Universal

UMEI

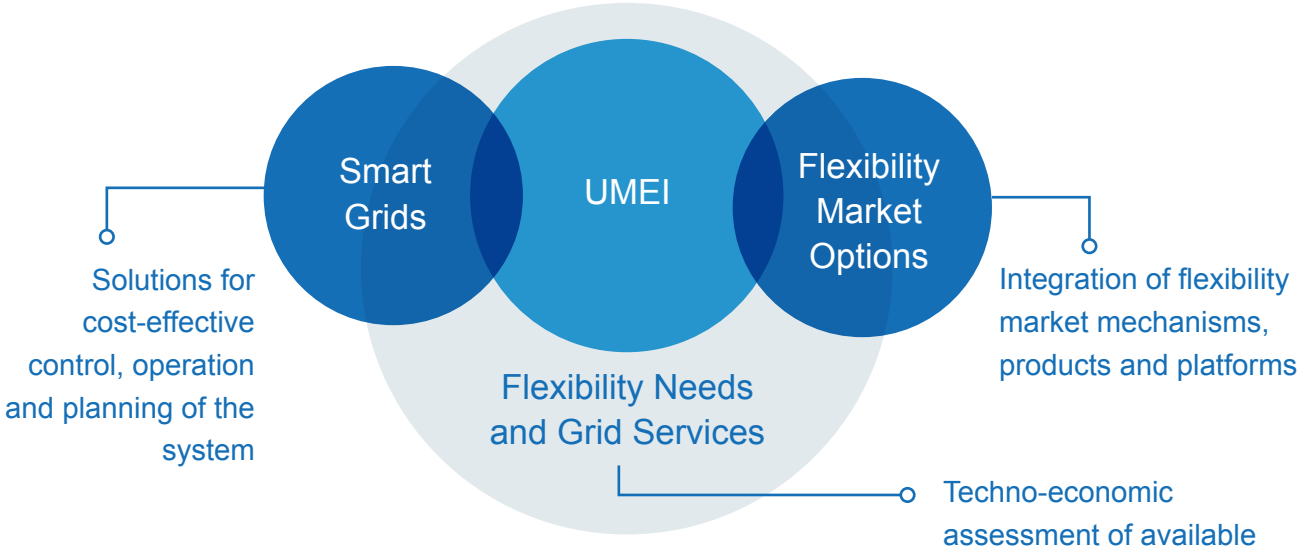
Let's flatten the energy curve

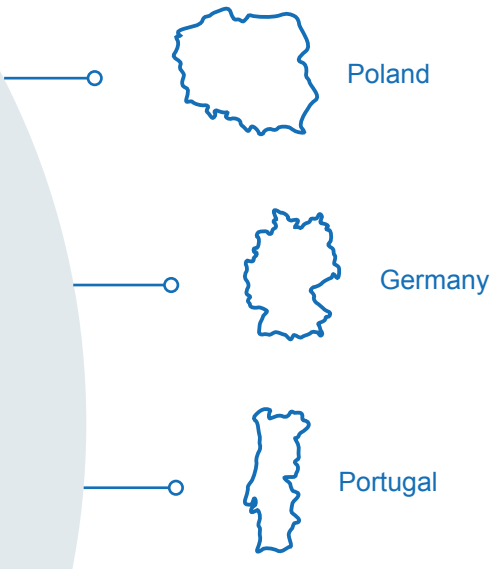
A UNIVERSAL APPROACH

Conceive & Develop

EUniversal aims to implement the **Universal Market Enabling Interface** (**UMEI**) concept and develop solutions to ensure effective implementation of an interoperable flexibility ecosystem across Europe.

How? A three-fold approach lays down the foundation for this implementation:





Test & Demonstrate

All these new capabilities will be implemented and tested in **three multi-scale DEMOs** to demonstrate their universality.

SUMMARY

Start date:
1st of February 2020

End date:
November 2023

Project total cost:
€ 9 774 227,50

EU contribution:
€ 7 999 997,50

Type of action:
Innovation Action (IA)

Grant agreement ID:
864334

Website:
euniversal.eu

The **EUniversal** project, funded by the European Union, aims to develop a universal approach on the use of flexibility by **Distribution System Operators** (**DSO**) and their interaction with the new **flexibility markets**, enabled through the development of the concept of the **Universal Market Enabling Interface** (**UMEI**) - a unique approach to foster interoperability across Europe.

The UMEI represents an **innovative, agnostic, adaptable, modular and evolutionary approach** that will be the basis for the development of new innovative services, market solutions and, above all, implementing the real mechanisms for active consumer, prosumer, and energy communities participation in the energy transition.

CONSORTIUM

Project coordination: E-REDES

The consortium brings together **19 partners from 8 different European countries** providing a multi-stakeholder approach.

INDUSTRY

SOLUTION PROVIDER

DSO

MNG. & SOCIAL

EUROPEAN ASSOCIATIONS

DSO

STORAGE

RESEARCH

ENERGY MARKETS

BUSSINESS ANALYSIS

REGULATION

SYSTEM RESILIENCY

SMART GRIDS

MARKET

PLATFORM OWNER

AGGREGATOR

CHALLENGES

EUniversal aims to support the EU on its journey towards a sustainable and low-carbon energy union. This transition brings along increasing levels of penetration of renewable energy and more electrification of demand. This in turn leads on the one hand to increasing levels of intermittency and variability in energy generation which poses challenges to grid stability and necessitates innovative solutions. Besides, the resulting additional loads on the grid lead to capacity constraints, requiring additional investments in grid upgrades.

To conquer these challenges, distribution grids will need to rely more on flexibility and smart-grid functionalities to safely host more renewable energy sources, integrate new loads and adjust demand profiles to the supply variations in renewable generation or to the available capacity in the distribution grids, moving away from the general principle where ‘generation used to follow demand’. 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:**

UMEI

On a marketplace, all involved parties need to be able to communicate before they can engage in an economic transaction. 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 and enlarges flexibility market entry costs. EUniversal resolves this problem by developing the UMEI.

DSO TOOLBOX

Before DSOs can benefit from flexibility, they need to adapt their grid planning and operation to interact with the new market ecosystem and accommodate flexibility services has an alternative grid asset. This implies among others that they need to forecast future grid status and quantify the amount flexibility needed across different voltage levels. This is a serious challenge, particularly for LV networks where a great majority of flexible resources will be connected. EUniversal proposes a toolchain integrating novel operation and planning tools specifically designed for distribution networks, enabling a smarter and more resilient distribution grid.

FSP

A properly functioning marketplace also needs the presence of sellers (namely FSPs). FSPs, however, still face numerous entry barriers in flexibility markets and to offer their flexibility to the DSO. Specifically, owners who only possess small volumes of flexibility face difficulties as 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. Furthermore, achieving sufficient FSP (end-user) engagement is challenging due to distrust in electricity markets (energy crisis), a lack of awareness, missing smart control and/or measuring equipment. In addition, there is a lot of technological innovation at the consumer side, due to which it is not always easy to assess which technology are in the most cost-effective position to delivery flexibility for specific DSO needs, considering location and timing.

MARKETS

Finally, a market can take different shapes. Today, there is not yet a lot of standardization in flexibility markets and there are still numerous design decisions to be made. Do we make use of independent market operator? How should products be designed? How can we ensure validation and settlement is done properly? How should DSOs and TSOs coordinate between each other? All these and other design choices are required to facilitate the establishment of flexibility markets and making them an efficient tool for system operators to solve grid problems.

UMEI

1

Problem

To test local flexibility markets, pilots and test projects are being set up due to the increased need for flexibility. However, the absence of standards or harmonization guidelines result in many different solutions and a lot of diversity in market implementations. The diversity of technological solutions limits adaptability and usability, creating a lock-in and increasing costs for DSOs to benefit from multiple platforms. To overcome these barriers we need an additional layer for data exchange that ensures compatible with various market platform solutions.

2

Solution

The UMEI creates an open interface to bring stakeholders together and ensure direct interactions between DSOs and other market players. It is a standard, agnostic, and modular combination of APIs that links DSOs and market parties with flexibility market platforms, facilitating communication between stakeholders without a central hub.

The UMEI's publicly available APIs on Github enable stakeholders to quickly adopt or develop new APIs while complying with the interface specification.

Flexibility Zones

Used by DSOs to define specific flexibility areas, composed by a set of portfolios.

Manage Portfolio

Used by FSPs to submit and manage portfolio on the market.

Managing Portfolio Baseline

Used by FSPs to manage baselines on the market.

List All Market

Used by market participants to retrieve the available markets.

Manage Market Order

Used by DSOs and FSPs to execute order's related operations in the market platform.

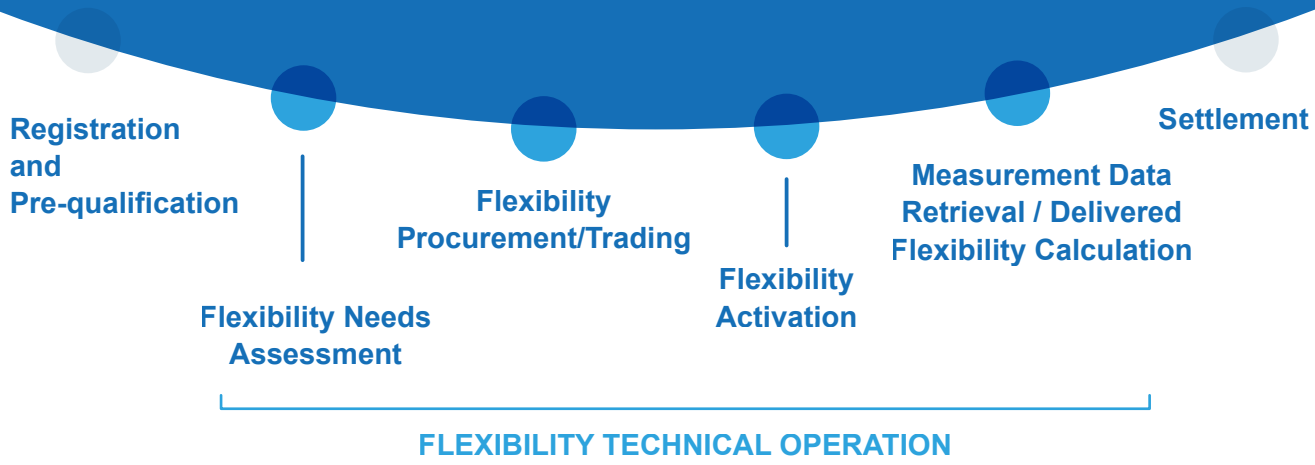
List Market Trades

Used by market participants to retrieve the market trades.

Manage Meter Readings

Used by the DSOs to manage metering data submission both to the FMO and the FSP.

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



3 Value and Impact

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	END CONSUMERS
Support to innovative business models	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

4 Uniqueness

The interface is adaptable, and it is not a rigid standard that obliges every market platform to take over the specifications of the UMEI.

E-REDES NODES N-SIDE centrica Business Solutions

DSO TOOLBOX

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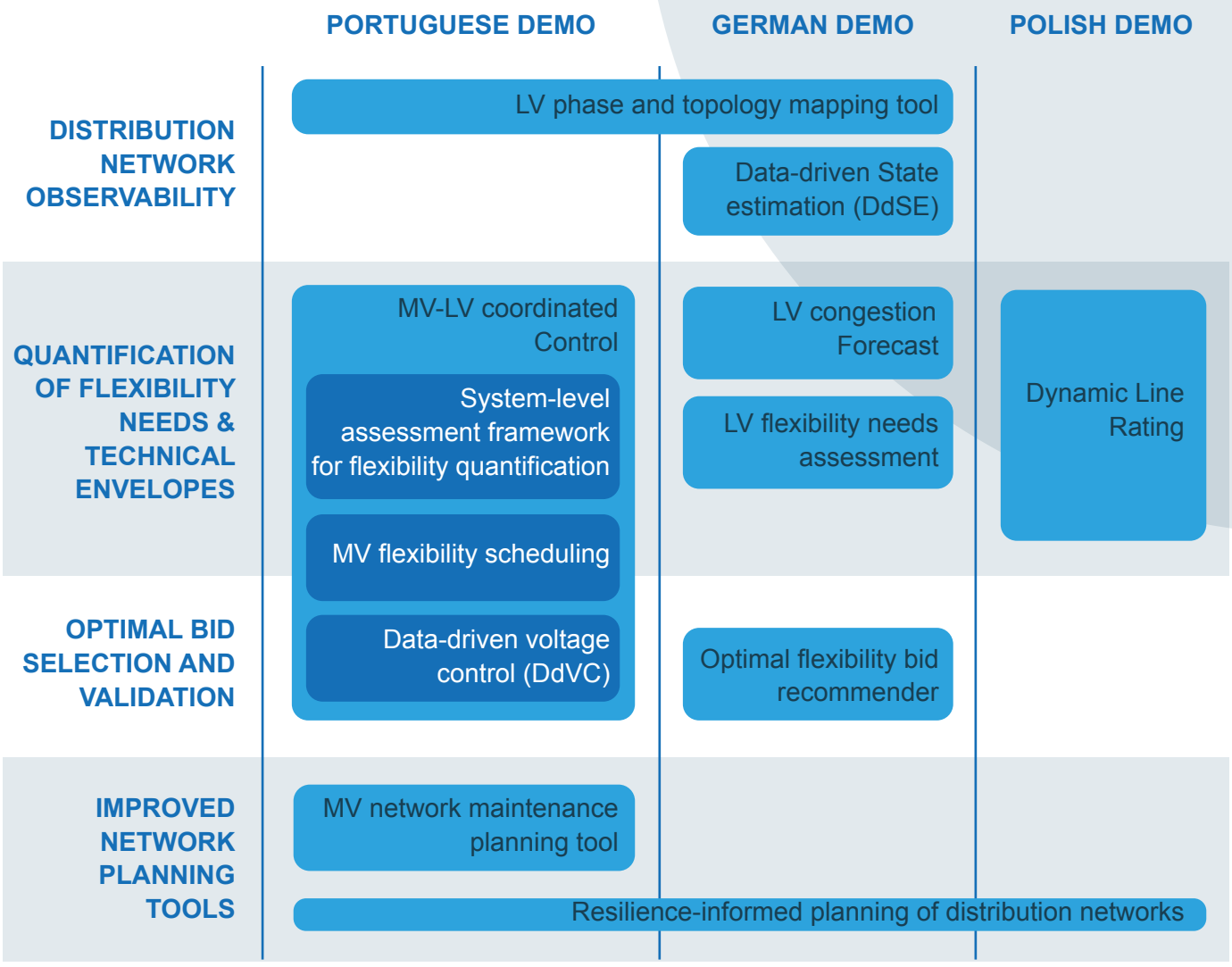


Network Observability

LV phase and topology mapping | perform the phase identification of the LV consumers and estimate the topology and electrical characteristics of the LV distribution networks, based on historical data from smart meters or other sources of information.

INESCTEC
KU LEUVEN

Data Driven State Estimator | Enables the estimation of voltage magnitude in each LV node, based on the historical data of the smart meters and a reduced number of (near) real-time measurements. Compatible with poorly characterized grids.

INESCTEC

Flexibility needs & Technical Envelopes

Dynamic Line Rating | Forecasts high voltage lines capacity, replacing static line according to weather conditions. Improves HV line flexibility with dynamic management of RES integration limits, minimizing its curtailment.

Energa operator

LV congestion forecast | This tool calculates the risk on congestions in the LV-network, based on even when there are reduced measurements available.

vito

LV Flexibility needs assessment | Computes flexibility needs to solve LV constraints using an optimal power flow (OPF) formulation with chance constraints to model the uncertainty of the load and generation. Requires full characterization of LV networks.

KU LEUVEN

MV and LV coordinated control | This framework enables DSOs to procure day-head flexibility services for both MV and LV networks to address congestion and voltage problems. It extends ADMS applications to LV networks, by integrating tools to forecast network conditions, estimate flexibility needs, and make optimal bid selections.

INESCTEC
ENGIE Impact
E-REDES

Data Driven Voltage Control | Estimates the flexibility needs, within a given area, to solve voltage problems, through a data-driven approach compatible with poorly characterized grids. Also defines technical limits for flexibility areas and resources to avoid further constraints. Includes a privacy protocol for handling personal data like active power measurements.

INESCTEC

Optimal bid selection & Validation

MV Flexibility Scheduling | Provides a computational efficient alternative to (optimal) power flow-based algorithms, identifying flexibility needs and areas and selecting most economical bids, based in sensitivity coefficients.

Optimal bid recommender | The optimal bid recommender (OBR) is a clearing engine that can be used by DSOs to help select the most optimal of flexibility bids. In this configuration the DSO can keep full control of both their data and actions.

Network Planning

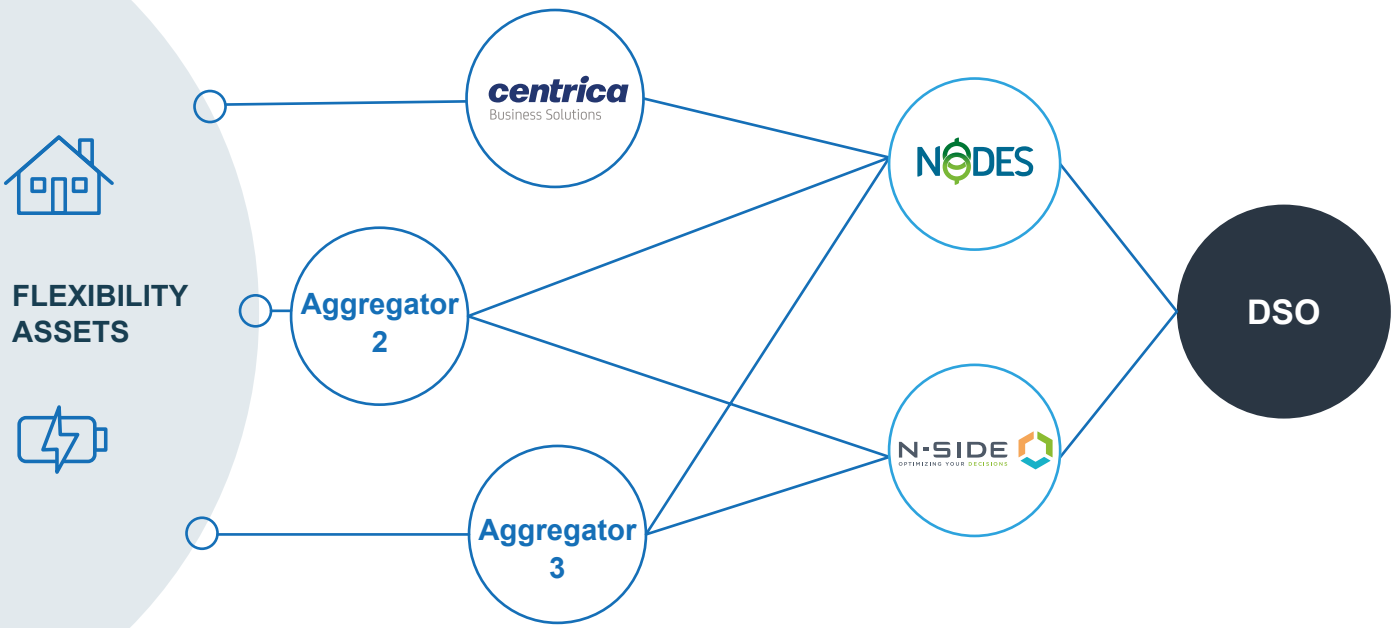
Resilience Planning Tool | Extreme weather events compromise distribution networks integrity. The tool includes a stochastic hazard scenario generator and an asset planner, integrating risk-based metrics to helping DSOs enhance resilience based on their risk strategy without significant compromises in reliability.

MV network maintenance planning tool | The tool supports maintenance action planning considering the possibility of mobilizing flexibility services in MV networks. It identifies the most economic periods to perform maintenance, considering flexibility needs to solve potential grid constraints.

OTHER KEY EXPLOITABLE RESULTS

Flexibility Markets

Flexibility markets facilitate access for system operators to distributed local and regional flexibility for grid management.

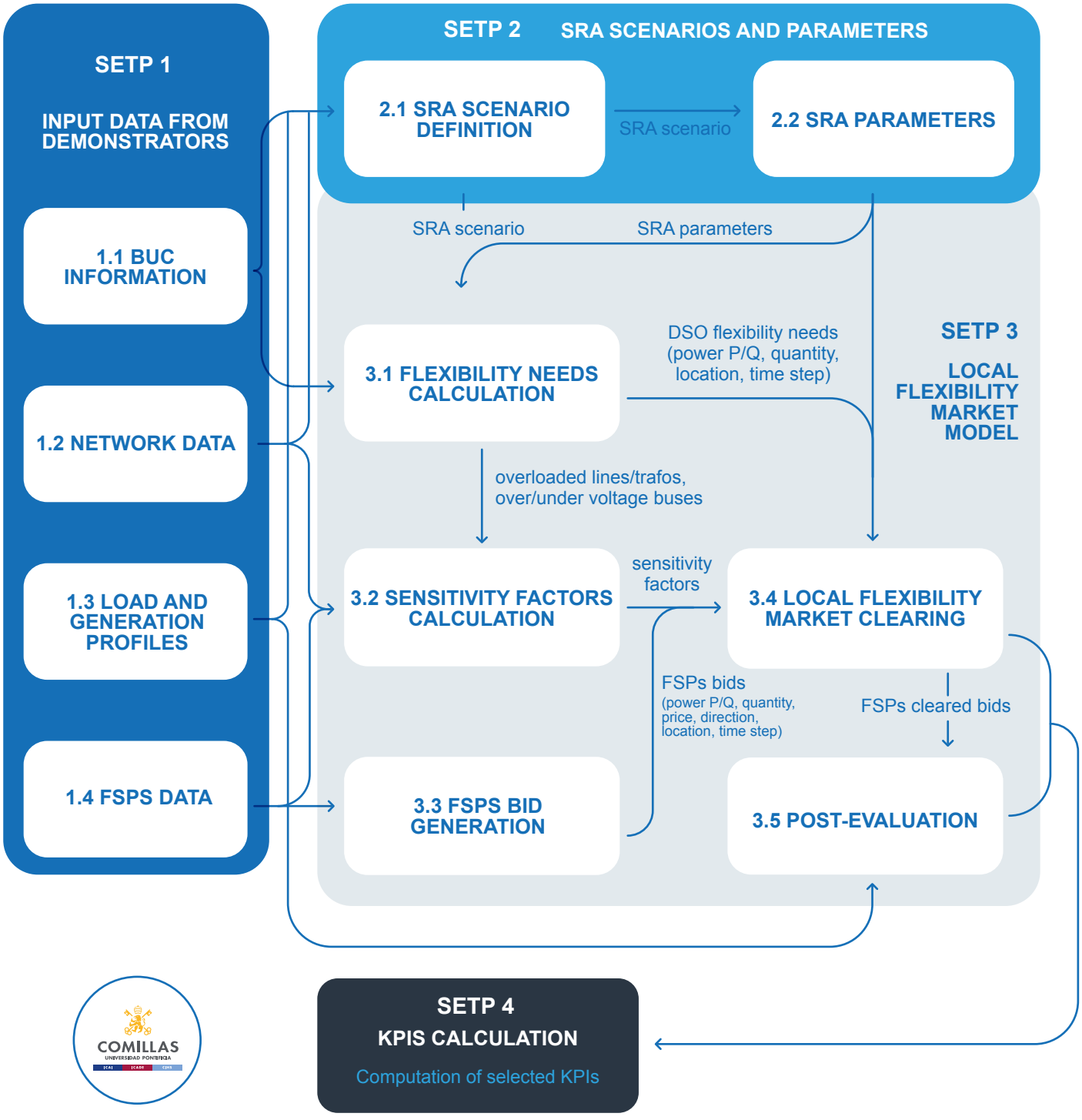


1. Regulatory recommendations
   Deliverable 10.3 shows how different flexibility mechanisms can be combined and discusses why regulatory sandboxes and market power remedies can be important for the optimal implementation of the mechanisms.

2. Business model innovation and CBA methodologies.

Improved Scalability and Replicability Analysis methodology

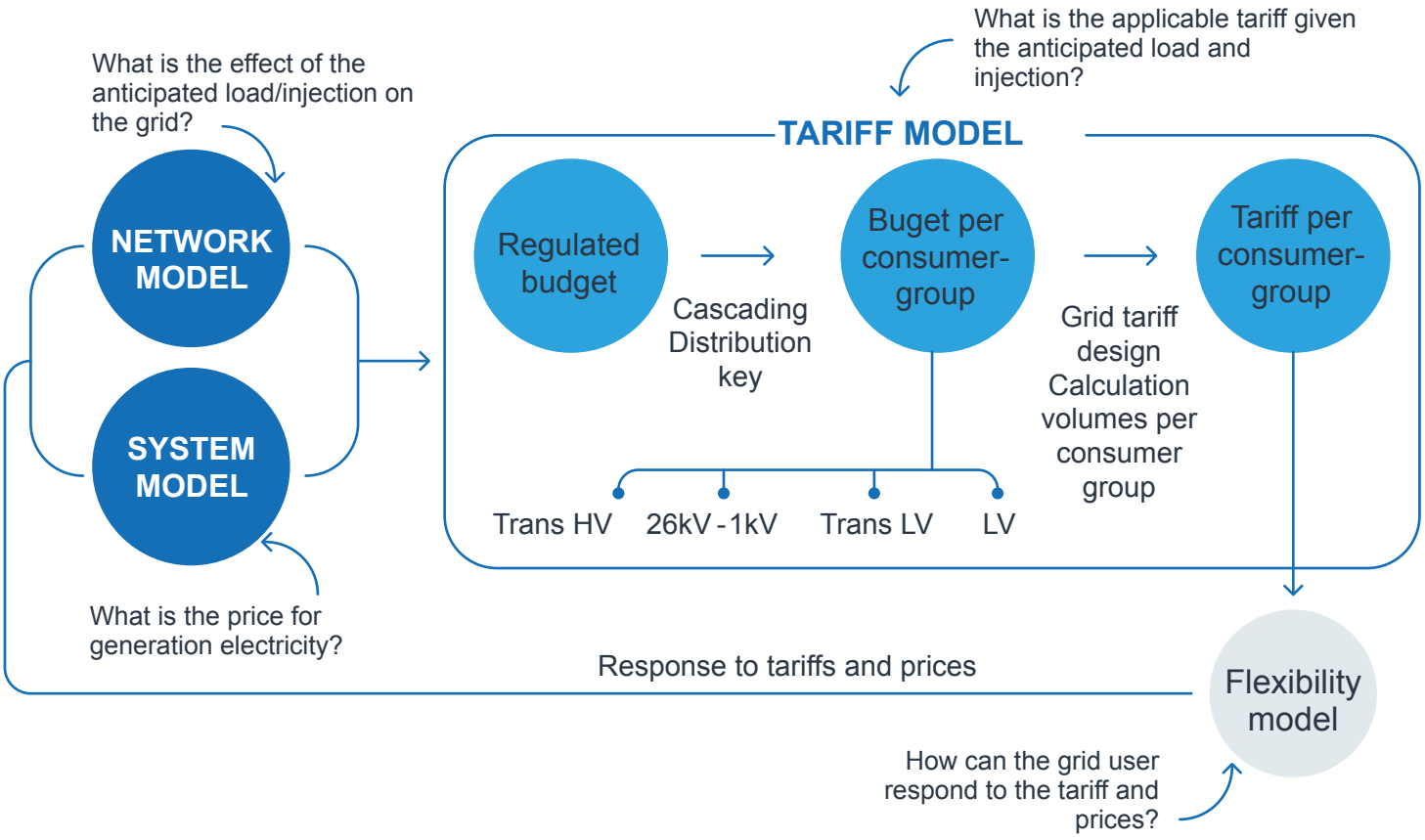
Local flexibility markets face multiple open questions. The improved simulation-based SRA methodology helps quantify flexibility needs and determine the optimal activation based on sensitivity factors. Results provide data-driven information on aspects such as when, where, how much or what type of flexibility is most useful.



Method for dynamic grid tariff design

vito

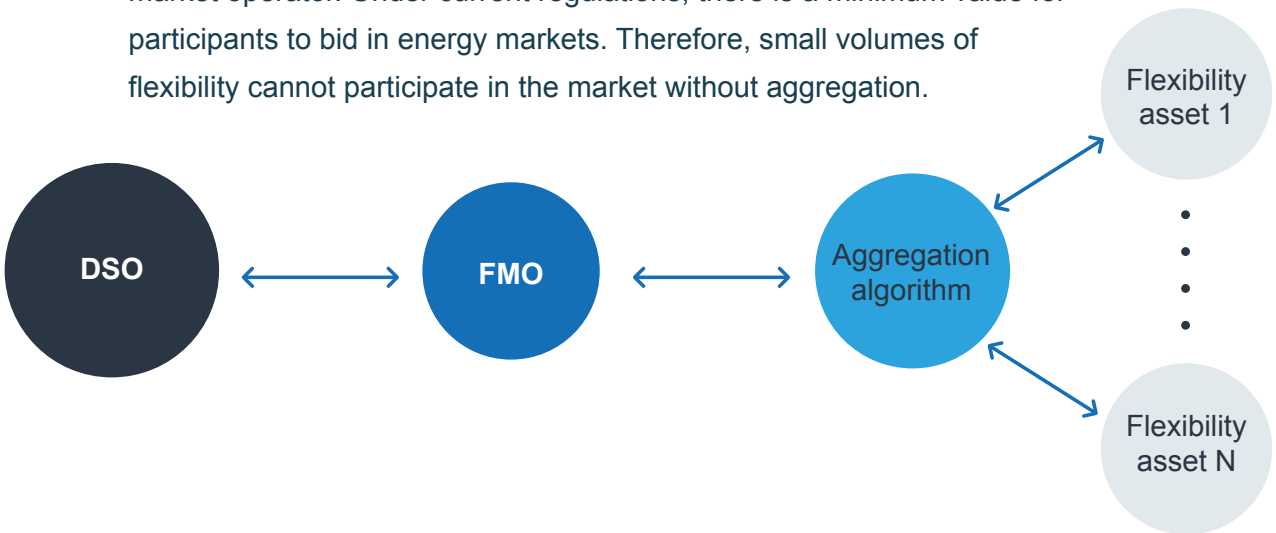
To trigger flexibility, proper incentives are needed. Setting appropriate grid tariffs is important in this regard, yet hard given the many unknown and uncertain factors. This improved methodology helps to design tariffs while taking into account grid constraints and different design dimensions.



Aggregation algorithms for local flex

centrica Business Solutions

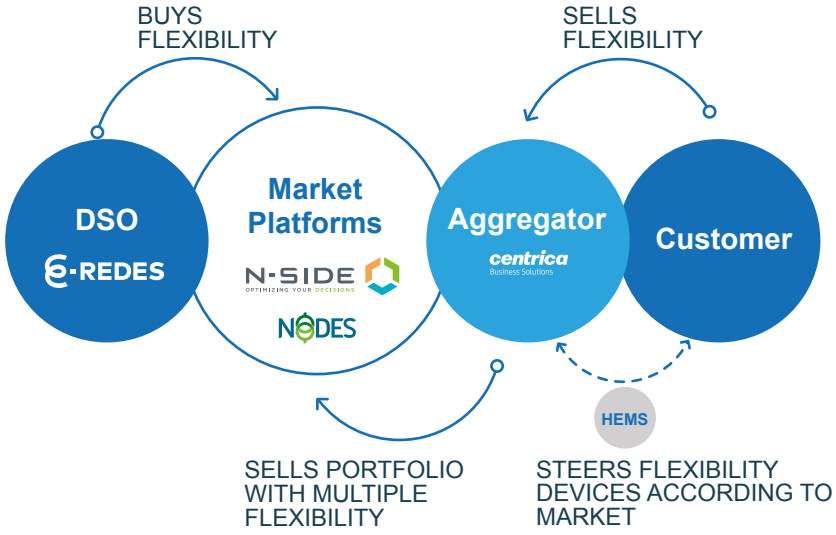
This algorithm aggregates the flexibility available at end-users' premises and enables the participation of small volumes of flexibility located in low voltage and medium voltage grids. This aggregated flexibility will be offered to the DSO via a flexible market operator. Under current regulations, there is a minimum value for participants to bid in energy markets. Therefore, small volumes of flexibility cannot participate in the market without aggregation.



PORTUGAL

The Portuguese demonstrator

is located in different regions in the country, served by E-redes, ensuring coverage of different contexts, including urban and suburban areas. including renewable energy producers at MV. The operative objective is to validate the UMEI and the DSO toolbox in different contexts and scenarios. The demo has tested the provision of market-based flexibilities from prosumers of the LV and MV grid via the UMEI.

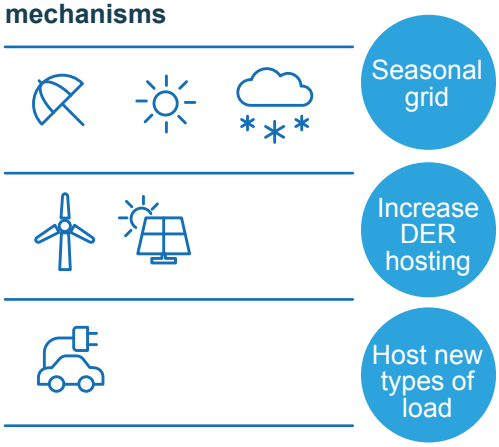


Using flexibility during planned maintenance action in MV grids

A NEW METHOD is proposed to:

- **Explore** network reconfiguration options
- **Procure** flexibility and reserve it during maintenance planning
- **Use** flexibility during planned maintenance

Congestion Management for medium and long-term grid planning through market mechanisms



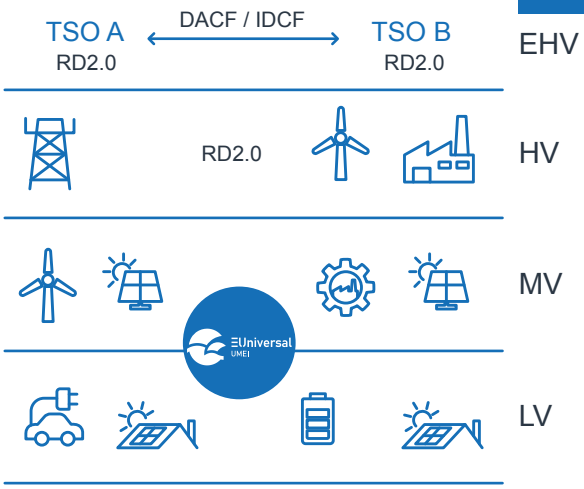
OBJECTIVES

- 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**.

GERMANY

German Demonstration

Integrating new types of assets into the distribution grid to use flexibility creates complexity and hardly predictable power flows in the distribution networks. The German Demonstration aims to overcome the existing limitations in the use of flexibility. For that purpose, smart grid tools for grid state assessment and active system management were developed.

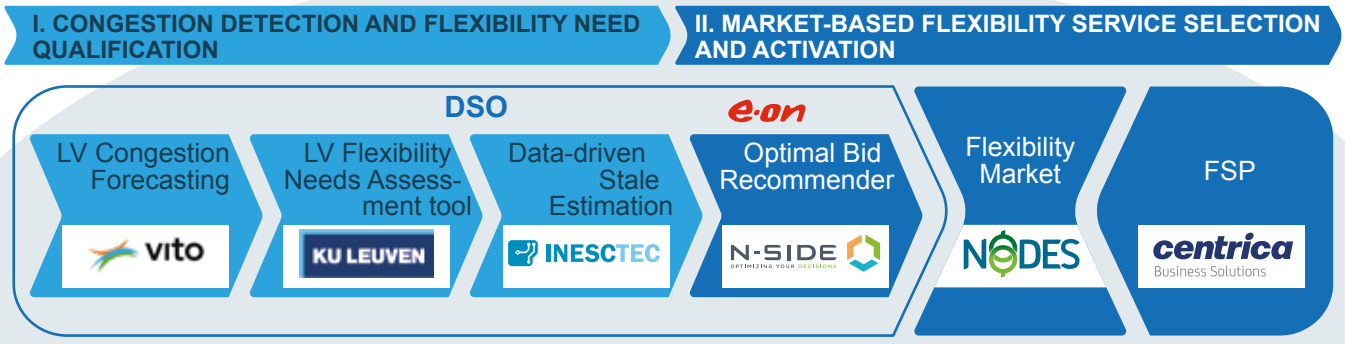


The German demonstration pilot was set up to test the flexibility value chain from congestion detection to market-based flexibility procurement via a local flexibility market. The pilot, conducted in the LV grids of MITNETZ STROM, examined the use of flexible resources for congestion management. More specifically, the demonstrator had the following objectives:

- **Connection** of schedule-based congestion management (Redispatch 2.0) & flexibility markets
- **Achieve** enhanced observability of the grid and im-proved congestion detection
- **Predict** the flexibility potential in the LV level
- **Provide** the flexibility over the UMEI to the market
- **Interlink** flexibility to higher voltage levels

OBJECTIVES

To achieve the goals 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 from the resources registered on the market platform to relieve the forecasted congestions.

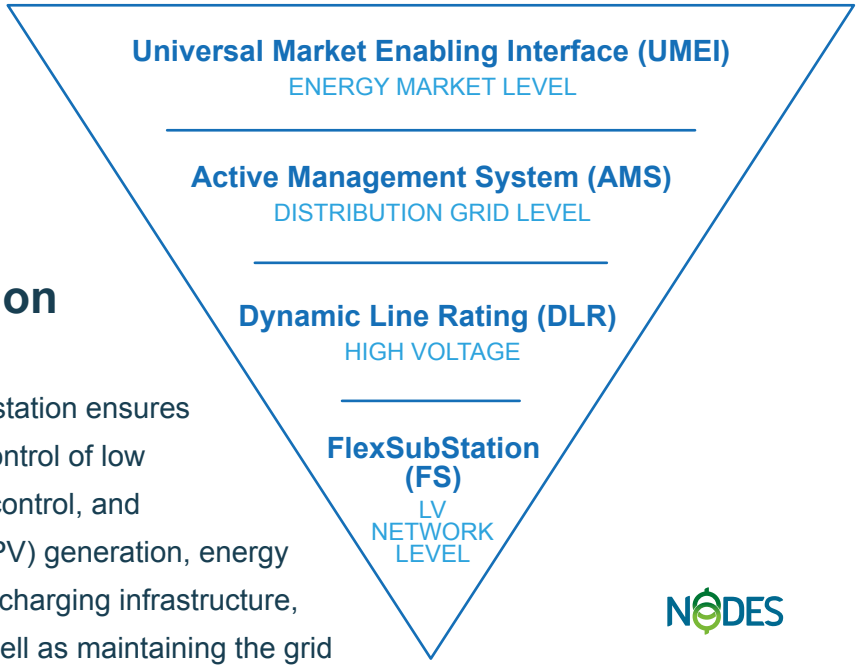


POLAND

The Polish demonstration

part of the project, was carried out in the following areas served by Energa-operator:

- Test flexibility services through the UMEI: In the Local Balancing Area near the Hel Peninsula with well-developed MV grid automation and a large number of smart meters.
- Dynamic Line Rating System (DLR) used in ENERGA as part of SCADA / EMS to assess the actual and short-term forecast line capacity. DLR is to be used as a source of the flexibility of services that can be offered to TSOs to reduce traffic congestion.
- Flexsubstation: On the territory of three Branches: in Płock (Mława), Kalisz (Ostrów Wielkopolski) and Gdańsk (Wejherowo), where 3 areas of the LV grid have been selected with a large share of variable renewable sources.



The FlexSubStation

New intelligent MV / LV substation ensures advanced monitoring and control of low voltage grids, autonomous control, and monitoring of photovoltaic (PV) generation, energy storage and electric vehicle charging infrastructure, faster failure detection, as well as maintaining the grid voltage within acceptable limits, especially with high PV saturation. Its functionality includes the remote control the position of the tap changer (OLTC).

The central controller is responsible for the control of the LV grid voltage and communication with the SCADA system, detection of damage to fuse-links, and monitoring of the PV installation. Information about voltages downstream of the network is collected from smart meters installed at customers' sites.

RECOMMENDATION

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.

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 communication solution.**

The UMEI decreases the fear of lock-in to one market platform. **It is important that any 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.**

The UMEI consists of a set of APIs and **it is important that there is an European API standard**. This will further facilitate the implementation of the UMEI in different environments.

To facilitate API-standardization, **market standards need to be defined**.

In the short run, it is **important to ensure that the UMEI is flexible and adaptable to different markets**. This is necessary because currently there is no common market framework yet.

EUniversal recommends having an independent market operator due to benefits linked to neutrality, transparency and customer engagement.

The European Commission should further support these open-source tools so that they can continuously be upgraded.

The UMEI covers all key trading market operations linked to flexibility procurement. There is the need to further develop the remaining process steps (pre-qualification and registration and settlement).

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. EUniversal 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 the Github is recommended, or a standardized API-structure is to be set-up.**

Consumer engagement

Flexibility markets can only function properly if there are sufficient FSPs offering sufficient flexible resources. This is necessary to ensure competitive prices 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 and, often, they do not see the benefits of offering flexibility. Finally, most DSOs do not have direct contact with the end-users to be the single point of contact for consumers and are yet also not incentivized by regulation to use flexibility markets.

Facilitation of consumer engagement

It is necessary that stakeholders who set up a flexibility market **commit sufficient resources to increase consumer awareness and to engage consumers**.

EUniversal has identified drivers and motivation as well as barriers for consumer engagement providing a guideline 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.**

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. Potentially, additional stakeholders with expertise in

different fields (social, economic, technical, or regulatory) might also be required.

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.

Incentives to increase consumer engagement

Consumers should get clear economic incentives to join flexibility markets. These may include a grid tariff reduction or taxation.

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 pertained consumer engagement beyond the project.

Aggregation to facilitate market access

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**.

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.**

IT and automation to facilitate implementation

Additional work is recommended in the field of remotely **activating flexibility**, as manual activation requires the involvement of end-users which is not the preferred option for most consumers.

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.

Furthermore, **enabling automation of data exchange and other administrative and organizational tasks** would be an important enabler for FSPs to offer flexibility.

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. Besides, 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 is easy to share. For grid security reasons, DSOs should not share data on grid representation, and GDPR makes sharing end-user data very cumbersome or impossible. 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 the following sub-categories.

Data sharing arrangements

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.

At LV, data sharing between partners is much more regulated (GDPR) and ideally **such points should be tackled already in the proposal phase**.

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.**

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.

Stakeholders' responsibilities

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 allows to take into account more detailed constraints (including alternative DSO options) without sharing sensitive network data, while the latter allows a more transparent, simple bid selection. Which option is best will depend on numerous factors, one of them being the network topology. **In case of meshed grids, bid selection outside the market options, or where the DSO can select and validate the bids, could therefore be better. In case of a radial grid, other bid selection options could be more appropriate.**

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. One solution was to share dynamic flexibility areas with the market platform, 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 will depend on flexibility market regulation and implementation model.

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 & self-awareness

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

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's tools demonstration have proven the **potential of 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.**

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. **We therefore recommend that DSOs use DLR to monitor and forecast the admissible line load, thereby improving the framework for flexibility services.**

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.**

Needs

System operators experience different types of flexibility needs, in different time span which are to be solved. These 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 different inputs from at least three Member States.**

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 and simple 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.

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 resources characteristics. Reliability of LV flexibility through its aggregations, when having a relevant flexibility capacity available.

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, as proposed in EUniversal, can solve technical constraints within a determined envelope. This will help aggregators provide more accurate bids and promote more effective use of flexibility resources.**

Planning (Operation & network investment)

As discussed above, DSOs need flexibility. This flexibility can, however, can 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 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.

Combination of mechanisms

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.**

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 these do not contain contradicting measures or actions.

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.**

DSO solutions

Flexibility markets can both be used to procure 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 have shown that flexibility mitigates the risk of congestion and voltage constraints and avoids curtailment of renewable energy, postponing or being an alternative for grid reinforcement. 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 operation

Actively integrating market-based flexibility for grid support requires the implementation of predictive operation, where network operator 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 based on 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.**

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.**

Maintenance planning and support

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.

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.

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.**

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.

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 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.**

TSO-DSO coordination needs to be further defined in terms of coordination between systems that consider the local nature of DSO flexibility markets.

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.

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.**

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.**

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