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EUniversal: the universal market enabling interface as a way to unlock flexibility solutions for cost-effective management of smarter distribution grids

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Tiago Simão[1] ✉, José M. Terras[1], Clara Gouveia[2], Helena Gerard[3], Leonardo Meeus[4], Carmen Calpe[5], Noske Slawomir[6], Thomas Otuszewski[7], Rafael C. Arín[8], Florian Gonzalez[9]

[1]*EDP Distribuição, Lisbon, Portugal*
[2]*INESC TEC, Porto, Portugal*
[3]*VITO, Mol, Belgium*
[4]*Vlerick Business School, Brussels, Belgium*
[5]*Innogy, Essen, Germany*
[6]*ENERGA, Gdansk, Poland*
[7]*EASE, Brussels, Belgium*
[8]*Comillas, Madrid, Spain*
[9]*EDSO, Brussels, Belgium*
✉ *E-mail: tiagofilipe.simao@e-redes.pt*

Abstract: This paper offers an overview of EUniversal H2020 project which aims to develop and demonstrate a replicable solution for the interaction of the DSO (through the UMEI – Universal Market Enabling Interface) with the new flexibility markets and services specified and developed within the project. The UMEI brings forward a universal, open, adaptable and modular approach to interlink active system management with electricity markets and foster the provision of flexibility services, also acknowledging the activation needs of DSOs and the coordination requirements with other commercial parties and TSOs. EUniversal comprises 3 demonstration sites: Portugal, focusing on the demonstration of the UMEI concept and of new data driven network operation tools for the management of market driven flexibility services for LV and MV grids; Germany, addressing congestion management using market-driven flexibility via the UMEI in LV networks; Poland, focusing on grid observability and future networks supporting flexibility management via the UMEI. The interdisciplinary and complementary expertise of the project partners will allow to capture and cover different requirements and solutions and to maximise their impact and replicability across Europe. Lastly, the project will develop business models archetypes for flexibility mechanisms, perform a Cost Benefit Analysis and deliver a Roadmap.

1 Introduction

EUniversal's concept intends to be a key tool to implement current and future EU energy policies foreseen in the Clean Energy for All Europeans package, aiming at enabling the massive integration of renewable energy sources via new flexibility services and market services centred in the consumers and energy communities. Based on recent directives and on the most promising initiatives, notably BRIDGE, European Smart Grid Task Force, ETIP SNET, CEER recommendations, joint transmission system operator and distribution system operator (TSO–DSO) platform, EUniversal not only opens new horizons for flexibility market uptake and active consumer and communities' participation but also contributes to the SOTA of distribution grid monitoring and operation in a challenging environment.

The project's structure includes the complete ecosystem that will enable the demonstration of EUniversal's concept, comprising the characterisation and quantification of the flexibility that can be provided by different technologies (i.e. electric vehicle (EV), electrical storage, power-to-X), the specification of the flexibility services and of the Universal Market Enabling Interface (UMEI), the development of flexible and resilient network operation and planning tools including flexibility as a new grid asset and finally the development of the market platforms and mechanisms enabling the implementation of the flexibility services. The work is supported initially by the identification of a future vision for flexible grids and well-functioning electricity markets, particularly by reviewing recent policy and regulatory initiatives that may shape the grids and markets of the future.

The following sections provide a detailed description of the main objectives and expected outcomes of EUniversal project, as well as the description of the three demo sites, where the EUniversal concept will be demonstrated.

2 Concept and methodology (EDPD)

EUniversal addresses the paradigm shift in grid operation to effectively overcome the challenges posed by the energy transition in a cost-effective and inclusive way. EUniversal's structure and implementation rely on the following four pillars: (1) UMEI; (2) flexibility enabling technologies and solutions; (3) Smart Grid Solutions for more flexible and resilient network operation and planning; (4) flexibility market mechanisms, products and platforms. The viability and universality of the concept will be demonstrated in several distinct environments to assess the impact

of flexibility technologies in distribution system operation, the potential of new smart grids services and tools, and to validate the market ecosystem necessary to enabling a proper interaction among all energy actors and fostering the market uptake.

3 UMEI concept

Being the core concept of EUniversal, the UMEI is a modular and adaptable API that works as the link between DSOs and market parties, in coordination with other flexibility users, such as TSOs. This solution aims at defining the rules and routines for the stakeholders to exchange data and services with the DSO (Fig. 1). The approach entails a comprehensive analysis of the energy system characteristics regarding requirements at both sides to implement an effective relationship between them. EUniversal intends to provide further insights on how DSOs and market parties need to communicate to foster the uptake of flexibility in the energy system, considering a close cooperation with TSOs.

UMEI is characterised by the following features:

- *Universality and replicability:* agnostic solution to unlock the flexibility provision regardless of the role of each actor in the system and of the ownership and/or operation of the solutions.
- *Regulation:* better conditions for the evolution of the regulatory frameworks through adjustability and modularity, in accordance with the new energy policies and sector evolution.
- *Supervision:* auditable processes and market mechanisms, giving regulators the capacity to oversee the well-functioning of the markets.
- *Interoperability:* open and standardised interface enabling the communication between entities either in the system operation or market world.
- *Modularity and flexibility:* capacity to modulate different use cases and adapt them to different needs, requirements and timeframes, ensuring that is future-proof.
- *Data provision:* seamless mechanisms to ensure bidirectional (grid and market parties) provision of data and services, independently of the solution providers, and ensuring compliance with cyber-security and GDPR.
- *Regulated and non-regulated activities:* clear separation between regulated and market activities according to the decisions of national regulators and the governance models to be set in place.
- *Market take-up:* development of innovative market services by clearly defining the services and the rules, and by gathering the whole value chain in order to engage stakeholders to succeed in replicating the solutions.

UMEI development and implementation require an open set of business use cases designed to answer DSOs' needs for flexibility, spanning from long-term to real-time operation, ensuring interactions with a solution and market providers, and the cooperation mechanisms with other stakeholders. Furthermore, the use cases need to reflect the different regulatory contexts, particularly, but not limited to, the ones in the countries where a demonstration will take place.

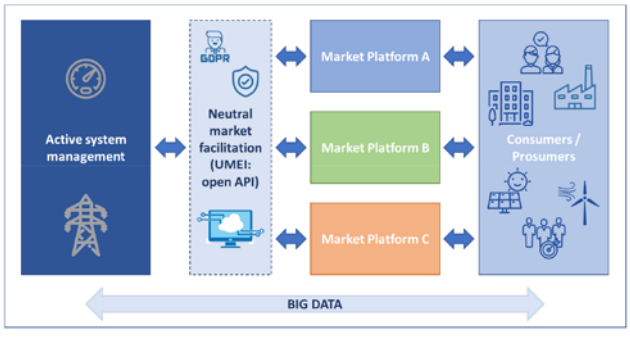

Fig. 1 *UMEI as an extra abstraction layer towards active system management*

4 Flexibility enabling technologies and solutions

To identify which technologies and services are best able to bring flexibility to the DSO EUniversal will follow three steps: (A) development of flexibility enabling technologies DSO toolbox identifying the technologies and systems most suitable to provide flexibility services to the distribution grid and mapping their availability at various grid locations and timescales; (B) link standardised flexibility services with, i.e. product specifications; (C) development of flexibility assessment tools, capable of quantifying flexibility available in the different points of the network to provide the specified services.

(A) The technologies able to bring flexibility (active or/and reactive power) to the network will be identified. The most promising relevant technologies will be taken into consideration. As a result, EUniversal will provide a toolbox with the main attributes of each technology and system for different locations and flexibility needs to be identified by the relevant DSOs.
(B) For the purpose of matching grid necessities with flexibility solutions, it is essential to integrate flexibility as a key resource of future distribution grid planning and operation requires a standardised approach for defining flexibility services, benefiting simultaneously the electricity system and the consumer.
(C) EUniversal will enable the quantitative and qualitative evaluation of flexibility availability for the provision of the standardised services, considering the toolbox previously defined and future network scenarios. A system-level assessment framework for the provision of flexibility services from individual and aggregated distributed energy resources (DERs) will be implemented to assess the contribution of flexibility services. The output of this flexibility assessment will be a techno-economic optimisation framework for the optimal definition of the type (e.g. voltage and congestion management), duration and general characteristics of different flexibility services.

5 Smart grid solutions (INESC)

EUniversal includes the development of novel operation and planning strategies integrating innovative flexibility services, specifically designed for distribution networks operating with a large share of distributed energy resources. The tools to be developed will enable market-driven flexibility services and mechanisms specifically designed for the distribution network and that can be provided by DER, microgrids and energy communities connected to the distribution network.

For the network operation, a multi-level preventive management strategy is proposed to coordinate the operation of flexibility support between low voltage (LV), medium voltage (MV) and high voltage (HV) distribution networks and avoid potential technical restrictions. Based on optimal power flow algorithms, an equivalent *PQ* availability of flexibility per node will be identified – *PQ* maps – at the interconnection point of different voltage levels (including interconnection with transmission networks). The operational planning will be implemented for day-ahead planning of operation and then combined with a distributed control strategy based on a data-driven approach to ensure more effective control of distribution networks close to real time. The distributed control is based on grid segmentation strategies, defining control zones according to the technical problems and the flexible resources available. This concept will also be considered for the implementation of self-healing strategies, where the participation of flexible resources will provide support during service restoration procedures.

The integration of a data-driven approach improves the computational efficiency of more traditional optimal power flow tools enabling its replicability to the distribution.

The long-term impact of flexibility services for distribution grids (e.g. long-term congestion management, extended asset lifetime, voltage control) will be analysed through novel distribution planning methodologies, considering different techno-economic decision-making criteria and mechanisms. A probabilistic approach

in terms of the hosting capacity of the grid will be adopted for integrating DER resources in existing DSO planning tools.

In addition to reliability considerations, the resilience of the distribution network will be proposed as a new metric for power system planning. The impact of new resilience criteria on the decision making will be analysed based on a multi-criteria analysis, considering resilience, sustainability and cost efficiency, for network enhancement. A key challenge and requirement of this novel resilience-oriented planning tool are to first sample the frequency of occurrence and magnitude of extreme events and afterwards model their impact on the risk profile of distribution. Next, the effect of the proposed enhancement solutions on the resilience of distribution networks will be quantified using risk (e.g. the well-established Value at Risk, VaR and Conditional Value at Risk, CVaR, metrics) and resilience metrics, including mainly time-domain metrics for capturing the behaviour and recovery of a distribution network during and following a disturbance (e.g. the FLEP resilience metric system), accounting both for operational and infrastructure resilience. This resilience assessment and quantification analysis will then feedback to the planning, decision-making procedure.

Different resilience enhancement solutions will be considered, including both the traditional distribution network reinforcement (e.g. adding new distribution assets or hardening existing ones) and emerging smart and flexible solutions, including example energy storage systems, DER and microgrids.

6 Flexibility market mechanisms, products and platforms

DSOs can use flexibility for a wide range of activities: connection and access, network planning, operational planning and real-time operation. For the procurement of flexibility, different kind of market mechanisms exist, such as explicit market mechanisms (e.g. procurement via flexibility market platforms) and implicit mechanisms (e.g. dynamic network tariffs, connection agreements, incentives and regulated payments) [1]. Within EUniversal, an assessment will be made of the most appropriate mechanism. This will amongst others depending on the nature of the service, the time-frame of procurement, the envisioned product requirements and the grid conditions (topology, voltage level, grid constraints). One of the challenges to include flexibility originating from demand response is the existence of individual consumer preferences. A methodology for the design of dynamic distribution grid tariffs, as one of the key market mechanisms, will be developed, taking into account individual consumer preferences. Moreover, the evolution towards a more consumer-centric market might require a fundamental shift in the organisation of electricity markets, leading to fully distributed market organisations (peer-to-peer). The impact of peer-to-peer market setting on product specifications and market mechanisms will be examined, in particular taking into account the coordination and information sharing with the DSO.

7 Demonstration sites

7.1 Portuguese (PT) demo

The PT demo will demonstrate the UMEI concept in the management of market-driven flexibility services for LV and MV grids. EDPD will lead the Portuguese demonstrator in different locations across Portugal, ensuring a wide set of scenarios and contexts to demonstrate the novel use cases. The PT demo will make use of the Smart Grid infrastructure currently in operation in Portugal, which comprises, apart from HV and MV levels, more than 2.5 million LV smart meters ready to interface home energy management systems, and over 22 thousand smart secondary substations.

PT demo will set, test and assess the potentiality of the innovative approach to the standard and optimised interconnectivity between grid operators and the different electricity market players. This will be done by connecting the DSO through the UMEI to (i) the two market platforms provided by two consortium partners (N-SIDE and NODES); (ii) residential and industrial customers (including agriculture irrigation systems); (iii) fleet management assets; (iv) MV and LV storage assets.

The PT demo-sites complement each other not only in the scope of the tools and services to be tested, such as smart grid functionalities, congestion management, resiliency, demand-side response, flexibility mapping, amongst others but also by providing an effective mean to demonstrate the universality of the UMEI concept.

7.2 German (DE) demo

The German demonstration aims to utilise flexibilities connected to the LV grid for congestion management and voltage control in LV and MV grids. These flexibilities will be provided via an aggregator and offered to two different market platforms in order to be used by a DSO. For congestion management and voltage control, the DSO predicts the flexibility needs in the LV grid. Additionally, the remaining flexibilities in the LV grid are aggregated at the local substation in order to be used in congestion management and voltage control in the MV grid. This aggregation uses limits in LV grid capacity in order to predict the flexibility potential at local substations as well. If flexibilities are needed in the MV grid, the system developed in the German demonstration is capable of segregating the need from the MV grid to address the offers at the market. The aggregated flexibility potential at the MV level can be used not only in the MV grid but also to support the HV distribution grid and in the end the TSO's EHV grid. From the DSO point of view, the most innovative part is the enhanced visibility of the LV grid and the state estimation with limited measuring points. To use flexibility in schedule-based congestion management, the aggregator needs to define a baseline as a base for the flexibility potential. This baseline will be used for power flow calculation at the DSO and is needed as input for the settlement as well. The schedule-based congestion management at the DSO starts the day ahead, but a satisfying probability of predicted flexibility potential and power flow could be reached only in intraday. Therefore, the horizon of prediction needs to be investigated. In Addition, the German demonstration will not only include generation but also load flexibility in this process. Due to the interdependencies between active and reactive power flow, predictability will be investigated for congestion management and voltage control.

7.3 Polish (PL) demo

An increased number of micro-generation systems (in the case of Polish network – PV installation) can potentially result in the following problems: increase of voltage levels above the admissible values and overloads of network elements (lines and transformers). Improving distribution grid resiliency by innovative monitoring and control devices and integrated tools/systems to support grid operation and planning and new market mechanisms and services incentivising flexibility will assure the energy supply and build a flexible market. The Polish demonstration will be conducted in the northern part of Poland including, in particular, the following areas:

- Local Balancing Area near city Gdansk with well-developed MV grid automation and high number of smart meters, DERs and energy storage;
- selected part of LV network with large shares of variable renewables supplied from selected secondary substation;
- 110 kV network as the source of flexibility services.

The main axis of the Polish demo is:

- Universal Market Enabling Interface.
- Active System Management (AMS) – tools for distribution grid planning and operations support which guarantee the security of

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supply and the use of flexibility products while integrating large shares of variable renewables.

- Flexible Secondary Substation (FSS) deployment – secondary substation for autonomous management of the connected LV network which provides and consumes flexibility grid features. Algorithms for the specified FSS functionality will be developed which can provide and manage flexibility services such as control and monitoring of PV, enhanced observability of the LV network.

8 Conclusion

EUniversal project is a way to connect system operation to flexibility markets in Europe. o projeto irá desenvolver e implementar um conceito inovador de um Interface Universal e Interoperável para articulação das necessidades de operação do sistema elétrico com as ofertas em mercado de flexibilidade, abrindo caminho à definição de soluções que possam vir a ser utilizadas por toda a Europa. The project will develop and implement an innovative concept of a Universal and Interoperable Interface to articulate the electrical system's operating needs with the offers in the flexibility market, paving the way for the definition of solutions that may be used throughout Europe.

9 Acknowledgments

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10 Reference

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