓	✓		
6 Data Driven State Estimator	✓			
7 Data Driven Voltage Control	✓			
8 Day-ahead LV cong. forec.	✓			
9 DLR Based flexible HV lines	✓			
10 Improved SRA method.		✓		✓

11 Method. for dynamic grid tariff design		✓	✓	✓
12 Framework for flexibility quantification		✓	✓	
13 Aggregation algorithms for local flex.	✓		✓	
14 Business models and policy		✓		✓
15 Day-ahead flexibility needs assessment		✓	✓	✓
16 MV and LV coordinated control	✓		✓	
17 LV phase and topology mapping	✓			
18 MV network maintenance planning tool	✓		✓	
19 Low voltage flexibility needs assessment	✓		✓	

In chapter 2, we summarized for each KER its added value for a specific customer or target group. It could be seen that the added value is spread out over multiple domains, ranging from data management, observability and predictability, network security, market design and clearing, unlocking flexibility from multiple types of stakeholders, economic incentives, better and more accurate calculations and predictions… For a more detailed discussion, we refer to chapter 2.

4.2.3 Revenue Streams

Figure 4-3 presents an overview of the revenue streams expected per Key Exploitable Result in the project. Some KERs are repeated, as they may have more than one application. The horizontal dimension represents the type of revenue expected, divided into non-monetary and monetary values. The non-monetary value created refers to policy recommendation and open-source software. The monetary value created refers to flexibility grid services & cost savings, where we mainly find the DSO toolbox KERS, other KERs that enable trading and aggregation, KERs that will be offered as either Software as a Service or through licensing, consulting services, and trainings created based on the learnings from the project. The vertical dimension represents the clients that each value is targeted to: DSO, Flexibility Service Providers, Regulators, and Stakeholders & Students.

It can be observed that the UMEI, KER 01, is an open-source solution that can contribute policy recommendations to regulators, as well as being an integral part of the flexibility grid services created during the project. Every KER has clearly identified the clients it serves, as well as its expected revenue model.

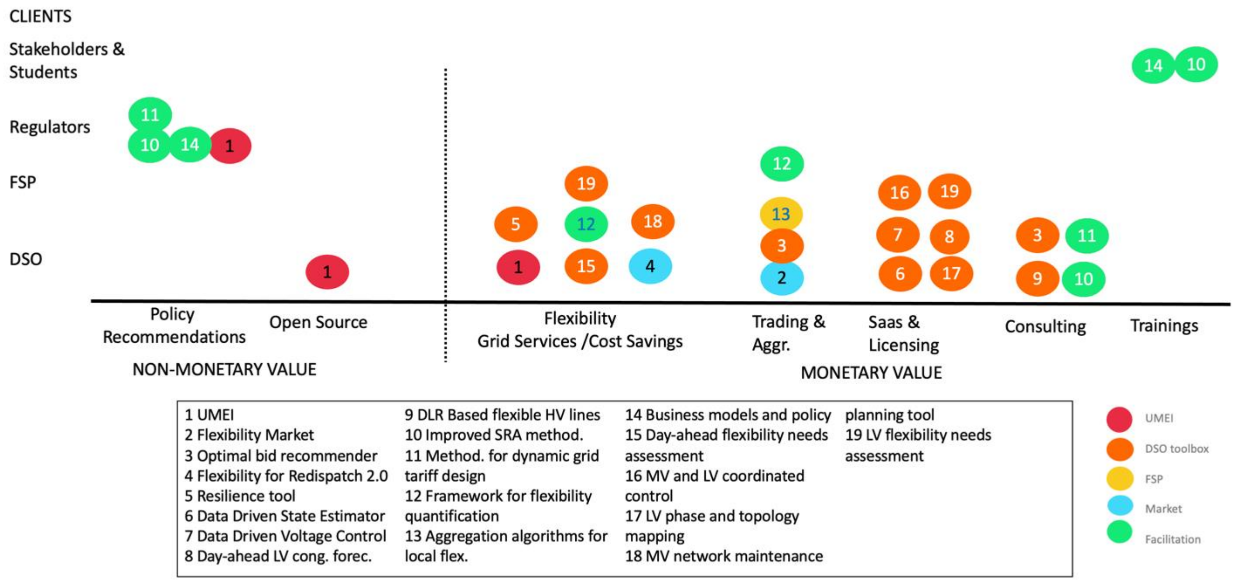


Figure 4-3: Revenue Streams per Key Exploitable Result

For the KERs that offer non-monetary value, exploitation is taken care of in two ways:

- For the policy recommendations, this deliverable summarized in chapter 3 all key lessons learned of the EUniversal project and it set up an overview table of all the recommendations. Throughout the project, these lessons learned, and recommendations are also given in the different deliverables and through scientific publications.
- Regarding the UMEI, we joined in further Horizon Results Booster workshops to further examine how to ensure the further exploitation and development of the UMEI, even if there are no revenue streams (as it is Open Source). These actions are still being done as of writing of this deliverable.

4.2.4 Exploitation Horizon

Figure 4-4 shows the exploitation horizon of the KERs, as described by the project partners, ranging from 1 year, 2-3 years and 5 years. We can observe that most KERs are being exploited during the project and within a 1-year horizon. This shows that most partners are already actively exploiting their tool, or they are at least taking further development steps (through new funding and R&D schemes). Some KERs are exploited over different exploitation horizons. This is because in the short run there are being tested and developed, but in the long run, the goal is to exploit in on a larger scale. The UMEI is one example of this. The UMEI's exploitation strategy includes further development and applications, therefore it is mentioned twice in the figure. Regulatory barriers are the main hindrance for the KERs that are to be exploited in the longer-term horizon. Regulatory modifications are necessary for them to be implemented.

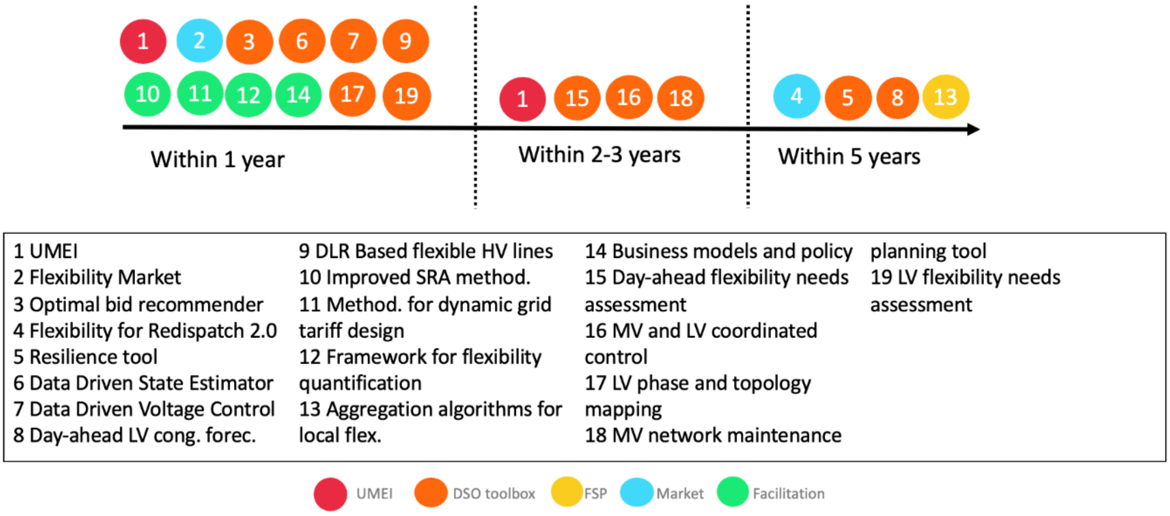


Figure 4-4: Exploitation Horizon of Key Exploitable Results

4.2.5 Impact

This subsection describes the impact of each KER per category:

- **Regulatory**: this category has an impact in regulatory discussions that affect the market for flexibility and or DSO operation.
- **Scientific**: this category presents an innovation on a scientific level that can be discussed by scientific peers.
- **Society**: this category refers mainly to the impact of opening flexibility market son the DSO grid to manage congestion, avoiding infrastructure costs, and to increase the use of RES.
- **DSO grid optimization**: this category encompasses all the tools developed to enable the integration of flexibility into the grid.

Table 4-2 presents the impact categories for all the EUniversal KERs. All KERs contribute to society values such as decreasing reliance on fossil fuels through the increased opportunities for renewables. Furthermore, society benefits through a more secure and reliable energy system which is good for general competitiveness of member states, for comfort of end-users and for economic growth. In addition, there are economic benefits for users linked to the fact that they have increased opportunities to value their flexibility. Second, most KERs help to optimize the electricity grid. This is extensively discussed throughout this deliverable. Finally, the focus of EUniversal was on flexibility markets, it is only natural that quite some KERs are also focussing on regulatory impact. Flexibility markets are still very immature, and the regulatory framework is still being shaped. Insights to support this process are therefore very important.

Table 4-2: KER Impact Categories

KER	Regulatory	Scientific	Society	DSO Grid Optimization
1 UMEI	✓		✓	✓
2 Flexibility Market	✓		✓	✓
3 Optimal bid recommender	✓		✓	✓
4 Flexibility for Redispatch 2.0	✓		✓	✓

5 Resilience tool		✓	✓	✓
6 Data Driven State Estimator			✓	✓
7 Data Driven Voltage Control			✓	✓
8 Day-ahead LV cong. forec.			✓	✓
9 DLR Based flexible HV lines			✓	✓
10 Improved SRA method.	✓	✓	✓	
11 Method. for dynamic grid tariff design	✓		✓	✓
12 Framework for flexibility quantification			✓	✓
13 Aggregation algorithms for local flex.	✓		✓	✓
14 Business models and policy	✓	✓	✓	
15 Day-ahead flexibility needs assessment			✓	✓
16 MV and LV coordinated control			✓	✓
17 LV phase and topology mapping			✓	✓
18 MV network maintenance planning tool			✓	✓
19 LV flexibility needs assessment	✓	✓		✓

4.3 IP and knowledge management strategy

Table 4-3 presents the IP strategy for all the KERs produced by EUniversal. To set up the IP and knowledge management strategy, we started with the original template, but then expanded it to the table below to further encourage partners to think about the different options related to knowledge management. We encouraged all partners to think about their knowledge strategy in three different ways:

- What are legal actions that can be taken?
- What are technical actions that can be taken?
- What are organizational actions that can be taken?

The figure below gives examples of the different options that exist in each of these three categories. This inspired partners to think further about the different options that they possess. The EUniversal project namely believes there are many more actions that can be explored than only legal actions. For instance, as many KERs focus on software solutions, with respect to coding, actions can be taken to make sure that externals cannot easily change or copy the code. Codes could contain black boxes in which part of the code is not visible, codes on Github can be blocked for adaptations, and partners can also ensure that their code is not shared beyond their company. Furthermore, partners can take organizational actions to ensure knowledge stays within their company. They can hire company experts and make sure that they have a back-up for experts in case that they would leave the company. They can set up contracts with the experts to clearly define who owns the knowledge. Furthermore, when collaborating with other partners, they can keep records of contributions to a specific product, and they can assign clear responsibilities for specific tasks.

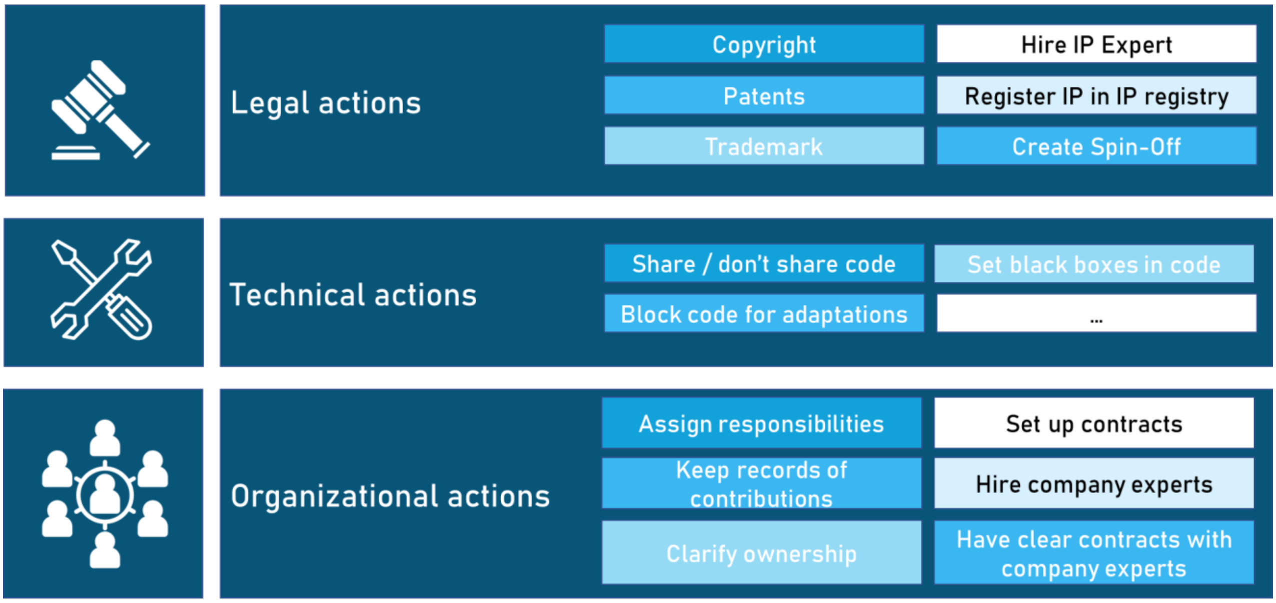


Figure 4-5 - Knowledge management actions

For most partners, during the project, taking legal actions was too ambitious. However, the answers in the table illustrates that they do consider opportunities related to technical and organization knowledge protection actions that they can take.

Table 4-3: Intellectual Property Strategy per KER

KER	Legal	Technical	Organizational
1 UMEI	Property rights by creators with open source license of use; UMEI is a joint result obliging every partner to clearly communicate every contributing party	Code freely shared in Github, yet, some parts of the code will be blocked so that the base code cannot be adapted without permissions	The design of the UMEI is based on the coordination and concept of E-REDES, coupled with the major contributions of N-SIDE and NODES bringing learnings from their previous experiences coupled with EUniversal market design discussions for the demos. The partners will form a governance board, to maintain the Github, and jointly discuss future use cases with the UMEI.
2 Flexibility Market	Copyright	Code is not shared. Market operators pay a license to use the platform.	Company secret
3 Optimal bid recommender	Copyright	Code is not shared. DSOs can use the optimal bid recommender tool after paying a license.	Company secret
4 Flexibility for Redispatch 2.0	When using the method together with other partners, our legal department is involved.	/	Multiple colleagues are involved, ensuring that the knowledge is well transferred and shared within the company.
5 Resilience tool	Licensing to Spinoff – pending coordination with UCY legal office	Share knowledge and outcomes of the tool with interested bodies – code not be shared	The code has a separate documentation that is available within the UCY. In case an expert-colleague leaves, somebody else can easily take over.
6 Data Driven State Estimator	Licensing to Spinoff	/	/
7 Data Driven Voltage Control	Licensing to external company.	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code has a separate documentation that is available within the company. In case an expert-colleague leaves, somebody else can easily take over. Furthermore, multiple experts know how to use the method.

8 Day-ahead LV cong. forec.	When using the method together with other partners, our legal department is involved. When sharing code, this is done via contracts in which foreground IP is clearly agreed upon. We only work with trusted third parties.	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code has a separate documentation that is available within the company. In case an expert-colleague leaves, somebody else can easily take over. Furthermore, multiple experts know how to use the method.
9 DLR Based flexible HV lines	No legal obstacles to using the method, however implementation by authors (IEN) is under general commercial terms.	DLR algorithm and corresponding software contain multiyear authors' experience, thus consisting of their technical intellectual property.	In the case of commercial deployment, ownership of both algorithms and software belongs to the company (IEN) and is offered on the licence base.
10 Improved SRA method.	When using the method together with other partners, our legal department is involved.	Code available in Github, but only accessible to those granted access. In general, the knowledge about the outcomes of the method is shared, but not the code itself.	The code has a separate documentation that is available within the company. In case an expert-colleague leaves, somebody else can easily take over. Furthermore, multiple experts know how to use the method.
11 Method. for dynamic grid tariff design	When using the method together with other partners, our legal department is involved.	We share knowledge related to the outcomes of the method, but we don't share the code itself	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.
12 Framework for flexibility quantification	When using the method together with other partners, our legal department is involved.	The knowledge about the outcomes of the method is shared, but not the code itself.	The documentation of the method is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.
13 Aggregation algorithms for local flex.	When using the method together with other partners, our legal department is involved.	The knowledge about the outcomes of the method is shared, but not the code itself.	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore,

			multiple experts know how to use the method.
14 Business models and policy	The results are publicly available under the name of each author. No legal measures are taken.	Knowledge sharing- the results have been published through conferences, papers and media.	The authors of published studies and deliverables remain available for enquiries.
15 Day-ahead flexibility needs assessment	Licensing to external company	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.
16 MV and LV coordinated control	When using the method together with other partners, our legal department is involved	The knowledge about the outcomes of the method is shared, but not the code itself.	
17 LV phase and topology mapping	Licensing to external company	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.
18 MV network maintenance planning tool	Licensing to external company	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.
19 LV Flexibility needs assessment	Licensing to external company	Don't share code with external partners. Code is implemented via Docker on the server of the trusted partners where only the trusted partners have access to.	The code and its documentation is available within the company. In case an expert-colleague leaves, somebody else can take over. Furthermore, multiple experts know how to use the method.

Annex

Annex 1: Overview EUniversal Business Use Cases

Demo	BUC ID	BUC name	Service	Mechanism	Market Platform
Germany	DE AP	Congestion Management & Voltage Control with market-based active power flexibility	• Congestion management • Voltage control	• Local flexibility market	NODES
Germany	DE RP	Congestion Management & Voltage Control with market-based reactive power flexibility	• Congestion management • Voltage control	• Local flexibility market	NODES
Poland	PL AP	Congestion Management & Voltage Control with market-based active power flexibility	• Congestion management • Voltage control	• Local flexibility market	NODES
Poland	PL RP	Congestion Management & Voltage Control with market-based reactive power flexibility	• Congestion management • Voltage control	• Local flexibility market	NODES
Poland	PL DLR	Congestion management using permissible line capacity based on Dynamic Line Rating (DLR) system.	• Congestion management	• Local Flexibility market (one FSP, RES competition)	NODES
Poland	PL FS	Voltage Control with the use of flexstation solutions	• Voltage control	• Bilateral contracts	NA
Portugal	PT1	Congestion management in MV grids for the day-ahead market (or between 1 to 3 days in advance)	• Congestion management	• Local Flexibility market	NODES / N-SIDE
Portugal	PT2	Integrated Voltage Control in MV and LV grids for the day-ahead market (AP+RP)	• Voltage control	• Local Flexibility market	NODES / N-SIDE
Portugal	PT3	Contracting flexibility services for avoiding voltage and/or congestion issues during planned maintenance action in MV grids	• Congestion management • Voltage control	• Local Flexibility market	NODES / N-SIDE
Portugal	PT4	Voltage Control and Congestion Management for medium and long-term grid planning through market mechanisms	• Predictive congestion management • Predictive voltage control	• Local Flexibility market	NODES / N-SIDE

Annex 2: Empty questionnaire

Part of Deliverable 10.4 is a joint and an individual exploitation, business and knowledge strategy plan. Each member of the consortium will build its individual exploitation plan according to its own exploitation strategy and capacities to cover all results developed in the project. The starting point will be the key exploitable results and the partners' background and foreground. Furthermore, a common exploitation plan will be defined and implemented according to the position of each partner within the value chain, as well as the existing background and foreground generated. Note that in the final review period, our project officer will also devote a lot of attention to this deliverable as it is important to prove that we take the project results further beyond the project.

To collect this information, we have set up the following questionnaire in which we expand the first questionnaire where we asked preliminary questions to identify the KERs. This questionnaire now has the purpose to:

- Finalize the KER description and detail it further where needed
- Determine the exploitation, business and IP & knowledge strategy per KER.

Step 1	Your first task is to finalize the KER and SWOT description. You have already provided this explanation earlier in the project and this information should now be updated as we come closer to the end of the project. You can find your previous answers here. Note that we reviewed your answers and asked additional questions for some of the KERs. Please, add your final KER and SWOT description in the questionnaire below and adapt it where needed. Make sure that the information is **to the point, clear, and comprehensible for external readers**. The information should also be adapted where needed to the final description of the KERs (some of them have changed).
Step 2.1	VITO has completed 2 draft questionnaires with answers on all the questions as an example for the other partners. You can have a look at the two examples to get an idea on what is expected from filling in the questionnaire.
Step 2.2	We will have a workshop in Gdansk where we will introduce to you the rest of the questionnaire below and discuss the questions and draft answers. In case you could not be present in the workshop, the draft questionnaires could help you and you can always contact VITO (Janka.vanschoenwinkel@vito.be) in case of further questions.
Step 3	Complete the rest of the questionnaire (explanation and business plan, IP and knowledge strategy). Note that we have added many tables with inspirational answers that can help you to better fill in the questionnaire. You are free to add additional answers or to adapt them to your own needs.
Step 4	Interviews: Vlerick and/or VITO will have an interview with you to discuss your answers, after which we can take them up in the final deliverable of the report.
Step 5	Report / Deliverable: we will take up your answers literally in the report. On top of that we will also add an analysis of the answers, make general categories, give definitions of the answers in the listing etc.…

Questionnaire:

KER name

Title KER	
WP	
Project tasks	
Key Partner	
Other partners involved (collaboration)	
Authors of / contributors to this document	
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer

Unique selling point	What is the unique selling point of key result / tool / innovation?
Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …
What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? …	
Weaknesses What could you improve?	

Where do you have fewer resources than others? What are others likely to see as weaknesses? …	
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **<u>In case there are questions that you cannot answer yet</u>**, please provide an <u>action plan of the steps</u> that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please <u>aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet</u>.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a	No example, please answer from your own experience	

product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).		
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	

Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also	

	find inspiration from other partners' strategies.	
Foreground IPR What have you developed in the project related to this specific KER?		
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	

Further actions (development) What further actions will you take to further develop this KER?	See table 10	

4.3.1.1 Inspirational tables

Target group (Table 0) Who is targeted by this KER? Who will be the customer of the KER?

Target groups:
- DSO
- Consumer: households
- Consumer: industries/tertiary sector
- Consumer: mobility
- Tech provider: storage, P2H
- Aggregator
- Platform owner/operator
- R&D center/academia
- TSOs
- Other business audience
- Policy audience (local, national, EU level…)
 	
Total Addressable market:
- Region (EU, non-EU…)
- Type of customer:
    o All EU DSOs and market Agents (EU and non-EU)
    o DSOs and regulators
    o DSOs, TSOs, and BRPs
    o Regulators, public bodies
- Other elements that determine your market…

TRL level (Table 1)
• TRL 1 – basic principles observed • TRL 2 – technology concept formulated • TRL 3 – experimental proof of concept • TRL 4 – technology validated in lab • TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) • TRL 7 – system prototype demonstration in operational environment • TRL 8 – system complete and qualified • TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Exploitation strategy / product offering (Table 2)

What product do you offer to this target group? Is this product new, improved, not new at all? What do you aim to achieve for this target group?

A significantly improved or a new product:

Which product (improved or new?)?

DSO decision making tools, smart grid tools… (improved and new depending on the tool)

Please explain further:

For instance:

- Novel optimization techniques for supporting the decision-making on efficiently integrating resilience in distribution network planning.
- Smart grid tools for improved observability of the grid and/or increased efficiency/applicability of the developed smart grid tools optimization.
- …

A significantly improved or new service

Which service (improved or new?)?

Neutral Market platform (improved)

Please explain further:

For instance:

- Delivering of market mechanisms to enhance participation in flexibility markets
- …

A significantly improved process

Which process?

...

Please explain further:

For instance:

- …

Consulting and knowledge services/products

Which services/products?

- New educational material and research outputs (courses, scientific papers, magazine articles, conference presentations….)

Please explain further:

For instance:

- Increase knowledge on specific technologies to facilitate the choice between them
- Increase general knowledge on distributed flexibility provision to …

- Course organization and awareness creation

A new method

Which method?

- Improved SRA methodology for smart grid solutions.

Please explain further:

For instance:

- ...

Other...

- ...

Associated business model (Table 3)

How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?

Economic value

- TOTEX optimisation by optimising planning and operation, and through extending assets life cycle
- Grid investment deferral by predicting and smart managing grid loads considering flexibility
- Savings behind the meter
- ...

Grid benefits

- Grid
  - Improving resiliency and quality of service.
  - ...
- Flexibility
  - Benefits from flexibility services provision (please specify which ones...)
  - Increasing capacity to own and operate DERs.
  - Functional Local Electricity Market Platform to reach DSOs, TSOs and end-consumers

Commercial benefits

- Increasing market liquidity to ensure energy actors can optimize their coordinated procurement behavior.

Network and knowledge value

- Reinforce our postgraduate and doctorate programs, including possible new PhD lines
- Ensure that the new knowledge created leads to proper policy, management, operational… decisions (please specify this)

Exploitation channels (Table 4)

Describe how the results can be concretely exploited, via which channels/methods

Type of result

- Hardware
- (Open source) Software
- Guideline
- Policy brief
- Recommendation
- Research data
- Knowledge and skills
- Algorithms
- Methodologies
- Simulation methods
- Educational concepts and materials
- …

Channels

- Digital Marketing channels (website, social media…)
- Technology transfer
- Licensing to a third party
- Set up further pilots/demonstrations/testing activities
- Launch a spin-off / start-up
- Internal networks
- Publication of high-impact, peer reviewed journal articles…
- Conferences
- Organisation/chairing of panel sessions in conferences and international events.
- Further expansion of education portfolio for energy.
- New consultancy services to the energy sector
- Other… (please specify)

Revenue streams (Table 5)

Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?

Software incomes

- Fees for platform participation through different possible models: per transaction, subscriptions…
- Licensing of developed tools for advanced management systems' manufacturers, Licencing of software tools and algorithms for improved grid operation, Licencing tools, other types of licensing…
- Pay per use
- Trading fees
- SaaS

Future revenue streams

- Future EU projects
- Exclusivity contracts

Selling of a product

- Purchasing trainings / services
- Selling tools
- Consulting
- Direct sales
- Public tenders
- Transfer technology
- Consultancy fees

No revenue streams

- No revenue stream (free open source) / not for profit (copyright)

Internal added value (Table 6) What is the added value internally for your company?
Knowledge exploitation - Increase internal knowledge on ... **Innovator label** - Become recognized as ... **Societal exploitation and networking** - Promote innovate policy recommendations in the direction of … (please complete) - Influence the future direction of flexibility market places … (please explain) - Participate in stakeholder boards and comment on regulatory projects - Foster synergies with different initiatives - … **Other** - …

Partners (Table 7)

Project partners
EDPD, INNOGY & ENERGA
E.DSO
EASE
INESC
UNIMAN
COMILLAS
VITO
TRACT
N-SIDE
NODES
REST
IEN
MIKRO
KUL
VLERICK
ZAB

Table 8

PARTNER	BACKGROUND IPR	FOREGROUND IPR
EDPD	>6M customers. Working on advanced grid management tools and on building a smart grid infrastructure in the Portuguese framework. EUniversal will leverage from this AMI and from the outputs of demos made in previous H2020 projects in order to develop tools which will allow the use of flexibility to improve the distribution grid.	EDPD will develop and test an interface (UMEI) which will allow the European DSOs to standardise their connection to external stakeholders' platforms. The UMEI will facilitate, among others, the provision of flexibility services from the market to the distribution grid.
INNOGY	462.000 km of distribution grid. >13M. Experience in distribution grid operation, already high influenced by RES connected.	Increase its knowledge on new market flexibility services for distribution grid and network management and operation improvements. All IPR-subject issues will be analysed during the project.
Energa	Smart grid infrastructure. >3M. Ensuring high quality electricity supply, increasing power system efficiency and enabling new services for consumers.	Increase its knowledge on new market flexibility services for distribution grid and network management and operation improvements. All IPR-subject issues will be analysed during the project.
E.DSO	Know-how on integrating the European vision to guarantee global solutions.	E.DSO does not apply any IPR protection.

EASE	EASE aims to shape and promote a regulatory framework and develop business models for the deployment of storage technologies, not using any IPR mechanisms.	EASE does not apply any IPR protection.
INESC	Software under copyright protection, registered in the Portuguese national authority. Binary code to preserve the source code.	Similar to the background, but patent protection is a possibility for the real-time control methods.
UNIMAN	Methodologies, algorithms and modelling tools, peerreviewed and published in international journals and coded in Matlab and FICO Xpress, to perform: technical, economic and commercial assessment of flexibility provided by DERs connected to distribution networks; resilience assessment.	Similar to the background, with specific developments relevant to use of flexible DERs to provide resilience services to both distribution and transmission systems
COMILLAS	COMILLAS will combine its know-how with the use of inhouse software tools as well as commercially available ones to perform the SRA.	New studies and recommendations to be including in public deliverables and scientific publications (observing data confidentiality). No IPR protection is envisioned for these results.
VITO	Know how on energy market and smart grid solutions.	Increased know-how on market mechanisms for flexibility needs and grid services. Enhanced grid decision support tools, with a focus on LV. IPRsubject

		issues will be analysed during the project.
TRACT	Know-how in power and energy systems modelling, simulation and optimisation. Know-how in software development and in data analytics and machine learning. Software tools could be used as a starting point for developing the functionalities required to meet the needs of the current project (no access to source code).	Smart Operation tool further tested and demonstrated with real DSO data and enriched by new functionalities. Those functionalities include in particular: Stochasticity; Grid reconfiguration & reactors. No access to source code will be provided (only deliverables).
N-SIDE	N-SIDE know-how and solutions related to electricity market clearing and coupling. N-SIDE know-how and solutions related to electricity market clearing and coupling developed by N-SIDE in the framework of various projects, including the EUPHEMIA project (day-ahead) and with Centrica (Cornwall project).	Addressing needs for local electricity market platforms. All knowledge related to the background will not be available without explicit consent from N-SIDE. To grant the possibility to access N-SIDE's background will be discussed and treated in a separate agreement.
NODES	NODES will bring the NODES platform: user interface, API, models and algorithms for configuration of grid areas, registration of assets for distributed energy management, product definitions and a trading- and settlement-engine.	The Foreground IP shall be owned by the project beneficiary carrying out the work (jointly owned in case two or more partners contributing).
REST	Know-how on solutions related to demand response and	Increased know-how on addressing needs for

	local energy markets. No IPR applies.	market platforms and location-based flexibility aggregation.
IEN	Algorithms and software for data acquisition and control built in Substation controller, Communication software, DLR software for line capacity calculation. All algorithms and software registered as company proprietary and storage/protected in company assets repository.	New algorithms and software for MV and HV network congestion management to be treated as the background IPR.
MIKRO	Devices and software for energy networks management.	Offering new software modules related to flexibility services and energy market. Most appropriate IP will be analysed.
VLERICK	VLERICK will combine its know-how with commercially available tools to perform its business model and regulatory analysis.	New studies and recommendations will be included in publicly deliverables, and scientific publication (observing data confidentiality). No IPR protection is envisioned for these results.
ZAB	Know-how in social awareness and engagement (>16y experience in social development, international cooperation and human rights). No IPR applies.	Increased knowledge on social innovation advisory for energy, gaining market share.

Internal actions (Table 9) Are there any specific actions that you will take inside your company to further exploit the EUniversal results?
- We will lobby more to achieve… - We will outsource ... - We will insource ... - We will hire… - We will do a more detailed feasibility study / market study - We will run further pilots, demonstrations, testing activities - We will make promotion… - ...

Internal actions (Table 10) Are there any specific actions that you will take inside your company to further develop the EUniversal results?
- We will hire ... to further explore internal research - We will outsource ... - We will insource ... - We will work further to comply with existing standards - We will raise capital - We will raise funding from (public) sources - We will further develop… - ...

4.3.1.2 Previous info from the grant agreement:

Product/service	Potential client	Supplier	Revenue stream	Total addressable market
UMEI	DSOs/Market actors	EDPD	Free open source	All EU DSOs and market agents
Api management tool	DSOs/market actors	EDPD	Not for profit. Copyright EDPD	All EU DSOs and market agents
EUniversal tools and algorithms	DSOs/market actors	R&D centres/academia	Licensing, transfer technology, consultancy fees All DSOs and market	All EU DSOs and market Agents (EU and non-EU)
	DSOs	Industrial actors	Consulting or SaaS	DSOs and regulators
Methodologies for flex analysis	DSO, TSO, aggregators	Industrial actors	Consulting or SaaS	DSOs and regulators
Flexibility provision	DSOs	Aggregators, prosumers	Direct sales, public tenders	All DSOs (EU and non-EU)
Market-based services	DSOs and TSOs	Tech. providers	Direct sales, public tenders	All EU DSOs and market Agents (EU and non-EU)
Market place for local flexibility	DSOs/Market actors	Market platform owners	Pay per use, trading fees	DSOs, TSOs, and BRPs
Research outputs	DSOs/TSOs/Policy makers	R&D centres/academia	Courses, consultancy fees for stakeholders	All EU DSOs and market Agents (EU and non-EU), regulators, public bodies

Annex 3 Completed KER templates from all partners

KER 1 UMEI

Title KER	UMEI
WP	**2**
Project tasks	T2.4, T2.5, T2.6
Key Partner	E-REDES
Other partners involved (collaboration)	NODES, N-SIDE, CENTRICA
Authors of / contributors to this document	Carlos Damas Silva
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
The UMEI has materialized in the conceptual architecture design and the implementation of a standard, agnostic, adaptable, and modular combination of different Application Programming Interfaces (APIs) to link DSOs and market parties with flexibility market platforms, in coordination with other flexibility users. APIs are software interfaces through which different stakeholders can communicate automatically. This approach allows distributed communication without the need for a central hub. It consists of publicly available APIs, allowing any stakeholder to adopt them or to develop new APIs concerning new services while complying with the UMEI interface specification. Figure 1 depicts the UMEI's setup to connect different stakeholders. Figure 2 describes the different UMEI functionalities that have been developed in the EUniversal project: flexibility zones, portfolio management, baseline calculation, market access, order management, market trades and meter readings.	

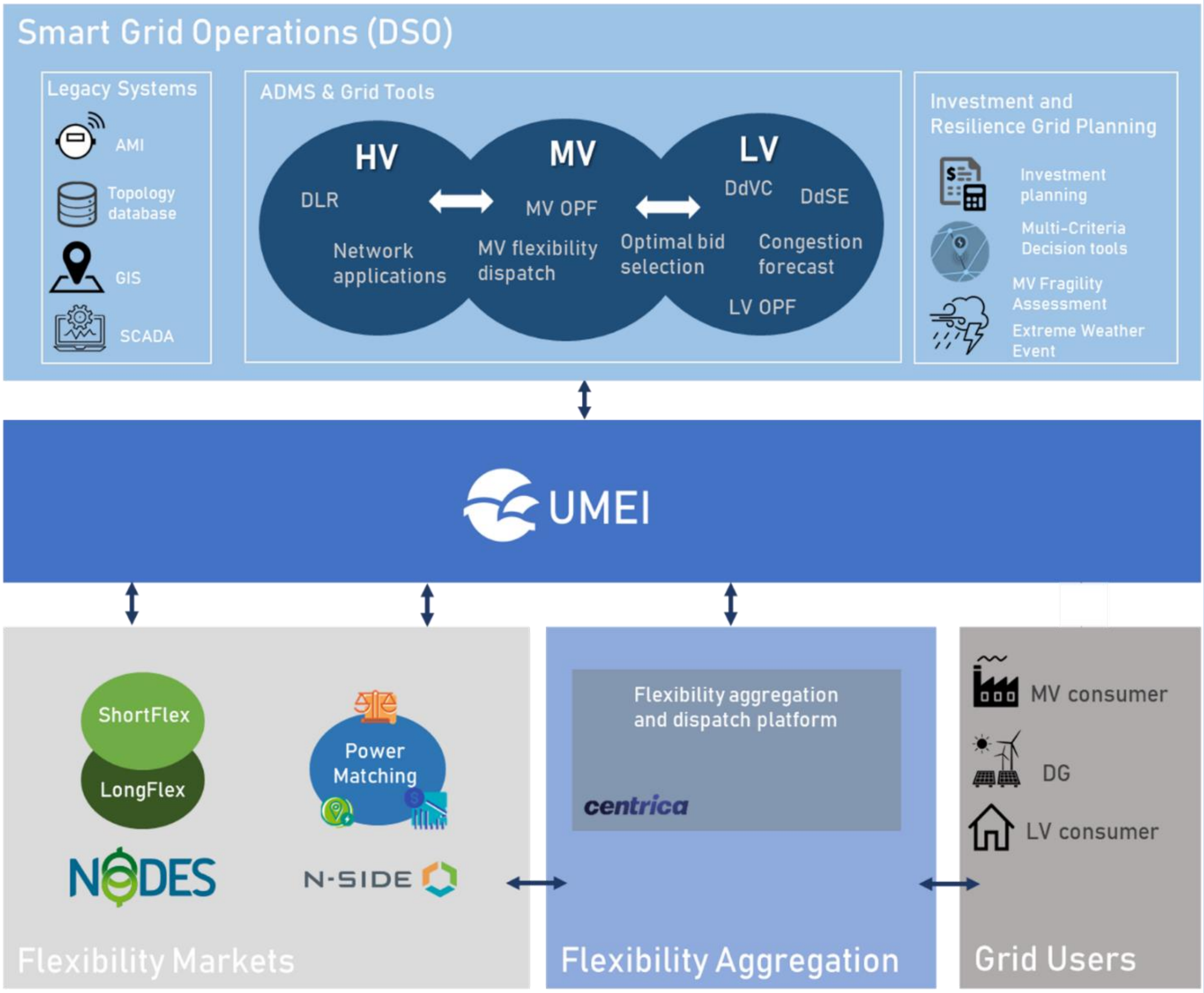


Figure 1: UMEI description

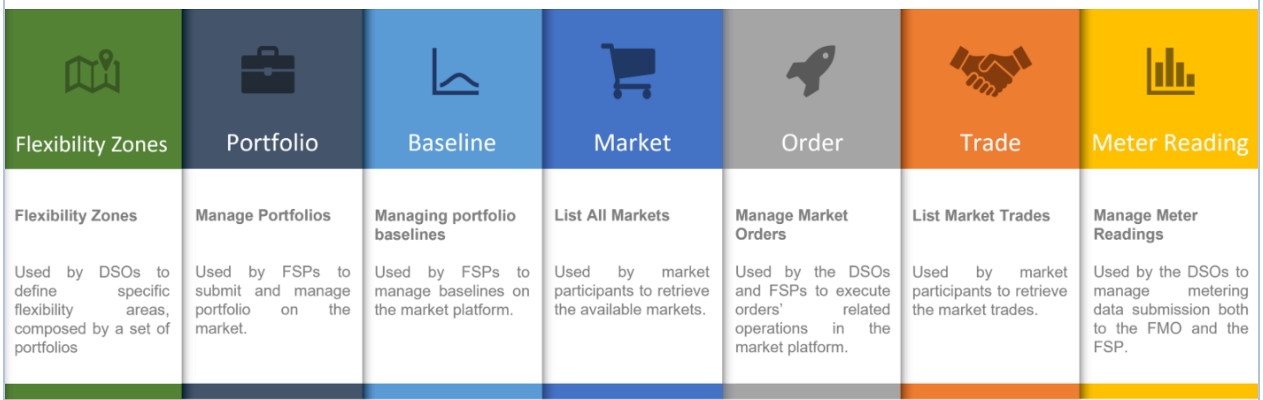


Figure 2: UMEI functionalities

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

A common way for market actors to interact with the flexibility markets, and amongst themselves, without the need of mediator components, such as data hubs or platforms, to procure system services for the distribution grid operation.
A mediation platform would need to be managed, involving costs, and implies a new role in the energy system. The UMEI does not need a mediator. This is one of the differentiating outputs in EUniversal with respect to other projects where developed an intermediary platform. This closes options as there must be a standard that everyone must comply with. This limits the development of the market operation and the data exchange formats.

Standards, at this point, might limit innovation and future options. The flexibility market is not mature enough to allow for standardization so far.

The UMEI provides easy communication between parties. For a market platform it's easy to adapt to the API, for the DSO it's easy to communicate to the platform and stakeholders. No big need of IT knowledge from the DSO point of view. The UMEI provides an easy way to accelerate the market exchange of flexibility, it can be implemented in the short term without the immediate need for standardization.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Standard end-to-end communication interface	Common, and easy to implement, interface to communicate with multiple market platforms and procure flexibility products	Distribution System Operators
Standard end-to-end communication interface	Common, and easy to implement, interface to communicate with multiple market platforms and offer available products	Flexibility Service Provider
Available set of components for interfacing with market actors	Pre-defined interface ready to be adopted and adapted by market platforms in order to increase liquidity and ease the interaction	Flexibility Market Operators
New incentive and revenue opportunities	Benefit of new forms of aggregation, which derive from the usage of the UMEI	End Consumers
Support to innovative business models	Potential for creating new business models which incorporate the provisioning of flexibility markets	Innovative Service Companies

Unique selling point	What is the unique selling point of key result / tool / innovation?

The UMEI is open-source and publicly available, both through the project website and github.

Expected impact	Explain the expected impact of this KER on: • Society • Environment • Economics • …

On society	With the UMEI available, another step is taken to assure that energy transition happens in the most cost-effective way, fighting the usage of fossil fuel-based electricity generation and ultimately the climate change that may result.
On the energy system	The UMEI provides the electricity distribution system with a valuable tool to support the current energy transition and consequent incorporation intermittent distributed energy resources and load demanding equipment. Different market operators, such as NODES and N-side have different market approaches, the messages sent by each can have differences. The UMEI is open to those different alternatives as it remains open, allowing the market operators to define the variables in the message. Customization is open depending on the internal market scheme and could be adapted to different regulatory schemes.
On EU/ national policy	EU Directive 2019/944 points towards the creation of a market framework for flexibility, in which all consumer groups can freely participate and trade flexibility. The UMEI represents the necessary tool to allow for the direct interaction between market players and flexibility markets for the provisioning and acquisition of flexibility services and products.

What are enablers / barriers in the development & implementation of this KER? **(Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)**

SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? …	Being an end-to-end and peer-to-peer communication tool, the UMEI does not require a mediator or active maintainer. Only sender and receiver are necessary, the participants in the communication. In order to implement the UMEI, the DSO needs to have an internal environment to determine the need for flexibility, in the future it will be integrated in the ADMS (advanced distribution management system). The data then needs to be translated into the format needed for the UMEI. It is easy to adapt existing / build new systems in order to implement the UMEI and deploy it.

<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	Currently, the UMEI does not support the pre-qualification and financial settlement processes. The first part of the settlement, sending the measurements to the FSP is done through the UMEI. However, it is certain that the successful testing of the UMEI will lead to further developments regarding registration and pre-qualification as well as validation and settlement. Anyhow, EUniversal as a research project is not being developed in a specific regulated environment, and without the present definition of flexibility remuneration, this will not allow for any monetary transaction.
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	As the UMEI appears as an open standard way to allow communication, it has the potential to be extended to more energy system actors and to cover more processes related to flexibility. Such as exploring the relationship with the TSO and the inclusion of other processes which compose the flexibility journey. Also, technically, more can be done in the future to increase the ease of adoption, such as the development of a client library and a test suite for the validation of the implementation.
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	The UMEI aims at becoming a European *de facto* standard for the flexibility market interaction. However, that will depend on the early adopters to the API specifications. Being an open standard, entities can also leverage and tailor the UMEI to their needs freely, which can pose a risk to its notoriety.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are making efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	Flexibility Market Operators, Distribution System Operators, Flexibility Service Providers, Large Consumers, Innovative Service Companies
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	The total addressable market includes all countries and regions that are implementing flexibility electricity market frameworks, particularly in the EU due to alignment with EU Directive 2019/944
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Currently, there is no major competitor offering similar end-to-end communication standard in the flexibility market - there are multiple different implementations of different data models.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	The UMEI is currently developed, with functionality testing ongoing. TRL8
Market maturity The market targeted by this innovation is:	• Not existing yet and it is not yet clear if the innovation has potential to create a new market	Emerging: there is a growing demand and few offerings are available

	• Not existing yet but the innovation has clear potential to create a new market • Emerging: there is a growing demand and few offerings are available • Mature: the market is already supplied with many products of the type proposed	
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	The UMEI provides a common, standard, and easy-to-implement interface for the procurement and offering of flexibility products.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	- The UMEI improves grid resiliency and quality of service by facilitating a practical and easy interaction with the flexibility markets. - It allows stakeholders to focus more on their business processes and reduce implementation costs in the long-term. It lowers IT efforts from and eases multiple integrations management for DSOs and FSPs. - Current and new FMOs can adopt a field-tested interface to ease the integration process with market actors. - It enables direct data sharing between DSO-FSP (ensuring GDPR). - It eases marketplace switching for market participants
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	UMEI is a OpenAPI specification, available on github. Dissemination channels might include • Project website • GitHub • Policy and Technology forums • Conferences • Project deliverables and scientific articles E-Redes will continue monitoring the open source code in the UMEI to keep it alive. Other DSOs are the main interested stakeholders in keeping open communications, without locking into any one standard. The FSPs might also have the same concerns.

		Maintenance activities will involve: answering implementation issues (ex. new DSO that will implement the UMEI), upgrading new functionalities, improvements, scalability, introduction of new stakeholders (Energy communities, buildings...), etc... The aim is to continue the UMEI as a collaborative initiative with other stakeholders.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	No revenue streams, the UMEI is opensource and publicly available. Therefore, it is free of usage. However, cooperation and community interest are essential to continue its maintenance and updates.
Implementation timeline When have you implemented this strategy or when will you implement it?	• During project lifetime • Within 1 year after the project • Within 5 years after the project	During the project lifetime. Internally E-REDES will continue developing the standard further in future European projects.
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Increased internal knowledge on the standardization of end-to-end communication interfaces, understanding of the flexibility market process, and technical skills in designing APIs
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	NODES, N-SIDE, CENTRICA
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Not applicable
Foreground IPR What have you developed in the project related to this specific KER?		Not applicable
IP	No examples, please answer from your own experience. If you have taken or	Not applicable

Did you identify any IPR-subject issues during the project and how did you tackle them?	are taking specific IP actions, please specify them.	
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	Not applicable
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	Dissemination through the available channels listed above The commercial parties involved are already using parts of the UMEI in their operations. E-REDES aims to develop it further in the context of European projects.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Dissemination in policy groups and associations, such as E.DSO and EU DSO Entity. Get advice from experts in open-source strategy to establish concrete actions before the end of the project. The exploitation strategy is also being expanded with the help of the 'Horizon Results Booster'.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Take the UMEI as basis for the development of additional features in other research and development projects. Consideration of the standard for future implementation in company's production systems.

KER 2 NODES Flexibility Market

Title KER	NODES Flexibility market
WP	**WP 7-9**
Project tasks	WP8.2 Set-up and screening of German Demo architecture and testing; WP7-9 Local Flexibility Market
Key Partner	Mitnetz, E-REDES, Energa, Centrica,
Other partners involved (collaboration)	Mikronika
Authors of / contributors to this document	Gesa Milzer
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
NODES Flexibility market algorithm facilitates access for system operators to distributed local and regional flexibility for grid management. NODES services cover all functional requirements of the three phases: Registration and prequalification, Trading and Validation and Settlement. The registration and prequalification are done with minimum data requirements and according to GDPR standards. In the Trading phase NODES market environment enables market participants to choose short-term and long-term products, ie. ShortFlex and LongFlex, allowing them to set up their business considering the most effective and reliable flexibility solution as well as with consideration of the asset type and characteristics. Validation and settlement performed by NODES monitors the correct activation and physical delivery of the contracted flexibility. Services offered range from FSP engagement, prequalification, trading and settlement. As such, NODES flexibility market supports the energy transition by providing temporal solutions to cope with grid congestions until grid expansion plans are finalized as well as a permanent mechanism for effective voltage control or congestion management in the LV and MV voltage grid.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
Contrary to regulated redispatch mechanisms the participation in the flexibility market is voluntary. Market prices are set by the market participants according to the offered/required service. As such NODES allows system operators to pick the optimal solution for their specific grid problem in terms of volume, location and price, while creating a level playing field for all types of assets. In addition, a new business case is also offered to FSPs, it adds to the SO's toolbox to solve grid constraints. At the moment both FSPs and SOs are needed to create a market. Through this solution FSPs will be able to solve problems in a higher granularity, in terms of location and volume. Current solutions are more expensive and have an effect on larger areas, local granularity is an added advantage.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem?

	Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Distributed flexibility of any size accessible and usable to system operators for grid management.	Using the flexibility market system operators can choose the optimal and most effective solution for their grid problem according to volume, location, and price	DSOs, TSOs
Distributed flexibility of any size can be offered to system operators for grid management	Asset owners can monetize their flexibility to produce/consume energy to help grid operators to manage grid constraints.	FSPs, Aggregators, BRPs

Unique selling point	What is the unique selling point of key result / tool / innovation?

Nodes market design allows flexibility to be offered/purchased across all grid levels. The effective use of available flexibility of any size may thus help to

- Support the energy transition until grid expansions are finalized
- Scaling of flexibility/energy required preventing oversized curtailments and compensation of required energy
- Facilitate use of available flexibility in the grid and thus reduce grid investment costs

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

An effective use of the available grid capacity due to smart up and down regulation of available assets

- prevents unnecessary curtailments of renewable energies and further up-regulation of fossil energies
- Reduces grid expansion costs
- May help to reduce the electricity bill of households and industrial assets

- Reduce the reaction time in case of congestions
- May keep grid limitations local/regional
- May help to reduce bottlenecks in the supply chain of source material

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	• The platform does not interfere with market agent`s responsibilities • Minimum data requirements • Level playing field for all types of assets • Flexibility to be used across all grid levels • May reduce or even substitute the need for grid investments • Facilitates use of optimal flexibility for each grid problem
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	• Effectiveness highly dependent on market liquidity and thus on regulation and customer participation
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• Once regulatory barriers are removed the market is an immediate and effective measure to use • Market prices are driven by all market parties according to the product and service
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing?	• Flexibility products and service will be too regulated • Grid tariff and tax regulation modifications disincentivizes offering flexibility • Flexibility market to be owned/operated by system operators vanishes independency and neutrality of the market • Limited market liquidity

What threats do your weaknesses expose to you?	
Suggestions grid codes	
Given the threats mentioned above, is it possible to identify some take away for the grid codes? Are their important elements to take into account / that you want to mention to ensure that it does not become "too" regulated?	In the Demos there has been lack of customer participation due to lack of incentives and slow smart meter roll out. If grid tariffs disincentivize participation, then the business case doesn't work for the customer. From a social point of view, only certain users would be able to offer flexibility by installing technology at home. Mechanisms to enable more users to be able to provide flexibility ought to be taken into account. Most system operators are not platform operators, their main responsibility is grid management. With an independent market platform operator, a fair selection of bids is ensured for both the DSO and FSP. The market would be more trustworthy with a neutral entity in between who has no stake in the outcome of the trades Communication model: the communication model used by TSOs (CIM) is quite complex and hard to implement. Implementing CIM as grid standard might leave out flexibility potential in the low voltage, it may exclude smaller DSOs or FSPs.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs and TSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	Worldwide; NODES market platform is a scalable product and is configured to function across the globe considering the different markets and market requirements
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	• Other flexibility market platforms connected to wholesale market: They are an attractive target specifically for industrial companies as the flexibility can be related to the wholesale market • Flexibility market platforms owned/operated by system operators as they undermine independency and neutrality of flexibility market platforms
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TLR9 – ready to go live
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market	Market maturity depends on the country and respective regulation, however due to regulation, market maturity is to categorized as emerging.

	- Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	- Neutral and independent market platform that offers short-term and long-term products for any type of grid constraints; - Market monitoring and surveillance, - The results of the project will lead to developing new products and services for Nodes' customers.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	System Operators: • Grid investment deferral • Improving resilience of the grid and quality of service. FSPs • TOTEX optimisation/Cost reduction Asset owners • Reduction of energy bill Society • Reduced investments and cost deferral for congestion management and fossil energy Others • Innovative technologies • Reduced need of source material (minerals, sand, water etc.)
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	• Recommendations to regulators, FSPs and SOs • Knowledge and skills • Algorithms • Methodologies

		• Simulation methods • The key takeaway from the project is that knowledge about testing products and set ups yielded lessons about implementation, such as the lack of interest of the residents who could be high potential flexibility providers.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	• Fees for platform participation through different possible models: per transaction, subscriptions… • Trading fees • Public tenders • Consultancy fees
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Whenever possible The NODES platform is ready to be implemented and has been tested, but they are facing regulatory barriers in all markets.
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Collaboration with relevant parties • Pilots in different countries and related regulation
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	/
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Market platform environment + architecture, market clearing algorithms, NODES market API and programming
Foreground IPR What have you developed in the project related to this specific KER?		Shaping of new products and services Market-specific platform adaptions UMEI

IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	Knowledge sharing and insights of market mechanisms and internal solutions in presence of a competitor and while developing the UMEI. NODES and N-SIDE had to find the way to make the UMEI more standardized so that the orders can be translated by both market platforms. As such the UMEI is a combined product of Nodes and N-SIDE's effort. Nodes has put a copyright note on the part of the code that belongs to the Nodes market design. The code will remain available on an open source basis.
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	N/A
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	Each partner will exploit the resources following their own commercial strategies.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Elaboration of developed products and services Elaboration of pilot results for pilots and industrial projects
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Aiming at establishing industrial projects and remove regulatory barriers. NODES is participating in regulatory discussions and dissemination activities.

KER 3 Optimal Flexibility bid recommender (OBR)

Title KER	Optimal flexibility bid recommender
WP	**8**
Project tasks	
Key Partner	N-SIDE
Other partners involved (collaboration)	/
Authors of / contributors to this document	Pierre Crucifix, Arnaud Debray, Chloé Dumont, Louise Adam

What is the KER doing? What value does it provide to which stakeholder?

Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

Among the challenges to be tackled in the design of a flexibility market, one is to minimize the cost of the flexibility that will be provided to the system. Usually, this is ensured by a process called market clearing which is done by the market platform. The process consists of a grid-aware optimization problem that finds the best combination of flexibility demand and offer orders (i.e. the combination that solves all congestions at the lowest cost).

When this is done at Market platform level, the drawback is that the System Operator (SO) has to share data about his grid with an external organization (market platform) which can be a sensitive topic. Furthermore, in the case of multiple market platforms, they could each perform an optimized market clearing, but to perform a global optimization taking into accounts sell bids from multiple market platforms would be very complex.

To tackle these challenges, we created the optimal bid recommender. This tool is a clearing engine that can be installed directly on the SO's servers and that can be used as a tool to help select the most optimal selection of flexibility bids. Instead of having the flexibility market platforms (FMO) performing the clearing, it is the DSO that will run an optimization algorithm (within the OBR). The OBR tool can use both the data fetched from multiple market platforms that operate in parallel, and the DSO grid-data. In this configuration the DSO can keep full control of both their data and actions. This solution can serve different market platforms.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

This section and the following ones are focused on the needs that are specific to the optimal bid recommender, compared to using a simple market platform. Needs tackled by market places for local flexibility are then implicitly covered (these can be found in KER 02)

The following needs are tackled by the OBR:

- Data privacy for DSOs
- Optimizing social welfare generated by trading flexibility on multiple platforms in parallel
- Ensuring grid stability

At the moment it is a market based solution, but it could be adapted to redispatch solutions with different types of contracting (smart energy contracts,etc...). The new market regulation is expected in Germany (non market approach) would not be a significant threat. This approach would combine both, the security of a direct control solution, or a market solution.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

This section and the following ones are focussed on the needs that are specific to the optimal bids recommender (compared to using a simple market platform). Needs tackled by market places for local flexibility are then implicitly covered (these can be found in KER 02)

Value	Description	Potential customer
Data privacy	The OBR is a SO tool that can run on the DSO/TSO servers, meaning there is no need to share data (such as grid topology) with external actors. The tool is provided, and the actual contracting and FSP management would be done directly by the SO.	DSO/TSO
Optimization of flexibility offered through multiple platforms	More flexibility platforms operated in parallel could help improving the liquidity (i.e. having more flexibility available). The drawback is that if each platform optimizes the flexibility on its own, without considering flexibility offered on other platforms. In this setup, it is impossible to reach a global optimum. The SO may have different platforms to choose flexibility from. With the OBR, it is possible to optimize all flexibility bids offered through multiple platforms together.	DSO/TSO
Ensuring grid stability	Using the OBR tool, the SO can input its most up to date grid topology and forecast, ensuring that the flexibility offered will solve congestions.	DSO/TSO

Unique selling point	What is the unique selling point of key result / tool / innovation?

Effective use of available resources even if shared across multiple market platforms while keeping full control of the data.

For example, in the Portuguese demo there are two market platform offering flexibility, to prove the flexibility of the UMEI for the same DSO and aggregator.

In the German demo the OBR is part of Mitnetz' cascading approach to their tool-chain. In this approach the DSO has direct control, showing the flexibility of the tool.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …

On society: Security of supply, lower grid investments; better use of the common good

On the energy system: Security of supply, lower grid investments, transition to a more sustainable energy usage, smarter utilization of the existing infrastructure

On EU/national policy: Effective measures to deal with EU/national energy challenges, rising impact and relevance of consumer behaviors

On the national landscape: Reduced need for grid investments and hence massive construction and interference with populated and natural spaces

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? …	- Possibility to optimize flexibility resources even if made available through different market platforms. This should lead to an increased liquidity. - Grid-aware flexibility optimization ensuring no grid issues will be created - The system operator remains in full control of its data - Optimal and scalable bid selection
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others?	- The DSO/TSO coordination scheme is not clear yet - Headrooms, meaning the maximum and minimum capacity of a line, are needed as input of the OBR. These values must be computed by the DSO, which can be complex. The process might decrease transparency for the FSPs

What are others likely to see as weaknesses? …	
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	- Adaptions of regulation, at the moment they are working in sandboxes. The aim is to help market stakeholders to know what is technically feasible given the current regulation. N-SIDE participates in demos and projects to test possibilities of future expected regulation. - Increased incentives to offer flexibility in the LV/MV grid - a numerous participation of flexibility providers in future local markets - Propose a common market clearing in regions with multiple flexibility platforms acting in parallel. - High needs for coordination between TSO and DSO
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	- Slow adaptation of the regulatory framework - Favouring grid investments - Gaming risks: the OBR itself doesn't create new gaming risks, it is the same risk already present in flexibility markets. The risk is that if the fear of gaming blocks the acceptance of flexibility markets in the regulation. - Having one single flexibility platform in a region without competition reduces the full added value of the OBR. The OBR enables a DSO to efficiently choose bids even from different market platforms if there is competition between platforms, or different platforms per region would be allowed. An OBR allows new, smaller, market platforms a fair chance of offering bids alongside a bigger competitor. Otherwise the risk is that new entrants cannot grow and would leave the market. - Lack of liquidity in the market - Lack of technical devices allowing either a good visibility on the grid state or a control on the electric appliances

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs and TSOs that don't want to share data or in regions with multiple market platforms operating in parallel.
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All DSOs and TSOs of Europe
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Main competitors are the internal developments in DSOs and TSOs, but none offer this KER to our knowledge.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies): The technology is used in the German demonstration for this project.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market	The market is emerging; SOs are more and more aware of the need of flexibility and that a tool such as the OBR can help optimize without

	- Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	sharing data externally, but local flexibility concept still needs to develop.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	New product: SO decision making tool. The new part is to propose a tool which enables the SO to run an optimization algorithm internally to perform a market clearing, taking into account grid data and sell bids from multiple market platforms.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Economic value: TOTEX optimization thanks to an optimized bid selection (through a market clearing). Grid benefits by choosing the selected bids to optimize grid constraints.
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Result is a software and an algorithm. Communicate about product through workshops, demonstrations, conferences, blog posts
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Software/Algorithm income: licensing of OBR tool (relying on the N-SIDE Power Matching Algorithm). This core algorithm is the same used for CRM in belgium, balancing markets in UK, used here in two demos, in Japan and India. They can rely on the same algorithm configured differently. Implementation time depends on how far the SO is with customer involvement (FSPs), and whether their requirements are clear. Implementation and testing can take a few months if the SO still needs to define their requirements. N-side is able to customize the tool to the SO's requirements.

Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	The tool was implemented during the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Increased internal knowledge on local flexibility markets and DSOs Understand how the N-SIDE POM algorithm can be used for local flexibility without positioning as a platform.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	The tool was developed by N-SIDE and adapted to the needs of Mitnetz in the German demo.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Know-how and solutions on electricity market clearing and coupling, adapted to local flexibility context and DSOs.
Foreground IPR What have you developed in the project related to this specific KER?		A tool that addresses needs for DSOs to leverage local flexibility.
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	OBR is N-SIDE IP, no specific IP issues. The IP is company secret on certain improvements building on common knowledge.
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	N/A
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	

Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	/
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Let a maximum of European actors benefit from the OBR - Place the OBR with other SOs - Dissemination: webinars, papers...

KER 4 Redispatch 2.0 combined with flexibility markets

Title KER	Redispatch 2.0 combined with flexibility markets
WP	WP 8
Project tasks	• Demonstration of congestion management using market-based utilisation of flexibility options in a LV grid • Use of the UMEI to facilitate access to available local flexibility and overcoming system-specific differences
Key Partner	MITNETZ, E.ON, CENTRICA, NODES
Other partners involved (collaboration)	
Authors of / contributors to this document	Helene Ask Uggla, Gesa Milzer
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

This KER investigates the feasibility of combining the cost-based approach (Redispatch 2.0) with the market-based approach. Studied and tested are the daily operations, technical requirements, required system architecture and energy infrastructure as well as the effectiveness to solve grid constraints with the available resources at a reasonable price.

To cover all technical and operational challenges related to grid management in the LV grid, several tools were developed and interconnected to correctly and precisely assess the state of the grid and the exact need of flexibility in terms of quantity, time and location. Mitnetz as DSO will then evaluate the existing offers (submitted by Centrica as FSP) on the market next to the assets available according to Redispatch 2.0 and select the offer that most effectively solves the grid constraint at the best price.

This operation is tested as Day-Ahead and Intraday process.

Before Euniversal, only flexibility in HV was considered in previous projects. EUniversal tests whether this cascade principle in Resdispatch 2.0 could be implemented in MV, (to solve problems in HV using flex in MV, and to solve problems in MV using assets in LV).

Figure 0-1 describes the set of tools and the market environment setup in twhich they have been implemented.

Note that this tool is different from KER 12 (System-level assessment framework for flexibility quantification) because they solve all voltage levels together, it doesn't work the same in Germany because you may have resources, and DSOs/TSOs at different levels. So there is a cascading method, iterating from the LV to the HV, and back if needed. The N-SIDE tool provides the optimal bid after congestion has been calculated.

An excerpt from the toolchain description is presented next. The full text can be found in: Brummund et al 2023, and D8.2 ' German Demonstrator – Demonstration of congestion management using market-based flexibility in the LV grid'.

Figure 3: Process diagram showing the different smart grid tools, and the market environment set-up.

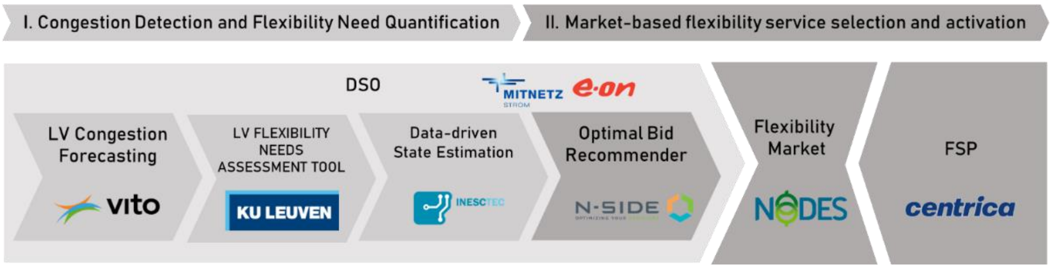


Figure 0-1: Process diagram showing the different smart grid tools and the market environment set-up

Within the demonstration, a set of smart grid tools is sequentially and iteratively used for precise grid state forecasting, analyses, and flexibility need assessment when congestions are identified. The DSO then connects with the flexibility market to find the most effective flexibility offers in terms of location, volume, and price from the resources registered on the market platform to relieve the forecasted congestions. Furthermore, the registered flexibility can be made available to the higher voltage levels in a cascaded process to be used for system-wide services. This architecture, as implemented for the demonstration, is shown in Figure 3, and consists of the following two steps:

I.Congestion Detection and Flexibility Need Quantification

- Flexibility resources are registered and prequalified on a flexibility market.
- A congestion forecast is performed and the headroom capacity for secure flexibility activation on the network is calculated.
- A distribution state estimation is run to allow monitoring of the real-time system state prior to activation.
- A network flexibility needs assessment is performed to determine the minimum amount of flexibility needed for ensuring network operational integrity.

II.Market-based flexibility service selection and activation

- An optimal bid recommender helps to select the most appropriate flexibility bid for the identified congestions.
- After identification of the required flexibility, the flexibility bid is submitted to the flexibility market. The FSP submits flexibility offers according to the registered local assets. Orders are cleared continuously applying Pay-as-Bid.

This operational set-up is implemented within a continuous, iteratively running framework, starting 48h-ahead, and extending to intraday, close to the delivery time when the flexibility is required. The iterations ensure higher accuracy of the calculation results due to more accurate weather forecasts while time progresses. Furthermore, they support the coordination between different system levels as corresponding assistance systems can consider the last forecast of the connected grid level without requiring a common computational model. This enables coordination across multiple voltage levels without having to disclose critical data, even in the case of several system operators. In the demonstration, the LV and MV grid levels and their respective flexibility requirements are considered.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

Effective use of local available flexibility from the LV grid combined with existing approaches. There is a need to determine how to combine flexibility market design, and market based flexibility with Redispatch 2.0

The limited capacity of the current grid could lead to congestion. Since more congestion are predicted due to the added prosumers and fluctuations of renewable energy sources, there is a need for flexible alternatives. The market-based flexibility procurement as a complementary tool to Redispatch 2.0 may be the optimal solution for an effective mitigation of congestions across all grid levels.

Throughout the project, the regulatory legislation of flexibility markets is under development and insights from the demonstration could be used to support adjustments of the regulatory framework.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Access to added available flexibility	Use of available flexibility provided by assets in the LV grid.	DSOs, FSPs
Effective and complementary solution to Redispatch 2.0	The flexibility market provides access to the assets that are not subject to Redispatch 2.0 acc. To German regulation (assets <100kW/DR)	DSOs, FSPs
Incentive for adaptive behavior of customer	Ability to benefit from selling own flexibility and help to relax grid overload . It is easier to adopt to the existing scheme than to create a new one. The concept would allow	FSPs, utilities, residential customers

	customers in LV to also offer flexibility, which was not available before the project.	
Creation of new business models	Provision of flexibility to the DSO enables FSPs to set up new Business models and revenue streams that were not available previously in LV.	FSPs, Aggregators, utilities
Visibility and accessibility of distributed assets	The actual potential of available flexibility in the LV/MV grid is to a large extent unknown. The flexibility market helps to visualize the available assets/flexibilities	DSOs
Transparent and neutral environment for flexibility procurement	The market-based approach via an independent market operator ensures equal treatment of all market participants Notes: the potential is to extend the solution proposed by Redispatch 2.0 to LV customers as well.	DSOs, FSPs

Unique selling point	What is the unique selling point of key result / tool / innovation?

Flexibility markets as a complementary tool to cost-based redispatch for grid constraints using existing and available assets in order to reduce or prevent unnecessary grid investments and function as an interim solution.

Flexibility can also be an interim solution while the grid can be reinforced when there is a repeated issue in the same location. Regulation still incentivises CAPEX in terms of grid expansion, rather than flexibility use (OPEX), and at the moment there is no real flexibility market that could be used.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics

	- ...

Economics: Potential cost saving – due to more effective congestion management using the combination of redispatch and flexibility markets. These tools enable a redistribution of grid and curtailment costs – goal is to reduce the costs for society as there would be less renewable curtailment.

Technical: Effective solution to solve grid constraints, possibility to avoid curtailments or extra investment on grid expansion-> Reduction of costs

Society: Relaxation of energy costs due to adaptive behavior and reduced tax due to redistribution of grid and curtailment costs

Environment: The additional demand response, via flexibility market to redispatch, can reduce curtailment of renewables.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	- Competitive and transparent approach to solve grid constraints at low(er) prices than current prices - Effective use of available resources - Inclusion of demand response - Long-term solution - The Redispatch 2.0 involves several communication channels for implementation, and the data model is complex. But since it is already implemented for high voltage it is better to use it than to create a new model.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	- Availability of technical devices to ensure data access and quality, e.g. smart meter, smart secondary substation - No standard interfaces and incentives by current regulation to enable demand response - low customer participation - Local solution, redispatch 2.0 only exists in Germany today– leads to differences within countries, hardware will differ, as well as regulation - Logistical challenge, hard to find resources, manpower and material, for installation. Specialized technicians, to only serve limited number of manufactures, by larger DSO, multiple manufactures are used

	- Lack of standards for technical devices to ensure compatibility and interoperability
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	- Application of the approach in various locations and with a large diversity of assets to assess full potential - Smart meter devices & economic incentives for adaptive/supportive customer behavior - ENWG (German Energy Law) – recent modifications reg. Storage and LV steering action for the DSO - There is still a chance to participate in the regulatory consultation. - Opportunity because it might allow DSO to use direct control flexibility from different types of flexibility sources (EVs, heatpumps, ...)
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	- Lack of smart meter installation - Counter-acting German Regulation, e.g. §14a EnWG steering without market involvement, no incentives for market approach - Redispatch regulation only for generation, demand response is not included - New mandatory redispatch solution "Redispatch 3.0" that includes assets <100kW and DR-Markets owned by system operators creating monopoly and suspicion of prioritization of assets/market agents - Prioritization of other market services e.g., for TSO frequency control

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSO, FMO, FSP
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	German DSOs and European FSPs; If Redispatch 2.0 scheme (or similar) are adapted to other countries than also DSOs in respective countries
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	KER is a process description, therefore no real competition, but dependent on regulation decisions

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 6; First steps of methodology have been tested in demo-phase, in a relevant environment, but with limitations due to market liquidity. An enhancement to the data model of redispatch 2.0 would be necessary and market liquidity is to be improved.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand, and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Necessary regulation not existing yet and it is not yet clear if the innovation has potential to become a standard solution for congestion management The link towards LV is possible to implement, but it would need to be integrated in the regulation (Redispatch 2.0). It is feasible but the costs of implementation are not clear since there are no standard interfaces, measuring equipment, IT equipment, experience, etc... In the demo experience each customer needs an individual customized. At the moment there is a proposal in the new regulation for standards that should be implemented at connection points. There is a minimum number of customers needed to have a significant amount of flexibility that would make a difference for the network and be economically feasible for the FSP. The liquidity in the LV is not always there. It makes more sense at the moment to start at the MV grid.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	- Due to low market maturity, it is still too early to think about exploitation strategy. Further assessment of potential impact needed. - Presentation and discussion of project results and solutions with other DSOs and FSPs are, however, being executed.

Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	**Economic value** - TOTEX reduction by enhanced economic efficiency in congestion management - Grid investment deferral by predicting and smart managing grid loads considering flexibility - Avoid curtailing renewables and compensation costs related. **Grid benefits** - Improving resiliency and quality of service
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	**Type of result** - Guideline/Recommendation based on developed methodology and algorithms **Channels** - Digital Marketing channels (website, social media…) - Set up further pilots/demonstrations/testing activities - Internal networks
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	**No direct revenue stream based on KER**; Improvement of grid resilience and reduction of congestion management cost (OPEX reduction) possible in case of regulation changes that lead to implementation of scheme - Additional revenue stream for FSPs due to ability to implement new business models
Implementation timeline	- During project lifetime - Within 1 year after the project	NODES flexibility market is ready to go live. Delays are due to regulatory and technical barriers. We therefore expect

When have you implemented this strategy or when will you implement it?	- Within 5 years after the project	implementation possible within 5 years after the project (but regulatory changes would be necessary)
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	**Knowledge exploitation** - Increase internal knowledge on flexibility markets - Evaluation of operational and technical feasibility of a flexibility market next to regulated redispatch schemes
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	E.ON, NODES, CENTRICA (+ Tool support by Technology provides)
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	E.ON -> In Germany alone more than 800.000 km of distribution grid. >48M customers. Experience in distribution grid operation, already high influenced by >900.000 RES connected. NODES: market platform and API
Foreground IPR What have you developed in the project related to this specific KER?		Digital flexibility value chain on the example of Brandenburg/Germany
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	No IP actions made

Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	Partners involved in this KER do joint tests in the German demonstration
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	- In order to implement the KER, market liquidity must essentially still increase and adjustments to regulation must be made. This will be closely monitored - We will analyse internal gaps to overcome for implementation - Potentially we will run further pilots, demonstrations, testing activities that are built on the knowledge during the project. (e.g. Focusing more on the MV grid). - The partners plan to monitor and participate in the regulatory process. The regulation would need to add incentives to offer flexibility. It needs to be incentivized enough to solve grid congestion, but not too much that it would impede necessary grid investments.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	- We will further develop concepts to implement useful additions to the redispatch 2.0 scheme - Shift the focus to MV and use resources located there. - New regulation in Germany focuses on direct flexibility asset control by the DSO, this would take priority in terms of implementation. - The lessons learned from Euniversal will be exchanged with other DSOs and future research projects.

KER 5 Resilience-informed planning of distribution networks

Title KER	Resilience-informed planning of distribution networks
WP	**4**
Project tasks	Task 4.4 Design of Resilience Enhancement Solutions for Distribution Networks
Key Partner	University of Cyprus (UCY)
Other partners involved (collaboration)	INESC TEC
Authors of / contributors to this document	
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
In this project, an optimal investment planning framework for MV distribution grid and a reliability evaluation method are developed. Within the optimal investment planning framework, the project provides the following tools: (1) Hazard scenario generator, developed based on network fragility curves to account for the vulnerability of individual network assets to natural hazards. (2) An optimizer tool that takes the hazard scenarios generated and the investment options as the input data to generate different optimal investment portfolios that enhances both resilience and reliability of the network. In addition, a reliability evaluation method using a state evaluation process to determine the load loss is performed by considering the time-dependency of flexibility use and its energy limitations is developed. This method implements the assets proposed by the planning tool to evaluate the system reliability under regular events. Moreover, additional details on the fundamental difference between reliability and resilience are elaborated in Section II of deliverable D4.4.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
The frequency of natural hazards and their impact on power systems is increasing. For example, Hurricane Leslie, in 2018, in Portugal, affected more than 15 thousand homes without power and severe damage to roads due to fallen trees. Similarly, Hurricane Ian, in 2022, in USA, caused widespread power outages affecting over 2.7 million customers, resulting in an estimated cost of $113 billion. Hence, it is essential to upgrade our current planning tools with inherent capabilities to cater to these catastrophic events. The current planning methodologies are mainly focused on enhanced reliability which is measured over an extended time period. This way of planning may oversee the impact of an event on the network. Hence, it is essential to include resilience, which is event based, measured in short-term, specifically for each event, in planning strategies. The developed planning tool considers both reliability and resilience aspects and hence can help power system planners and DSOs to plan their investments on assets that enhance resilience and reliability of the network.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation.

	Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Risk-based Resilient Investment Planning	Provide a set of optimal asset portfolios for different sets of investments and risk trade-offs to optimize the selected performance metrics (e.g., reduction of lost load or operational costs). From this, the planners can be able to choose the right asset portfolio based on their requirement.	DSOs, Power System Planners and policy/regulatory decision-making bodies

Unique selling point	What is the unique selling point of key result / tool / innovation?

There are few tools available in the market that do techno-economic analysis. However, this is the first tool for resilience planning that will allow DSOs to plan their networks with enhanced resilience and optimize their investments based on their risk appetite. In other words, the DSOs can choose their level of risk (risk averse, risk neutral or partial-risk) to plan for their investment in network reinforcement and flexibility enhancement assets.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

Society: Gives a better strategy on planning for resilience and decreases the impact of natural hazards on power systems thereby reducing the impact on societies during the event.

System Performance: For the investments planned by the DSOs on network upgrades with an allocated budget, this tool finds the optimal assets based on risk-driven resilience metrics that can improve the system performance during the events and also improves the system reliability during regular conditions. For example, in the Portuguese Demo, for an investment of €6 million, the tool improves the system performance against windstorms with expected energy not served by 36.79% and the conditional value-at-risk of energy not served by 28.29% from the base case (without any asset upgrade) for the scenarios considered. Moreover, with the same asset options, the popular reliability

indices such as SAIDI and SAIFI improved by 27.14% and 25.49%, respectively. This shows that the tool is capable of improving both resilience and reliability of the network.
What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	The tool is modular and will be able to provide optimal assets that can reduce the impact of natural hazards on the power system. Since it is developed on python, it can be adaptable to multiple environments.
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	This tool depends on historical data of natural hazards to derive its characteristics.
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	Since the frequency of hazards are increasing across the globe, this tool finds an opportunity to help DSOs or power system planners with their investment planning. The solution offered by this tool will improve the resilience against natural hazard (in this case windstorm) and also enhance grid flexibility with the storage system proposed by the tool.
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	Recession in the market could make investors think that climate change is a myth which may slow down progress towards resilience.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs and Power System Planners
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All power system planners and decision-making bodies worldwide. There are currently hundreds of DSOs in Europe only, hence the market and potential customers is significant.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	There are many software companies that offer conventional planning solutions for separate/individual problems. However, they don't have an integrated solution for all planning issues. If resilience is the priority, as of today, other software packages don't offer a standardized method. We are using a multi-metric approach to solve this.

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 4-5. The EUniversal Portugal demo allowed to test the tool within a relevant environment.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	There is a potential for this tool to go to market. It is an emerging market as energy systems are being increasingly exposed to extreme weather and natural disasters looking for novel solutions to reinforce their resilience against such events
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	A new product: We offer a tool for improved resilience of the grid, that enables DSOs to get optimal asset portfolios that can withstand and improve the system resilience against extreme weather events.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	• Grid investment with our planning tool can improve both resilience and reliability. • In a situation where the network planners are for network upgradation, this tool helps them make decisions considering both reliability and resilience aspects.
Exploitation assets and/or channels	See table 4 for inspiration	We are exploring the possibilities of research partnership with other DSOs to validate the tool in new environments.

Describe how the results can be concretely exploited, via which channels/assets		The options with us are yet to be explored, however there is an ongoing effort to develop this as a software as a service (SaaS) product. An alternative might be to provide licensing of the software for consultancy services to DSOs, power system planners and decision-making bodies. But a final decision on the exploitation of the product is still to be reached.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not yet determined.
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 5 years after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Knowledge exploitation • Demonstrate that as a research institute we can build practical applications.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	UCY is the sole developer of the tool.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also	Methodologies, algorithms and modelling tools developed in-house to address DSO needs e.g. Planning methodology

	find inspiration from other partners' strategies.	
Foreground IPR What have you developed in the project related to this specific KER?		• Adapting the existing tool-suite to the specifics of the Portugal Demo setting. • Inclusion of the tooling within the demo environment.
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	None
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	None
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	• Increase TRL level of tool by testing the tool in additional, and different environments, to increase robustness of the results. • Add user interfacing, to make it more user-friendly.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Tool will be further tested within EU and/or other projects • In collaboration with a DSO, the tool can be co-developed. • Expanding the planning tool for transmission grid. • Exploring options to collaborate with Earth digital-twin European project to integrate for better resolution of weather event integration in planning tool.

KER 6 Data-driven State Estimator

<table>
<tr><td>Title KER</td><td>Data-driven State Estimator</td></tr>
<tr><td>WP</td><td>WP04</td></tr>
<tr><td>Project tasks</td><td>Task 4.2 (ST4.2.1)</td></tr>
<tr><td>Key Partner</td><td>INESC TEC</td></tr>
<tr><td>Other partners involved (collaboration)</td><td></td></tr>
<tr><td>Authors of / contributors to this document</td><td>Gil Sampaio, Ricardo Bessa, Clara Gouveia</td></tr>
<tr><td colspan="2">What is the KER doing? What value does it provide to which stakeholder?</td></tr>
<tr><td>Description of the exploitable result(s)</td><td>A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results</td></tr>
<tr><td colspan="2">The DdSE enables real-time estimation of voltage and active power in LV networks using exclusively a combination of historical data and real-time measurements, also quantifying and expressing the uncertainty associated with the estimation results. Therefore, it does not rely on topological and electrical information of the network, which are commonly incorrect or inexistent, as opposed to traditional approaches. Additionally, the DdSE does not require full network observability, meaning it can operate even in areas without complete monitoring. It performs an estimation for each meter individually based on historical data, ensuring flexibility and adaptability.
Another significant aspect of the DdSE is its capability to integrate weather measurements and forecasts. This feature enhances the accuracy of estimation results, particularly in LV networks with a substantial presence of renewable resources.</td></tr>
<tr><td>Needs</td><td>To which need is this KER responding? Which research/market gaps is this KER filling in? <u>What</u> is the problem you are solving?</td></tr>
<tr><td colspan="2">The limited monitoring capability of LV networks poses challenges for DSOs in identifying technical problems and quantifying flexibility needs. Additionally, as renewable sources and electric vehicles (EVs) increase, voltage and congestion issues are likely to arise. However, without adequate monitoring, many of these problems go undetected, and the installation of real-time communication meters is not economically viable. On the other hand, smart meters can measure voltage and record this information synchronized with the daily load profile, communicating this data periodically (e.g., every 24 h). The DdSE leverages this historical data, along with additional information and a few real-time measurements, to provide estimations for the meters that do not communicate in real time.</td></tr>
<tr><td>Value proposition</td><td>What value does the exploitable result provide? <u>How</u> do you solve the previously described need/problem?
Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?</td></tr>
<tr><td colspan="2">
<table>
<tr><td>Value</td><td>Description</td><td>Potential customer</td></tr>
<tr><td>Allows to know when and where a voltage violation is occurring.</td><td>For each 15-min period, the tool will tell the most likely voltage value for each meter that does not communicate in real time.</td><td>DSO</td></tr>
</table>
</td></tr>
</table>

Enables the use of flexibility to solve voltage problems.	By knowing that a voltage violation exists, the DSO can act in order to solve it.	DSO
Enables flexibility exchanges without compromising voltage limits.	By knowing the voltages of the system, the DSO can act in order to avoid violations.	DSO

Unique selling point	What is the unique selling point of key result / tool / innovation?

The unique selling point of the DdSE lies in its ability to perform real-time state estimation in LV grids using a limited number of real-time telemetry. This is achieved by leveraging historical data from smart meters, along with some real-time measurements and other relevant information. Unlike traditional approaches, the DdSE does not require full network observability or detailed knowledge of the network's topology and electrical characteristics.

Furthermore, the DdSE goes beyond deterministic estimation by providing estimations with conditional uncertainty expressed in the form of quantiles. This feature enhances operator awareness by defining the significance of the information conveyed and enables the identification of potential issues through probabilistic alarms.

Another key selling point is the DdSE's capability to incorporate weather measurements and forecasts. This inclusion of weather information is particularly valuable in networks with high levels of renewable resource integration, such as photovoltaics (PV), even under self-consumption regimes.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …

The DdSE contributes to society by enhancing the overall reliability and efficiency of LV grids. It enables operators to have real-time information about voltage and active power, leading to improved grid stability and optimized energy distribution. This can result in a more resilient and robust electricity supply, reducing disruptions and improving the overall quality of service for consumers.

Having a better knowledge about the state of the system, the DSO can better manage flexibility, facilitating the efficient utilization of renewable energy sources while reducing reliance on fossil fuels and decreasing greenhouse gas emissions.

By taking advantage of the large volumes of data produced by smart meters, real-time estimations are obtained without the need of substituting current equipment that does not communicate in real time, thus bringing additional economical benefits.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths?	• Only a sub-set of the meters need to communicate in real time. • Topological and electrical characterization of the grid is not necessary.

…	• Ability to quantify and express uncertainty in estimation results. • Flexibility in operating with limited network observability and topological information. • Integration of weather data for improved accuracy.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	• Depends on the availability of historical data. • Any topological or electrical irregularity that may occur in a grid invalidates the existing historical data. • Some real-time data is still needed to support the estimation process.
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• DSOs can easily start monitoring LV grids with little financial investment (replace/update some meters to communicate in real time). • Real-time monitoring enables the opportunity to better manage flexible resources, allowing the integration of more renewables and avoiding problems from the presence of more EVs.
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• In some regions the metering infrastructure is not managed by the grid operator. This may hinder the access to the data.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions...? How many customers can you target?	See table 0 for inspiration	Worldwide
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	There are no competitors.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL8 – The tool has been extensively tested in different grids, with different operators, and is ready to be deployed.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market	Emerging

	- Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	A new product: Real-time observability over the the LV grid is achieved with little investment. The tool will be offered by a DMS vendor that is a spinoff of INESTEC, licensing is still in negotiation.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	By providing a real-time monitoring, it enables the use of flexibility from resources connected to the LV grid without compromising technical limits.
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	• SaaS • Licensing of software tools. • Direct Sale of tool as a product
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	• SaaS • Licensing of software tools. • Direct Sale of tool as a product • Maintenance contract
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 1 year after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Knowledge transfer to industry. • Solving a real industry problem with advanced algorithms

Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	n.a.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Estimation algorithm had been developed and tested before the project.
Foreground IPR What have you developed in the project related to this specific KER?		Industrialization: the tool is now a containerized package ready to be deployed in any linux-based system. Besides the algorithm, it includes the necessary databases and a communication module (Rest API).
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	none
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	none
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	n.a.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Licensing to a DMS vendor is being negotiated.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Tests

KER 7 Data-Driven Voltage Control

Title KER	Data-driven Voltage Control
WP	**WP04**
Project tasks	Task 4.1
Key Partner	INESC TEC
Other partners involved (collaboration)	
Authors of / contributors to this document	Gil Sampaio, Ricardo Bessa, Clara Gouveia
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
The DdVC (Data-driven Voltage Control) provides exploitable results for effective voltage control in LV networks. It calculates sensitivity factors, offers preventive and real-time modes, determines flexibility perimeters and ranges, selects flexibility bid offers, and conducts system state analysis. These results enable accurate voltage control, proactive violation detection, optimized flexibility utilization, and informed decision-making for improved LV network performance.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
Conventional flexibility management tools require a complete topological and electrical model of the grid, which is typically incorrect or inexistent in LV systems. Considering this limitation, the DdVC, based exclusively on the historical data of smart meters, is able to quantify flexibility needs, flexibility ranges and select optimal bid offers when applicable.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Enables the use of flexibility to solve voltage problems.	The DSO can run optimization algorithms and find how much flexibility is needed to solve voltage problems.	DSO
Enables flexibility exchanges without compromising voltage limits.	The DSO can define exchange limits (envelopes) that ensure the non-violation of grid constraints.	DSO
Market clearing tool	From a list of flexibility bids, it can select the most cost-efficient solution to solve violations.	DSOs

Unique selling point	What is the unique selling point of key result / tool / innovation?
The unique selling point of the DdVC is its data-driven approach tailored specifically for LV networks. It stands out by utilizing the existing smart metering and measuring infrastructure, eliminating the need for additional measurement equipment. This approach ensures cost-effectiveness and efficiency by leveraging the available infrastructure without requiring additional installations. Furthermore, the DdVC implements a privacy-preserving strategy, ensuring the confidentiality and protection of sensitive data collected from smart meters.	
Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …
The DdVC contributes to society by improving the reliability and stability of LV networks. By accurately controlling voltage values, the DdVC helps prevent voltage violations, reducing power disruptions and ensuring a more reliable electricity supply. This enhances the overall quality of service for consumers, minimizing inconvenience and potential damage to electrical devices. The utilization of existing smart metering infrastructure also promotes cost-effectiveness, enabling the adoption of voltage control measures without the need for additional equipment installations. By effectively managing voltage levels, the DdVC optimizes the utilization of distributed energy generation, such as solar photovoltaics, within LV networks. This allows for increased integration of clean energy sources and reduced reliance on fossil fuel-based generation. Consequently, the DdVC helps mitigate greenhouse gas emissions and supports the transition to a more sustainable and environmentally friendly energy system. Finally, the DdVC offers economic benefits through improved operational efficiency and cost savings. By preventing voltage violations and optimizing voltage values, it minimizes downtime and maintenance expenses. Additionally, the utilization of existing smart metering infrastructure lowers the need for additional investments in measurement equipment, resulting in cost-effectiveness and enhanced economic viability.	
What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? …	• Effective voltage control in LV networks without the need for additional measurement equipment, enabling cost-effectiveness and efficiency. • Adoption of a privacy-preserving strategy, ensuring the confidentiality of sensitive data. • Data-driven approach utilizing historical data, avoiding topological and electrical characterization of the grid.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	• It relies on the existence of historical data. • Any topological or electrical that may occur in a grid invalidates the existing historical data.

<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• DSOs can easily manage flexible resources connected to LV grids without further investments. • Inclusion of new resources, such as renewables and EVs, can be done with less uncertainty about their impact on the grid stability.
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• In some regions the metering infrastructure is not managed by the grid operator. This may hinder the access to the data.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	Worldwide
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	There are no competitors.

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL7 – The tool has been tested in different grids and scenarios, and is ready to be deployed.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Emerging
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	A new product: Flexibility management for LV grids. This tool, along with the related tools by INESTEC are under negotiation to be licensed to an associated SME that offers demand side management services.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	It enables the use of flexibility from resources connected to the LV grid without compromising technical limits.
Exploitation assets and/or channels	See table 4 for inspiration	• SaaS • Licensing of software tools. • Direct Sale of tool as a product

Describe how the results can be concretely exploited, via which channels/assets		
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	• SaaS • Licensing of software tools. • Direct Sale of tool as a product • Maintenance contract
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 1 year after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Knowledge transfer to industry. • Solving a real industry problem with advanced algorithms
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	n.a.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Different approaches to the same problem were explored in the past
Foreground IPR		Industrialization: the tool is now a containerized package ready to be deployed in any linux-based system. Besides the algorithm, it

What have you developed in the project related to this specific KER?		includes the necessary databases and a communication module (Rest API).
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	none
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	none
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	n.a.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Licensing to a DMS vendor is being negotiated.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Tests

KER 8 LV congestion forecasting tool

Title KER	Day-ahead LV congestion Forecasting tool
WP	**4**
Project tasks	Task 4.2 Smart grid tools for improved observability and control of distribution networks
Key Partner	VITO (main contributor), Mitnetz (data provision)
Other partners involved (collaboration)	/
Authors of / contributors to this document	Reinhilde D'hulst, Koen Vanthournout
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
The LV congestion forecasting tool is a tool that aims at calculating the risks for congestion on a LV distribution feeder for a forecasted day. These congestions are overvoltages, undervoltages or overcurrents anywhere within the feeder, or overloading of the MV/LV transformer. The tool does not deterministically calculate congestions, as for this calculation the necessary input would be impossible to acquire (e.g. deterministic forecasts of single connection consumption is not available), but merely outputs a congestion risk based on the statistically possible LV feeder states during the forecasted period. The congestion risks are defined as the probability a particular congestion may take place and is based on a predefined risk threshold that is calculated per node and per time step. The calculations within the tool are based on historical, and (if available) recent grid and connection profile measurements, as well as weather forecasts. The tool assumes that the grid lay-out is known, however the phase-connectivity of the single-phase connections is assumed to be unknown by the DSOs.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
The proposed tool allows DSOs to have a view on their LV network, the part of the network that is (almost) not measured nor monitored automatically, and forecast what is likely to happen on that network. To have a view on the LV network, is a prerequisite for any tool or method that builds on the state of the LV network: from congestion management to so called 'grid traffic light' methods.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation.

	Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
LV congestion forecast	Provide a congestion risk for LV networks, given sparse measurement data.	DSOs

Unique selling point	What is the unique selling point of key result / tool / innovation?

The tool provides a risk of the congestion on a particular LV network, even when there are little to no measurements available on the given network. The only prerequisite of the tool is that the network lay-out must be known, all other unknowns are covered through exploiting statistical methods to assess the congestion risk.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …

On Society: By having a better view on the LV networks, DSOs are able to manage their assets better, leading to improved asset use and eventually lower costs for society.

On the energy system: The LV forecasting tool will allow an improved management of the distribution network, and will also allow for a safe activation of flexible assets on the LV network for ancillary services, helping the overall energy system.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? …	The tool is able to provide a forecast even when there are many unknowns.
Weaknesses	The tool relies on historic measurements, calculated risks might be inaccurate when little historic measurements are available.

What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	The need for flexibility within the energy system will only be growing. Having a congestion forecast of the LV network may be an enabler to unlock the flexibility on the LV side.
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Recession in the investment market, especially in the energy sector, lowering the need for innovative tools. • Lack of awareness of the need for such tool within DSOs.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All European DSOs
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	A number of existing players offer products that enable simulation of (existing) LV systems (e.g., Envelio, Venios, Plexigrid, etc.). Most of these offerings produce a deterministic output, and thus do not take into account possible unknowns in the system. Only some tools are able to produce a timeseries-based output, most tools are aimed at giving a single-shot (worst-case) congestion impact assessment.

		There are no commercially available products that offer a day ahead congestion forecast which also includes weather parameters.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL = 6-7, it is not yet commercially viable, but in testing phase. The EUniversal German demo allowed to test the tool within a relevant environment.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Not existing market yet but there is a lot of potential. We will create the market by creating awareness with many DSOs on our product.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	A new product: We offer a tool for improved observability of the grid, that enables DSOs to get an accurate view on what happens in their network taking into account the weather conditions. The tool is able to produce on a daily basis the risks for congestion on the LV network.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Economic and grid benefits: • Grid investment deferral by predicting better what happens in the network, and provide the necessary info the congestion mitigation methods. • Improved resiliency and quality of service by providing the DSO a more accurate view on the network status.

Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Software • Channels not determined yet probable options are SaaS (system as a service-), technology transfer, or licensing to a third party. Set-up of a spin-off is also an option.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not determined yet, probable option is: • SaaS • Licensing of software tools and algorithms . • Direct Sale of tool as a product
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 5 years after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Knowledge exploitation • Demonstrate that as a research institute we can build practical applications.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	• VITO developed the product alone. • Mitnetz facilitated the testing of the product by providing demo infrastructure
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You	• Methodologies, algorithms and modelling tools developed in-house to address DSO needs, a.o. congestion forecasting

Foreground IPR What have you developed in the project related to this specific KER?	can also find inspiration from other partners' strategies.	• Adapting the existing tool-suite to the specifics of the German Demo setting. • Inclusion of the tooling within the demo environment. • Headroom calculation as an extra feature of the congestion forecast result.
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	None
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	None
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	• Increase TRL level of tool by testing the tool in additional, and different environments, to increase robustness of the results. • Add user interfacing, to make it more user-friendly. Further steps: • Additional pilot/demo • Feasibility study to know market potential • Make promotion to increase interest in tool: through conferences, exhibitions, and demos.

Further actions (development) What further actions will you take to further develop this KER?	See table 10	• Tool will be further tested within EU and/or other projects • In collaboration with a DSO, the tool can be co-developed.

KER 9 FDLR

Title KER	The DLR-based flexible allowable capacity of the HV lines (acronym FDLR)
WP	**WP09**
Project tasks	SUBTASK 9.1.1. THE TECHNICAL SOLUTION PROJECT AND NETWORK INFRASTRUCTURE DEPLOYMENT Elaborating the extension of the existing DLR system for weather-dependent HV line forecasted capacity calculation as the flexibility service. SUBTASK 9.1.2. ACTIVE MANAGEMENT SYSTEM IMPLEMENTATION AND MARKET PLACE INTEGRATION FOR DEMONSTRATORS (Leader: MIKRONIKA; Participants: ENERGA, IEN, NODES) This subtask focuses on the implementation of an Active Management System for HV, MV, and LV network and deploys oy UEMI solution for flexibility services market management.
Key Partner	ENERGA
Other partners involved (collaboration)	
Authors of / contributors to this document	Adam Babs
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

RES energy producers have a connection agreement with the DSO in which a power limit is defined. In case the forecasted renewable power generation exceeds the defined power limit, RES will be curtailed. The limiting line capacity factors is the safety of the line operation. Safety of the line implies that in every time span the distance to the earth should be kept within normative limits. It can be defined in a traditional way through static line rating (SLR) where it is generally fixed depending on the season of the year, but it can also be done based on DLR (dynamic line rating).

DLR values are usually larger than SLR value, providing more flexibility. As a result, FDLR can be used for operational planning by considering the full-line flexibility of the transmission and distribution network. It can look at the full line capacity utilisation and as such have a more efficient load dispatching, avoiding the so-called 'bottleneck' which provides safety for the OHL lines operation. FDLR utilises weather-based dynamic line rating (DLR) which is nowadays the only measure to cope with increased power transmission demand, especially in the situation when network infrastructure upgrading (for example restringing) is hardly possible. DLR is calculated based on the measured or forecasted weather conditions along the line (ambient temperature, wind speed, wind direction, and solar radiation).

RES energy producers have a connection agreement with the DSO in which a power limit is defined. In case the forecasted renewable power generation exceeds the defined power limit, supplying the power above this limit requires DSO permission, which can be done by buying the flexibility service on the flexibility market.

For the majority of the wind farms (WF) contractual connection capacity is lower than the installed capacity. This means that these WFs in some windy conditions can deliver more power than was agreed in the connection agreement.

For this extra power, it may be necessary to exploit the extended transfer capabilities of the HV lines, especially those located in the vicinity of these farms. Calculated by the DLR system forecasted allowable capacity for these lines may be offered to WFs owners as the flexibility service on the flex market.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

FDLR can help to more efficiently use the transmission capacity of HV lines by matching this capacity to current or forecast weather conditions without jeopardizing the safe operation of the grid. As a result, it is possible to offer a flexibility service for the energy producers willing to produce more than previously agreed on the connection agreement. Usually, the maximum produced power set in the connection agreement is lower than the nominal power of the wind farm, as nominal power production is seldomly achieved by wind farms. This methodology could help connect wind farms while still waiting to reinforce the network.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
More accurate calculation of the wire location over ground The clearance of the line will change depending on the weather and the current flowing through the line. The temperature of the line is affected by current, wind, solar and environmental conditions. During	Better estimates help to ensure safety of the HV line operation while simultaneously also offering higher line capacities to RES producers.	DSOs, TSOs

EUniversal they have developed a better thermal model of the line, the parameters of the model are individual for each wire. The added value is to prepare the DLR software to offer flexibility services in the market.		
Adapted (higher) line capacity available for RES when exceeding the connection agreement. Enabling services in the market: Wind producers can deliver more energy than previously agreed in their connection agreement. They offer energy on the wholesale and balancing markets.	In case RES energy producers exceed the power line capacity, they can issue a buy order with the DSO to get access to higher capacity levels.	RES energy producers

Unique selling point	What is the unique selling point of key result / tool / innovation?

The unique selling point of the tool is the high accuracy of the calculated results and low cost in comparison to other methods, especially when the system serves multiple lines. In practical deployment, when DLR values are used for short-term load flow and congestion analysis, the very accurate thermal model of the HV lines in the steady state is used. Presently the calculation accuracy of the wire location over the ground is better than +-10 cm, as proved in the field installations. Accuracy of the wire location over the ground is very important for the safety of the HV line operation in terms of keeping the normative distance to the ground. There are very few companies who offer a similar solution.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...
FDLR can be used for operational planning and together with other software (Power flow software), it is possible to detect possible congestion. In the short term, DSO can offer the flexibility service which may be bought by energy producers, especially energy from predictable renewables.	
What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	1. Very reliable and proven calculation thermal model of the OHL 2. 10 years of practical experience and installation of DLR system for monitoring more than 1000 OHLs 110 kV. 3. Unique specialized knowledge and experience in field deployment.
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	1. Insufficient marketing. 2. Limited number of personnel for realizing big projects in a short time. 3. Lack of experience in proceeding with the project abroad 4. Long decision-making process and regulation of DSOs. DSOs, the potential buyers, are regulated companies. DSOs have a regulated grid planning process. The decision-making process to improve their grid is quite long and subject to tendering rules.
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	Yet, there is a need for the DLR system by other DSOs/TSOs in Europe. 2. Depends on the orders from the power sector companies. 3. Necessity to operate the power system close to the technical limits. The DLR system enables the use of more RES, while deferring investment in new lines.
Threats	1. Recession in the investment market, especially in the energy sector

What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	2. Lack of situational awareness among potential clients. DSOs are not currently aware of their admissible line capacity and possible threats to the network in real-time. 3. Competitors organize meetings, with the potential clients, seminars and offensive marketing

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	Today, we already target national DSOs and TSOs. In the future we target the same group but internationally (within Europe)
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	European DSOs and TSOs
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Ampacimon SA (Belgium): The solution offered by Ampacimon has the same goal but is technically different from our solution. The price is significantly higher.

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 9, TRL at start of the project also TRL9 but now they have new features.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Mature: there are very few sellers (producers) of DLR system in the EU.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	The offer relates to the DLR system which in the case of the admissible line rating forecasting functionality consists only of software. In the case of the monitoring of line allowable capacity + forecasting of allowable line capacity, the offer contents also the equipment (weather stations) mounted on the HV line poles + extended software. In the above both cases delivery on the "key turn" basis
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Grid benefits through Congestion relief (minimalizing) Economic benefits through flexibility services selling

Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Selling to DSO, TSO and deploying DLR system within OT infrastructure of DSO, TSO. Software is usually sold as a license unless the customer has special requirements.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Direct sell to DSO, TSO via public tenders. Usually, Guarantee maintenance and post-selling service (even "hotline") is provided by us according to an agreement with the client.
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project	During project lifetime: the product is currently already sold to other DSOs in Poland (on request).
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Increasing internal knowledge of weather forecasting and HV line thermal modelling.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	No, we developed it alone
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also	Dedicated software, elaborated as the extension of existing so far DLR software, allows for selling the flexibility services resulting from DLR functionality.

Foreground IPR What have you developed in the project related to this specific KER?	find inspiration from other partners' strategies.	Software for communication with SCADA system
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	NA
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	NA
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Take up promotional actions in other EU countries. We will make promotion, papers, conferences
Further actions (development) What further actions will you take to further develop this KER?	See table 10	The product could be improved based on client requirements and technological developments.
Recommendations for the Grid codes: **Results in numbers/figures:** **Eg. X % of RES avoided curtailing**		

KER 10 Improved methodology to perform SRA for local flexibility markets

Title KER	Improved methodology to perform SRA for local flexibility markets
WP	**10**
Project tasks	T10.3
Key Partner	Comillas
Other partners involved (collaboration)	Vlerick
Authors of / contributors to this document	Orlando Valarezo, Matteo Troncia, Rafael Cossent, Eliana Ormeña
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

This KER consists of an improved methodology to perform a simulation-based quantitative SRA (scalability and replicability analysis) of use cases related to applying local flexibility markets to prevent or alleviate distribution grid constraints.

The aim of this type of SRA is to assess the impact on a certain number of Key Performance Indicators (KPIs) (e.g. grid constraints avoided, flexibility costs, etc.) of changes in several factors or boundary conditions relevant to upscaling and replication, i.e. grid characteristics (impedances, voltage levels, topology), existing grid users (load/generation profiles), and FSP characteristics (type, technology, flexibility availability, costs, location). These factors drive, on the one hand, the amount and type of flexibility needs by the DSO and, on the other hand, the capability and cost of the FSPs to solve them.

The results aim to address questions such as:

- DSOs: how much flexibility is needed in a given distribution area? What type of flexibility is most suitable for my needs (upwards/downwards, active/reactive power, etc.)? What potential FSPs should I prioritize in my engagement strategies considering their type, location, size, etc.?
- FSPs: what is the value of my flexibility for the local DSO? How competitive may I be in a local flexibility market? What grid location can maximize the value of my flexibility?
- Market operators/platform developers: what is the impact of alternative grid modelling in the accuracy or efficiency of the market results? In what locations would DSOs be more interested in a certain market design (service, product, etc.)?

This methodology builds on the results obtained in a previous EU project (i.e. CoordiNet) and the software tools developed therein. These tools are optimization models that quantify the flexibility requirement by a DSO and determine the optimal flexibility activation to address this need based on nodal sensitivity factors. The pre-existing tools allowed solving voltage issues and network congestions separately using reactive and active power respectively. In fact, both tools were developed in different programing languages (GAMS for congestion management and Matlab for voltage control). Moreover, the local market is cleared centrally by a Market Operator (MO) based on a pre-defined flexibility requirement.

Within EUniversal, new modelling capabilities have been developed in order to enable a more efficient use of flexibility and the analysis of additional use cases. More specifically, the following developments have been made: implement the full set of tools within the same environment using Python language, joint use of active and reactive power, calculation of sensitivity factors for congestions based on a coupled AC power flow (DC power transfer distribution factors were used in previous implementations), comparison of market-clearing by a MO vs. DSO determined flexibility activations (involving different grid-modelling approaches), and solving congestions and voltage problems jointly.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

Given that local flexibility markets are at an early development and implementation stage, there are many open research questions related to their design and implementation (e.g. flexibility product definition, clearing methods, DSO need determination, etc.). The improved SRA methodology and associated modelling tools aim to provide data-driven information on some of these open issues such as when and where flexibility is most useful or what the required conditions for it to be useful are.

These results can also be useful for policy makers and regulators to better understand the value of flexibility for policy and regulatory design as well as to evaluate investment plans integrating flexibility submitted by DSOs.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Evaluation of the value of flexibility under different grid conditions or the most suitable flexibility product to solve an existing need	The methodology can be used to shed light on some open questions posed by DSOs and run many sensitivities at a low cost.	DSO
Testing of alternative market formulations (grid modelling, objective functions) for local market algorithm design	The methodology can be applied to analyze the impact of alternative market models, evaluating how this can affect flexibility procurement costs or computational requirements under different scenarios	Market operators, platform developers
Deeper knowledge on the value of their flexibility potential for grid operators in different areas or under different flexibility market designs	The modelling tools can be used to assess the value of flexibility in different grids and locations, which can be useful to FSPs to identify areas or specific markets or services with high value for flexibility.	Flexibility providers
Become knowledgeable on the latest developments on a hot topic for distribution systems and regulators such as local flexibility markets	The lessons learnt can be used to integrate in the curricula of postgraduate courses, to be used in master theses for additional analyses, or as a starting point for new PhD theses	Postgraduate and PhD students from engineering degrees

Unique selling point	What is the unique selling point of key result / tool / innovation?
The ability to combine modelling, regulatory and power systems expertise into a single methodology to evaluate the performance of use cases on local flexibility markets under different scales and contexts. The new developments include a result analysis and visualization module which supports the interpretation of results and decision-making based on them.	
Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …
• More efficient development of distribution grids and integration of DER thanks to the proper design of flexibility markets (after the project) • Postgraduate students with a deeper knowledge on local flexibility markets coming out of the university to work for the energy sector • Lower network costs and/or more efficient grid connection. • Availability of new knowledge on local market design for key stakeholders. • Availability of new data-driven conclusions supporting possible regulatory developments about the use of flexibility in distribution grids	
What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? …	• Ability to combine expertise from modelling, regulation, and power systems • Integrated model combining several local flexibility services and products • Flexible modelling environment allows for customization of analysis to the desired market design/scenarios • Strong postgraduate and PhD program on power systems
<u>Weaknesses</u> What could you improve?	• Software tools not developed as a commercial package, so it requires the direct involvement of the developers.

Where do you have fewer resources than others? What are others likely to see as weaknesses? …	• The need to use complex tools and mathematical optimization may hamper the interpretability of the results by some potential customers
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• Local flexibility markets are being pushed by EU legislation for a more efficient grid development. • National regulators and DSOs are exploring alternatives for complying with the EU Directive mandate. • Sector stakeholders are demanding work force with specialized knowledge
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Being this a hot topic for research and consultancy, there is much competition for providing the services.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	**Example answers**	**Answer**
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	Project-based exploitation: DSOs, market operators, platform developers, flexibility providers, regulators/policy-makers (potentially) Teaching: postgraduate and PhD students from engineering degrees
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	EU-wide distribution sector stakeholders mostly. Possible to address stakeholders in USA through collaboration with partner institutions due to the growing interest in the so-called non-wire alternatives. For teaching purposes, mostly Spanish students at master's level, worldwide for PhD studies.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a	No example, please answer from your own experience	Research organisations in Europe with an expertise on the use of flexibility at distribution level. Platform developers and specialized software companies with in-house experts. Some consultancy firms with a specific focus on energy. The main issue here is how to combine expertise in

product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).		regulatory topics with expertise on distribution grids planning and operation, as well as the required modelling know-how.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 7-8, the methodology has been tested in the demonstration project with real grids and realistic data, but adjustments and new developments may be required for the specific needs of a potential customer.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	It is unclear whether the market for such analyses exists yet, but the interest in these topics is definitely growing and we believe there is potential for a short/medium term growth. Regarding the inclusion of this knowledge in teaching activities, the market is there as both master and PhD students show interest in these topics.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Consultancy type services based on the use of the methodology, and inclusion of key lessons learnt and case studies in teaching materials.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Economic value - TOTEX optimisation by optimising planning and operation - Grid investment deferral Flexibility

		- Benefits from flexibility services provision by improved knowledge on where/when each type of flexibility is more valuable to the DSO Network and knowledge value: - Reinforce our postgraduate and doctorate programs, including possible new PhD lines - Ensure that the new knowledge created leads to proper policy, management, operational decisions
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Assets: - Guideline - Recommendation - Knowledge and skills - Algorithms - Educational concepts and materials Channels - Publication of high - impact, peer reviewed journal articles… - Conferences - Further expansion of education portfolio for energy. - New consultancy services to the energy sector
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Future revenue streams - Future EU projects Selling of a product - Purchasing trainings / services- - Public tenders - Consultancy fees

Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 1 year after the project (the Task finishes right at the end of the project; exploitation should be ready right after it finishes)
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Knowledge exploitation - Increase internal knowledge on local flexibility markets analysis - Enlarge capabilities to offer to potential customers - Improve scientific publication track record Societal exploitation and networking - Influence the future direction of flexibility markets and products - Participate in stakeholder boards and comment on flexibility projects - Promote educational activities in the realm of local flexibility
	See Table 7 for the partners	Comillas as developer of the methodology and tools Vlerick as WP leader and task contributor.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Methodologies, algorithms and in-house software modelling tools, regulatory knowledge, and scientific publications in relation to local flexibility markets, DER integration and distribution grid planning/operation.
Foreground IPR What have you developed in the project related to this specific KER?		New studies and recommendations to be included in public deliverables and scientific publications (observing data confidentiality), modelling toolbox for local flexibility market assessment. No IPR protection is envisioned for these results.
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	NA

Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	NA
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	The joint exploitation could be tied to forming consortiums in new consultancy projects. Vlerick and Comillas will disseminate the results in presentations, research output and conferences.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	We are looking at multiple follow-up steps to exploit the methodology: - We will apply the methodology in other EU projects (already doing so in One-Net) to test the robustness and identify required adaptations for the assessment of other distribution grids and flexibility services - We will use the methodology and results obtained to use for teaching purposes in specialized master courses
Further actions (development) What further actions will you take to further develop this KER?	See table 10	We are looking at multiple follow-up steps to enhance the methodology: - We will work on improving the market clearing algorithms, modelling of market sequences, and output visualization modules. - We aim to raise additional funding from public and private sources to enhance the methodology and check the additional questions it can address - We may develop new master and PhD theses to enhance internal knowledge - We will explore the possibility to integrate local flexibility market modelling with the modelling of TSO-DSO coordination schemes

KER 11 Improved methodology for dynamic grid tariff design

Title KER	Improved methodology for dynamic grid tariff design
WP	**5**
Project tasks	**5.2**
Key Partner	VITO
Other partners involved (collaboration)	KULeuven, Nodes, EDPD, Mitnetz, Energa
Authors of / contributors to this document	Annelies Delnooz (VITO)

What is the KER doing? What value does it provide to which stakeholder?

Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

A comprehensive methodology for the design of (dynamic) grid tariffs able to mitigate both short-term and long-term congestions. The methodology includes a qualitative and quantitative part.
The **qualitative analysis** incorporates the conceptual framework of establishing grid tariff designs which includes the different design dimensions, provides a review of dynamic tariff design methodologies and best practices and studies the congestion needs that have to be addressed. The result of the qualitative part is the definition and selection of alternative grid tariff designs which can address the congestion issues under investigation.
During the **quantitative analysis**, a simulation environment is used consisting of different sub-models: a *system model* which represents the electricity system in a clustered fashion, a *network model* which represents the distribution network, the *tariff model* which defines the selected tariffs, the *flexibility model* which represents the (residential) demand on the level of individual consumers. This simulation environment is used to assess the impact of the different tariff designs identified in the qualitative assessment on end-consumers on the one hand and on the overall power system on the other hand, assessing the effects of the introduced tariffs on alleviating network congestions and voltage issues.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

Assessment methodology to define and evaluate dynamic grid tariff designs to accommodate grid congestion. Higher flexibility needs require the need to give triggers to FSPs to offer flexibility at the right place and at the right time when the DSOs needs it. To achieve this, well adapted grid tariffs are needed. This methodology helps DSOs, TSO, regulators… to set up appropriate tariffs in an environment with many unknown and uncertain factors.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Advise on tariffs and prices	The methodology can assist several actors to define, evaluate and set tariffs and prices.	DSOs, TSOs, suppliers, regulators

	The methodology can be applied to grid tariff design, including distribution and/or transmission grid tariffs, but also to (dynamic) commodity pricing and a combination thereof.	
Input into EU and regional policy discussions	The methodology can be used to provide recommendations for regulatory arrangements and needed adaptations related to tariff design and electricity pricing.	EU / regional policy makers, regulators
Guiding methodology to design an incentive for adaptive behavior of the consumer	Ability to benefit from providing flexibility in response to an indirect flexibility signal and help to relax grid congestion	DSO, TSO, FSP, residential consumer
Methodology to access LV flexibility for management of LV grid constraints	Use of available flexibility provided by assets in the LV grid to accommodate for LV grid constraints	DSO, FSP
Methodology to access LV flexibility to manage need for redispatch	Use of available flexibility provided by assets in the LV grid to accommodate for a redispatch need	TSO, FSP

Unique selling point	What is the unique selling point of key result / tool / innovation?

Comprehensive methodology which can be used to define and evaluate the impact of alternative design of several electricity pricing components on the consumer, society and the electricity grid. By using the methodology developed, DSOs and TSOs are enabled to design dynamic grid tariffs which are capable of providing an implicit flexibility signal to the residential consumer to adapt its behaviour in function of the grid state. Hence, by applying the methodology, implicit tariff signals could lead to reduced grid operation costs.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …

- Increased transparency: The use of this methodology to design dynamic grid tariffs leads to a greater transparency in the tariff design process and the criteria used to set tariffs are clear and objective.
- Improved efficiency: The use of a methodology to design dynamic grid tariffs could lead to more efficient use of the electrical grid, as consumers are incentivized to shift their energy consumption to times when it is most desired from a grid point of view.
- Reduced grid congestion: By using the methodology, implicit tariff signals can be designed to incentivize customers to shift their energy consumption away from peak demand periods. Dynamic grid tariffs could reduce grid congestion and help to avoid the need for expensive grid upgrades, leading to economic (and societal) benefits.

- Improved demand response: The methodology for designing dynamic grid tariffs could assist in encouraging demand response programs, and could provide the necessary (additional) trigger for consumers to step into a demand response program.
- Improved effectivity: The methodology ensures that grid tariffs can be designed in such a manner that envisioned targets and objectives can be obtained.
- Collaboration between stakeholders: The design of dynamic grid tariffs may require collaboration between stakeholders from different sectors, including utilities, regulators, and consumer groups. The methodology used to design the tariffs provides an objective framework to facilitate this collaboration and ensure that all stakeholders are represented in the redesign process.
- Stimulating innovation: The development of the methodology for designing dynamic grid tariffs could stimulate innovation in the energy sector, as companies and researchers seek to develop new approaches and technologies to support the implementation of the tariffs.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	• Comprehensive methodology • Modular approach; sub-models and scenarios/assumptions can be adapted depending on the case study • Methodology makes it possible to design grid tariffs from the view point of multiple objectives (and also incorporating the viewpoint of multiple stakeholders). • Making the link between grid state and billing of consumers
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	• Assumptions on price elasticity / consumer model could be further improved • Scenario definition / data assembly is case specific and can be cumbersome • Calculation time of the quantitative model can be extensive depending on the scenario
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• Distribution and transmission grid tariffs and electricity pricing across EU will need to be reformed the coming years following EU and national regulation • In combination with other tools, the methodology can be used to evaluate the flexibility potential of different alternative implicit and explicit flexibility mechanisms
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Difficulty in estimating future trends and political impacts which impact the result of the analysis • Very distinct country-specific contexts can hamper the application of the methodology to certain EU countries.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs, TSOs and regulators
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	European DSOs, TSOs and regulators
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Research organisations in Europe with an expertise on tariff design. Regulators (and to some extend DSOs and TSOs) with in-house experts of tariff design. There is a certain level of competition but in most cases this is a case-by-case assessment of tariff design, applied to a certain EU country. Also, the topic of dynamic tariff design is rather new and certainly the quantitative assessment of these designs require

		advanced modelling. This modelling knowledge is in most cases not present in combination of the quantitative knowledge on tariff design.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 7-8, the methodology has been tested in demo-phase, in a relevant environment. First commercialization steps have been made but methodology can benefit from improvements.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	The methodology provides a tool for an existing market need and can assist DSOs and regulators in the design of appropriate grid tariffs. The innovation of incorporating the grid state and the reflection in dynamic grid tariffs is still new. We see a growing interest in this aspect and hence forecast an increased interest in the innovation.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Consulting and knowledge service; by applying the methodology we are able to assist stakeholders in the design of dynamic grid tariffs, from the point of view of different objectives.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Economic value: - TOTEX optimisation by optimising planning and operation - Grid investment deferral Policy value:

		- Ensure that the new knowledge created leads to proper policy, management, operational… decisions Societal value: Reduction of Mattheus effects and guarantee fair and transparent billing of grid costs
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	**Assets**: - Guidelines - Policy brief - Recommendation - Knowledge and skills - Methodologies **Channels** - Digital Marketing channels (website, social media…) - Publication of high-impact, peer reviewed journal articles… - Conferences - Organisation/chairing of panel sessions in conferences and international events. - New consultancy services to the energy sector
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	**Future revenue streams** - Future EU projects - Exclusivity contracts **Selling of a service** - Consulting - Public tenders - Consultancy fees

Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	During project lifetime
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	**Knowledge exploitation** - Increase internal knowledge on dynamic grid tariff design **Societal exploitation and networking** - Promote innovative policy recommendations in the direction of dynamic grid tariff design - Influence the future direction of implicit flexibility - Participate in stakeholder boards and comment on regulatory projects - Foster synergies with different initiatives
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	VITO as developer of the KER. Support in the task of: KULeuven, Nodes, EDPD, Mitnetz, Energa
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Know how on energy market and smart grid solutions.
Foreground IPR What have you developed in the project related to this specific KER?		Increased know-how on implicit mechanisms (i.e. dynamic grid tariff designs) for flexibility needs and grid services.

IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	NA
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	NA
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	We are looking at multiple follow-up steps to enhance the methodology: - We will work further on the methodology to ensure the applicability to other EU-countries and contexts - We will run further pilots, demonstrations, testing activities to test the resulting dynamic tariff designs in practice and learn more about the practical implementations (e.g. price elasticities).
Further actions (development) What further actions will you take to further develop this KER?	See table 10	We are looking at multiple follow-up steps to enhance the methodology: - We will raise funding from (public and commercial) sources to enhance the methodology and improve the quantitative and qualitative assessment. This will also ensure that changing context (and underlying assumptions) are adapted - We started a PhD to further develop our internal knowledge on the topic and methodology

KER 12 System-level assessment framework for flexibility quantification

Title KER	System-level assessment framework for flexibility quantification
WP	**3**
Project tasks	T3.3
Key Partner	ENGIE Impact
Other partners involved (collaboration)	INESC
Authors of / contributors to this document	Christian Merckx, Gerd Küpper
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

This KER consists of a methodology to assess the available flexibility in a distribution grid, and their impact on operational planning of the electricity network under different conditions. More generally, it contributes to the question on how to design local flexibility markets, in terms of product definition and market delineation.

Based on simulations of a detailed electricity distribution grid, this methodology contributes to this discussion in two ways.

First, it aims at characterizing the issues (mainly congestions and under- or over-voltages): when, how often, how long and where are issues happening. When considering the market introduction this is relevant information to define the products to be traded in Local Flexibility Markets (LFM).

Second, we provide insights about the solutions and the interaction of various assets located at different places in the grid (low and medium voltage in particular). This helps defining the geographical scope of LFM and their performance compared to regulatory solutions.

The proposed methodology consists of a techno-economic optimization framework for the definition of flexibility products. The main characteristics of the product that can be identified are the type, location, capacity and duration of the flexibility.

Different versions of the grid model have been proposed, to consider different situations in the network and different resources, including EV. The results aim to see how load and generation will evolve. The model is a network from Portugal used as a representative network.

Variants of the network have been implemented with different changes in the load and production pattern, in order to have a good representation of a southern or northern country. Different scenarios have been calculated.

The model is an intraday optimization, that identifies congestion or voltage problems according to the nature of the network. It will run on an intraday basis to determine the optimal control that needs to be applied for the following day. The value of the KER is in the methodology to define the flexibility that can solve the congestions identified by an existing optimal power flow analysis. The methodology will identify the kind of problems: eg. congestion and/or voltage problem. The nature of the flexibility available is more important than the value, because it will define the product that is needed.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

DSOs may procure flexibility services, rather than reinforcing the grid, which might be costly and take time. However, the question when and how to organize such Local Flexibility Markets (LFM) is still an open debate.

We are not aware of such preliminary quantification exercise in the initiatives studied. These initiatives were not transparent on the framework used to assess future needs in flexibility, to characterize them and to define an appropriate LFM to procure required services.

This is why we performed optimal power flow simulations, in view of getting quantified and realistic insights on the available flexibility of distributed generation and new loads, and their impact on operational planning of the electricity network under different conditions. In particular, we aimed to quantify the congestion and voltage issues that are expected to appear in a distribution grid characterized by increasing shares of intermittent RES generation and new loads.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Characterizes the issues (mainly congestions and under- or over-voltages): when, how often, how long and where are issues happening	The methodology can be used to define the products to be traded in LFM	DSO, FSP
Quantifies the available flexibility and its impact on operational planning of the electricity network under different conditions	The methodology can be used to assess the value of flexibility in different locations and conditions	DSO, FSP
Contributes to the question on how to design local flexibility markets (LFM), in terms of product definition and market delineation	The methodology can be used to answer some questions posed by DSOs about the definition of LFM	DSO, regulators, EU/regional policy makers

Helps defining the geographical scope of LFM and their performance compared to regulatory solutions	The methodology can be used to answer some questions posed by DSOs about an alternative to a LFM	DSO, regulators, EU/regional policy makers

Unique selling point	What is the unique selling point of key result / tool / innovation?

ENGIE Impact is able to combine modelling, regulatory and power systems expertise into a single methodology to evaluate the performance of use cases on local flexibility markets under different conditions (penetration of RES and EV charging stations). ENGIE Impact also owns the required tool (multi-period optimal power flow on a distribution network).

Some of the use cases that can be applied are:

- networks previously discussed under different scenarios of RES and EV penetration.

- evolution of the network for the next 10+ coming years (2030, period to be considered for establishing the market)

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

- More efficient development of distribution grids and integration of DER thanks to the proper design of flexibility markets or regulation adaptation
- Lower network costs and/or more efficient grid operation
- lower investment cost (CAPEX)
- OPEX : flexibility cost vs internal tools that DSOs use to solve congestion (if they are available). Control means of the DSO (DLR, reconfig...) are usually free of charge, while flexibility will have to be paid.
- CAPEX should decrease, while OPEX might increase, the objective is to decrease the global cost.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well?	• Ability to combine expertise from modelling, regulation, and power systems

What unique resources can you draw on? What do others see as your strengths? …	• Software tool used in the methodology is already a commercial product supporting the required equipment and controls (OPF tool –GridOS, multiperiod OPF –24 hours). • Scenario definition requires high level expertise in power system planning. Same for the optimization tool.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	• The modelling environment is not very flexible as we are using a commercial tool that was developed by a Canadian startup and has been partially acquired by Engie. • Scenario and KPIs used in the methodology need to be validated on different use cases • Different scenarios and different KPIs are used to evaluate network problems and the required flexibility to solve them. So far it has been applied on two networks (Southern and Northern), perhaps the scenarios and KPIs can be enriched taking account different use cases.
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• Local flexibility markets are being pushed by EU legislation for a more efficient grid development • National regulators and DSOs are exploring alternatives for complying with the EU Directive mandate
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• The methodology is public and can be easily implemented if you have a Multi-period Optimal Power Flow and qualified people. There is thus a competition for providing such services.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	Project-based exploitation: DSOs, regulators
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	DSOs in EU mostly.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Consultancy companies with a specific focus on energy. There are not so many of these companies because they need to combine expertise in regulatory topics with expertise on distribution grids planning and operation, as well as the required modelling know-how.

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	The methodology is ready to be implemented for new customers (DSOs or reglators), but the construction of the scenarios and choice of KPIs can still be refined. (TRL 5 or6).
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	The number of DSOs considering the possibility to set up Local Flexibility Markets is growing. We think there is potential for a short/medium term growth.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Consultancy type. By applying the methodology we are able to assist DSOs in deciding whether to establish LFMs and where to locate them.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Policy value - the methodology leads to proper policy, management, operational… decisions (no local flexibility market is not appropriate) Grid benefits - Grid ○ Improving quality of service

		- Flexibility - Increasing capacity to own and operate DERs Economic value - TOTEX optimisation by optimising planning and operation - Grid investment deferral
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Assets - Guideline - Recommendation - Knowledge and skills - Tool: multiperiod OPF Channels - Publication of high - impact, peer reviewed journal articles… - Conferences - New consultancy services to the energy sector
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Future revenue streams - Future EU projects Selling of a product - Consulting - Public tenders
Implementation timeline	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 1 year after the project

When have you implemented this strategy or when will you implement it?		
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Knowledge exploitation - Increase internal knowledge on local flexibility markets analysis - Enlarge capabilities to offer to potential customers - Improve scientific publication track record
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	Support in the task of INESC and IEN
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Know - how in power and energy systems modelling, simulation and optimisation, regulatory knowledge, DER integration and distribution grid planning/operation.
Foreground IPR What have you developed in the project related to this specific KER?		New studies and recommendations to be included in public deliverables and scientific publications (observing data confidentiality).
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	NA
Patents	No examples, please answer from your own experience	NA

Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?		
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	We will apply the methodology in other (EU or not) projects to test its robustness and identify required adaptations for the assessment of other distribution grids and flexibility services.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	We are expecting to: - Improve the definition of the considered scenarios (modelling the RES and EV charging stations penetration in the distribution network, especially the LV part) - Expand our experience to improve the general conclusions we can draw from the simulations done taking into account situations that can be very different from one region to the other, depending on the grid topology, the generation mix, meteorological conditions, etc. - Improve the way we are selecting flexibility sources for activation. We are currently using a predefined order, which is only a suboptimal representation of a "merit order" including opportunity costs of alternative uses of resources. - The different types of flexibility used to solve the network problems are selected following a predefined order representative of their costs. The use of an enhanced optimal power flow with additional capabilities could allow to avoid using such a simplified approach.

KER 13 Improved aggregation algorithms for local flexibility markets

Title KER	Improved aggregation algorithms for local flexibility markets
WP	**WP7, WP8**
Project tasks	Provide flexibility to DSO via flexible market in Germany and Portugal
Key Partner	Centrica, E.ON (Mitnetz), E-REDES, NODES, N-SIDE
Other partners involved (collaboration)	-
Authors of / contributors to this document	Mahtab Kaffash

What is the KER doing? What value does it provide to which stakeholder?

Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

The primary objective of this KER is to design an algorithm to aggregate small volumes of flexibility located in LV and MV grid to provide services for distribution system operators (DSO). This small volume of flexibility is located at end-users' premises. Under the current regulations, there is a minimum value that participants must bid into energy markets. Therefore, small volumes of flexibility cannot participate in the market individually and require aggregation. This aggregated flexibility will be offered to the DSO via a flexible market operator (FMO).

To solve congestion and voltage issues in the DSO network, local flexible assets installed at the end-users' premises can be used. Centrica, as flexible service provider (FSP), will aggregate the available flexibility from different flexible assets, such as battery, electrical water heater, electric vehicle. This aggregation serves not only to mitigate the uncertainty associated with the energy consumption and behavior of individual end-users, but also to meet the minimum flexibility required to participate in the market. Within the scope of the EUniversal project, the aggregated available flexibility will be estimated and subsequently offered to FMO via UMEI API. Depending on the market design and type market, the aggregated flexibility will be chosen either by FMO or DSO afterwards to solve the grid constraint.

The goal here is to gain a better understanding of the DSO market with different types of flexibility. Whereas in the past, only batteries were considered, EUniversal has expanded its focus to include hot water tanks, PV systems, and EVs.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? <u>What</u> is the problem you are solving?

With the current regulations, there is a minimum value required for the participants in energy markets. Therefore, small volumes of flexibility cannot participate in the market without aggregation. This algorithm enables the participation of small flexible assets to participate into DSO market.

Value proposition	What value does the exploitable result provide? <u>How</u> do you solve the previously described need/problem?

	Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Enabling the participation of LV and MV customers	Owners of small volume of flexible assets can offer their flexibility to the DSO via the flexibility market and receive some profits from their participation.	End-users, FSP
Solving the grid issues using the aggregated flexibility	The aggregated flexibility can solve DSO grid constraints such as voltage and congestion issues.	DSO
Being active in DSO market	This aggregated flexibility will be submitted to the FMO as flexibility services for the DSO.	FMO, DSO, FSP

Unique selling point	What is the unique selling point of key result / tool / innovation?

With the increasing numbers of distributed energy resources (DERs) on the consumer side of the main grid, the available flexibility of these DERs can be used to solve the issues of the local grid. This aggregated flexibility can reduce the need for system operator investments in grid expansion, mitigate potential curtailment of renewable energy assets, and even prevent a black-out events. Additionally, this algorithm can empower end-users to maximize their benefit from installing flexible assets and minimize their energy cost.

This algorithm can model different types of flexible assets, calculate their available flexibility at each time step, aggregate it, and offer it to the market while respecting end-users' comfort level.

This algorithm consists of different parts: modeling of assets, optimization (aimed at minimizing customer costs or other objectives) to calculate optimal bidding, the imposition of constraints, (e.g., comfort levels, maximum power injection into the grid), and considerations for data driven methods of controlling the assets. Due to the lack of data, a simpler MPC (model predictive controller) is employed.

One noteworthy feature of this algorithm is its modularity and high adaptability. If there are changes in technology, adjustments would primarily involve updating the asset descriptions, not to the core of the algorithm. Without access to this algorithm and the expertise of a knowledgeable FSP, customers may be unable to meet the minimum requirements and navigate the complexities of the market.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics

	- ...

- Society: Reduce energy cost of end-users, reduce greenhouse gas emission by optimally operating renewable energy sources (RESs)
- Energy system: Avoid unnecessary investment on grid expansion, maximize the use of RESs, avoid/reduce load curtailment.
- EU/National policy: Help to overcome bottlenecks of supply

- Regarding UMEI: it was easy as an FSP, user of the UMEI to connect to two markets at once using the same communication channel.
- The UMEI is not covering prequalification and settlement, it would need to be expanded for real life cases.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	• Allow small scale flexible assets to benefit from participating into the energy markets • Effective use of available resources while considering the end-users' comfort level • Modular and easily adaptable to new technology. A demonstration has previously been tested in Cornwall with limited functionality.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	• Low customer interest – customers were hard to engage, specially during Covid. • Lack of IT infrastructure for remotely reading sub-meter data and remotely control the flexible assets
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• Empowering the deployment of advanced IT infrastructure, such as smart meters. • Encouraging LV and MV customers to go in the direction of clean and green energy systems. • Regulation in the Clean Energy Package is stimulating consumer engagement.

<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Low customer participation • Basic ICT infrastructure in the demo sites • Due to market regulations and DSO preferences, the grid topology cannot be shared with FSP. • Different flexible assets such as heatpumps, PV or EVs need to be compatible with the home energy management system (EMS). Each EMS has its own features, it is not feasible to build tailor made solutions in every case to control the assets.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	- DSO - Consumer: households - Consumer: industries/tertiary sector - Consumer: mobility - Tech provider: storage, P2H - TSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	Worldwide, Centrica algorithms are scaled and can include different types of flexibility and provide services to different markets.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your	No example, please answer from your own experience	• Other aggregators, but currently DSO markets are not widely available so it is hard to tell.

target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).		
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL8,
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Mature and emerging depending on the country, market regulation, available ICT infrastructure at the end-users premises
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	• Provide flexibility to different energy markets via aggregation of small scale of different flexible assets. • Innovation aspects: modeling of flexibility and solving optimization problem. In the past they have sold algorithms to interested parties like the EPEX spot, but at this stage they don't have an intention to sell the software. They aim to provide the aggregation service themselves.
Associated business model	See table 3 for inspiration	• Economic value: Grid investment deferral, Savings behind the meter

How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?		• Grid benefits: peak-shaving, solve congestions, solve voltage issues, help SO to balance the grid • Environment: reduce CO2 emission, maximize the use of RESs. • Intermediation: by managing consumers' flexibility the FSP enables the use of flexibility by the DSO; while the DSO can focus on their core capabilities.
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	• Type of results: Software, Knowledge and skills, Algorithms, Methodologies, Simulation results • Channels: Set up further pilots/demonstrations/testing activities, New services to the energy sector, Internal networks
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	• Reach to TRL9 after the project • Future EU projects • Improve the current platform • Provide aggregation services
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 5 years after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Knowledge exploitation on DSO flexibility markets, Improve the current aggregation algorithm and perform and test it in two demo sites
Involved partner	See Table 7 for the partners	EDPD, N-SIDE , NODES, Mitnetz, end-users

With whom did you develop this product (co-developer)?		UMEI: they all adapted their systems to the UMEI, but they all need to adapt to the market regulation and FMO regulation.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Know-how on solutions related to demand response and local energy markets. No IPR applies.
Foreground IPR What have you developed in the project related to this specific KER?		Increased know-how on addressing needs for market platforms and location-based flexibility aggregation.
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	We have not encountered IPR-related issues during the project.
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	• No patents have been identified that could cause issues.
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	• The UMEI API makes it easier for all the market players to communicate. It is therefore in every partner's interest to exploit the work done and keep using this API for future communications. • Centrica, as a flexibility service provider, will continue to develop improved algorithms for control of residential assets in the context of DSR. The DSOs will continue to

		require solutions to solve congestions and will therefore benefit from more and/or cheaper flexibility bids.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	• We will run further pilots, demonstrations, testing activities. • We also aim to participate in dissemination, (CIRED papers during EUniversal). • Participation in regulatory consultations to the regulation and market design. • Participation in other projects to provide feedback for a standard for residential Demand response interoperability.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	• We will do a more detailed feasibility study / market study • We will run further pilots, demonstrations, testing activities • There are a lot of opportunities for LV customers due to their flexibility, also a lot of issues in the DSO network can also be solved with this flex. If the ICT infrastructure allows, flex could solve local voltage issues. They do believe in the potential of LV flexibility, and they see indications in the UK market which is more advanced. • Base project on standard for interoperability: IDSR

KER 14 Recommendations, business model innovation and policy support

Title KER	Recommendations, business model innovation and policy support
WP	10
Project tasks	Vlerick
Key Partner	Ariana Ramos
Other partners involved (collaboration)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
Authors of / contributors to this document	Ariana Ramos, Vlerick; Adam Ondra, EDSO
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

This KER consists of 1/regulatory recommendations and 2/ Business model innovation and CBA methodologies.

Regulatory recommendations are presented in ' D10.3 Regulatory recommendations for flexibility options and markets.' The deliverable shows how different flexibility mechanisms can be combined and discusses why regulatory sandboxes and market power remedies can be important for the optimal implementation of the mechanisms. Six flexibility tools are defined: flexible access and connection agreements, dynamic network tariffs, local flexibility markets, bilateral contracts, cost-based mechanisms and obligations. The compatibility of the tools is discussed separately for congestion management and voltage control. The main implementation options of dynamic network tariffs, flexible connection agreements and local flexibility markets are discussed and summarized. Finally, regulatory sandboxes are proposed as a solution for regulators to test the impact of different implementation options in practice.

Business models are compared in 'D10.1 business model canvas and comparison of CBA methodologies'. The deliverable analyses first, the business models of the EUniversal demos and examines distribution planning methodologies in Europe. The business models are built using Osterwalder's business model canvas. Second, the deliverable describes the evaluation of distribution planning methodologies in Europe, with a focus on the trade-off between flexibility and network investments.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

This KER fills the need to create knowledge and regulatory recommendations regarding the implementation of flexibility mechanisms in terms of regulation and business models. There are many tools available to implement flexibility, national and European regulation is not harmonized, and the trade-offs between the different options is not straight forward. The results of this KER are targeted towards: 1/regulators, 2/stakeholders (DSOs, Flexibility service providers, market operators,…), 3/students and academics, 4/ public bodies.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Regulatory recommendations on implementation options of different flexibility tools	Tool compatibility, possible sandboxing mechanisms to test regulation, and implementation options are compared and described in the results.	1/regulators, 2/stakeholders (DSOs, Flexibility service providers, market operators,…), 3/students and academics, 4/ public bodies.
Flexibility market business models for different use cases tested in the project are outlined.	The business models describe the main value created by the use cases proposed, the key activities for their implementation, and the main revenue and cost drivers identified.	1/regulators, 2/stakeholders (DSOs, Flexibility service providers, market operators,…), 3/students and academics, 4/ public bodies.
Evaluation of distribution planning methodologies in Europe	Five aspects of distribution network planning were analysed: planning frequency, scenarios and alignment with the TSO, network representation, and inclusion of flexibility as an alternative to investments and transparency.	1/regulators, 2/stakeholders (DSOs, Flexibility service providers, market operators,…), 3/students and academics, 4/ public bodies.

Unique selling point	What is the unique selling point of key result / tool / innovation?

Often regulatory analysis is presented in reports on a country per country basis, making it difficult to evaluate the tradeoffs in different flexibility or planning methodologies.

In the results mentioned above, a series of interviews and workshops with experts led to abstractions of the main building blocks behind the different tools used across Europe. This leads to a summarized bird's eye view of the different tools available.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

Impact	Vlerick	E.DSO
On society	Using flexibility in distribution networks helps mitigate rising network investment costs that are transferred to the public. Concise results allow fruitful discussions with stakeholders for future projects/ follow-up of results.	The objective is to turn Euniversal's research results and innovative approaches into concrete value and impact for society. Given that E.DSO participates in multiple EU Funded projects, the project results will be used in other research activities other than those covered by the action concerned, impacting not only stakeholders that are directly involved in the project themselves but also the scientific community, industrial partners and/or policymakers.
On the energy system	More efficient integration of DER and possibly electric vehicles in distribution networks. Lower network costs and efficient grid connection. On-going education for the workforce on key regulatory topics.	Being an association that is there representing DSOs from across Europe the results developed have the potential of being directly implemented into the energy system of the future. As an association we are also involved in the promotion of upskilling and reskilling of the current energy workforce and the results developed in this project can be used for exactly that.
On EU/ national policy	Regulatory recommendations based on real life experience and expert discussions. The comparison of sandbox methodologies offers tools for regulators to test new regulation.	E.DSO comprises of a policy team which could help bring regulatory recommendations to life by including results developed through Euniversal in various discussions, panels and workshops that would include policy makers at an EU level. With regards to National Policy, given that we have members coming from all over

		Europe, the results developed could also be disseminated directly to the DSOs themselves.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)		
SWOT analysis	Set up a SWOT analysis of your KER	
	Vlerick BS	E.DSO
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? …	Ability to bring together expert opinion to interviews and workshops, and to abstract regulatory frameworks, comparing different tools and market mechanisms.	We bring together various experts from DSOs across Europe which is a strength we can draw on as an association in the project.
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? …	The market is still immature and flexibility services tend to have very local specifications. This can lead to a wide range of options that may not be applicable everywhere.	Due to the differences related to national context it is sometimes difficult to collect and elaborate aggregated information from our members which is then also transposed when it comes to the dissemination of said results.
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	There is wide interest in examining how demand can be more actively managed. Rising shares of DERs, along with dramatic electricity price increases, are changing the landscape of energy consumption. Consumers will be more interested in being active and offering flexibility, and	Our members have a high interest in involving their customers and finding optimal solutions to further develop their services in a more customer centric approach.

	DSOs can take advantage of this interest to implement flexibility markets.	
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	There are several institutes providing regulatory advice and education. At a country level, regulators seek their own local institutes for this kind of knowledge. Changing market conditions mean that the knowledge needs to be updated periodically or it risks becoming obsolete in one or two years' time.	As explained above, due to our members coming from different countries and thus sometimes having differing opinions, it can sometimes be challenging to take a single stance that best represents all their common interests.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs, FSPs, Regulators, consumers
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	European DSOs and stakeholders.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Other research institutes, universtities, and consulting firms.

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL9
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Emerging: there is a lot of talk about implementing flexibility markets in Europe, regulatory implications, and demonstration projects. It is an emerging market because most projects are in a sandbox state at the moment, they are not widely rolled out. Regulation needs to be adapted in most cases to allow scaling.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	The use of the knowledge created to be used in new EU-funded projects advancing the state of the art. Design of teaching activities for master students and executive education. Creation of new workshops and discussions for experts and regulators.
Associated business model	See table 3 for inspiration	Vlerick BS: Courses for Master Students, executive partnerships with interested stakeholders, and workshop events.

How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?		E.DSO: E.DSO we will use our various channels to get results across. The main channels will be our website together with other social media platforms including LinkedIn and Twitter. Given our position, that being an association that gathers 35 DSOs and 2 national associations, the following on our platforms includes multiple stakeholders. Apart from the latter, given our position in Brussels we have the unique opportunity to be directly in constant contact with policy makers, making it easier for our expert members to have much needed discussions.
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	Vlerick: - Our exploitation strategy is first done through dissemination activities: White papers, published papers in peer reviewed journals, - Trainings: Through in-person or online courses/workshops - Research chair partnerships with industry.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	-Revenue collected from students attending graduate programs. - Revenue from research chari partnerships with industry.
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	- Already being implemented.
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Knowledge creation and exploitation: - Increase internal knowledge on local flexibility markets regulation and business models. - Enlarge capabilities to offer to potential customers

		- Improve scientific publication track record Societal exploitation and networking - Influence the future direction of flexibility markets and products - Participate in stakeholder boards and comment on flexibility projects - Promote educational activities in the realm of local flexibility
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	Vlerick Business School as WP and Task Leader, VITO & Comillas as co-authors and content contributors.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	VLERICK brought its know-how with commercially available tools to perform its business model and regulatory analysis.
Foreground IPR What have you developed in the project related to this specific KER?		New studies and recommendations have been included in publicly deliverables, and scientific publication s(observing data confidentiality).
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	No IPR protection is envisioned for these results.
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No

Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	Authors from contributors have been credited in each publication.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Partnering with other research institutes, such as FSR, to continue organizing and contributing to current regulatory debates. Publishing of scientific publications and white papers.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Continued analysis, possible new PhD students to funded through research partnerships. EDSO: promotion of the UMEI among associated DSOs.

KER 15 Day ahead flexibility needs assessment

Title KER	Day ahead flexibility needs assessment
WP	WP 4
Project tasks	4.1 - Coordinated control of flexibility resources and services mobilisation for LV, MV and HV distribution networks and TSO cooperation.
Key Partner	INESC TEC
Other partners involved (collaboration)	E-REDES and ENGIE
Authors of / contributors to this document	Fábio Séster Retorta, Clara Sofia Gouveia
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
MV_FST is a computational tool designed to address and provide the flexibility within medium voltage (MV) electric grids when grid issues are anticipated. The tool utilizes two distinct methodologies to compute flexibility: a) Grid segmentation procedure: This approach involves identifying zones within the grid based on sensitivity coefficients. These zones offer flexibility to effectively resolve foreseen grid issues like congestion management and voltage control. b) Optimization of flexibility bids: This method focuses on optimizing flexibility bids through a cost minimization process. By considering sensitivity coefficients, the tool selects the most suitable flexibility bids, considering the grid constraints, to address congestion and voltage challenges. The combination of these two methodologies allows MV_FST to accurately compute and offer the required flexibility in MV electric grids.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
Distribution system operators (DSOs) require computational tools to effectively manage their grids in an economically and operationally efficient manner. The MV_FST tool has been developed with methodologies that align with the current needs of DSOs. Methodology a) introduces a new perspective for DSOs to address foreseen grid issues, such as congestion and voltage control. It enables the activation of a group of resources within a specific zone or a combination of resources across multiple zones, providing enhanced flexibility. Additionally, methodology b) offers a novel optimization approach by leveraging sensitivity coefficients to select appropriate flexibility bids in response to forecasted issues (e.g. congestion and voltage control). Unlike the non-linear optimum power flow problem, this approach presents the advantage of handling a linear problem, streamlining the solution process. By employing these methodologies, the MV_FST tool empowers DSOs to tackle grid challenges proactively, enhancing grid management capabilities and promoting economic efficiency in their operations.	

Value proposition	What value does the exploitable result provide? <u>How</u> do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Enables the quantification of flexibility needs in MV networks through zones	Methodology a) involves segmenting the MV grid into distinct zones to compute the active power flexibility required for addressing forecasted voltage and/or current issues. This segmentation methodology enables the DSO to publish flexibility needs specific to each zone. Consequently, aggregators can optimize their resources portfolios within each grid zone to offer the required flexibility.	DSOs/ Aggregators
Enables the quantification of flexibility needs in MV networks through combination of zones.	Similar to the description provided earlier, methodology a) also offers the required flexibility to address grid issues by combining zones. In this scenario, the outcome is the flexibility that can be activated by considering tuples of grid zones to resolve grid constraints. This approach allows for a more comprehensive and efficient solution of grid constraints by leveraging the flexibility offered by multiple zones simultaneously.	DSOs/ Aggregators
Computationally efficient for running in close to real-time	Methodology b) employs an optimization approach to enhance the flexibility bidding process by utilizing a linear model that considers sensitivity coefficients. With this methodology, DSOs have an alternative to the traditional method of computing an OPF for selecting flexibility bids. This linear model offers a more practical solution for DSOs, eliminating the need to perform complex and time-consuming OPF computations.	DSOs/Aggregators/Commercial market parties

Unique selling point	What is the unique selling point of key result / tool / innovation?

Methodology a) segments the MV electric grid into distinct zones, enabling precise identification and communication of flexibility needs for each zone. This methodology ensures effective resolution of foreseen voltage and/or current issue on a zone-by-zone basis by computing the required flexibility of the grid buses.

Methodology a) identifies the optimal combination of grid zones that collectively provide the necessary flexibility to overcome grid limitations. By considering tuples of grid zones, the methodology ensures a holistic and coordinated approach to addressing grid challenges.

In methodology b) DSOs can leverage this feature to optimize their flexibility needs, selecting bids that align with grid requirements and constraints. The utilization of this feature improves grid management and operational decision-making for DSOs.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

By implementing this tool various benefits on the energy system can be realized, such as:

- Enhanced grid efficiency: the availability of flexible resources allows for better management and optimization of distribution grids;
- Increased renewable energy penetration: it enables the integration of DER, such as solar panels, wind turbines and energy storage systems, in a way that ensures optimal grid performance and stability;
- Demand response: allowing consumers to actively participate in grid management. Through incentivized mechanisms, consumers can adjust their electricity consumption patterns, contributing to load balancing and grid stability during peak demand periods;
- Economic efficiency: properly designed flexibility solutions (markets) promote competition among stakeholders. The efficient allocation of flexible resources based on market-driven mechanisms leads to economic benefits for both grid operators and DER providers;

Flexibility solutions have significant impacts at both the EU and national policy levels. These impacts include:

- Integration of renewable energy: flexibility solutions enable the efficient integration of renewable energy sources into the grid as well as support the achievement of EU and national renewable energy targets;
- Policy Alignment and Harmonization: flexibility solutions support the alignment and harmonization of energy policies across EU member states. They provide a framework for cross- border cooperation, allowing for the efficient exchange of flexibility services and resources;
- Grid modernization: flexibility solutions drive grid modernization efforts by facilitating the deployment of smart grid technologies, advanced metering infrastructure, and digitalization. They enable the optimization of grid operations, asset management, and distribution system planning and operation;

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	• Methodology a) provides a systematic grid segmentation procedure based on sensitivity coefficients; • Methodology b) introduces an optimization model considering sensitivity coefficients for flexibility bids; • Both methodologies offer solutions for addressing forecasted grid issues in a day-ahead and intraday timeline; • Methodology a) enables flexibility activation in specific zones, effectively resolving grid problems; • Methodology b) simplifies the selection of flexibility bids through a linear optimization model;
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	• Methodologies a) and b) require careful computational and calibration of sensitivity coefficients; • The effectiveness of the methodologies depends on the accuracy of the underlying grid model and sensitivity coefficients computation; • Methodology a) is computationally intensive for real MV grid scenarios (hundreds or more buses/lines); • Methodology b) is computationally intensive for numerous bids (hundreds or more);
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• The methodologies can be adapted and customized to fit different grid environments and operational contexts; • Further research and development can refine both methodologies, improving their accuracy and effectiveness; • The adoption of the methodologies improves the utilization of grid assets, delaying the need for grid reinforcements;
Threats What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Potential challenges may arise when integrating the methodologies into existing grid management systems; • The success of the methodologies depends on stakeholder acceptance and collaboration; • Competing methodologies or alternative approaches may emerge, requiring continuous improvement and innovation;

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSO, Aggregators
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All EU DSOs
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several	No example, please answer from your own experience	The authors believe that the proposed grid segmentation procedure is innovative. Additionally, for the optimization of flexibility bids, several companies have developed commercial software solutions to facilitate flexibility markets, such as NODES and Piclo.

major players with strong competencies, infrastructure and offerings).		
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	At the moment the computational tool is TRL 4. The computational tool will undergo validation within the Portuguese demonstration, with the aim of achieving a TRL 7.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Methodology a) not existing yet, but there is a lot of potential. Similar solutions to methodology b) are emerging in various projects. These solutions are being tested in R&D projects (e.g. IREMEL) and are also commercially available (e.g. Nodes and Pico Flex).
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	The exploitation strategy for methodologies a) and b) should focus on fostering collaboration, demonstrating benefits, and disseminating the findings to ensure wider adoption and maximize their impact in the energy sector. With that in mind the following statements are described. Methodology a) • Collaborate with DSOs to implement and validate the grid segmentation approach based on sensitivity coefficients; • Showcase the benefits of the methodology through pilot projects; • Continuously refine and improve the methodology based on feedback and lessons learned from practical implementations;

		Methodology b) • Collaborate with DSOs and flexibility market operators to integrate the optimization model for flexibility bids into existing flexibility market frameworks; • Engage with stakeholders, including aggregators and market participants, to communicate the advantages and value proposition of the methodology; • Establish partnerships with relevant industry players to explore commercialization opportunities and scale adoption of the methodology;
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Methodology a) Consulting and services model: offer consulting services to DSOs for implementing and utilizing the grid segmentation approach based on sensitivity coefficients. Provide expertise in data analysis, sensitivity coefficient calibration, and grid segmentation techniques; Methodology b) Software as a service: Develop and offer a software platform that incorporates the optimization model for flexibility bids.
Exploitation assets and/or channels Describe how the results can be concretely exploited, via which channels/assets	See table 4 for inspiration	The developed computational tool can be jointly explored by INESC TEC and a consortium partner specializing in Distribution Management System, among other areas of expertise. By working together, they can explore the tool's functionalities, assess its applicability, and collectively contribute to its further development and optimization. Through this partnership, both parties can benefit from shared insights, expertise and resources, fostering innovation and advancement in the fields of Distribution Management System and related areas.

Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Methodology a) Generate revenue through project-based consulting engagements and log-term service contracts with DSOs; Methodology b) Generate revenue through recurring subscription fees based on the usage and scale of the software platform;
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Both methodologies within 3 years after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	• Knowledge exploitation: leverage the developed methodologies to extract valuable insights and generate new knowledge in the field of flexibility tools and markets; • Societal exploitation and networking: Influence the evolution of flexibility markets by introducing the methodologies, potentially leading to the emergence of novel market models that incorporate methodology a);
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	• INESC TEC sole development: INESC TEC independently developed both methodologies a) and b); • E-REDES collaboration: collaborate with E-REDES to test the methodologies using real world data for demonstration purposes
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You	In-house developed methodologies, algorithms, and modeling tools cater to DSO requirements

Foreground IPR What have you developed in the project related to this specific KER?	can also find inspiration from other partners' strategies.	• Customize the existing tool-suite to align with the specific requirements of the Portuguese demo setting • Integrate the tools seamlessly into the demo environment for optimal functionality and performance
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	None
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	None
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	NA
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	• Enhance the tool's TRL level by conducting testing in diverse environments, thereby improving the robustness of the results.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	• The tool will undergo additional testing in EU and/or other projects; • Collaboration with a DSO offers an opportunity for co-development of the tool; • Encourage the involvement of academic students to contribute to ongoing research and further enhance the methodologies. This collaboration fosters knowledge exchange, promotes innovation and ensures the continuous improvement and evolution of the methodologies;

KER 16 MV and LV coordinated control

Title KER	MV and LV coordinated control
WP	**4**
Project tasks	Task 4.1 and WP7
Key Partner	INESC TEC
Other partners involved (collaboration)	ENGIE Impact, E-REDES
Authors of / contributors to this document	Clara Gouveia, Gil Sampaio, Christian Merckx

What is the KER doing? What value does it provide to which stakeholder?

Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results

The MV and LV coordinated control methodology enables DSO procurement of day-ahead market-based flexibility services for congestion management and voltage control.

An iterative procedure is adopted for enabling LV flexible resources to help solving technical constraints in the MV network, while ensuring that no further technical problems result from flexibility provision. It involves the coordination of different tools developed within the project that forecast the network status and expected l MV and LV network constraints (voltage violations and congestions), estimates the flexibility needs in both MV and LV networks and defines the optimal selection of bids if necessary.

Besides ensuring the safe mobilization of aggregated LV resources for MV operation support, it also considers that MV network optimization would also solve some of the restrictions detected in LV networks. It also enables the selection of flexibility bids also considering the impact of flexibility mobilization in both LV and MV network.

This framework is compatible with different market designs, both continuous or auction based, with day-ahead and/or intraday activity.

Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?

The large scale integration of DER at the LV networks, reinforces the need for promoting coordinated control between LV and MV networks, to ensure effective voltage and congestion management. Also, given that local flexibility markets are at an early development and implementation stage, there are many open questions related to their design and implementation (e.g. flexibility product definition, clearing methods, DSO need determination, etc.). Being compatible with different market designs, the proposed coordination methodology allows for evaluating the different approaches and their associated modelling tools.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation.

	Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Promotes coordinated control between MV and LV networks	The methodology proposed ensures effective coordinated operation between MVand LV networks. Today LV network monitoring and control is quite limited and coordination with MV network limited to fault location	DSO
Define operating envelopes at the MV/LV substation	Tools integrated in this framework allow defining the LV flexibility mobilization limits that can securely participate in MV operation	DSO
Better market & grid integration	Solve grid problems (congestion or voltage violation) by means less costly than grid reinforcement or equipment improvement. Promotes more liquidity for the local markets through the integration of LV resources in	DSO
Unlocking local flexibility (demand side flexibility) potential	Local flexibility providers can more easily value their flexibility in the distribution system.	Flexibility providers

Unique selling point	What is the unique selling point of key result / tool / innovation?

It is a management framework enabling DSO procurement of day-ahead and/or intraday market-based flexibility services for congestion management and voltage control for both MV and LV networks. To date, ADMS applications are mainly focused in MV and HV networks. LV network applications are mainly focused in Outage Management and fault location. This framework effectively coordinates different tools designed specifically for LV networks and MV networks.

It is compatible with different market designs. The framework has been tested and adapted to the NODES and N-side market designs. From the N-side design, where the clearing is done on the platform, privacy is maintained while network limits are communicated and maintained. From NODES the bid selection is done from the DSO side with full network knowledge.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

By implementing this tool various benefits on the energy system can be realized, such as:

- Enhanced grid efficiency: the availability of flexible resources allows for better management and optimization of distribution grids;
- Increased renewable energy penetration: it enables the integration of DER, such as solar panels, wind turbines and energy storage systems, in a way that ensures optimal grid performance and stability;
- Demand response: allowing consumers to actively participate in grid management. Through incentivized mechanisms, consumers can adjust their electricity consumption patterns, contributing to load balancing and grid stability during peak demand periods;
- Economic efficiency: properly designed flexibility solutions (markets) promote competition among stakeholders. The efficient allocation of flexible resources based on market-driven mechanisms leads to economic benefits for both grid operators and DER providers;

Flexibility solutions have significant impacts at both the EU and national policy levels. These impacts include:

- Integration of renewable energy: flexibility solutions enable the efficient integration of renewable energy sources into the grid as well as support the achievement of EU and national renewable energy targets;
- Policy Alignment and Harmonization: flexibility solutions support the alignment and harmonization of energy policies across EU member states. They provide a framework for cross-border cooperation, allowing for the efficient exchange of flexibility services and resources;

Grid modernization: flexibility solutions drive grid modernization efforts by facilitating the deployment of smart grid technologies, advanced metering infrastructure, and digitalization. They enable the optimization of grid operations, asset management, and distribution system planning and operation;

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	Promote coordinated control algorithm without requiring joint modelling of MV and LV networks, which would result in high computational burden and implementation dificulty. Other MV and LV tools could be adopted to implement the MV-LV coordination algorithm, as long as they are able to provide the inputs and outputs for each step of the algorithm. Ability to combine expertise from modelling, market design, and power systems.

	The need to use complex tools, mathematical optimization and data-driven technics may hamper the interpretability of the results by some potential customers.
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses?	Further testing is required to evaluate the accuracy and replicabiity of data driven tools and linearized models from LV and MV tools. The iterative algorithm could be further studied and compared to full optimization, considering it may represent a more conservative approach. Software tools developed by different partners, so it requires the involvement of several companies.
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	Local flexibility markets are being pushed by EU legislation for a more efficient grid development. National regulators and DSOs are exploring alternatives for complying with the EU Directive mandate.
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Potential challenges may arise when integrating the methodologies into existing grid management systems; • The success of the methodologies depends on stakeholder acceptance and collaboration; • Competing methodologies or alternative approaches may emerge, requiring continuous improvement and innovation • Being an emerging field of application, competition is growing, with some ADMS providers now proposing solutions for the LV network operation.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSO
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All European DSOs
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	ADMS providers

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	The software tool will be validated within the Portuguese demo, reaching a TRL 7.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Emerging market as the monitoring and control of LV networks becomes increasingly important to ensure a safe integration of DER
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Can be exploited as a software module, incorporating different tools that can be integrated by the DSO or by an ADMS provider. The main innovation is to provide integrated operation between MV and LV networks. INESTEC is licensing certain software tools to an associated SME who offers DMS services for LV networks.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	This tool helps DSO to improve MV coordinated monitoring and operation, as well as decision making, considering new features (local flexibility markets). Is also related to the provision of short-term flexibility services for congestion and voltage management
Exploitation assets and/or channels	See table 4 for inspiration	Software

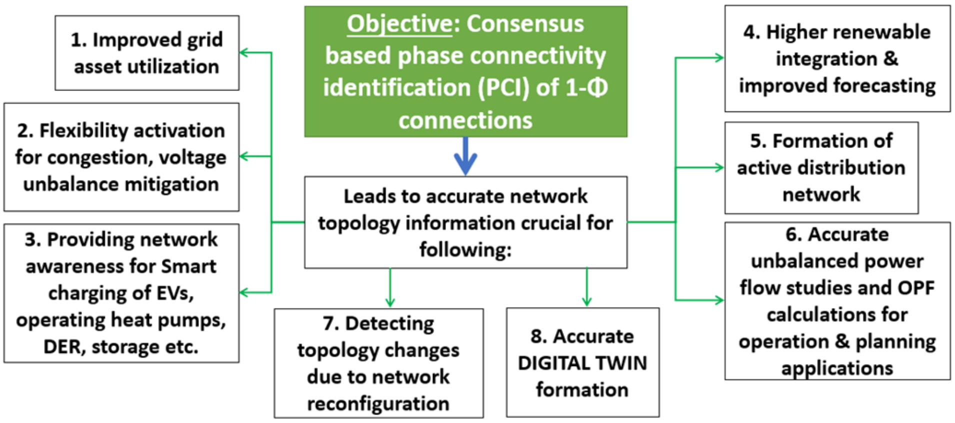
Describe how the results can be concretely exploited, via which channels/assets		Potential new projects for testing and integration of tool in existing platform. Probable options are SaaS (system as a service-), technology transfer, or licensing to a third party
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not determined yet, probable option is: • SaaS • Licensing of software tools and algorithms . Direct Sale of tool as a product
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 2-3 year after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Improving existing algorithms through the testing with real network data. Knowledge transfer to industry. Solving a real industry problem with advanced algorithms.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	n.a.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Related with the tools incorporated in the framework (namely DdVC and DdSE for LV state estimation)
Foreground IPR		The coordination algorithm and the individual tools that are included

What have you developed in the project related to this specific KER?		
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	Internal invention disclosure form that allows IP department to evaluate potential protection strategies.
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No patents known
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	n.a.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Not identified so far
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Further development and testing of tool, ensuring the replicability and scalability of the methodology developed.

KER 17 LV Phase and Topology Mapping tool

<table>
<tr><td>Title KER</td><td>LV Phase and Topology Mapping tool</td></tr>
<tr><td>WP</td><td>WP04</td></tr>
<tr><td>Project tasks</td><td>Task 4.2 -</td></tr>
<tr><td>Key Partner</td><td>INESC TEC , KUL</td></tr>
<tr><td>Other partners involved (collaboration)</td><td></td></tr>
<tr><td>Authors of / contributors to this document</td><td>Clara Gouveia, Jean Sumaili, Jorge Pereira, Conceição Rocha
Md Umar Hashmi</td></tr>
<tr><td colspan="2">What is the KER doing? What value does it provide to which stakeholder?</td></tr>
<tr><td>Description of the exploitable result(s)</td><td>A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results</td></tr>
<tr><td colspan="2">The LV phase and topology mapping tool performs the phase identification of the LV consumers and estimates the topology and electrical characteristics of the LV distribution networks, avoiding the need for human intervention to characterize the LV network.
Two different algorithms were also developed by INESC TEC and KUL considering different data availability scenarios. INESC TEC considers that the majority of the LV consumers are equipped with smart meters, while KUL considers lower levels of observability in the distribution network. The later tool is developed in the context of the German demonstration where the smart meter penetration is less than 5%.
The tool consists of two main functions that can be called separately, namely:
Phase mapping tool, that can identify the most probable consumers phase of connection.
LV topology and electric characteristics estimation, it is able to estimate the phase connection, determines the network branches (bus from and bus to) and its electrical parameters (resistance and reactance).</td></tr>
<tr><td>Needs</td><td>To which need is this KER responding? Which research/market gaps is this KER filling in? <u>What</u> is the problem you are solving?</td></tr>
<tr><td colspan="2">The low monitoring capability of LV networks and poor characterization of feeders' topology and electric characteristics doesn't allow the DSO to identify technical problems in LV networks and quantify flexibility needs. This doesn't allow for the adoption of conventional power flow tools requiring full model of the network. Typically, LV network characterization is conducted on-site by field crew, implying high investment. This tool potentially reduces the investment need, providing a first characterization proposal of the network.

The phase connectivity information would lead to following potential impacts:</td></tr>
</table>



Essentially, the topology information is improved with accurate phase connectivity information estimated by our proposed tool.

Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Enables the identification of phases and characterization of network topology and electrical characteristics without intervention in the field.	Provides the most probable phase of connection for LV consumers.	DSOs
	Provides an estimate of electrical characteristics of LV cables	DSOs

Unique selling point	What is the unique selling point of key result / tool / innovation?

It is a data-driven tool designed for LV networks, which doesn't require the installation of additional measurement equipment or requires field crews mobilization, since it takes advantage of existing information such as smart metering and measuring infrastructure.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - …

On Society: By having a better view on the LV networks, DSOs are able to manage their assets better, leading to improved asset use and eventually lower costs for society.

Economics: Taking advantage of existing information avoids the need to install additional metering equipment and the intervention of crew fields, leading to a more efficient operation of the distribution grid.

Potential impact: The phase connectivity information is valuable for operational and planning of an active distribution networks due to improved distribution network (DN) topology information leading to (1) Improved grid asset utilization, (2) Flexibility activation for congestion, voltage unbalance mitigation, (3) Providing network awareness for charging of EVs, operating heat pumps, DER, storage etc. (4) Higher renewable integration & improved forecasting, (5) Formation of active DN, (6) Accurate unbalanced power flow studies and OPF calculations crucial for operational and planning of DNs, (7) Detecting topology changes due to DN reconfiguration, and (8) More accurate digital twin formation for evaluating in time ahead and real time.

Economic rationale: The phase connectivity information is crucial for DN operation and resource planning. In absence of this, either manual phase connectivity identification (PCI) is performed or using expensive hardware which often requires sensor placement at the reference point and in the premises of single-phase consumer. Both these methods are intrusive and expensive. In our work, we utilized historical voltage time series information for PCI. Voltage magnitude is measured by most smart meters/other measurement devices either already existing or economical to install. Further, for highly accurate phase identification, our PCI methodology does not require the distribution network to be fully observable. Thus, the proposed would save a substantial amount for the system operators. For instance, in the UK there are 11 million distribution network feeders. Performing PCI for these feeders would cost multiple millions if not billions of euros.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? …	The LV phase and topology mapping tool performs the phase identification of the LV consumers and estimates the topology and electrical characteristics of the LV distribution networks, avoiding the need for human intervention to characterize the LV network and installation of additional monitoring equipment.
Weaknesses What could you improve?	One of the algorithms requires the deployment of smart meters to identify phase and electric characteristics, requiring both historical measurements from voltage and active power.

Where do you have fewer resources than others? What are others likely to see as weaknesses? …	
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	Observability of LV networks is recognized by DSOs as critical for ensuring the security and quality of supply. Data driven applications are now becoming well accepted by DSOs as important decision support tools. Efficiency of operation is critical topic for DSOs. Therefore, tools that could reduce investments and operation costs are well accepted.
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	The main threats is the need for data. Therefore, the deployment of these tools is dependent on smart meter rollout or other sensors to be installed at the LV network. Being a data driven tool, it must be extensively tested to be validated and exploited. Access to LV data maybe be a barrier due to GDPR rules.

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSO
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	European DSOs. Other countries such as Australia and New Zeland
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	There is a growing market for platforms and data driven applications for DSOs. For phase mapping tools there two main commercial solutions: one requiring the installation of equipment at the MV/LV substation (ENEIDA, ZIV, merytronic Gorlan, .) and other data driven (Turning Tables). Purely data driven solutions are still maturing.

		French company odit-e performs phase identification for the system operators.
TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 5. Tools will be tested for demonstration networks. Exploitation will require demonstration in additional networks.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	- Emerging: there is a growing demand and few offerings are available
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Offer a new application (software) that can be integrated in other existing commercial solutions.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Reduce costs in network and phase mapping campaigns. Improve supervision and efficiency of LV network operation
Exploitation assets and/or channels	See table 4 for inspiration	Software

Describe how the results can be concretely exploited, via which channels/assets		Potential new projects for testing and integration of tool in existing platform. Probable options are SaaS (system as a service-), technology transfer, or licensing to a third party.
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not determined yet, probable option is: • SaaS • Licensing of software tools and algorithms . Direct Sale of tool as a product
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 1 year after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Improving existing algorithms through the testing with real network data. Knowledge transfer to industry. Solving a real industry problem with advanced algorithms.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	n.a.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Existing knowledge from prior projects, considering other algorithms developed before.
Foreground IPR		New algorithm that can integrate a new service for the DSO

What have you developed in the project related to this specific KER?		
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	Internal invention disclosure form that allows IP department to evaluate potential protection strategies
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No patents known
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	n.a.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Yes. New project with a potential platform/software provider capable of integrating the application developed.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Further development and testing in national funded project

KER 18 MV network maintenance planning tool

Title KER	MV network maintenance **planning tool**
WP	**4**
Project tasks	Task 4.3**. The tool will be validated in the Portuguese pilot under WP7**
Key Partner	INESC TEC
Other partners involved (collaboration)	E-Redes
Authors of / contributors to this document	Bruna Tavares, Jorge Pereira, Clara Gouveia
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
The MV network maintenance planning tool is a decision support tool to help network operators to plan network reconfiguration actions required to ensure service to a maximum number of consumers and considering the participation of flexible resources through voltage and congestion management services. The tool first identifies alternative network topologies for a configurable time frame (e.g. a set of days) selected by the operator, considering the network area out of service due to maintenance. Then if technical problems are identified, the flexibility needs are quantified. The possible alternatives of periods for maintenance are then ranked according to pre-defined KPIs (cost, interruption time interval, amount of flexibility mobilized, number of switching actions, etc.).	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
The MV network maintenance planning tool is crucially needed due to its ability to leverage network flexibility and minimize the impact on end customer service during maintenance. This tool allows for strategic planning and execution of maintenance actions, ensuring that necessary maintenance tasks are performed without causing disruptions to the distribution services. By utilizing the local flexibility markets, maintenance can be scheduled during periods that are less expensive, such as avoiding costly Sunday mornings when maintenance crew costs are higher, but the regulator allows interruptions in distribution services without penalties. As a result, maintenance can be efficiently provided at alternative times, ensuring smooth operations while optimizing cost-effectiveness.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation.

	Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Network topology optimization	Provide optimal MV network topology, considering the isolation of maintenance area.	DSO
Identification of network congestions	Analyses the new topology considering the foreseen profiles in the network nodes	DSO
Negotiation of medium to long-term flexibility in NODES and N-SIDES	Determines flexibility needs and selects optimal bids, to solve the technical problems identified	DSO
Supports network operator maintenance planning	Today decisions are mostly taken considering pessimistic operation scenarios The tool provides a set of viable maintenance periods, recommends topology and flexibility needs that can than be selected by the network operator..	DSO

Unique selling point	What is the unique selling point of key result / tool / innovation?

The unique selling point of the MV network maintenance planning tool is its ability to support network operator maintenance planning, recommending optimal maintenance actions while minimizing disruptions to end customer service by using flexibility offered in the local flexibility markets. This tool ensures to schedule maintenance activities, while reducing costs and maximizing the availability and reliability of the network for customers.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

Society: The tool's ability to carry out maintenance actions without disrupting end customer service translates to improved reliability and availability of the distribution network. This ensures that individuals and businesses have consistent access to electricity, reducing the inconvenience caused by unexpected outages. Moreover, by optimizing maintenance schedules, the tool minimizes the need for planned service interruptions, resulting in increased satisfaction and productivity for consumers.

Economics: The tool's impact on economics is two-fold. Firstly, by optimizing maintenance scheduling, it helps DSO reduce maintenance costs. Secondly, the improved reliability and availability of the network resulting from efficient maintenance planning translate to economic benefits for businesses and industries that rely on a stable power supply. Reduced downtime and improved productivity contribute to overall economic growth and competitiveness.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)	
SWOT analysis	Set up a SWOT analysis of your KER
Strengths What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	We have a robust and extensively tested network topology optimizer that incorporates a distributed optimizer power flow. We have integrated flexibility into the decision-making process for maintenance interventions. This means that we consider the available flexibility form local markets when determining the optimal periods for carrying out maintenance activities.
Weaknesses What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	Currently, we lack forecast tools for MV profiles or local flexibility markets. There is an opportunity for improvement by incorporating projected flexibility into the network optimization module. This enhancement would enable us to select the network topology already considering the foreseen flexibility.
Opportunities What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	• DSOs are currently more open to the use of decision support tools, considering the increased complexity of operation with the integration of DER; • The core algorithm used in the tool developed is based on OPF algorithm, which is a tool well accepted by the DSO; • However, the tool is adapted to determine effectively alternative topologies and flexibility needs when technical problems arise; • The regulatory environment today requires DSOs to operate the network in a more dynamic way facilitating the use of flexibility.

<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	• Potential challenges may arise when integrating the methodologies into existing grid management systems; • The success of the methodologies depends on stakeholder acceptance and collaboration; • Competing methodologies or alternative approaches may emerge, requiring continuous improvement and innovation

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	DSOs
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	All European DSOs
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	ADMS providers

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	The software tool will be validated within the Portuguese demo, reaching a TRL 7. Contacts with potential partners are being exploited during the duration of the project.
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Not existing market yet. However the Portuguese DSO show a lot of interest about this tool features.
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Can be exploited as a software module that can be integrated by the DSO or by an ADMS provider. Usually, maintenance planning is provided by DSO teams that studied the different possibilities without considering flexibility markets. This tool not only provides the optimized maintenance schedule as it also considers the possibility of contracting flexibility from local markets.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	This tool helps DSO decision making, considering new features (local flexibility markets). Is also related to the provision of long/medium term flexibility services for congestion and voltage management
Exploitation assets and/or channels	See table 4 for inspiration	Software

Describe how the results can be concretely exploited, via which channels/assets		Potential new projects for testing and integration of tool in existing platform. Probable options are SaaS (system as a service-), technology transfer, or licensing to a third party
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not determined yet, probable option is: • SaaS • Licensing of software tools and algorithms . Direct Sale of tool as a product
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Within 2-3 year after the project
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	Improving existing algorithms through the testing with real network data. Knowledge transfer to industry. Solving a real industry problema with advanced algorithms.
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	n.a.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Existing OPF module developed in C#
Foreground IPR		New methodology that can be implemented as new module for the DSO

What have you developed in the project related to this specific KER?		
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	Internal invention disclosure form that allows IP department to evaluate potential protection strategies
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No patents known
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	n.a.
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Not identified so far
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Further development and testing of tool, ensuring the replicability and scalability of the methodology developed.

KER 19 Low Voltage Flexibility Needs Assessment

Title KER	Low voltage flexibility needs assessment
WP	**WP 4 and WP 8**
Project tasks	
Key Partner	KU Leuven
Other partners involved (collaboration)	-
Authors of / contributors to this document	Md Umar Hashmi
What is the KER doing? What value does it provide to which stakeholder?	
Description of the exploitable result(s)	A short description of the main functionalities and characteristics of the exploitable results which can be certain tools / methodologies / task results
Flexibility needs assessment (FNA) refers to the amount of flexibility the DSO needs to plan or procure from the flexibility market to avoid probable Distribution Network Incidents (DNI). The probable DNI are captured using modeling uncertainties, and using generated scenarios that emulate the different Monte Carlo realizations which could happen. The scenario generation utilizes the nodal load and generation forecast along with historical forecast errors. A flexibility needs assessment-optimal power flow (FNA-OPF) problem is solved for each of the scenarios. The robust FNA, considering the worst-case scenario, if used for flexibility procurement would lead to substantial over-procurement. In order to avoid this, a risk-based index, e.g. a chance constraint (CC), is introduced. Higher values of the CC would project on to greater risk the DSO might have to encounter by facing unresolved DNIs. DNIs in low voltage grids are often local problems in which flexible resources in the proximity may respond to avoid these incidents.	
Needs	To which need is this KER responding? Which research/market gaps is this KER filling in? What is the problem you are solving?
Quantification of flexibility needs for a distribution network in order to avoid probable congestion incidents.	
Value proposition	What value does the exploitable result provide? How do you solve the previously described need/problem? Please describe this value briefly / give further explanation. Indicate for each value who benefits from it / who is the potential customer?

Value	Description	Potential customer
Quantification of locational and temporal flexibility needs of a distribution network in time head setting	The flexibility quantification considers parameter uncertainty for pre-emptive planning of flexibility in the distribution network for avoiding probable network congestion incidents. The congestion incidents encompass voltage limit violations, line overloads, and can also be extended to power quality (voltage and current unbalance, power factor, etc.) violations.	System operator, market operator, software companies

Unique selling point	What is the unique selling point of key result / tool / innovation?

Time ahead temporal and locational quantification of flexibility needed to avoid probable distribution network congestion or power quality deterioration incidents.

Customizing the above feature for different grid topologies, with different levels of observability which hard to do in traditional power system analysis software companies that are not as flexible to adapt.

Expected impact	Explain the expected impact of this KER on: - Society - Environment - Economics - ...

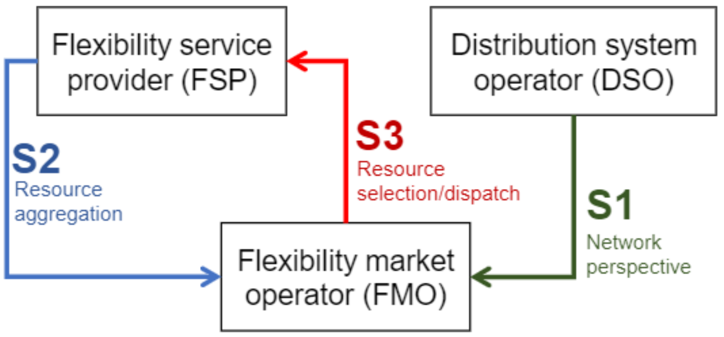
Impact for the stakeholder: the system operator can plan or procure flexibility resources considering the network needs.

Impact for society: ensuring reliable operation of the power network.

Impact towards environment and economics: due to better flexibility planning and risk based flexibility needs assessment, flexibility over and under procurement incidents are avoided.

What are enablers / barriers in the development & implementation of this KER? (Note that insights here will be used in the KLLs, but also by yourself in your exploitation strategy. For instance: you should tackle threats and make use of opportunities)

SWOT analysis	Set up a SWOT analysis of your KER

<u>Strengths</u> What do you do well? What unique resources can you draw on? What do others see as your strengths? ...	The flexibility needs assessment framework is mathematically complete. This makes it easy to apply in different grids. Peer reviewed work: "Hashmi, M.U., Koirala, A., Ergun, H. and Van Hertem, D., 2023. Robust flexibility needs assessment with bid matching framework for distribution network operators. *Sustainable Energy, Grids and Networks*, *34*, p.101069."
<u>Weaknesses</u> What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses? ...	High level of observability is required in the distribution grid. Data limitation needs to be further explored.
<u>Opportunities</u> What opportunities are open to you? What are enablers to implement your KER? What trends could you take advantage of? How can you turn your strengths into opportunities?	DSO can bring the network perspective into the flexibility procurement value chain. 
<u>Threats</u> What threats could harm you? What are barriers to implement your KER? What is your competition doing? What threats do your weaknesses expose to you?	How the flexibility market is operated may affect the relevance of the tool developed?

How will you exploit this KER?	
Current AND future Exploitation actions	Explain the exploitation actions that you are or will be taking. Indicate whether you have already started up this action. Note that it is important to show to the project officer that we are doing efforts to also exploit our results beyond the lifetime of the project. **In case there are questions that you cannot answer yet**, please provide an action plan of the steps that you will take to come to the answer. (See table 9 for inspiration: for instance, if you don't know the market yet, you can plan a market study). Also, please aim to describe what a probable option is you are thinking about in case you don't know the answer to a specific question yet.

Question	Example answers	Answer
Target group Who is targeted by this KER? Who will be the customer?	See table 0 for inspiration	Distribution system operator, local flexibility market operator, software vendors
What is the total addressable market? Where can you find all your customers? Which countries, which regions…? How many customers can you target?	See table 0 for inspiration	There are 100s of large distribution system operators with more than 250,000 consumers served in their network. These system operators could be the possible customers.
Other competitors on the market Who are your main competitors in the market? Are there other companies/organizations who offer this KER to your target group of customers? Is the competition strong? (no major players / established competition but non with a product like the one in this KER / or several major players with strong competencies, infrastructure and offerings).	No example, please answer from your own experience	Depsys (Switzerland), Plexigrid (Spain),

TRL / Product maturity level How far is your product in the development process? Is it already exploitable/commercially viable?	See table 1	TRL 6 (tool is in operation for the German demonstration in the EUniversal project)
Market maturity The market targeted by this innovation is:	- Not existing yet and it is not yet clear if the innovation has potential to create a new market - Not existing yet but the innovation has clear potential to create a new market - Emerging: there is a growing demand and few offerings are available - Mature: the market is already supplied with many products of the type proposed	Emerging: there is a growing demand and few offerings are available
Exploitation strategy What product, process, service… do you offer to this target group? What is new, innovative about this product, process, service…?	See table 2 for inspiration	Offer a new application (software) that can be integrated in other existing commercial solutions.
Associated business model How does the target group benefit from this exploitation strategy / from this product offering? What is the value for them?	See table 3 for inspiration	Reduce the congestion mitigation cost
Exploitation assets and/or channels	See table 4 for inspiration	Potential new projects for testing and integration of tool in existing platform. Probable options are SaaS (system as a service-), technology transfer, or licensing to a third party.

Describe how the results can be concretely exploited, via which channels/assets		
Revenue streams Give a qualitative description of how this will lead to revenue streams. If you can quantify it, this is welcome too. What are your main income sources?	See table 5 for inspiration	Not determined yet, probable options are • SaaS • Licensing of software tools and algorithms .
Implementation timeline When have you implemented this strategy or when will you implement it?	- During project lifetime - Within 1 year after the project - Within 5 years after the project	Implementing the algorithm for the German demo for EUniversal project.
Internal added value What is the added value internally for your company? What do you get out of this KER yourself?	See Table 6 for inspiration	
Involved partner With whom did you develop this product (co-developer)?	See Table 7 for the partners	N.A.
Background IPR What did you bring in the project related to this specific KER?	Adapt the description from the grant agreement (see Table 8) with the focus on this KER. You can also find inspiration from other partners' strategies.	Existing knowledge from prior projects, considering other algorithms developed before.
Foreground IPR		New algorithm

What have you developed in the project related to this specific KER?		
IP Did you identify any IPR-subject issues during the project and how did you tackle them?	No examples, please answer from your own experience. If you have taken or are taking specific IP actions, please specify them.	
Patents Do you have an idea of patents that exist in the market (and that might potentially cause problems in the future)?	No examples, please answer from your own experience	No known patents
Joint exploitation In case there are multiple partners involved in this KER, how do the partners identified in this table work together on this KER now and in the future?	No examples, please answer from your own experience	
Further actions (exploitation) Are there any specific actions that you will take to further exploit the EUniversal results? This question is especially relevant if you could not answer all questions above.	See table 9	Yes. New project with a potential platform/software provider capable of integrating the application developed.
Further actions (development) What further actions will you take to further develop this KER?	See table 10	Further development and testing in national funded project