D9.13: Roadmap

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aFRR:	Automatic Frequency Restoration Reserve
BESS:	Battery Energy Storage System
BUC:	Business Use Case
CACM:	Capacity Allocation and Congestion Management
CDPSM:	Common Distribution Power System Model
CGMES:	Common Grid Model Exchange Standard
CIM:	Common Information Model
CM:	Congestion Management
DG:	Distributed Generation
DSO:	Distribution System Operator
DNUT:	Dynamic Network Usage Tariff
DSBA:	Data Spaces Business Alliance
ECCo SP:	ENTSO-E Communication and Connectivity Service Platform
ECP:	Energy Communication Platform
EDX:	Energy Data Exchange
ESMP:	European Standard Market Profiles
EQ:	Equipment Profile
FR:	Flexibility Register
FRO:	Flexibility Register Operator
FSP:	Flexibility Service Provider
HEMRM:	Harmonised Electricity Market Role Model
IACMS:	Integrated Asset Condition Management System
IEGSA:	Interoperable pan-European Grid Services Architecture
IDN:	Intelligent Distribution Node
IDNC:	Intelligent Distribution Node Controller
IDS:	International Data Spaces
IEGSA:	Integrated pan-European Grid Services Architecture
LEC:	Local Energy Communities
MAS:	Modelling Authority Set
mFRR:	Manual Frequency Restoration Reserves
MO:	Market Operator
MOL:	Merit Order List
OWL:	Web Ontology Language
PTDF:	Power Transmission Distribution Factors
PUN:	Prezzo Unico Nazionale
RDF:	Resource Description Framework
RES:	Renewable Energy Sources
SGAM:	Smart Grid Architecture Model
SO:	System Operator
SOGL:	System Operations Guidelines
SSH:	Steady State Hypothesis Profile
TDCPO:	TSO-DSO Coordination Platform Operator
TSO:	Transmission System Operator

EXECUTIVE SUMMARY

The future of the European energy system has embarked into ambitious energy transition targets towards Net-Zero carbon emissions by 2050. Targets that are ratified by several initiatives such as Fit for 55[1] and REPowerEU[2], and oncoming Network Codes and Guidelines on Demand-side Flexibility[3]. This journey has far-reaching implications for the evolution of electricity systems, having at its core the integration of significant shares of renewable energy sources and the decarbonisation of various sectors through sector coupling initiatives.

In this journey, system operators will face new challenges requiring greater coordination and collaboration in the procurement of ancillary services for an effective and reliable operation of the electricity network. Striving for an optimal TSO-DSO coordination, the INTERRFACE project plays an important role aiming to improve cooperation among system operators providing access to services which are commonly beneficial for the secure operation of their systems. Ancillary services have thoughtfully been assessed (under deliverable D 3.1[4]) and tested in the pilot demonstrators. Seeking for a cost-effective operation of distributed resources whilst empowering end-consumers to become active market participants.

In this respect, the goal of the INTERRFACE project is to design, develop and exploit an Interoperable pan-European Grid Services Architecture (IEGSA) to act as an interface among system operators and end-users for the procurement of grid services whilst fostering consumer-centric technologies such as demand response and self-generation.

INTERFFACE Roadmap shapes the vision on how the IEGSA IT platform could become a fully integrated architecture across Europe. This document steers us towards the main bottlenecks that a pan-European IEGSA platform will face in its replicability and scalability pathways. The main objective of this Roadmap is to highlight challenges and outline key recommendations from the standpoint of the IEGSA IT architecture. It is worth mentioning that IEGSA Roadmap elaborates upon its replicability and scalability pathways, where replicability denotes the propagation of concepts tested during the pilot demonstrators and deals with foreseen aspects associated with the procurement of services throughout different grid conditions across Europe. Similarly, scalability refers to challenges linked to the increased scope and volume within which the IT architecture will operate.

This document incorporates key lessons learnt from pilot demonstrators and relevant European projects where synergies with INTERRFACE are found. In this approach, pilot demonstrators and relevant EU projects serve as a foundation (FIGURE 1) for the identification of future bottlenecks in the replicability and scalability of IEGSA. Each challenge is then categorised per dimension which influence IEGSA platform in different ways.

[1] Fit for 55 - The EU's plan for a green transition Fit for 55 | Consilium (europa.eu)
[2] REPowerEU: affordable, secure and sustainable energy for Europe REPowerEU | European Commission
[3] Network Codes (entsoe.eu): https://www.entsoe.eu/network_codes/
[4] INTERRFACE Public Deliverable D3.1 - Definition of new/changing requirements for services: www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.1_V1.0.pdf

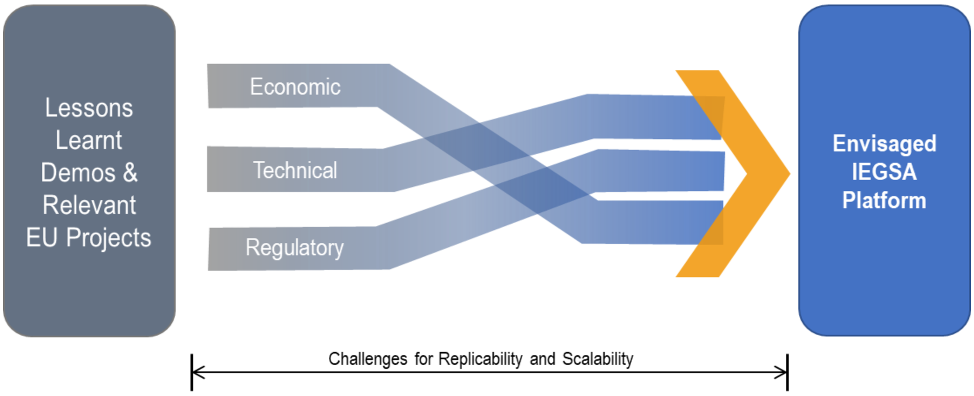

FIGURE 1 : METHODOLOGY - GAP ASSESSMENT

As a summary, all envisaged challenges are classified in three dimensions: economic, technical and regulatory and depicted in FIGURE 2:

FIGURE 2 : IEGSA CHALLENGES CATEGORISED BY DIMENSION

After identifying future challenges for IEGSA, this Roadmap outlines an extensive set of recommendations which facilitates the replicability and scalability roadmap of IEGSA. These recommendations have been consolidated in key messages listed as main footsteps for the replicability and scalability of IEGSA, presented as follows:

I. Further adoption of role description as defined by Harmonised Electricity Market Role Model.
II. Guarantee IEGSA's flexible design, adaptability and robust algorithms coping with future market arrangements.
III. Ensure interoperability by aligning with standarisation activities and initiatives such data space architectures (i.e., GAIA-X, FIWARE, IDSA, DSBA), leveraging approaches for metadata determination and handling.
IV. Integration with distributed data exchange platforms across EU member states and sectors.
V. Consider ICT scalability aspects during the implementation phase of a pan-European IEGSA IT architecture.
VI. Full compliance with existing and future regulatory frameworks.

1 INTRODUCTION

Given the long-term vision and the variety of contexts, it is clear that the future of the European electricity system will require an interoperable architecture which fosters the integration of a wide range of flexibility resources and technologies interacting seamlessly across Europe. Throughout this INTERRFACE project, the consortium has assessed different aspects of a interoperable pan-European architecture. With a holistic vision, different scenarios were studied to envisage future bottlenecks that the Integrated pan-European Grid Services Architecture, namely the IEGSA IT platform, would face at a larger scale. This entails to address to most fundamental challenges to ensure a progressive and secure scalability of the IEGSA platform.

In this respect, this INTERRFACE Roadmap acts as a guidance helping transmission and distribution system operators, and all stakeholders in their decarbonisation strategies by promoting the integration of more flexible means to cope with the needs of a renewable-dominated electricity system. This document guides us towards the main challenges that IEGSA IT platform will encounter on its aim for a fully EU integrated system. To this end, the Roadmap's main objective is to outline key recommendations which will constitute the pathways for replicability and scalability of the IEGSA platform across Europe.

This document also includes key findings and results from INTERRFACE pilot demonstrators and relevant European projects. It provides a comprehensive summary of lessons learnt and synergies for the integration of more low-carbon technologies and flexibility resources. The identification of these challenges and their replicability and scalability pathway considers future system needs that are relevant for all electricity networks and their own local conditions within Europe.

1.1 Purpose and Scope

The main purpose of this Roadmap is to describe current and future bottlenecks for replicability and scalability of IEGSA. By replicability and scalability, the document refers to the increased scope in which the IT architecture will operate, suitable for all local conditions throughout Europe. Thus, challenges and recommendations are strictly described from the standpoint of the IEGSA IT platform.

It is worth mentioning that the Roadmap elaborates upon its replicability and scalability pathways, where replicability denotes the propagation of concepts tested during the pilot demonstrators and deals with foreseen aspects associated with the procurement of services throughout different grid conditions across Europe. Similarly, scalability refers to challenges linked to the increased scope and volume within which the IT architecture will operate.

1.2 Structure of the Document

The first two chapters of this Roadmap describe the purpose of the document and provide an introduction to the IEGSA IT platform outlining the current layout and purpose design of the IT architecture. In chapter 3, an overall description of the methodological steps and a gap assessment is presented as well as a link to the pilot demonstrators and relevant European projects where synergies are found with the INTERRFACE project.

Chapter 4 focuses on the lessons learnt from demonstrators and other EU projects. It includes a summary of main outcomes which are relevant for the replicability and scalability of IEGSA. Chapter 5 presents a qualitative gap assessment starting from the lessons learnt towards the envisaged IT architecture suitable for a full pan-European system. Gap analysis highlights the main challenges that IEGSA will be encountering, which are classified in three main categories: technical, economic and regulatory.

Chapter 6 describes the main replicability and scalability pathways which are composed by key recommendations tailored for IEGSA IT platform replicability and scalability.

2 IEGSA PRODUCT DESCRIPTION

The IEGSA platform is developed by the INTERRFACE project to perform as a common platform to connect multiple actors such as Market Operators, Systems Operators (i.e. TSOs and DSOs), Flexibility Service Providers (i.e. Balance Service Providers or Aggregators), Settlement Responsible Parties, along various electricity markets focusing on providing support on the procurement of services (such as balancing, congestion management and ancillary services) from assets connected to the network both at transmission and at distribution level, in a coordinated way, implementing multiple coordination schemes between TSOs and DSOs. Therefore, IEGSA provides a channel that establishes the seamless coordination among system operators towards their efficient communication on procuring network services by enabling flexibility from all levels. The increasing participation of stakeholders (i.e., providing or trading available flexibility), implies the need for an interactive channel to allow the secure information and data exchange, requirement which is well addressed by IEGSA platform.

IEGSA proposes a modular architecture platform which enables the data exchange with existing hubs in Europe, enabling the interconnection of different actors such as TSOs, DSOs and other market participants or customers connected to the system. The conceptual and logical architecture design of the IEGSA platform essentially allows the facilitation of interactions among system operators as well as flexibility providers. Therefore, IEGSA comprises a data exchange platform enabling the digitalisation of the energy value chain ensuring data security and privacy requirements by-design. Particular effort is given to engage flexibility services from multiple types of Balancing Service Providers, and facilitating access and interconnection with various market platforms, covering different timeframes, enhancing also the coordination among TSOs and DSOs with the introduction of standardized services and market designs. IEGSA platform encompasses advanced tools and technologies as a matter of integrating multiple actors and systems to serve various business requirements focusing mainly on the flexibility procurement in a coordinated way among TSOs and DSOs. The logical and conceptual technical composition of IEGSA platform is demonstrated in FIGURE 3.

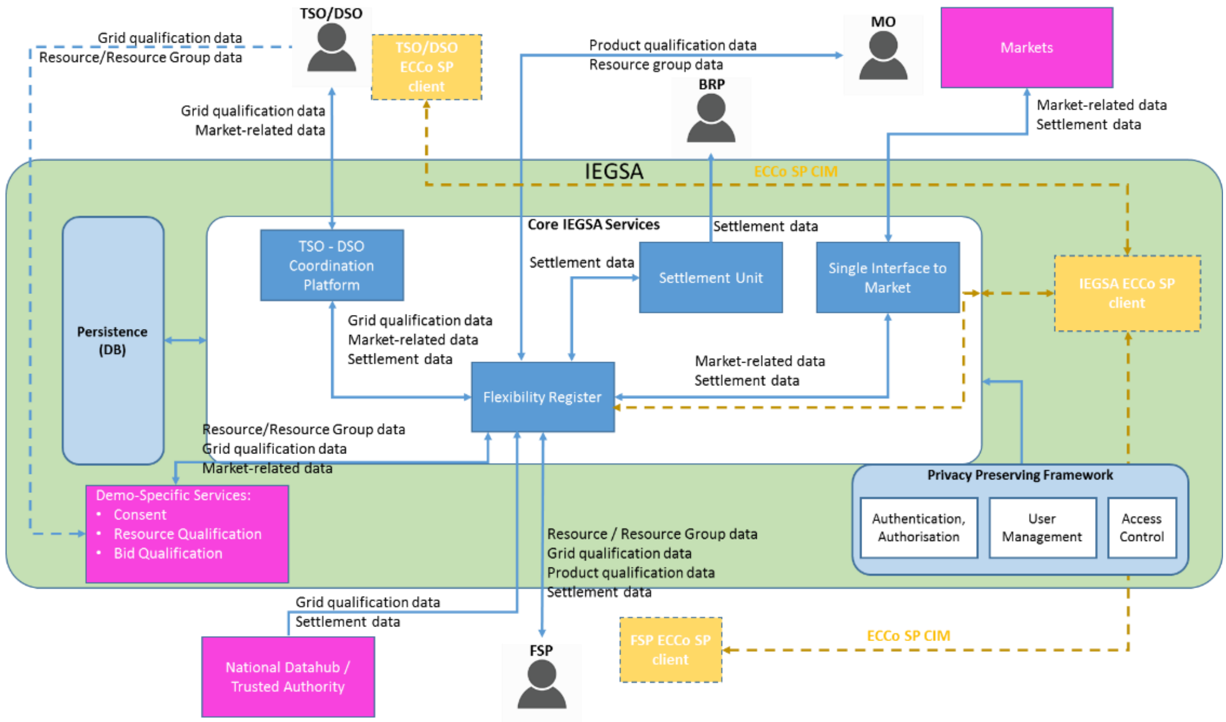

FIGURE 3 : IEGSA ARCHITECTURE

IEGSA's design follows the Smart Grid Architecture Model (SGAM) Framework and has been implemented in its different layers, so-called business, function, information, communication and components layer, respectively. The combination of the communication, information and function layers acts from a technical standpoint as the middleware between the Business Layer with the needs of users and their BUCs (Business Use Cases); and the Component Layer, where the demo specific implementation meets the business layer requirements.

There are four main functional blocks that lie in the architecture which follow a modular approach to integrate complementary services and functionalities within the IEGSA framework. Those functional modules -illustrated with blue boxes in FIGURE 3- are the following:

- **Flexibility Register (FR),** acting as the core component; processes that are performed within this module include: user management, resource/resource group registration, interaction with consent manager, product definition, trigger of product, grid and bid qualification. FR module can be accessed by all users of IEGSA such as Flexibility Service Provider (FSP), Market Operator (MO) and the System Operators (SOs). Each of them has different rights when accessing it. Several user interface functionalities reside in FR to ease resource registration (i.e. view and update existing, add new), resource groups definition (i.e. view and update existing, add new), qualification status tab (preview resources and resource groups qualifications status), product definitions and product qualification requests.
- **TSO-DSO Coordination platform** which essentially is the module that enables the coordination among SOs. Therefore, this module interacts with the bid and grid qualification services and market-related processes (e.g. merit-order list documents) via the flexibility register. Subsequent UI functionalities are implemented to support SOs to view resources and resource groups. Regarding resources the SOs may proceed with changes on the qualification status. A dashboard for the merit order lists of all IEGSA integrated markets is also available for SOs which also may allow the activation of certain bids directly from IEGSA. Activated bids can be previewed on the "Trades" environment of TSO-DSO Coordination platform.
- **Single Interface to Market** is essentially a backend component that acts as the gateway to connect energy markets with IEGSA, essentially allowing the exchange of market related data. The Single Interface to Market is essentially a set of standardized RestAPIs, which handle the communication of IEGSA with the various markets that it is connected with. This component lies on the back-end and there is no dedicated User Interface. The APIs that comprise the Single Interface to Market are responsible for the transfer of data that facilitate all the processes in IEGSA that surround the market integration. The scalable and standardized design of the APIs allows the agnostic connection to different market platforms and the seamless data exchange. Thus, IEGSA can exchange bids, Merit Order Lists and Activation Orders with all interconnected market. The connection to different markets gives a more holistic overview of the available offers and bids to the System Operators, allowing the more efficient and secure grid management.
- **Settlement Unit** which performs the energy settlement of all trades. The FSP may upload documents related to metered and/or sub-meter readings along with activated volumes for all the metering points affiliated with the particular resource object for all metering points.

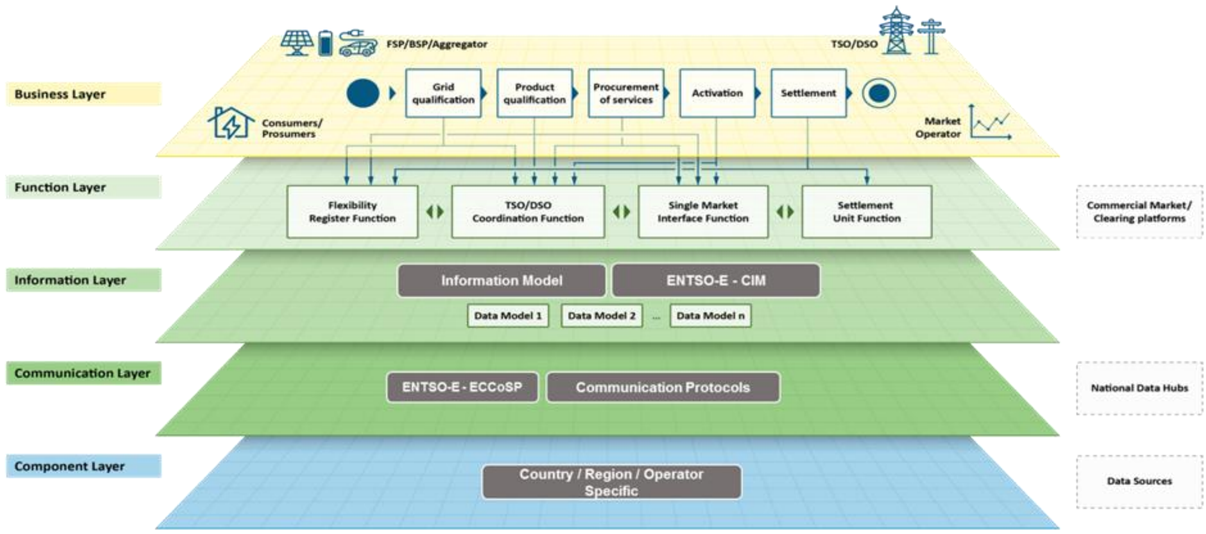

FIGURE 4 : SGAM-BASED IEGSA ARCHITECTURE

2.1 Needs and Challenges

In modern power systems it is important to enable the network operators to procure services (such as balancing, congestion management and ancillary services) from assets connected to the network both at transmission and at distribution level, in a coordinated way. This will in turn enable more efficient and effective network management and optimisation, for the benefit of increased demand response and the ability to integrate increasing shares of renewables. The same pool of resources will be used by Transmission System Operators (TSOs) and Distribution System Operators (DSOs): actions by either grid operator can mutually affect each other. To achieve this there is need to allow seamless and secure data and information exchange among multiple stakeholders that are involved in the energy value chain. IEGSA is designed to provide support and streamline grid qualification, product qualification, procurement, activation and settlement processes. Given this the following functionalities are proposed in IEGSA to address those challenges, in line with the Active System Management report[5], as follows:

- Common (for TSOs-DSOs) grid and bid qualification algorithms, structured views for Merit Order List and Trades,
- Direct bid activation of bids from TDCP,
- Flexibility availability, which is reported on the Flexibility Register,
- Product qualification (including potential need for product re-qualifications when resources/resource groups are modified),
- Interoperability of tools such as Ecco SP and estFeed for data exchange,
- Data standardisation among actors (ESMP, CGMES, CDPSM)

2.2 Assumptions Towards IEGSA Implementation

The design and implementation of IEGSA platform aims to address the Business and System Use Cases that have been formulated within INTERRFACE, towards the creation of a pan-European standardizable IT architecture which was extensively used for the procurement of flexibility products and services. Nonetheless, due to IEGSA testing in several different pilots with broader scopes, certain assumptions were made in the development as follows:

[5] https://www.entsoe.eu/news/2019/04/16/a-toolbox-for-tsos-and-dsos-to-make-use-of-new-system-and-grid-services/

- All data exchanges are primarily served utilising CIM data profiles based on European Standard Market Profiles (ESMP); in certain cases, custom profiles or customisations of standard profiles were adopted in order to address the demo needs. Therefore, the wider utilisation of IEGSA would involve an update of its APIs to be fully compliant with IEC CIM data profiles for all business processes. (CGMES/CDPSM could be utilised in an extensive adoption of IEGSA).
- Partial bid activation of congestion management bids can be performed directly via IEGSA TDCP module. The simplification applied hereby, refers to the fact that partial activation and divisibility characteristics are not supported by CIM profiles so custom adjustments were performed.
- Settlement process does not account implicitly for sub-metered data and baseline reports. More specifically, the priority was put to a method where the actual flexibility is calculated from the average measurements between the activation period and the previous hour. It turned out to be too simplified a method and posed insurmountable challenges in situations where behaviour of a resource in the previous hour was not even close to normal. This is the case, for example, when activation takes place during two consecutive hours. Therefore, implementation of a more advanced baseline method would have been the preferred way to go.
- Flexibility Register might have direct connectivity with resources so that updated technical information (e.g., actual max up/down regulating power) that are essential for flexibility availability reporting can be automatically updated.

3 REPLICABILITY AND SCALABILITY METHODOLOGY

3.1 Methodology Description

Replicability and scalability of the IEGSA platform is a key aspect for the large-scale deployment of Interoperable Grid Services at pan-European level. The successful display of pilot demonstrators may not ensure that the IEGSA platform will have a sufficient performance level in a larger scope with different boundary conditions. Thus, it is fundamental to extrapolate the understanding gathered by the pilot demonstrators into a larger pan-European system to identify challenges and bottlenecks that play a role in terms of IEGSA replicability and scalability.

In the scope of the INTERRFACE project, a three-step methodology approach has been developed to identify the pathways for the replicability and scalability of the IEGSA platform. The methodology is depicted in FIGURE 5, illustrating a process flow and description of the methodology steps.

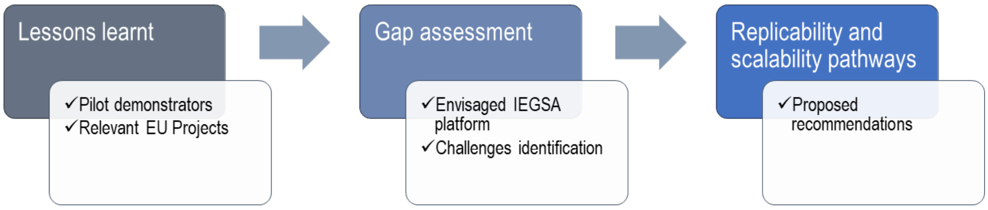

FIGURE 5 : METHODOLOGY PROCESS FLOW

As depicted in the above figure, the replicability and scalability methodology comprise three steps:

1. <u>Lessons learnt</u>

   The starting point in the methodology is to compile relevant outcome information from the pilot demonstrators which were helpful to envisage the feasibility and usability of IEGSA in interaction with distributed flexible means in a variety of contexts and conditions. Also collecting lessons learnt from other relevant EU projects addressing the needs for increasing flexibility in the power systems through centralised platforms. In this section, important outcomes are highlighted from both demonstrators and other European projects where synergies can be used in benefit of the replicability and scalability of IEGSA.

   The following is an introduction to pilot demonstrators conducted during the INTERRFACE project:

   - Asset-enabled Local Markets:
     Automated marketplace for local electricity transactions and an integrated asset-management system. The goal of this demo is to incentivise the participation of low- and medium-voltage grid users providing market access to local communities while supporting congestion management and reliability of supply at distribution level.
   - Blockchain-based TSO-DSO flexibility:
     Pilot demonstrator aims at creating an intelligent platform (EFLEX) with blockchain-based technology to allow trading of flexibility services among prosumers and system operators (TSOs and DSOs). It adopts blockchain technology as a mean for secure, reliable and transparent cooperation and information sharing. A flexibility market prototype is tested with blockchain based, smart contract and smart billing system to expand opportunities for market participants to be part of balancing and flexibility markets.
   - DERs into Wholesale:
     The objective of this demo is to create a methodological framework, integrating the Day-Ahead Market (DAM) model with the Balancing Energy Market (BEM) model, while including the

participation of DERs taking into consideration forecasting outputs for PV, wind, and demand forecasting tools. Pilot demonstrator focuses on simulating uncertainty parameters such net demand, CO2 price, natural gas price, and interconnection capacities under low, medium, and high conditions. 81 scenarios were tested on three different market design options, as follows:

a. *Market design #1 | No TSO-DSO coordination:* Distinct requirements for operational congestion management services at both TSO and DSO levels. In both cases, these are treated as mFRR services.

b. *Market design #2 | TSO-DSO coordination – Integrated Operational congestion management services at both TSO and DSO levels:* Integrated TSO's and DSO's requirements for operational congestion management into a shared requirement.

c. *Market design #3 | TSO-DSO coordination – Integrated mFRR and Operational congestion management services at both TSO and DSO levels:* mFRR and operational congestion management requirements at both TSO and DSO levels are integrated into a shared requirement.

- DSO and Consumer Alliance:
  Pilot demonstrator aims at maximising the potential of distributed energy resources with the integration of large- and small- assets, battery aggregator and local energy communities (LECs) in interaction with local DSOs. It does this by using the IEGSA IT platform to monitor and handle local flexibility resources -owned by FSP- to mitigate grid congestion and enhance quality of supply of distribution networks. Demonstrators established three Business Use Cases aiming at providing flexibility for short-term congestion management, optimising the use of battery storage and demand response, and increasing microgrid flexibility to maximise self-consumption of local RES and reduce reverse flows into the transmission network.

- Intelligent Distribution Nodes:
  Demonstrator enables distribution connected costumer to optimally manage their energy portfolio, while actively participate in system flexibility service provision. This demonstration employs an Intelligent Distribution Node Controller (IDNC) to support Balancing Responsible Parties (BRP) in the provision of grid services to SOs. This IDNC interacts with Battery Energy Storage System (BESS), PVs, EV-chargers, and the conventional demand of a multi-user building for the procurement of balancing and congestion management services at both distribution and transmission level. Several uses cases have been tested in the provision or services ranging from ERMS, aFRR, mFRR and CM in combination with different prices schemes (hourly spot price and flat price). This pilot demonstrates the interoperability of Intelligent Distribution Node (IDN) with other digital assets in the network and used IEGSA IT platform as a key resource to centralise information flow for all stakeholders involved.

- Single Flexibility Platform:
  Demonstrator exhibits an efficient allocation of flexibility resources by a common flexibility market used by system operators (transmission and distribution). Pilot further elaborates on cross-border processes, models and solutions for balancing and new congestion management markets, fostering the collaboration of market participants such as Flexibility Service Providers with Market and System Operators in individual marketplaces. The IEGSA platform plays a crucial role automating specific processes such as bid qualification and settlement with the usage of locational bid information. The demonstrator is comprised of six use cases which examine the performance of various products for congestion and frequency management in different system conditions.

- Spatial Aggregation of Local Flexibility:
  Demo focussing on a wholesale market design which includes geolocational information to enable the collaboration of participants regardless their size. Refined spatial dimensions are introduced

into the existing wholesale market design with a holistic mathematical formulation for optimal market outcomes and optimal use of local flexibilities –based on the pan-European day-ahead energy market coupling's EUPHEMIA model – has been developed and configured to suit the demonstration's requirements.

In addition, some relevant EU projects have been identified where synergies with INTERRFACE as follows:

- EUSysFlex:
  Project assesses the pan-European power system under ambitious renewables scenarios (>50% renewable integration) and identify technical scarcities within each system condition. The project's aim is to propose recommendations for grid infrastructure, smart flexible technologies and market enhancement improving the readiness of the electrical system. Same as for INTERRFACE, this project also focuses on the benefits of improved TSO-DSO coordination to optimise accessibility and utilisation of system resources.
- CoordiNet:
  The primary goal of this project is at demonstrating how TSO-DSO coordination can provide favourable conditions to enable the increased participation of customers and small market participants connected to distribution networks. It also defines requirements for the development of standard European platforms helping the scalability of tools and define common methodologies for grid operators and flexibility service providers.
- OneNet:
  Aiming at creating a fully replicable and scalable architecture, this project enables the pan-European electrical system to operate as a single system allowing the participation from small to large stakeholders regardless their physical location. OneNet project intends to develop a customer-centric approach for grid operation where new grid services foster the participation of demand response, storage and distributed generation in a transparent and optimal manner.
- TDX-ASSIST:
  In this project the goal is to design and develop novel Information and Communication Technology (ICT) tools and techniques in a scalable information system where system operators could exchange data safely. Same as IEGSA, the project focus on a scalable solution where new users and large volumes of data is exchanged based on current and future smart grid ICT standards.

As mentioned in previous sections, these projects share similar goals and challenges as the INTERRFACE project, aiming also to provide a strong guidance to meet net-zero European targets. The solutions given by these projects have features that could potentially enhance or partly cover functionalities defined in IEGSA, hence the relevance as a starting point for the replicability and scalability of the IEGSA IT platform.

2. <u>Gap assessment</u>

In line with the project objectives, the present methodology relies on the comparison of the lessons learnt from the previous sections with an envisaged IT platform infrastructure relevant with congestion management and flexibility across Europe. For this purpose, a qualitative gap assessment is performed between the lessons learnt from pilot demonstrators plus relevant EU projects, with the IEGSA platform, mapping where IEGSA plays a crucial role as enabler for future flexibility services. Key aspects are then classified in three main dimensions economic, technical and regulatory (FIGURE 6).

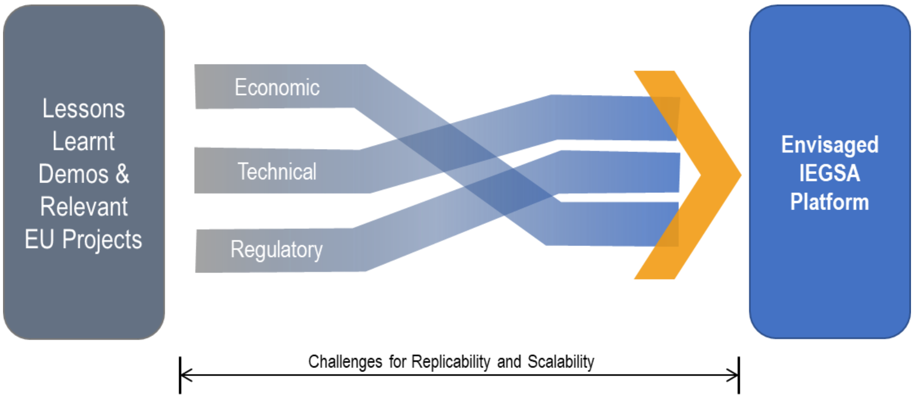

FIGURE 6 : METHODOLOGY - GAP ASSESSMENT

3. Replicability and scalability pathways

The final part of this methodology is to propose key recommendations on the set of challenges identified in the gap analysis. Recommendations outline the pathways for a successful replicability and scalability of IEGSA platform across Europe.

These proposed recommendations are based on three main dimensions involving economic, technical and regulatory aspects. Such categorisation reflects the framework in which persisting challenges shall be addressed.

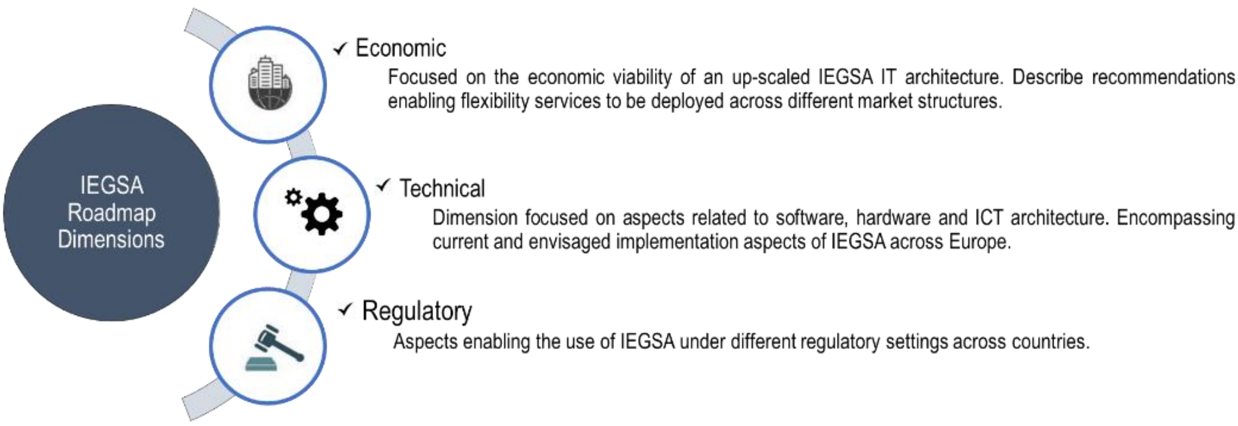

FIGURE 7 : ROADMAP DIMENSIONS

4 LESSONS LEARNT FROM PILOT DEMONSTRATORS AND HORIZON PROJECTS

4.1 INTERRFACE Pilot Demonstrators

1. Asset-enabled Local Markets: As described above, the aim of this demo is to create an asset-enabled local electricity market which considers distribution grid's state during the trading process and facilitates transactions beneficial for the reliability and security of supply. To this end, a simulated local Peer-to-Peer (p2p) market operating on real metering and grid data enables consumers to buy electricity from other local parties regardless their local utilities/supplier. Also supporting the exchange of energy of grid users having small RES-production units with other parties in their local network. Local market aims at minimising undesired effects of local grid transactions by the application of Dynamic Network Usage Tariff (DNUT). Congestion management through DNUT reduces tariff on local transactions to solve congestions locally in benefit of network flows.

   In addition, pilot uses additional grid information from an Integrated Asset Condition Management System (IACMS) which constantly monitors critical network elements and provides real-time estimations about their actual loading levels. This approach helps both solving congestions and reducing network losses while contributing to the voltage stability of the distribution grid. The following are main lessons learnt out of this pilot demonstrator:

   - The provision of data, particularly network data is fundamental for system operators to control and coordinate their actions. At European level, it is conceived that in the future several local P2P markets will be established and therefore, system operators (TSOs and DSOs) will require a single interface (IEGSA) for the optimal exchange of grid information, and towards other market parties as well. Network data exchanges not only for the efficient allocation of market exchanges but also related to topological changes in the grid which should automatically be handled by IEGSA.
   - Currently, several DSOs have their own "sign-in" web-based solutions. This helps the effective communication between grid users and local DSOs. Simulated P2P market also employs user interface where the local market platform acknowledges or refuses user registration. Registered users are recognised through his grid connection point and other data. The verification process is based on a database provided by the DSO as part of the initialisation step listing grid users with connection points and other parameters stored in the flexibility register of the IEGSA platform. On a larger scale, flexibility register should be capable to handle significant amount of grid users with sufficient efficiency and security levels.
   - Distribution system operator will also share metering data through IEGSA within which historical metering data should remain available for post-operational evaluation. In addition, market results shall also be forwarded to IEGSA, and stored in the flexibility register for the settlement process as well.
   - There should be a level of communication of real-time data implemented by IACMS between IEGSA towards relevant distribution system operators. This to ensure an automated and proper representation of the network condition in the marketplace.

2. Blockchain-based TSO-DSO flexibility: As described above, this demo focuses on developing a marketplace platform in a decentralised way to solve congestion issues in the grid and improve coordination between TSO and DSO. Some key lessons for a pan-European platform like IEGSA which aims to improve the coordination between various actors in the electricity grid would be:

- With the increasing climate risk and higher electricity cost people are transitioning to renewables and clean local energy. To meet the demand for renewable energy there is a need to accommodate decentralised energy system which comprises the energy produced from DER's. To support such a system and improve the coordination between the actors involved, a platform like IEGSA plays a crucial part in helping achieve this transition.
- The role of DSO's has changed considerably with the arrival of renewables and smart grid technologies. First, some of them have to manage local markets in the distribution system level and second, handle the data received from smart meters and utilise them for the purpose of forecasting, risk management, scheduling and planning of distribution systems. DSO's will benefit from the successful deployment of IEGSA interface which addresses the above-mentioned challenges.
- IEGSA's integration with several other marketplaces and platforms makes it a central hub which promotes data transparency and flexibility. The interoperability enables reusing modules. With this approach there will be less intermediaries and more market participants which eventually leads to lower energy costs.
- The technology platforms need to be updated regularly with every new change or release. It is necessary to keep up with the rolling changes since they come up with performance improvements and bug fixes. Every functional block integrated to IEGSA has its own technology stack and the modular approach helps for seamless upgrades. The modular architecture not just helps with efficient updates but plays a major role in scaling.

3. DERs into Wholesale: As described above, the aim of this pilot demonstrator is to develop a systematic modelling framework for the optimal operation of both DAM and BEM, including the participation of DERs in both energy and ancillary services provision. Initial DAM's input data uses demand and RES forecast as well as market participants' adopted strategies. After DAM model's successful execution, the model determines initial energy market schedule, cross-border electricity flows, and resulting electricity price in each bidding area. Later, based on forecasting updates (demand and RES-infeed) plus newly submitted bids for the balancing market and thermal units' techno-economic data; the balancing market model determines the optimal balancing energy and reserves scheduling.

   For the participation of DERs, demo considers Energy Storage Systems (ESSs) in the form of batteries, Electric Vehicles (EVs), and Demand Response Programs (DRPs). Whereas balancing products include: (i) upward and downward balancing energy, and (b) several types of reserve capacity, including upward and downward FCRs, aFRR, and upward (spinning and non-spinning) mFRR, as well as upward and downward congestion management capacity at both TSO and DSO levels. The following points are main lessons learnt out of this pilot demonstrator:

   - Pilot has demonstrated that there is a high potential for DERs participation in energy and reserve markets in high-RES power systems due to the significant flexibility capacity. Still, an increased DERs participation at a pan-European level -having different technology requirements and applications in the provision of flexibility- will potentially require harmonised product definitions and effective interoperability among different markets to unlock DERs full flexibility potential.
   - On the other hand, dispatchable generation could also help in the provision of balancing and congestion management services, as well as smoothing extreme fuel prices fluctuations. The challenge for IEGSA replicability would be to accommodate whatever type of technology as per the generation/flexibility portfolio exists at different network locations. To this end, harmonised rules for aggregation should provide an effective way to cluster flexibility means for the optimal provision of services to System Operators.

- Additionally, during this pilot extensive modelling and computational efforts were required. In terms of IEGSA scalability, computational performance and data handling capabilities should be carefully considered, as operational processes will compute significant amount of data.
- Finally, data transparency requirements should also be defined ensuring optimal interaction among ENTSO-E Transparency Platform and other bodies in order to provide transparent and predictable information for current and future flexibility owners.

4. DSO and Consumer Alliance: As mentioned, this demonstrator seeks to maximise DER full usage potential and integration into the flexibility and ancillary service markets. IEGSA IT platform serves as an interface between local DSOs and FSPs municipal mini-grids with substantial shares of non-programmable RES and DG plants. Some of the key lessons drawn from this pilot demonstrator are:
   - Product definition: Under a highly interactive system integrating several flexibility technologies with different technical parameters, it is crucial the MOs define and harmonise product requirements (e.g. minimum capacity, response time etc) for resource groups having diverse portfolio mix and patterns depending on their local conditions. For IEGSA this is a challenge in the integration of several technologies in one single marketplace. Having sufficient flexibility to incorporate flexibility resources with very different technical requirements. In particular, the use of IEGSA to manage local energy communities as FSPs demonstrate the difficulty to consider Local Energy Communities as potential market operator/FSPs in the market. Indeed, Product definition is usually difficult, especially when residential users are involved, since minimum capacity requires the involvement of a huge amount of flexible resources (at final users) who must be also coordinated. For this reason, the main lesson learnt is that, even if IEGSA IT platform has been successfully used for product definition of local energy communities, it is difficult to set a market for flexibility achievable by LECs.
   - Harmonised data exchange: It is envisaged that in a larger scope, IEGSA will have to interact with significant number of FSPs which should manage their own portfolio and resource groups, as well as provide the correct information for IEGSA optimise their usage and flexibility allocation. Whenever a flexibility resource has upgrade/degrade its installed capacity, or is on partial maintenance, or decommissioned; FSP shall have precise information about updates and status of all their flexibility resources and consistently provide data to IEGSA that can be used by DSOs. For this reason, criticalities can emerge when dealing with small prosumers in local energy communities; in which the precision of information requested can be insufficient.

5. Intelligent Distribution Nodes: As described above, this demo developed an innovative IDN's cloud-based platform to ensure the interoperability with other digital assets such as IDNC. This cloud-based platform included operational user-interfaces for different IDN users, encompassed a portfolio of task-based applications capable of computing high-level algorithms for calculating optimal operation schemes for the IDN, managed the bid-data within the IDN data space, and orchestrated the interaction of all the system processes from the interaction with the IDNC to enabling the link for the Interoperable pan-European platform for the INTERRFACE project (IEGSA). While the IDN demonstrator developed and deployed innovative technology at both physical and artificial intelligence levels, key lessons learnt derived from this pilot are listed as follows:

- Flexibility products and regulatory framework. As mentioned, this pilot has been developed in Sofia, Bulgaria where the IDN technology controls a portfolio of energy assets in a distribution connected multi-user building. While the IDN has proven to successfully provide ancillary services to both DSO and TSO, the product definition of these services as well as the regulatory guidelines for their provision are yet under development with this jurisdiction. Hence, IEGSA (as leading pan-European level platform) will require continuous evolution to be able to adapt to ongoing developments at regulatory levels for balancing and congestion management provision.
- Although the IDN successfully provide balancing services to the TSO (aFRR and mFRR), it is recognized that isolated distribution assets (or when dealt in small scale) represent little impact to no impact to the overall power system. In this context, aggregating schemes are key to enable a satisfactory integration of distributed energy resources into transmission level ancillary service markets. IEGSA, as centralised channel for all stakeholders, will require the addition of aggregating roles for stakeholders encompassing a large number of IDNs.
- One of the features developed within the cloud-based IDN platform is the management of the IDN data space. This data space offers immense opportunity for system operators, specially at distribution level, to learn from consumer/prosumer behaviour. In coming years IEGSA will require additional efforts, hand to hand with system operators, to outline relevant data packages to be extracted from customers which will be characterized and categorized as new products to be acquired and in turn new economic opportunities to be explored.

6. Single Flexibility Platform: As described, this pilot demonstrator exhibits a trading-based optimisation of grid resources among system operators and other flexibility owners in a transparent and cost-effective manner. Some of the important lessons learnt when it comes to IEGSA replicability and scalability are:

- Products and markets used for trading need sufficient alignment with the current ones. This seems feasible based on the demonstration results. Adding resource information to current products and integrating them to the IEGSA process. On a scalable IT architecture, further alignment on product definitions and market interoperability will be required.
- The process of utilising grid data as part of the flexibility trading is crucial to handle both flexibility needs and constraints in the electricity network. This hinges on the network data that is exchanged through IEGSA including a common observability area which should accurately represent the state of the electrical network with an optimal level of granularity. Too granular data has redundant content which can make the process heavy, even more when interacting at pan-European scale. This includes additional development to offer FSPs a transparent view to system operator’s flexibility needs, so that they could built their flexibility portfolios in areas where flexibility needs are high.
- Adequate management of market data relates to the administration and exchange of sufficient information from all market parties, flexibility service providers and their portfolio of flexibility resources. The exchange of necessary information is key to optimise resource allocation and to avoid overlapping of products, helping to the procurement of services by the SOs. In this sense, it is crucial to have sufficient TSO-DSO coordination to maintain liquidity of the markets without fragmenting them.
- Flexibility Register stores resource spatial information and this, when combined with grid and bid data, enables system operators to procure flexibility from right locations. The included metering point information enables IEGSA to connect trades with interval metering data for

verification and settlement. In the future, improved data standardisation will support the addition of relevant spatial information in the data exchange process.

- During the demonstrator it has also been encountered many aspects related to the interaction of FSPs in the market. Building flexibility portfolios is one important aspect, but more challenging is that FSPs need to offer their flexibility from the right location in the right time. This requires for FSPs to be able to estimate how much flexibility is available when the need comes. To this end, there is a fine balance between allowing the SO to procure with very high granularity on a single resource level, and the FSP's possibility to offer from a portfolio and manage its own risks - avoiding non-delivery penalties.
- The envisioned further development of common procurement of flexibility resources by TSOs and DSOs relies on how well operators can identify the common needs for flexibility. For a scalable IEGSA IT platform, an indirect aspect is the improvement of system operator's forecasting and uncertainty management capabilities. So that they can procure flexibility in advance, at the right time, and with correct volume to solve the congestions with sufficient level of confidence. Market performance -and inherent IEGSA's performance- will depend on the accuracy of which needs and flexibility resources availabilities are predicted close-to-real-time.
- Lastly, it has been recognised that the modularity of the IEGSA supports progressive deployment of the common flexibility platform. This flexibility facilitates to the deployment of a common pan-European platform as the needs for frequency and congestion management will emerge at different paces depending on the local grid conditions.

7. Spatial aggregation of local flexibility: As described in previous chapter, the method to include spatial dimension and the resolution of the spatial dimension has been selected. Zonal representation is favoured to align the market algorithm to the existing EUPHEMIA-type market optimisation algorithm. Thus, it is more applicable for the European market setting instead of nodal congestion management. So, the resulting single market framework is sensible and intelligible for all market players and includes the SO specific short-term and operational congestion management services with well-known energy trading auctions.

   The spatial aggregation market is positioned around the intraday timeframe. Flexibility is defined in twofold: first, local DSO-specific flexibility capacity demand is defined as an mFRR-like (12,5 min full activation time) capacity product. And second as a short-term, energy product with 15-min. time resolutions both on different network and/or power system levels. This helps mitigating balancing costs and allowing pricing of internal congestions according to the corresponding Capacity Allocation and Congestion Management (CACM) network code requirements, also applicable after the day-ahead timeframe. Shadow prices to determine order clearing prices are used to solve grid-related constraints regarding flexibility sources on the DSO level which is then demonstrated by simulation. Effects of DSO usage of such resources on bidding zone market outcomes are also simulated, including the introduction of PUN-type (Prezzo Unico Nazionale – Single National Market Price) cost-averaging pricing for the distribution of flexible capacity procurement costs. Important lessons learnt for the IEGSA replicability and scalability are:

   - The benefits of such approach for spatial aggregation of local flexibility include distribution of costs incurring from local flexibility procurement: PUN pricing is extended to have energy and flexibility capacity products. The IEGSA platform accelerate and open the possibility for different scales of aggregation. This IT platform supports different market participants to easily access the market. The single framework combines energy-only participants, TSO, DSO and local flexibility providers in a holistic market approach. As the framework is derived from the existing market models, it consists of multiple evolutionary additions to the existing TSO-level intraday auctions.

- The resulting market model is tuned to incentivize local flexibility by enabling local participants to bid on a connected TSO-DSO market. The connection of the global-TSO and the local-DSO dimension and the joint allocation of energy and local flexibility provides proper price incentives through coupling different slices of trading. This is done first by the grid prequalification step and after through the bid qualification before the matching algorithm execution. The harmonisation is based on the flexibility register where common data structure is required. With this IEGSA based approach, a single solution is applied to the various grid users and system operators to register themselves to the market. Price incentives are aligned, as multiple stakeholders observe single energy and capacity prices, according to their location expressed into various congestion zones. Harmonised products for different services should deliver proper alignment of the market flexibility resources cleared thus committed at the same timeframe, for the same delivery period.
- According to the stakeholder needs, the market provides short-term congestion management services as its primary grid service. Also, this intraday auction-based platform provides an opportunity to trade energy in a finer, 15-min. time granularity (that allows BRPs to mitigate balancing cost) while allowing pricing of internal congestions according to corresponding CACM Network Code. In terms of IEGSA replicability and scalability, careful consideration should aim for optimal data granularity and efficient interaction with other markets.
- In the pilot, IEGSA works as a container application that is deployed to a local machine. To connect to IEGSA, the demo application needs to be started in interactive mode. The GUI is active during the bidding period. Order files can be uploaded via the "Load order file" or to an open OneDrive folder regularly polled by the application while new orders are registered each time a new file is uploaded. Every order passed to the application is sent to IEGSA for prequalification and then a static validation is run locally. The results of the prequalification process are then written out into the validation field of the order file; this way, the uploader can get feedback on the prequalification. Valid orders are then saved for later processing. The challenge foreseen for the scalability of IEGSA is the automated, continuous and stable operation of the platform. This relies on the harmonisation of data formats (which may differ depending on the local regulations), the expected computational capacity (handling significant amount of data) and finally harmonised market specifications such as products, services, timing and identifiers that are currently not fully harmonised for local flexibility markets.
- Out of this pilot, it is considered that the zonal approach is the preferred way in the European markets. The spatial aggregation of local flexibility shall consider this method, even in the case of DSO constraints, as a possible, manageable, gradual development of the wholesale market. With the spread of distributed energy sources, this uniform pricing approach does not lead to the desired, market-based functioning of short-term trading, as the socialisation of the network constraints through system usage tariffs lead to inefficient incentives in market prices. It is seen that exact congestion locations vary frequently. Thus, the application of zonal configuration shall be carefully considered. The advantage of using a single market platform for different spatial dimensions is to have a unique and liquid trading platform. Zonal congestion management + PUN-like pricing has been demonstrated to provide a solution to system operators solving the local congestion issues and simultaneously providing a way to participate in the wholesale market. As we consider all required flexibility demands in a single auctioning platform, the coordination of different TSO and DSO needs can be appropriately aligned with the usage of incentivising price determination, capable of relieving

the grid tariff cost burden from local flexibility markets. At this stage, even for the already standardized balancing products the prequalification steps are not yet harmonized. IEGSA provides a sensible framework for the qualification process and applicable solutions, services for key qualification steps (e.g. flexibility register, TSO-DSO interface, settlement).

A compilation of the challenges foreseen through the demonstrators is depicted in the following figure:

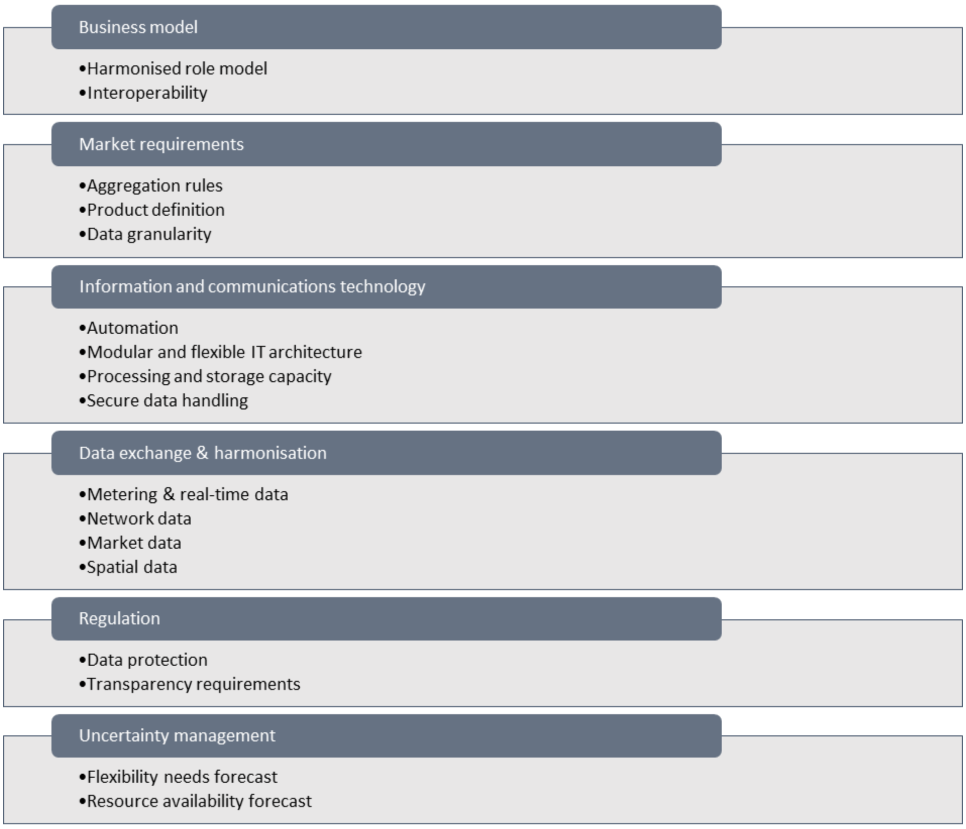

FIGURE 8 : LESSONS LEARNT FROM PILOT DEMONSTRATORS

4.2 Relevant EU Projects

i. EU-SysFlex:

With the aim to roll-out an industrialised solution throughout Europe, this project also provides a detailed assessment for the scalability and replicability of EU-SysFlex solutions which has based on main finding from its pilot demonstrators[6]. Most relevant lessons learnt are presented as follows:

- From the Finnish demonstrator some hurdles were found in relation to the regulation and economic aspects of replicability and scalability. It has been seen that some adaptations on aggregation rules could promote the integration of a large number of assets (adaptations such lower bid limits and larger fast response times). Aggregation rules -in particular- are a matter of harmonisation when replicating any IT solution at pan-European level. Additionally, there is a lack of harmonised rules for managing reactive

[6] EU-SysFlex Deliverable D10.4 Assessment of the scalability and replicability of EUSysFlex solutions: https://eu-sysflex.com/wp-content/uploads/2022/03/EU-SysFlex-D10.4-SRA.pdf

power flexibility at DSO levels, or no rules depending on the country. For the replication of a scalable solution, an appropriate level of harmonisation shall take place for the definition of products and services among TSOs and DSOs and across Europe.

- Cross-border data exchange and its correlation to the authentication of data users and data access rights are foreseen as challenges for the scalability at EU level. For these aspects, harmonisation of role models and oncoming EU regulations are expected to address these aspects in the mid-term.
- Some challenges seen during the pilot demonstrators is the usage of proprietary standards or other types of standards. This could represent a barrier for the integration of additional stakeholders. Therefore, it is conceived that the use of non-proprietary open standards could have a positive impact on costs and could foster the integration of multiple vendors providing offers.
- Additionally, other encountered challenges out of pilot demonstrators come from components such hardware, software and IT communication architecture. These challenges are associated to the computation performance when dealing with larger electrical grids, to the dependency of grid topology, and also to the increase data volumetry when scaling-up. Nonetheless, these have not been considered as real impediments because preliminary prototypes are usually tailored for each demonstrator scope and interaction. Therefore, it is expected that in the roll-out of an industrial-scale solution, these challenges will naturally be considered and addressed.

ii. CoordiNet

The aim of this project is to establish different collaboration schemes among system operators and consumers to contribute to the development of a smart, secure and more resilient energy system. Its long-term vision is to facilitate the scale up of markets and platforms, and ultimately paving the way for the creation of a pan-European platform. With this purpose, project CoordiNet focuses on the analysis and definition of flexibility means at every voltage level ranging from TSO and DSO domains towards consumer participation. The following are important lessons learnt derived from this project:

- The CoordiNet project has witnessed potential benefits arising from the complementarity of different FSP types and their capabilities. Out of workstream 1 of the project[7], Spanish and Swedish demonstrators have shown that the diversity of flexibility resources arise from local conditions, consumption patterns and technologies. For instance, FSP technologies in southern systems are primarily based on renewable technologies (used mainly for downward capacity). While FSP provision in northern systems is mainly based on storage and demand response. A positive outcome from this project is that an optimal combination of different FSP technologies could be highly beneficial for system operators across different contexts. For IEGSA, additional challenges on the integration of different technologies such as product definition, product qualification and data harmonisation are certainly envisaged.
- Another important outcome[7] of the demonstrators related to congestion management is that in some cases system operators might not entirely solve overloading problems even after procuring the maximum FSPs availability. Thus, they will be obliged to use other measures. Same occurs for voltage management, as congestion and voltage phenomena

[7] CoordiNet Deliverable D6.4 Scalability and replicability analysis of the market platform and standardized products, June 2022: https://private.coordinet-project.eu//files/documentos/62cc728e10495COORDINET_WP6_D6.4_SRA%20METHODOLOGY%20AND%20RESULTS_V1.0_27.06.22.pdf

are locational dependent, their control effectiveness increases when FSPs are properly located in areas where violations occur; being more efficient than rather having larger regulation capacities in less effective busbars. In this respect, a proper allocation of flexible technologies will be needed in order to procure resources where the network need the most. For IEGSA, this implies the transparent exchange of information to FSPs and flexibility owners reflecting current and future needs of flexibility resources in the grid.

- In addition, and in participation of Action 7 of the BRIDGE initiative, CoordiNet has contributed to the formulation of roles and responsibilities for the HEMRM. Rather than defining the attribution of roles to specific market actors, CoordiNet examined fundamental principles such transparency, timely information exchange, and avoidance of cost duplication which will depend on the context and local market structures. Project recommends including a common EU-level definition of roles and responsibilities in the new network codes at distribution level.[8,9]

iii. OneNet

With the vision of a seamless near real-time integration of all actors across EU countries, the OneNet project aims at creating suitable conditions for the use of a new generation of grid services into a customer-centric electricity grid operation. For this ambitious goal, a holistic approach is defined based on several steps integrated in four phases that runs over a three-year period. OneNet project outcomes are still in progress nonetheless, preliminary lessons learnt could be drawn already:

- As noted in Deliverable 2.5[10], project highlight the need for further alignment in the Harmonised Electricity Market Role Model (HEMRM): In a highly interactive marketplace, as it is envisaged, the harmonisation of role and responsibilities are crucial to maintain a proper functioning level through the exchange of relevant information among actors. Important to highlight that there is a clear distinction between a role and an actor, in which roles constitute the intended behaviour of an actor, and an actor represent a party which performs its activities in a specific and well-defined manner. Some roles easily describe the behaviour of the TSOs and DSOs, but other analysed roles were identified to better include DSOs and third parties' responsibilities.
    - On a pan-EU level, some overlaps and gaps might be seen in terms of roles and responsibilities which will require further harmonisation as well as the creation of new roles.
    - Observability Area is another concept highlighted in the Harmonised Role Model (HRM) which requires further alignment and yet, defined as "part of distribution systems and neighbouring TSOs, on which TSO implements real-time monitoring

[8] CoordiNet Deliverable D6.7 Roadmap towards a new market design including the implementation of standardised products for system services, June 2022: https://private.coordinet-project.eu//files/documentos/62cc7568dcddfCOORDINET_WP6_D%206.7_ROADMAP%20TOWARDS%20A%20NEW%20MARKET%20DESIGN%20_V1.0_06.07.22.pdf

[9] CoordiNet Deliverable D7.2.3 Common position paper with related projects in the same call, May 2021: https://private.coordinet-project.eu//files/documentos/62d6ea1821c59CoordiNet%20d7.2.2%20joint%20position%20paper.pdf

[10] OneNet D2.5 Recommendations for the Harmonised Electricity Role Model, Dec 2021: https://fraunhofer.sharepoint.com/sites/OneNet/Freigegebene%20Dokumente/WP02/Task%202.4/Deliverable%20D2.5/OneNet%20Deliverable25_v1.3.pdf?CT=1657799021487&OR=ItemsView

and modelling to maintain operational security in its control area including interconnectors" (Article 3 of SOGL[11]).

- Another example is the Flexibility Service Provider role model where alignment is still necessary. In this case, FSP could act as Balancing Service Provider in many cases. Yet, it is not limited to only balancing services, it could also provide other services such congestion management, inertia provision, voltage regulation and restoration support.

iv. TDX-ASSIST

As mentioned in previous chapters, the TDX-ASSIST project proposed a coordination between Transmission and Distribution System Operators through data exchanges for renewables integration through scalable, advanced and secure ICT systems and tools. The project aimed to design and develop innovative ICT tools and techniques to facilitate secure and scalable information systems and data exchange among system operators. Some lessons learnt from TDX-ASSIST project are:

- Aiming to an improved TSO-DSO coordination, system operators will require further alignment of the necessary information to be exchanged. Exchanged data shall have sufficient degree of consistency to accurately represent network conditions. To this extend, CIM Profile standardizes what is necessary for the exchange of data for TSO level, but some details on the DSO side need to be further standardized. The project also introduces the concept of Observability Area to properly define a boundary region where a TSO and a DSO should exchange their data with the intention that both parties properly perceive network changes from relevant neighbouring grids[12].

[11] System Operation Guideline (SO GL) - Art 3: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.220.01.0001.01.ENG&toc=OJ:L:2017:220:TOC#d1e394-1-1

[12] TDX-ASSIST D1.8 Specifying UML and profile descriptions, March 2019: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c2eeacae&appId=PPGMS

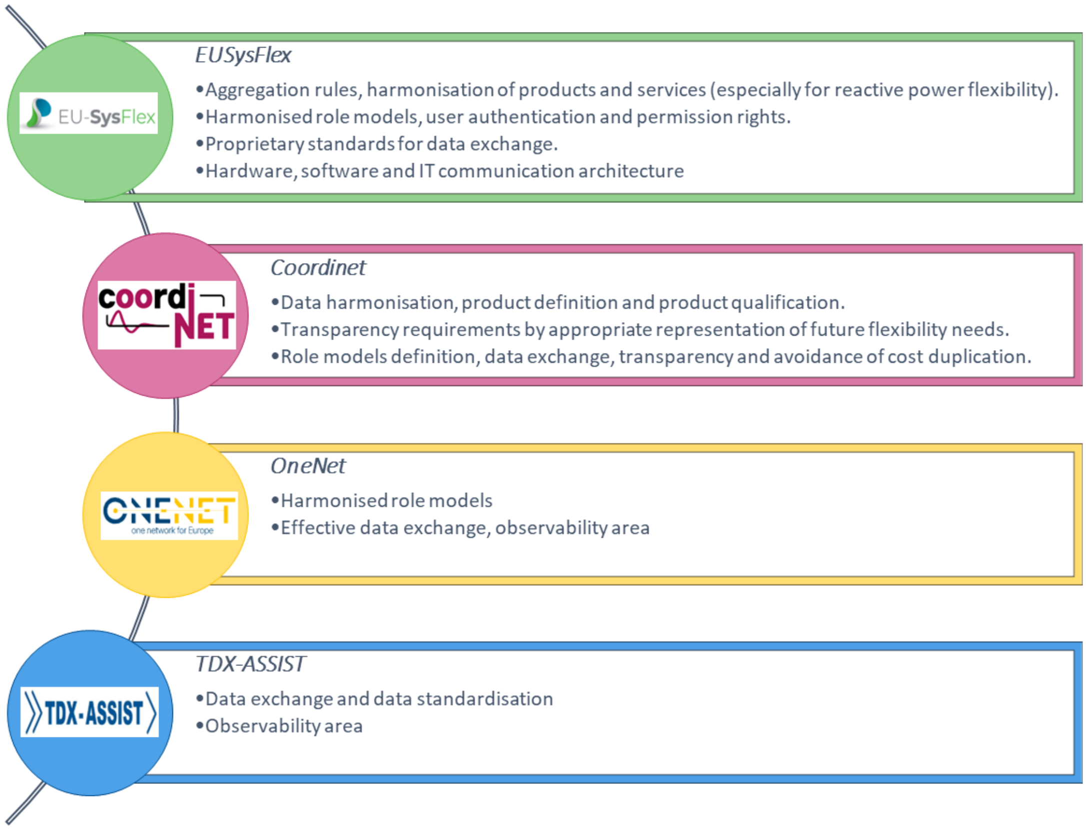

FIGURE 9 : LESSONS LEARNT FROM RELEVANT EU PROJECTS

4.3 Replicability and Scalability Dimensions

Based on these lessons learnt several challenges have been identified for the replicability and scalability of IEGSA. Challenges have an influence on the successful deployment of a pan-European IT architecture and represent the ground floor for the gap assessment. For a better understanding, all bottlenecks relevant to IEGSA replicability and scalability Roadmap have been classified in three main dimensions as depicted in FIGURE 10.

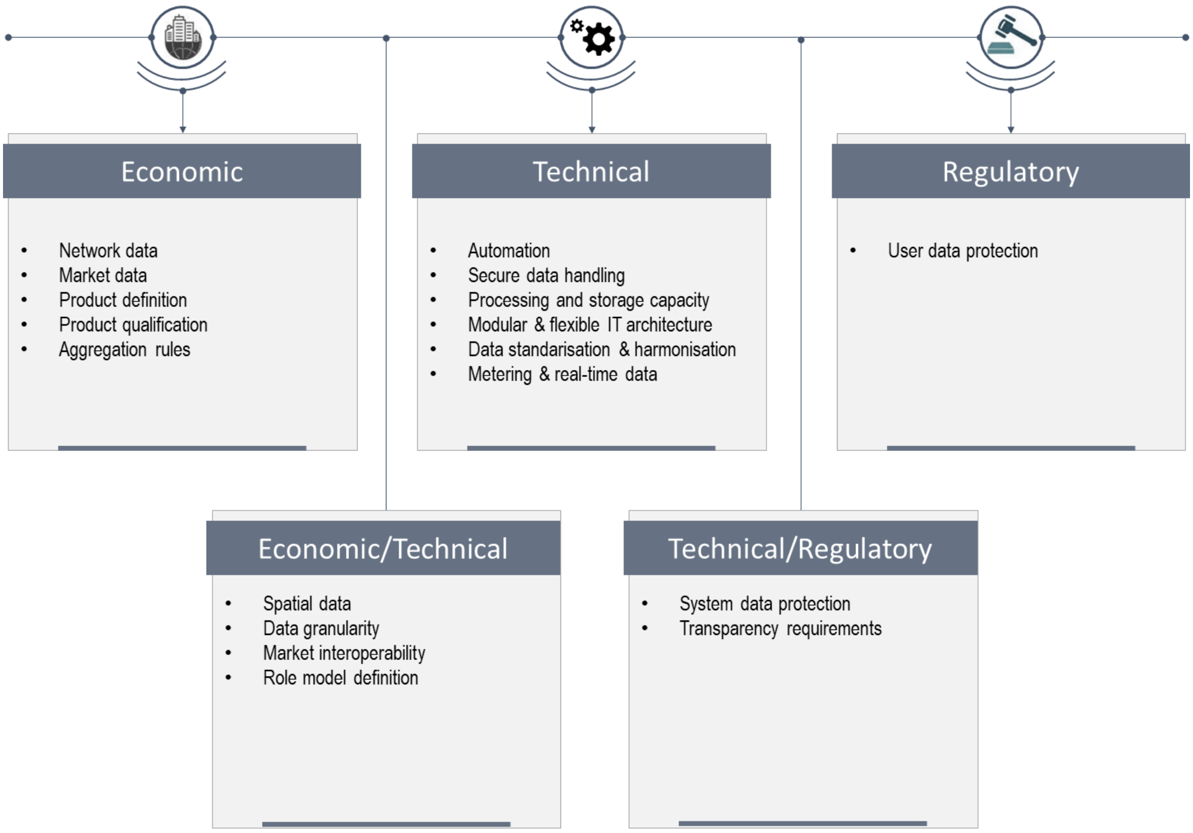

FIGURE 10 : LESSONS LEARNT – CHALLENGES CLASSIFIED BY DIMENSIONS

5 GAP ASSESSMENT

As it has been described in previous stages during the INTERRFACE project, the envisaged IT architecture should aim to fulfil the European long-term vision on enabling system operators to procure services such as balancing, congestion management and ancillary services from assets connected to the electricity network at both transmission and distribution level, in a coordinated, transparent and non-discriminatory manner across Europe.

Considering this long-term vision and the role that IEGSA plays in this context, a qualitative identification of challenges is performed and categorised according to the three replicability and scalability dimensions.

5.1 Economic

Under this economic dimension, Roadmap elaborates on aspects related to the business model continuity, future flexibility requirements and related market challenges for the replicability and scalability of IEGSA.

5.1.1 Business Model

1. **Harmonised role model**

IEGSA connects and allows communication between different actors of the energy value chain. The system provides added value for Flexibility Service Providers, Aggregators, Transmission and Distribution System Operators, Market Operators and Balance Responsible parties, and Imbalance Settlement Responsible. In order to achieve an enhanced interoperable system, IEGSA utilises the role description as described in the “Harmonized Electricity Market Role Model (HEMRM)”. INTERRFACE, through the IEGSA platform, also proposed the introduction of new roles to the HEMRM that are considered vital in the future setting of the digitized energy systems. Hence, for the replicability of IEGSA as a wider data exchange platform to be adopted for pan-EU coordination of electric network operations, it is important that there is neat designation of the business roles. The latter is of significant importance, since IEGSA’s operation relies on specific considerations for roles which were also proposed for future update of the HEMRM. Subsequently, for the wider adoption of IEGSA, assuming the existence of multiple instances, it is vital that business roles are properly aligned. More in detail, at INTERRFACE project the following proposal for new roles or comments for existing roles were made:

a) *Imbalance Settlement Responsible,* the Imbalance Settlement Responsible may delegate the invoicing responsibility to a more generic role such as Billing Agent. Within INTERRFACE this role will be allocated to the IEGSA platform, implying that it is handed over by IEGSA backend with automated triggers for performing settlements as well as repetitions in case of any failures.

b) *Settlement Unit Operator,* this new role has been proposed from INTERRFACE for calculating the settlement, i.e., the difference between the contracted quantities and the realised quantities of energy products for the Balance Responsible Parties in a Scheduling Area and for publishing the settlement results to the markets and storing them in the flexibility register.

c) *Market Operator,* that is a party that provides a service whereby the offers to sell electricity are matched with bids to buy electricity. Additional Information: This usually is an energy/power exchange or platform. At IEGSA context the Market Operator has direct access to Flexibility Register module for product definitions or product update as well as to qualify resource groups requests (as the product qualification process).

d) *Flexibility Register Operator,* as a new role proposed acting as:

- administrator of all the information that is stored in the Flexibility Register. Responsible for allocating access rights to the various actors and controlling the level of access.
- stores flexibility assets, results of qualification (both product and grid), stores market results, grid information,
- aggregates flexibility information,
- stores the results of the settlement,
- and forwards activation signals to flexibility assets upon request of the SOs. The Flexibility operator should be a trusted authority due to the sensitivity level of the information being handled.

e) *TSO-DSO Coordination Platform Operator* as a new role proposed at INTERRFACE that connects the SOs to the IEGSA platform. This role can be taken over either by a TSO or a DSO or both at the same time to ensure coordination among them.

f) *Single Interface to Market Operator* as a new role proposed at INTERRFACE that is the responsible entity for connecting the IEGSA platform to market operators. Responsible for all actions described in the Single Interface to Market Component.

g) *Resource Provider (or Flexibility Service Provider),* a role that manages a resource and provides production/consumption schedules for it, if required. This role is proposed to have access to the Flexibility Register, managing resources by clustering them into resource groups.

The newly proposed roles at INTERRFACE project do not explicitly refer them to a specific actor; hence, there might be the need to introduce additional role-based access rules, especially if NRAs or third parties are proposed. The upscaling of IEGSA to serve pan-EU needs might need to address the incorporation of any additional new roles aligned with latest updates of the Harmonized Electricity Market Role Model. Additionally, as proposed in BRIDGE Data Management WG there might be a need to define a wider set of roles extending Harmonized Electricity Market Role Model to the Harmonized Energy Role Model allowing the seamless cross-sector coordination of multiple energy vectors alongside.

2. Other platforms competitiveness

As mentioned above there is number of H2020 research projects close to finished or ongoing, which focus on coordination of TSO-DSO-FSP and the development of data exchange tools and interfaces between grid operators and market participants, such as:

- **EUSysFlex** focused on development of Flexibility Platform for System Operators and FSPs that enables the trading of different flexibility products and services. With support of proposed data-exchange platform, the project proposed the prequalification, the bidding, the activation and the verification processes supporting solution, which includes coordination of several operators for the use of the flexible resources.
- **CoordiNet** proposed an aggregation tool, to enable the participation of small and medium-sized (< 1 MW) FSPs in local and common markets and assist with bids management. With addition of FSP interface, the project aimed to facilitate market participation for all FSPs. It addressed the exchange of production/consumption schedules, market participants notifications and data exchange with other actors/platforms.
- **OneNet** is still ongoing and focuses on developing tools and solutions to support the coordinated information exchange for short-term and long-term congestion management, balancing, operational planning, reactive power flexibility and power quality.

- **TDX-ASSIST** focused on data exchange and coordination mainly within DSOs and FSPs. It was addressing the information exchange and communications between the system operators to be based on existing and emerging international smart grid ICT standards.

The solutions provided by these projects have features that could enhance or partly cover functionalities provided by IEGSA. Therefore, interoperability is the key to make sure that system operators are able to interconnect different coordination tools, towards their harmonic co-existence. As interoperability is an important technical aspect as well, it is further elaborated in section 5.2.1.

5.1.2. Long-term Flexibility Needs

The long-term vision of EU carbon-neutral power grid will be mostly based on variable and weather-dependent energy sources. This triggers the need to increase the capacities of flexible means in order to maintain acceptable levels of security and resilience of the European electricity systems. Flexibility provision will come from various sources such as generation, demand, storage, sector coupling and grid infrastructure enabling exchanges at local, regional and pan-European level.

As a comparative evaluation, the matrix below (FIGURE 11**Error! Reference source not found.**) indicates a potential diffusion of each flexibility source in contrast with their current use for a given flexibility need. The matrix is based on the expertise of the ENTSO-E Project Team Vision 2050 members and relevant external sources[13]. This matrix depicts the trends of average flexibility requirements among European countries. However, it does not intend to provide a relative comparison of the expected contribution of each flexibility source by 2050. Some technologies are likely to see much higher uses when applied to specific conditions.

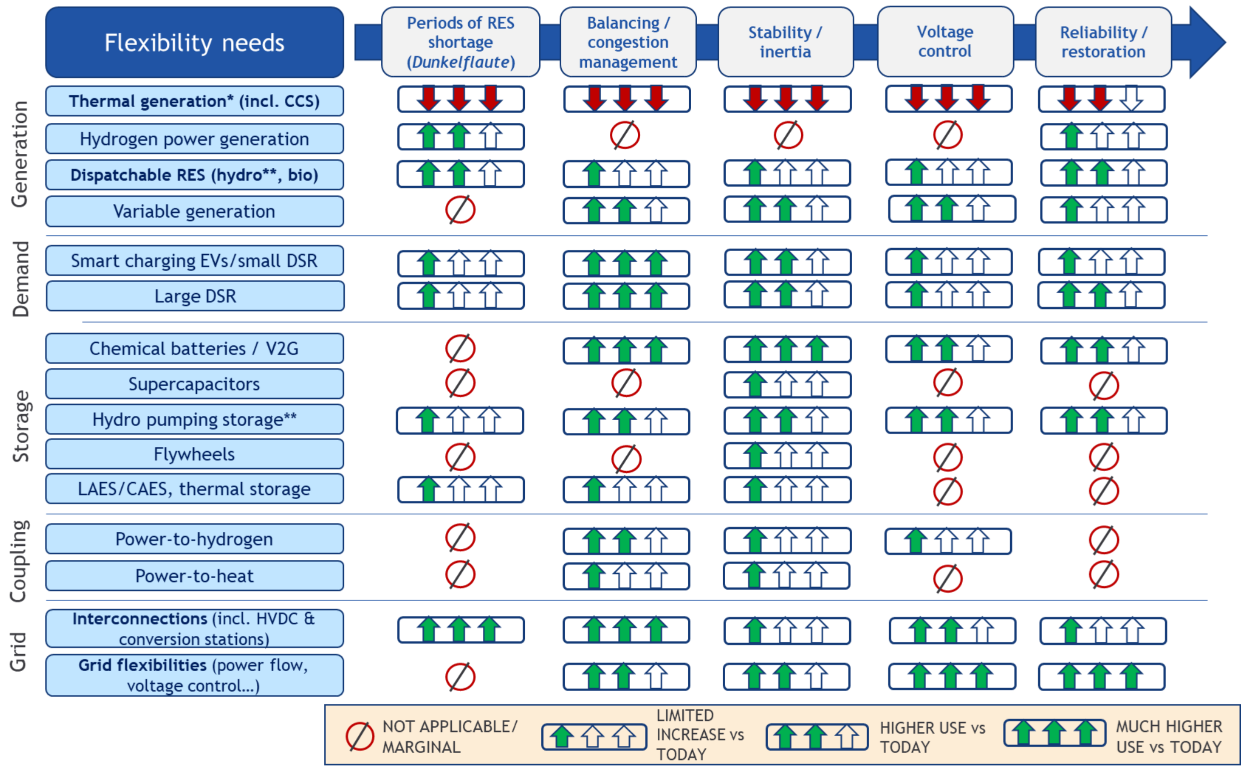

FIGURE 11: FLEXIBILITY NEEDS MATRIX[13]

[13] ENTSO-E VISION A Power System for a Carbon Neutral Europe, ENTSO-E (2022)

It is recognised that future technological developments could significantly differ from what is depicted above. The level of integration of these flexibility sources will depend on the different decarbonisation strategies and contextual conditions at national level. This is important for the scalability and replicability of the IEGSA platform since different sources and technologies will not strictly be the same across Europe and therefore, the product and technological requirements will differ from context to context. Thus, IEGSA's capability to integrate different technology types and flexible means with different configurations is crucial and shall have sufficient adaptability to accommodate different technologies in one single marketplace. The challenges identified by future long-term flexibility are linked with the adjustability of different product definitions, resource prequalification and aggregation rules which are further elaborated in the next section.

5.1.3 Market Challenges

This subsection considers various market-related challenges and bottlenecks that IEGSA may face (see FIGURE 12). While IEGSA does not directly execute any market tasks, its aim is to act as the middleware enabling changes to the overall market architecture and coordination across markets and timeframes.

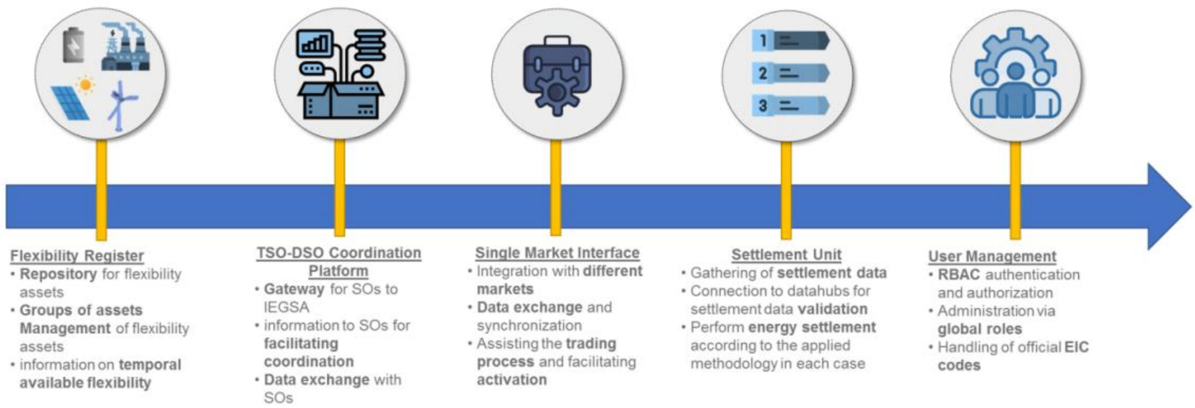

FIGURE 12 : MAIN IEGSA MODULES (SOURCE : INTERRFACE D 3.4, p37)

1. **Product Definition**

While, activation of bids for mFRR does normally not take place through IEGSA, activation of bids for CM can be performed either through or outside IEGSA. As presented in deliverables D3.1[14], D3.2[15], and D.3.4[16] of INTERRFACE, the new non-standard products being introduced and tested in the Demos are Long-term congestion management, Short-term congestion management, and operational congestion management.

In the case of long-term CM, reservation of available capacity is performed several weeks or months ahead, while it is also envisaged by some Demos for operational CM (whereby the reservation is made the day before). Interactions are foreseen with mFRR (and aFRR in some cases) in terms of bid qualification, constructing and updating Merit Order Lists, bid forwarding, reception and forwarding of settlement results, etc. Some of the aforementioned tasks and

[14] INTERRFACE Public Deliverable D3.1 - Definition of new/changing requirements for services: www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.1_V1.0.pdf
[15] INTERRFACE Public Deliverable D3.2 - Definition of new/changing requirements for Market Designs: www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.2_v1.0.pdf
[16] INTERRFACE Non-public Deliverable D3.4 - Revision and Amendments of D3.1- D3.3 according to feedback of Demos designs

processes may require to be repeated separately by IEGSA, for instance in cases where requirements and standards differ.

Short-term congestion management services, on the other hand do not foresee a reservation process and are not integrated with other reserve-based services such as balancing.

Some degree of interaction has also been foreseen with the Day-Ahead and Intraday markets, where products are for the most part standardised across Europe.

IEGSA has been able to manage small deviations from the product definitions provided in D.3.1. Scaling up and replication may require handling even more local specificities, be it in terms of aimed services (e.g. inclusion of voltage control), additional product specifications, and interactions with other existing measures and processes (e.g. may-not-run or must run). The challenge goes for product definitions (cross-border/pan-EU product) which goes beyond national needs and it shall contain clear and full technical information for the impact that they might reflect on national product and services procurement. For this purpose, a set of rules shall be accompanied with the product definition to identify how the new products act on national markets (e.g., product qualification, bid and grid qualification).

The abovementioned challenge is accompanied by another set of issues, which will likely emerge as IEGSA increasingly interacts with other market platforms. The future EU system will be composed of several flexibility markets, be they local, national, or cross-border. This will pose a challenge for IEGSA and potentially imply the need for additional dynamic functions that would deal not only with other product definitions, but also with the definition of processes for determining the impact of neighbouring markets' products. This added complexity may impact several tasks and processes, from grid and bid qualification, merit order lists, activations, etc. For this, a common product qualification status synchronisation process may need to be agreed at national, regional or even pan-EU level.

2. Prequalification Requirements

Prequalification is a process "to ensure that an individual resources can be connected at specific points in the grid without violating any grid limits (grid qualification) and also a resource group (being comprised by individual resources) meets the minimum criteria for the provision of a product or service (product qualification). This concerns the abilities related to both the flexibility service provider and the flexibility resources contracted to it, on the one hand, and the grid where the resources are connected to, where the flexibility service is to be delivered to, and any intermediate grid, on the other hand." Deliverable 3.2 foresees two distinct prequalification processes, namely grid prequalification and product prequalification. Bid qualification takes place during the market phase and is assessed further below under procurement.

i. Grid Prequalification Process

Grid qualification refers to a process where new resource groups are created or registered, network topology or network limits are updated, or certain updates on the flexibility resources technical parameters are necessary. D3.2 in particular highlights the role of the flexibility resource register able to prequalify resources based on their geographical location and the network topology.

The IEGSA architecture foresees two distinct ways for carrying out grid qualification:

1) forwarding the qualification request to each concerned SO, which then performs an assessment based on their internal procedures and methodologies. The result obtained by the SOs is then sent to the Flexibility Register via the TSO-DSO

Coordination Platform. Afterward, the Flexibility Register aggregates the results per resource.

2) employing an automated qualification service, which utilises the aggregated maximum upward and downward capacities (at TSO metering point level or for certain components in-between the DSO metering point and TSO-DSO border point) to perform the grid check of each resource. The Flexibility Register then assigns the qualification result to the respective resources.

Regardless of the alternative qualification approach selected, in the end, the Flexibility Register aggregates the result for the resource group, stores the results, and makes them available (both per resource and resource group) to the FSP.

Perhaps an additional crucial bottleneck concerns the sourcing of flexibility resource data from national datahubs. Where no such datahubs are established, the information would need to be provided directly by the user. This could pose a risk of double-counting and other data inputting errors, would prevent the qualification calculations from being performed internally in IEGSA, and eventually undermine the grid prequalification process. Additional, back-end processes would be necessary to address the validity and consistency of inputs and the proper synchronisation of them with other legacy systems.

ii. Product Prequalification Process

Once the grid prequalification has been completed, the Flexibility Register forwards a product qualification request which is assessed internally by the IEGSA platform. Results are then forwarded to the Market Operator, who will then be able to review the information on the Flexibility Register. The MO will then proceed manually to the product qualification assessment, and returns the result to IEGSA ("qualified, "not qualified", "pending qualification").

Here, a first distinction is necessary:

- Product qualification for existing products (aFRR, mFRR)
- Product qualification for new congestion management products (LT, ST, operational)

In addition, new products may emerge, either answering the same needs as above (balancing, congestion management) or new ones (voltage control, local P2P). As mentioned earlier in this document, the inputting of product definitions may result in a large number of different products and product qualification processes, which in turn may create additional complexity for all parties involved (be it the Market Operator or the FSPs).

IEGSA should strive to ensure that products which have comparable attributes should have streamlined prequalification steps when service providers already meet some requirements. However, their prequalification along different types of products should not be systematically automatic.

Given that aggregation rules differ both across countries, services and markets, automating resource grouping requests will also represent a challenge for the replicability of IEGSA.

3. Procurement

i. Bid Qualification

This is the second step of the grid assessment (the first one refers to grid prequalification), which is performed during the procurement phase. Depending on whether the resource was labelled as "qualified with restrictions", it may be necessary to determine the exact impact of activation of each resource on the grid's nodes and branches, using the metering point ID of each resource and the grid topology. The TSO-DSO Coordination Platform will play a key role in supporting these real-time data exchanges between SOs.

As noted in Interrface D5.5 *"Bid qualification process differs depending on product type: mFRR – bid is either qualified or rejected as a single entity, or CM – bid is broken down into partial "child" bids, which are complemented with locational information, in order to aid the SOs to identify specific bids that could relieve congestions in already identified congested parts of the network"*.

For the grid and bid qualification the approach adopted in IEGSA examines limit violations; the bid with highest energy price is removed from the list and appended to a list of rejected bids. Step is repeated until there are no limit violations, or every bid has been rejected.

While a two-step grid qualification process in general is a widespread practise, in practise it would need to be checked against the existing national processes. A lack of harmonisation of prequalification process across flexibility markets and services creates additional barriers to entry; at the same time harmonisation may not be feasible or even desirable due to the need to reflect national and/or local specificities. A certain degree of customisation would need to be borne by IEGSA so as to address the risk of higher barriers to entry for FSPs.

ii. Flexibility Register and Aggregation of Bids

The Flexibility Register module, as is currently described, would not only rely on the provision of so-called "static" data concerning the flexibility resources (location, hardware information) but would also require FSPs to upload their sub-hourly, daily or weekly schedules for down/up regulation. This would be done either manually or through dedicated API endpoints. The use of this data is key to the overall functioning of the platform, as it would directly communicate with the single market interface and settlement modules.

The functionalities of the flexibility register in IEGSA go significantly beyond the minimum specifications of those flexibility registers that have already been deployed in several European countries (e.g., Belgium, UK). While in those countries, the flexibility register is a tool supporting the TSOs and DSOs to have a common view of the resources located in their grid such that they can perform the grid prequalification. In the case of IEGSA, this tool is also meant as a supporting tool for the Market Operator to conduct the product prequalification, and for FSPs to manage their portfolio.

Looking at the future upscaling and replication of IEGSA, some degree of alignment with already established platforms at national level will be needed. This could either result in TSOs and DSOs adding requirements to their own flexibility registers in order to perform close to real-time data exchanges, or alternatively it may require IEGSA to perform these exchanges outside the flexibility register, which could create additional complexities.

The expected challenge is on the aligning of specifications of the IEGSA flexibility register module with already established ones being used by TSOs and DSOs which may require the exchange of schedule data to take place on a separate platform or module.

More fundamentally, however, this challenge poses the question of how, under a decentralised approach to the Flexibility Register concept (i.e. besides IEGSA, having several other Flexibility Registers in operation), one would split the regulated and commercial domains. This would likely increase complexity with regards to data exchanges and would require alignment between system operators, flexibility providers, flexibility platforms, and regulators across multiple dimensions. In particular, the proper design of the Flexibility Register architecture with corresponding roles and responsibilities should be considered.

iii. Creation of MOLs'

The IEGSA MOL provides the SOs with a view of bids in locations on different grid levels. As mentioned by some demonstration partners, this functionality has still room for improvement in order to manage the location more easily and prepare the system for a situation where there might be large number of bids, which need to be efficiently managed and displayed. Additionally, in the case of interactions with national and/or cross-border products and services, it should be sufficiently clear ahead of time whether these should form integrated or separate MOLs with other local or national products.

iv. Bid Change/Cancellation and resource group modifications

Since all the bids refer to the resources registered in the flexibility register module, the system must be able to handle the modification to the resources at any point of the process. The resources can be changed while there is a bid submitted to the market, or while it has been already accepted for activation, or after the activation when the bid is pending for settlement. For this reason, the IEGSA manages the modifications to the resources and resource groups by assigning new identification numbers to each revision so that the process always refers to the correct version of the resources. Strict synchronisation for bids status/availability and capacity or volume is vital for the seamless operation and coordination of national markets with the pan-EU one and implies the necessity for secure communication channels to transmit such information.

When looking at the upscaling of IEGSA at a cross-border or even pan-EU level, interactions with other coexisting platforms will pose new challenges for the way in which bid changes or cancellations can effectively be managed. The synchronisation of all available bids and corresponding information needs to be ensured. In addition, rules on who can cancel a bid, until when, and with what settlement repercussions need to be clarified.

v. Utilisation of Transparency Platform

While the pilot demonstrators within INTERRFACE did not plan to test data exchanges with the IEGSA Platform using data from the ENTSO-E Transparency Platform, such a use case has been mentioned by some of the projects that participated in the Open Call. For instance, Digital4Grids foresee at least one such specific use case: the user interface used to help evaluate the Homeowner's carbon footprint per DER and home appliance would require the Grid data published through the European transparency platform to be retrieved in close to real-time. This would require the exchange of flexibility measurements per grid node towards the ENTSO-E transparency platform leveraging CIM derived standards.

Other use cases may also be foreseen, requiring additional exchanges of data with the Transparency platform. Transparency Platform shall be used both for reporting essential technical information from FR and TDCPO as well for posting relevant information from Data Exchange Platforms such as IEGSA, which could be proved essential for the pan-EU network, given that important information can be made available to cross-border actors. Additionally, IEGSA and other relevant platforms could act as potential data consumer for TP retrieving data that can be used to support decision makers e.g., for operational flexibility needs.

The extent to which data exchanges with the Transparency Platform can take place at such a granular level (i.e. grid node, hourly or sub-hourly) would need to be further investigated. This would also likely require additional functionalities to be added such as developing dedicated APIs and/or by making changes to the existing IEGSA modules.

vi. New policy objectives with regards to publishing GHG content and RES share, and impact on future flexibility platforms

As per Article 20a of the upcoming revision Renewable Energy Directive (REDIII), TSOs and DSOs will be required to make available information on the share of renewable energy sources and the GHG content of the electricity they supply in order to increase transparency of and give more information to electricity market players, aggregators, consumers and end-users. One possible implication of this new measure could be that flexibility providers will choose to place their bids not only based on price signals, but also taking into account non-price signals (i.e. marginal impact on RES share and GHG emissions). Increasingly, and especially with the introduction of more elaborate types of Power Purchase Agreements (PPAs) and more granular types of Renewable certificates (Guarantees of Origin), both consumers and producers are adopting an active role in ensuring a positive marginal impact of their consumption/production patterns on the "greenness" of the system.

Flexibility platforms should in the future be able to retrieve this type of data from TSOs and DSOs and make it available to market participants in such a way that non-price signals can offer additional value to end-consumers and stimulate even further provision of flexibility.

It is unclear at this stage whether existing modules within the IEGSA platform could be adapted to accommodate these new tasks, if new modules may in the future need to be added, or if such services are to be plugged-in at local/national level.

4. Activation

I. Market Optimisation

The market is managed in order to select the resources according to a dedicated merit order list. The selection is performed after the day-ahead energy market and activations are optimized in order to avoid imbalance. While IEGSA does not itself perform the market optimisation (which is carried out by the relevant Market and/or System operators), particular care needs to be given to the risk of double activations and uncoordinated counter-activations.

5. Settlement

I. Baselining Methodology

There is a dedicated screen on the IEGSA User Interface (UI) where FSPs will be able to download the settlement results for the bid of their choice. All settlement processes initiated by IEGSA are performed through API calls.

The Following data is used in settlement process:

- A40 – flexibility acquired for time period by SO (based on A37 bid offering by FSP).
- A14 – flexibility activated by FSP for time period.
- A64 – measurement data from metering points, the actual amount of energy per FSP metering point produced or consumed. It is used to calculate the actual amount of delivered flexibility.
- Baseline – estimated amount of energy per FSP metering point produced or consumed if flexibility had not been activated.

The actual flexibility delivered by FSP is calculated either based on the previous hour's measurement data or baseline. In both options there are one minute measurement data for settlement period to compare either with previous hour or baseline.

New approaches are needed in case of small, distributed resources to check if they had delivered what they were asked for. This means baseline accuracy and access to sub-meter data. SCADA connections and balance schedules (for individual resource) are not available in this case. Also metering on connection point level may not be sufficient always because behind one connection point there are many different resources (and not all of them are participating in flexibility provision) and also the data granularity may not be sufficient (one-hour data, 15-minutes data). Harmonised methodologies and technical tools must support the verification process.

Several of these points are currently being discussed as part of ACER's framework guidelines on Demand Side Flexibility, which will introduce some degree of harmonisation but still allow for national differences (e.g. on the disaggregation of data in the settlement phase).

IEGSA should monitor the introduction of different (and potentially more complex) baseline methodologies which may be more suitable to the wide range of flexibility providers, including small-scale actors.

II. Prevention of Gaming and Strategic Behaviour

As noted in the literature[17], the introduction of local flexibility markets may create adverse incentives to certain market players. The co-existence of a zonal and local market in succession of one another inevitably means that flexibility providers will consider potential gains in the second market when bidding in the first one. Should a flexibility provider be located at one or another end of a known congested area, this may give rise to underbidding, overbidding, and in certain cases the supplier would even collect the price spread between the markets without any energy delivery at all. Such cases may cause significant distortions to market functioning, including in the day-ahead, especially where the demand from System Operators is inelastic (i.e. they have no choice but to accept up or down regulation bids).

Several reports[,18] have recognised the need for mitigating measures to be taken to avoid or correct such behaviour. These may include actions to be taken by SOs (long-term contracts, bid caps and floors) as well as specific tasks to be built into flexibility platforms.

[17] ENTSO-E (2021). Review of Flexibility Platforms; https://eepublicdownloads.azureedge.net/clean-documents/SOC%20documents/SOC%20Reports/210957_entso-e_report_neutral_design_flexibility_platforms_04.pdf

[18] Nodes (2020). Market Based Redispatch: why it works. https://d1jagcpmche0d6.cloudfront.net/wp-content/uploads/2020/10/10125244/Market-based-redispatch-why-it-works.pdf

While IEGSA already allows for long-term CM contracts to be concluded between FSPs and SOs, additional tasks may be required, which may range from FSP ratings to algorithm-based fraud detection (as is done in DAM) and monitoring of relevant data (from bid specific information to weather conditions and other economic indicators). Some degree of information sharing with regulatory authorities may also be requested in the future[19].

III. Payment and Penalty Processing

As noted in an ENTSO-E report[17], "flexibility platforms may also play a role in the processing of payments or hold financial settlement in escrow until such time it has validated that obligations have been satisfied. Should the validation process identify irregularities, the platforms may also implement sanctions in line with market rules". In the case of IEGSA, all settlement processes are performed through API calls since the platform only forward bids to other market platforms. Therefore, the applicable sanctions and rules are those defined in each one of these markets.

While the IEGSA platform does not itself process payments within their ecosystem, sufficient information should be made available to FSPs on the applicable rules and sanctions in each national or local market. Such a feature could be provided directly on the interface for FSPs connecting to the platform.

Settlement processes are vital for the establishment of effective and liquid flexibility markets. The incorporation of new flexibility products (including harmonized pan-EU products) denotes the need to thoroughly define clear rules on granular and accurate measurements to assess the settlement. Proper algorithms shall be proposed based on philosophy that measurement requirements shall be harmonized along across all types of products.

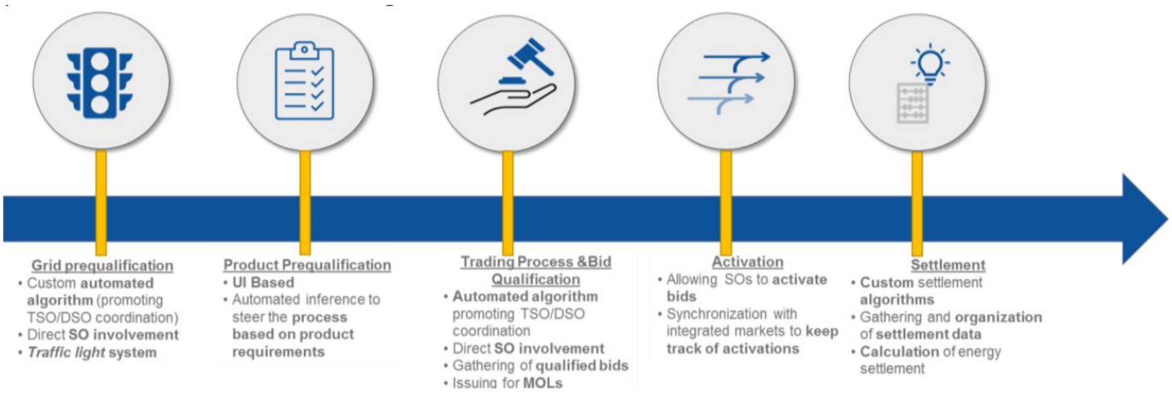

FIGURE 13 : MAIN IEGSA PROCESSES (SOURCE: INTERRFACE D.3.4, p36)

5.2 Technical

This technical dimension outlines key elements such data exchange and ICT in relation to IEGSA's internal IT architecture.

[19] Risk of distortion on balancing markets, which fall under the REMIT regulation imposing the need for data exchange and reporting is of particular relevance here too.

5.2.1 Data Exchange

1. **Data Interoperability**

The value of interoperability specifications is determined by the extent of implementation in various large-scale pilots on projects like BD4NRG[20]. The big data interoperability is a complex challenge for the organisations deploying big data architectures due to the heterogeneous nature of data used by them. Big Data consists of extensive datasets – primarily in the characteristics of volume, variety, velocity, and/or variability – that require a scalable architecture for efficient storage, manipulation, and analysis. Therefore, lessons learnt from using big data are an important asset to consider for future scalability and consolidation of respective architectures, platforms, etc.

The following high-level conclusions made from the projects that use big data for energy are important to consider for further IEGSA scalability.

Alignment with the popular initiatives mentioned below ensures that implementations or parts thereof also make sense for IEGSA scalability.

- Agile standardisation and the focus on fit for purpose models ensure that the IEGSA interoperability features serves the needs of the users, not the other way around.
- Setting up a synergy with initiatives, which are responsible for realising a Semantic Interoperability Toolbox that enables the semantic alignment of data from various users can be used as input for the agile standardisation process.

Regarding interoperability requirements, there are some important priorities concluded in different R&D projects:

- Interoperability between different data sources (e.g. cross sector integration)
- Interoperability with well-known open data sources (e.g. European Open Science Cloud, Data Space Business Alliance, etc)
- Interoperability among integrated technologies (Blockchain, AI)

Examples taken from large scale projects that use big data, interoperability aspects and standardisation are not fully taken into consideration in the IEGSA and should be further addressed in the future.

2. **Alignment with Key Initiatives**

   I. **Metadata**

Access to consistent, high-quality metadata is critical to finding, understanding, and reusing scientific data. General definitions of metadata can be found in many manuals. Most of them are very short and simple. The most commonly used generic definition states that "Metadata are data about data" but more precise definition states: Metadata is data that defines and describes other data. In the data exchange process, one important aspect that should be considered is the representation of the data with metadata.

➢ Currently the metadata are not represented as part of the information layer of the IEGSA and this is an important gap to be considered. From the metadata perspective, it is important to use one single model for the header and metadata, covering the needs of the TSO and DSO community. However, considering the great variety of requirements and handling metadata, it is recommended to cover this in different places as presented in the FIGURE 14.

[20] Big Data for Energy, EU project: https://www.bd4nrg.eu/

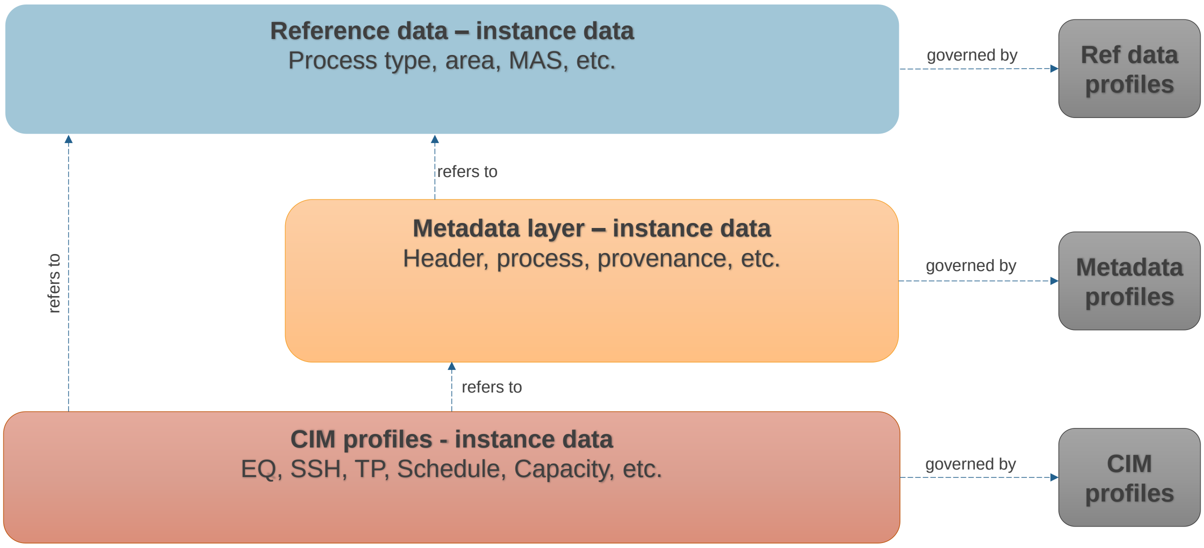

FIGURE 14 : RELATIONS BETWEEN REFERENCE DATA, METADATA, AND CIM PROFILES

In the data exchange there are three main layers: the instance data that is governed by CIM profiles. This data has header information; the metadata layer instance data which describes the processes and can describe the provenance of the data; the reference data which describes common data to be referenced from either metadata layer or instance data of the core profiles that are exchanged for various profiles, e.g. Equipment Profile (EQ), Steady State Hypothesis Profile (SSH), Modelling Authority Set (MAS), etc.

II. IDS Information Model

The International Data Spaces (IDS) Information Model is technically a Resource Description Framework (RDF)/ Web Ontology Language (OWL) ontology, which is often represented conceptually as a hexagon. The IDS Information Model is independent of concrete application domains and thus does not provide terminology for the content of data resources specific to the Energy domain. Instead, it encourages the use of RDF and domain ontologies to include metadata about the domain-specific semantics and, similarly, the structure of content.

- The current IEGSA version does not fully consider the RDF/OWL, especially for metadata.

III. Alignment with Data Spaces Business Alliance (DSBA)

The Data Spaces Business Alliance hubs brings together diverse actors to realise a data-driven future, where public and private organisations can share data and thus unlock its full value, ensuring sovereignty, interoperability, security and reliability. To achieve this goal, DSBA offers support to organisations, as well as tools, resources and expertise. For example, it is working on the development of a common framework of technology agnostic blocks that are reusable across different domains to ensure the interoperability of different data spaces. The next figure shows the core elements of the DSBA technical reference architecture.

FIGURE 15 : DSBA REFERENCE ARCHITECTURE

- Currently, IEGSA does not follow the updates and components present in the DSBA model which is a gap to be considered in the future IEGSA versions.

3. Data Harmonisation

For the scalability, data harmonisation is important since it enables all actors to exchange the data in a scalable way. The data harmonisation among the different actors within IEGSA provides a reliable system that can be replicated also between the different layers. Data Harmonisation such as the Harmonised Role Model must be set to tackle the system scalability, increasing the use case harmonisation between the energy participants. It is recognised that future collaboration is needed across member states stemming from an HRM-driven framework.

4. Data Standardisation

Public data standardisation is important for the well-functioning of energy systems. As increasing number of stakeholders and data requirements will be seen in power systems, standardized data exchange will facilitate the incorporation of new participants and market players and the interchange of necessary data for a common evaluation and procurement of grid services.

In the context of the INTERRFACE project, exchanges will require both sending and receiving various types of datasets, such as:

- Resource Qualification Market Document
- Product Qualification Market Document
- Acknowledgement Market Document
- Reserve Bid Market Document
- Activation Market Document
- CGMES profile fragments
- PTDF Matrix Profile
- Voltage factor matrix Profile

Standardized data profiles -such as the Common Information Model (CIM)- will help to the effective participation and coordination of various actors across Europe, enabling the replicability and scalability of interoperable systems. IEGSA was so far implemented and tested using CIM existing and custom profiles in particular for the Single Flexibility Platform Demo. The upscaling of IEGSA, being, a data middleware shall consider solely IEC standard profiles that are commonly adopted in the context of EU.

For the scalability roadmap of IEGSA, a major challenge is the usage of standardisation of public data. The envisaged IEGSA platform should primarily rely on the public standards. Nonetheless in case that private standards are needed, it will impact the effectiveness within which participants will exchange information and therefore, the scalability of the platform.

5. Data Exchange Tools

Data exchange tools are important because they enable secure and reliable data delivery among system operators. Tools support the interaction with other market parties. The communication layer of IEGSA currently supports two very well developed and highly secure communication channels. One is through the advanced set of OPEN-APIs, which are standardised based on the CIM formats, allowing seamless and secure data exchanges between actors, systems and hubs. The second is through ECCo SP (ENTSO-E Communication and Connectivity Service Platform), which provides an additional communication channel to be compatible with legacy systems especially of TSOs, who have already integrated ECCo SP in their day-to-day operations facilitating inter-TSO communication and exchanges but also interconnection with the Transparency Platform of ENTSO-E. ECCo SP has been developed as the tool for standardised data exchange which is composed by two main platforms:

- Energy Communication Platform (ECP): Component providing end-point messaging services with a function of central directory.
- Energy Data Exchange (EDX): Aimed at managing network configuration.

ECCo SP platform utilises digital signatures and encryption, as well as authentication and authorisation mechanism with public key infrastructure and digital certificates. IEGSA's deployment also includes an ECCo SP node. An IEGSA user can deploy locally an ECP endpoint, so that data exchange between the user and IEGSA can take place through ECCo SP. This additional feature of integrating ECCo SP at IEGSA platform, deploying the central node at IEGSA, provides twofold perks:

a. an IEGSA user (by deploying an ECP endpoint at their premises) may use the alternative communication channel of ECCo SP to send files/xml data exchanges instead of the IEGSA API endpoints,
b. IEGSA platform interconnects with the outer world that is currently using the ECCo SP as a secure communication channel e.g., Transparency Platform, enhancing its interoperability with third party platforms.

The latter is of high importance, especially, concerning the assurance of interconnection with Transparency Platform since IEGSA can potentially fetch important data that can support flexibility procurement through well informed energy stakeholders, but also allowing IEGSA to act as data provider for the Transparency Platform, as it was analytically addressed in the D8.4[21]. Thus, IEGSA IT platform gives to its users the possibility to exchange information through a communication channel that already exists (as most TSOs do) instead of the IEGSA APIs and therefore, enhance interoperability between systems.

In terms of IEGSA replicability and scalability, the reliable exchange of standardised data should be ensured by using platforms such ECCo SP. However, IEGSA IT platform should also be able to use and interact with other platforms encouraging the participation of all system operators and market parties across Europe.

5.2.2 Information and Communications Technology

The IEGSA platform has been developed as a scalable system in order to be able to accommodate a versatile set of actors and scenarios. The architectural design allows the easy extendibility with minimum

[21] INTERRFACE Non-public Deliverable D8.4 - Final application and end users feedback report

effort. The relational database of IEGSA can be easily expanded in order to fit additional and more complex datasets, depending each time on the needs of the various use cases.

The current implementation has been tailored to the needs of the INTERRFACE demonstrators. This means that a detailed requirement analysis was performed during the initial stages of the project, which allowed for the identification of the expected number of users, the volumes of data that are expected to be exchanged during the piloting phase, the payloads, the computational speed and the capacity of the communication channels. Based on the outcomes of this analysis IEGSA was designed as a system capable of supporting the needs of the existing demonstrators and accommodating all requirements.

Obviously, this same system could not be used in a different scenario where the number of users would be e.g. 100 times higher with a respective increase in the volume of the exchanged data. This would require an extension of the database, the deployment in Virtual Machines with higher capacity, etc. Nevertheless, the changes that are required in the core of the system in order to ensure the upscaling are minimal.

Apart from the technical implementation, the environment of IEGSA is scalable itself. IEGSA includes an environment aiming to support the processes that surround the trading of products and services in electricity markets. Currently and for the needs of the INTERRFACE demonstrators, IEGSA was integrated with market in various countries for Congestion Management, MFRR and locational intra-day products, as well as some custom products for novel market designs that were proposed by the project. Nevertheless, IEGSA can easily support the integration with any market platform and facilitate the trading of a large variety of products and services based on its extended set of APIs for market communication which are standardized and based on the CIM standard. The trading environment is customizable for each product and can accommodate different inherent qualities of the different markets (either for different products or for the same products in different countries). This of course cannot be programmed by the IEGSA administrator and requires additional development effort. However, the design of the platform has foreseen a great number of parameters that allow the almost plug-and-play creation of new market environments for new products and services.

5.3 Regulatory

Under public deliverable 2.4.[22] ''Regulatory Framework'' of the INTERRFACE Project, ''new research domains have been identified in which the Clean Energy Package (CEP) allows for the implementation of national regulatory frameworks to be set up''. The aim of that deliverable was to provide an idea on how ''innovation with regulation at Member State level, guided by the e-Directive, can serve as inspiration for new network codes or guidelines or for amendments of existing ones''. This section, on the other hand, aims to provide a practical gap analysis focused on the main replicability and scalability challenges that the IEGSA Platform in specific may encounter in complying with the existing regulatory framework during its implementation.

5.3.1. Personal Data Protection

As described above, the IEGSA Platform is developed to act as a common platform to connect multiple actors in the energy market in a coordinated way. In order to facilitate such coordination, system operators will require access to the Platform via the creation of user accounts. Currently, the creation of such user accounts requires system operators (and their relevant staff) to provide certain information to the IEGSA Platform, such as their usernames, e-mail addresses, countries, and roles. In the instance that such information (such as e-mail addresses) can be used as a means to identify a natural person, that

[22] INTERRFACE Consortium, INTERRFACE Deliverable 2.4., *Regulatory Framework*, p. 8, available at: http://www.interrface.eu/sites/default/files/publications/INTERRFACE_D2.4_v1.0.pdf

information shall be deemed as ''personal data'' under the ''Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data'' (hereinafter, ''the GDPR''). In that case, the compliance of the IEGSA Platform with the EU GDPR can raise as a challenge of scalability.

Pursuant to the GDPR, any operation (e.g. collection, recording, organisation, structuring, storage etc.) performed on personal data in the context of the activities of an establishment of a controller or a processor in the European Union falls under the scope of the GDPR. Therefore, it is important that the IEGSA Platform provides the necessary safeguards for the protection of its users' personal data. Nevertheless, considering that the processing of personal data by the IEGSA Platform is limited to the processing of users' contact details for the creation of their accounts, the impact on the rights and freedoms of data subjects in this case is limited.

In any case, in order to be scaled on a pan-European level, the IEGSA Platform needs to take into account the principles relating to the processing of personal data under the GDPR, and process personal data of its users only based on appropriate legal grounds of processing. In addition, the IEGSA Platform should include appropriate privacy notices for the users, informing them on the processing of their personal data and their rights under the GDPR. Indeed, the IEGSA Platform currently has a ''Terms of Service and Privacy Policy''. However, this policy should be revised to ensure full compliance with the GDPR, creating a current gap for the scalability of the IEGSA Platform in terms of ensuring an appropriate safeguard for users' privacy.

Currently, the envisaged operation of the IEGSA Platform does not foresee the processing of any other personal data (such as electricity consumers' personal data). However, in case that the scope of the IEGSA Platform is increased in such sense, for example by the processing of households' electricity consumption data via the use of smart grids, the protection of personal data may bring further challenges in terms of replicability of the platform. In such case, an extensive Data Protection Impact Assessment in terms of the GDPR should be conducted in order to identify the privacy and security risks that may rise as new challenges.

5.3.2. System Data Protection

Aside from the protection of personal data, the protection of market and grid data on the IEGSA Platform, and compliance with the existing legal requirements regarding the exchange of this data between system operators represents a more obvious challenge for the scalability of the Platform. In that regard, as also identified by the relevant EU Project EUSysFlex[23], the IEGSA Platform should indeed be compliant to regulatory frameworks that provide provisions for such data exchanges, including the Directive (EU) 2019/944 on Common Rules for the Internal Market in Electricity, Regulation (EU) 2019/0943 on the Internal Market for Electricity, Directive on Energy Efficiency, Guideline on Electricity Balancing, Guideline on System Operation, Network Code on Demand Connection, Network Code on Requirements for Grid Connection of Generators, Network Code on Requirements for Grid Connection of HVDC systems and power park modules, Network Code on Electricity Emergency and Restoration, Guideline on Capacity Allocation and Congestion Management, Guideline on Forward Capacity Allocation, NIS Directive, and the Regulation on Submission and Publication of Data in Electricity Markets. Although some of these regulatory frameworks are referred to under the following chapters, a detailed analysis of all related regulations is beyond the scope of this deliverable.

[23] EU-SYSFLEX Consortium, European level legal requirements to energy data exchange (Task 5.1.), 2019, p.7, available at: https://eu-sysflex.com/wp-content/uploads/2019/10/EUSYSFLEX-5.1.5-Legal-requirements-to-data-exchange-2019.10-FINAL.pdf

5.3.3. Transparency Requirements

The Regulation (EU) N°543/2013 on Submission and Publication of Data in Electricity Markets ("Transparency Regulation") lays down the minimum common set of data relating to generation, transportation and consumption of electricity to be made available to market participants. In line with the obligations of the Transparency Platform, ENTSO-E has established and is operating the Transparency Platform, as made available to the Transparency Platform Data Submitters, the Data Users and the IT Service Providers (as defined under the Transparency Regulation and/or Terms of Use of the Transparency Platform).

The primary role of the Transparency Platform for the IEGSA Platform is to provide the available market data on the platform for the stakeholders and players. Furthermore, IEGSA itself or an extension (tool, application, service etc.) is planned to be used as an ''Uploading Solution'' as defined under the Transparency Platform Terms of Use, meaning any software which is installed on the Transparency Platform Data Submitter's IT System in order to submit data to the Transparency Platform. In that regard, the compliance of the IEGSA Platform both as a Data User (an entity which gathers data from the Transparency Platform) and an Uploading Solution under the Transparency Platform Terms and Conditions impose a challenge for the replicability of the IEGSA Platform. Thus, considering the legal framework set up by the Transparency Regulation, IT Service Providers shall ensure the strict observance of all access and use requirements imposed by ENTSO-E.

Under the Transparency Platform Terms of Use, it is stated that the use of an Uploading Solution, such as the IEGSA Platform, even in connection with the use of the Transparency Platform for Transparency purpose, is made under the sole responsibility of the Transparency Platform Data Providers. Thus, ENTSO-E does not provide any security or maintenance for Uploading Solutions which are developed and made available by third parties. Therefore, the provision of adequate security and maintenance for the system operators when using the IEGSA Platform for submitting any data to the Transparency Platform remains a replicability challenge. If this challenge cannot be overcome, Data Submitters may risk non-compliance with the Transparency Regulation obligations.

Note also that the national requirements on transparency may go well beyond the scope of ENTSO-E Transparency Platform – especially in the area of publishing non-validated real time data. This means that in practice there are additional platforms implemented by TSOs to accompany the ENTSO-E TP. The integration of IEGSA with such platforms maybe challenging especially if the latter do not comply with latest interoperability requirements, and consequently the transparency requirements may not be fully fulfilled on the national level.

5.3.4. Intellectual Property Rights

As explained above, the IEGSA Platform aims to use the ENTSO-E Transparency Platform to provide the available market data on the platform for the stakeholders and players. In such a case, it should be ensured that the IEGSA Platform does not cause any prejudice to the copyright or related rights on relevant Transparency Data, which may be owned by other entities who submitted their data on the Transparency Platform as an obligation (primary owners of data). ENTSO-E publishes on the Transparency Platform and regularly updates the list of the Transparency Platform Data which can be freely re-used with no need to seek for the prior agreement of the respective primary owners of data under open-source licenses. Therefore, the responsibility of the IEGSA Platform to regularly check this list, or in any other case to obtain the primary data owners' consent remains as a challenge of scalability and replicability.

5.3.5. Compliance with Future EU Regulations

In addition to the above-listed current regulatory challenges of replicability and scalability, upcoming EU Regulation may also impose new challenges for the IEGSA Platform within close future. In this section, some of these future challenges are pointed out as potential gaps, including the upcoming Network Codes on Cybersecurity and Demand Response, the Data Act, and the implementing acts on interoperability requirements and data access.

Although still at the approval stage, the upcoming ''Network Code on Cybersecurity'' aims to set a European standard for the cybersecurity of cross-border electricity flows. It includes rules on cyber risk assessment, common minimum requirements, cybersecurity certification of products and services, monitoring, reporting and crisis management. This Network Code provides a clear definition of the roles and responsibilities of the different stakeholders for each activity. In that regard, being compliant to the Network Code on Cyber Security shall be one of the regulatory challenges for the implementation of the IEGSA Platform.

The European Commission is currently proposing a new set of rules on who can use and access data generated in the EU across all economic sectors. The proposal for the Data Act includes measures to allow users of connected devices to gain access to data generated by them, and means for public sector bodies to access and use data held by the private sector that is necessary for exceptional circumstances particularly in case of a public emergencies, among other requirements. While the scope of the Data Act is still not final, the requirements of this future Act might create new regulatory challenges for the implementation of the IEGSA Platform, especially with regards to the use of smart grid technologies.

Moreover, pursuant to Article 24(2) of the Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (hereafter referred to as the "Electricity Directive"), the European Commission is developing the implementing acts on interoperability requirements and procedures for access to data referred to in Article 23(1) of the Electricity Directive. The adoption and entry into force of the implementing act regarding metering and consumption data is expected by Q1 2023. On the other hand, the implementing acts for data required for customer switching, demand response and other services, is still in the development phase. These implementing acts will be a regulatory challenge for the implementation of the IEGSA Platform. This is because, as mentioned in 5.3.2 regarding the scope of the IEGSA Platform, there is a possibility that the scope of the platform is expanded to cover also consumer data, for example regarding the processing of households' electricity consumption data via the use of smart grids.

Further, on 2 June 2022, ACER published its draft Framework Guideline on Demand Response (FG on DR) for public consultation. This FG on DR is developed in order to set out clear and objective principles for the development of harmonised rules regarding demand response, including rules on aggregation, energy storage and demand curtailment (hereafter referred to as the "new rules"), pursuant to Article 59(1)(e) of the Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (hereafter referred to as the "Electricity Regulation"), and to contribute to market integration, non-discrimination, effective competition and the efficient functioning of the market pursuant to Article 59(4) of the Electricity Regulation. The final FG on DR is expected by December 2022.

The formal drafting of the new rules in the form of a Network Code will start early 2023. In addition, the new rules will most likely entail the amendment of certain existing regulations[24]. Therefore, the new Network Code on Demand Response and the potential amendments of existing regulations shall be another regulatory challenge for the implementation of the IEGSA Platform.

[24] Although the consequential amendments are not certain at this stage, the new rules might entail the amendment mostly of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL), and Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (EBGL), but maybe also Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (HVDC NC).

Note also that the transposition of EU Directives at national level as well as the implementation of Terms, Conditions and Methodologies at regional or national level may pose challenges to the replicability and scalability of IEGSA. In many cases, the deadlines for transpositions or implementations are not met and are delayed. Especially when considering the scalability of IEGSA by means of cross-border or even pan-EU level use, the non-harmonized normative frameworks on the national level may represent serious barrier for IEGSA's replicability and scalability.

5.4 Summary of Challenges

Based on the qualitative gap assessment in chapter 5, a summary of challenges is depicted in FIGURE 16 to envisage the future Roadmap for IEGSA. Challenges are categorized by dimension; however it is worth mentioning that some of the challenges might have an impact on one or two different dimensions as referred below.

As an example, product definition is considered as a significant challenge that will require a proper level of harmonisation especially when it comes to products and services for congestion management where currently there is a lack of harmonisation among congestion management markets across Europe and their applications among system operators. Another example, this time more related to the scalability of IEGSA is computational processing and storage capacity that a pan-European platform will have to consider. This particular aspect is perceived as a natural challenge but not considered as a limitation due to the fact that current IEGSA's prototype has been tailored for the purpose and scope of the INTERRFACE project. Thus, it is known that a larger and industrialised deployment of IEGSA will consider scalable aspects and address them during the implementation phase.

FIGURE 16 : IEGSA ROADMAP CHALLENGES

6 REPLICABILITY AND SCALABILITY PATHWAYS

This chapter presents specific recommendations, addressing the challenges described in previous sections, towards large-scale deployment of Interoperable Grid Services at pan-European EU level. The presentation of the recommendations is organized in three main dimensions: economic, technical and regulatory.

6.1 Economic

6.1.1 Business Model

Policies tackling flexibility markets should endorse long-term planning to safeguard business sustainability and security of operation for FSPs and interacting stakeholders. The increasing complexity of electric power system, e.g., with the integration of heterogeneous assets and systems/platforms, new stakeholders, the necessity towards pan-European systems' integration including the cross-sector element as well and the definition of specific set of rules and responsibilities at pan-European level is of essential importance to enable the transparent and non-discriminatory coordination among market participants.

- In relation to Harmonised Role Models (as described in chapter 5.1.1), the role model definition among actors of the energy value chain should be well established and defined according to the envisaged pan-European system. This is a pre-requisite for enabling the harmonisation of flexibility markets across Europe. IEGSA platform utilises the description established by HEMRM which should focus on an impact assessment that reflects the attribution of roles in flexibility markets. As presented in Chapter 5, INTERRFACE has already proposed the introduction of new roles in the HERM. Hence, to steer the pan-European vision for the power networks and markets, it is vital to <u>propose harmonized roles and responsibilities</u>, easing this way the integration and subsequently the coordination of data exchange platforms such as the IEGSA. To <u>establish harmonized ground on HEMRM it is crucial to establish cooperation between ACER and the NRAs, considering pan-European and local/nation-wide considerations.</u>

6.1.2. Market

The context of market design might have several elements to frame towards the realisation of pan-European grid, from the product definition up to the procurement of flexibility and ancillary services. The impact of organising the market structure (i.e., formulation of harmonized products, possible establishment of pan-European flexibility markets, harmonized settlement processes etc.), are of high importance for the development of market platforms and/or multi-stakeholder data exchange platforms (such as IEGSA). Therefore, a list of proposed recommendations can be proposed:

- The upscaling of IEGSA for its utilisation in wider context shall consider the market challenges, and potentially needs an extension on the product definition attributes, allowing for the incorporation of new rules on how to treat cross-border products. The current implementation of IEGSA is flexible enough to allow for definition of a product offering multiple eligibility attributes along with a flexible product definition for the prequalification of resource groups. Nonetheless, IEGSA in its current implementation allows for the definition of a single country's product.

  <u>Data exchange platforms</u> e.g., IEGSA, shall allow for the <u>incorporation of cross-border or pan-EU products;</u> hence, there should be further <u>extension of the product definition</u> incorporating also a set of rules on how those <u>interact with nationwide products. Concurrently, at pan-European level it is suggested to define harmonized and flexible product prequalification requirements.</u>

- The future EU system will be composed of several flexibility markets, i.e., the local, national, or cross-border. It will be a challenge for IEGSA, and generally local platforms, and potentially imply the need for additional dynamic functions, to not only deal with other product definitions, but also to define processes for determining the impact of neighbouring markets' products. This added complexity may impact several tasks and processes, from grid and bid qualification, merit order lists, activations, etc. For this, a common product status qualification synchronisation process may need to be agreed at national, regional or even pan-EU level. A certain degree of customisation would need to be borne by IEGSA so as to address the risk of higher barriers to entry for FSPs. The need to designate guidelines for comprehensive grid and bid qualification algorithms considering topological structures able to synchronise national and cross-border needs, despite differences in market design, product definition, prequalification processes, settlement rules is of imperative importance. The composition of some guidelines for grid and bid qualification would increase the potential available flexibility, based on more transparent and fair methodologies applied in platforms like IEGSA. Lack of standardized product definitions and qualification algorithms will hinder interoperability. This will create an additional overhead for platforms such as IEGSA; in order to compensate for this, platforms will have to define extensive sets of different APIs for the same processes so that cross-border and cross-market integration becomes feasible. Even if this could work, it leads again to fragmented solutions and the establishment of additional data silos, which goes against the current EU objectives. These challenges are not explicitly referring to the need of additional features at IEGSA level, but rather the need for establishing or forming a set of prequalification requirements that would allow for pan-EU products. The ongoing implementation of recent EU legislation (EU Regulation 2019/943)[25] and especially the expected publication of new Guidelines on Demand Side Flexibility will enable greater standardisation for the (pre)qualification of distributed assets, as well as for the specifications used by platforms to carry out these tasks. This push will make it easier for flexibility platforms such as IEGSA to scale up via a greater number of registered flexibility providers. However, it is likely that the new legislation will fall short of full standardisation of products due to the need to balance with other policy objectives. Thus, IEGSA (as well as other flexibility platforms) may need to compensate this with additional features.

- The existence of multiple data exchange platforms or market platforms, implies the need for seamless synchronisation of them in regard to product status or the flexibility availability; the latter is important since flexible assets might be providing flexibility services into one or more markets and might be participating in national regional or pan-EU markets. The creation of a pan-European integrated electric network would undoubtedly require the seamless exchange of data (i.e., both data provision and consumption) with the Transparency Platform (TP). The TP ensures transparency can constitute a valuable source of data for the operation the planning of electricity grids. More data fed into the TP can positively affect the coordination of actors and the more efficient and targeted procurement of flexibility. This synchronisation between platforms and the TP allows for providing and getting access to versatile useful information that are of interest of all energy stakeholders e.g., FSPs, TSOs, DSOs, ESCOs. In Chapter 5, it was already discussed that IEGSA has already tested the case of deploying an ECCo SP node locally, allowing IEGSA users to interact with IEGSA either restAPIs, the GUI or via the ECCo SP option. For a wider integration it would be rather crucial to utilise the ECCo SP for the seamless and secure provision and consumption of data foresees to be crucial for complete integration with TP, which could act as key mediator towards the pan-EU network. Addressing such challenges, IEGSA shall need the integration with secure communication channels (i.e., ECCo SP or OneNet connector, or with other similar ones) to synchronize with other data exchange platforms, market platforms or data hubs. This need of extensibility is important since that could address assigned prequalification

[25] Regulation (EU) 2019/943 [EUR-Lex - 32019R0943 - EN - EUR-Lex (europa.eu)]

challenges ensuring that data is not obsolete. Crucial data that is important to be synchronized is product and grid qualification status, resource and flexibility availability, Merit Order Lists, bid activation/cancellation/modification.

- New approaches are needed in case of small, distributed resources to check if they have delivered what they were asked to deliver. This means baseline accuracy and access to sub-meter data, were existent. SCADA connections and balance schedules (for individual resource) are not available. Also metering on connection point level may not be sufficient always because behind one connection point there are many different resources (and not all of them are participating in flexibility provision) and also the data granularity is fixed (one-hour data, 15-minutes data). Harmonised methodologies and technical tools must support the verification process. Several of these points are currently being discussed as part of ACER's framework guidelines on Demand Side Flexibility, which will introduce some degree of harmonisation but still allow for national differences (e.g., on the disaggregation of data in the settlement phase). IEGSA should monitor the introduction of different (and more complex) baselining methodologies which may be more suitable to the wide range of flexibility providers, including small-scale actors. With regard to settlement processes, it is foreseen that the incorporation of new flexibility products at national and pan-EU level necessitates the definition of new rules on granular and accurate measurements, assuming new settlement algorithms with baseline considerations. IEGSA is by design flexible enough to be configured to accommodate new algorithms for the settlement process. Therefore, this challenge is rather relevant to the harmonisation of the settlement process across new pan-EU products.

6.2 Technical

6.2.1 Alignment with Data Spaces

Alignment with popular initiatives mentioned in chapter 5 (Subchapter 5.2) and setting up a synergy with initiatives that are responsible for realising a Semantic Interoperability Toolbox that enables the semantic alignment of data from various users should be considered for scalability.

- Efforts should be increased to align and follow the activities that enable the interoperability between different data sources, with well-known open data sources, and among integrated technologies. Additionally, there shall be harmonisation across data formats such as the ESMP documents, CGMES documents exploiting also linked data principles (e.g. rdf, json-ld).

- As IEGSA platform intends to incorporate CIM/CGMES standard as an important asset that has the potential to cover various TSO and DSO needs. Therefore, the integration of the associated metadata in the future IEGSA versions is a must to consider as integrated part of the models. IEGSA scalability should consider incorporating the metadata together with CIM/CGMES and other potential information models in the information layer. This should follow the standardisation process and be aligned with existing EU initiatives.
- As the IDS Information Model is a standard semantic web standard the IEGSA platform should, consult and adopt it to meet its own requirements. This is in line with other standardisation requirements described in the deliverable, where, standards that promote common data formats and exchange protocols, are considered very valuable for IEGSA updates.
- IEGSA reference architecture has to ensure that the new updates and versions of IEGSA will consider the reference architecture defined at the DSBA.
- IEGSA is foreseen to be further developed within the OneNet project with the complete integration of the OneNet connector allowing for any data exchange with the OneNet ecosystem.

The implementation of the OneNet Decentralised middleware and the OneNet Connector bases its conception on the IDS reference model and FIWARE interfaces. The usage of IDS Connector and FIWARE Context Broker was identified as the best solution to be adopted for ensuring a high level of standardisation, interoperability, scalability and reuse of OneNet solution. OneNet connector relies on the FIWARE TRUE Connector (FTC), a connector for the IDS (International Data Space) ecosystem. FTC enables the trusted data exchange to be active part of an IDS Ecosystem, a virtual data space leveraging existing standards and technologies, as well as governance models well-accepted in the data economy, to facilitate secure and standardized data exchange and data linkage in a trusted business ecosystem. The FTC includes the Execution Core Container, based on the IDS Reference Model for the integration of the IDS based services and metadata exchange as well as the NGSI-LD Data App, able to enable the data exchange using the FIWARE NGSI-LD Context Broker. Therefore, the explicit integration of IEGSA with the OneNet connector can be established in favour of the data exchanges with other data exchange platform, ensuring compliance with the IDS information model towards data spaces.

6.2.2 Seamless Data Exchanges

Increased needs for multi-actor data sharing implies that there should be well defined data access policies ensuring the compliance for data sovereignty, governance and provenance, in the particular case where data exchange platform have to open new communication channels with third party platforms. The recommended solution to ensure trusted and secure communication along with data ownership might be addressed by the evolving European data spaces.

ECCo SP platform is located in the Communication Layer of SGAM and presents many technologies operations like AMQP (Advanced message Queuing Protocol) for near-to-real-time, File System Shared Folder (FSSF) for the exchange of grid models on long-term planning. By applying ECCo SP, IEGSA is capable to exchange standardised data reliably. Nevertheless, to accommodate large number of system operators and other users across Europe, IEGSA should be able to also use different data exchange tools, in a way of reusing existing data exchange infrastructure and lowering upfront investment IT costs.

6.3 Regulatory

The gap analysis under section 5.3 of this deliverable is focused on the main replicability and scalability challenges that the IEGSA Platform may encounter in complying with the existing regulatory framework during its implementation. Indeed, several existing and upcoming regulatory frameworks that the IEGSA Platform should be in compliance with have been identified under that Chapter. In that regard, the identified frameworks are the following:

- Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data
- Directive (EU) 2019/944 on Common Rules for the Internal Market in Electricity
- Regulation (EU) 2019/943 on the Internal Market for Electricity, Directive on Energy Efficiency, Guideline on Electricity Balancing
- Guideline on System Operation
- Network Code on Demand Connection
- Network Code on Requirements for Grid Connection of Generators
- Network Code on Requirements for Grid Connection of HVDC systems and power park modules
- Network Code on Electricity Emergency and Restoration
- Guideline on Capacity Allocation and Congestion Management
- Guideline on Forward Capacity Allocation

- Regulation (EU) 543/2013 on Submission and Publication of Data in Electricity Markets
- ENTSO-E Transparency Platform Terms of Use
- Network Codes on Cybersecurity aspects of cross-border electricity flows
- Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on harmonised rules on fair access to and use of data (Data Act)
  Implementing acts on interoperability requirements
- Harmonised rules regarding demand response
- DIRECTIVE (EU) 2016/1148 concerning measures for a high common level of security of network and information systems cross the Union (NIS Directive
- Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on measures for a high common level of cybersecurity across the Union, repealing Directive 2016/1148 (NIS 2 Directive)

It is also recommended that <u>IEGSA should be adapted throughout time when regulatory evolutions are necessary</u> and undertaken.

A detailed analysis on the implementation of all relevant provisions of the above-mentioned regulatory frameworks on the IEGSA Platform operation is beyond the scope of this deliverable. However, from the regulatory perspective, <u>IEGSA's compliance with these identified frameworks remains a pathway for replicability and scalability.</u>

7 CONCLUSIONS

This Roadmap supports the large-scale integration of flexibility resources considered from the viewpoint of IEGSA. It includes an overview of INTERRFACE pilot demonstrators and relevant EU projects where other IT architectures were envisaged to unlock the flexibility potential across Europe. Thus, pathway recommendations serve as a guideline to the deployment of a pan-European IT architecture which combines and considers all local specificities with the aim of an efficient and coordinated procurement of flexibility services. Each national power system has its own distinct characteristics, such as flexibility portfolio, ancillary services and markets maturity, grid interconnections and constrains, etc. It is therefore necessary to implement consistent rules and strategies at the European level in order to maximise the effectiveness of flexibility provision while recognising the local needs and conditions across Europe.

This final section provides key messages that are needed to ensure a successful IEGSA Roadmap implementation across Europe. Key messages are a consolidation from all recommendations captured in previous chapters:

1. Role model definition is a crucial aspect for the interoperability of IEGSA. The proper **adoption of role descriptions** defined by HEMRM will allow an efficient interaction and coordination among different actors.
2. Market challenges are inherently tied to the complexity and multiplicity of new and existing products, services, markets, and processes across Europe. While new regulation (e.g., Network Code on DSF) will undoubtedly enable greater compatibility across markets, these new rules may also impose stricter requirements on market platforms. For IEGSA to be scaled up and replicated in the future, a combination of **flexible design, customizability and sufficiently powerful algorithms** will be required to meet these evolving standards.
3. Technical challenges require further alignment and compliance with existing and future **standardisation** activities. Moreover, future IEGSA development should consider alignment with key initiative at EU and International level, such as: DSBA architecture, metadata, IDS information model, etc, to ensure enhanced interoperability.
4. **ICT scalability** aspects are perceived as a natural challenge rather than a limitation. During the implementation phase of IEGSA in a pan-European scale, these aspects will certainly be addressed.
5. **Integration with multiple distributed data exchange platforms** at cross-border or even at cross-sector level. Is also a necessary step for replicability and scalability of IEGSA. The interconnection of such multiple data-exchange platforms and system aims to release data-driven services among the different business actors.
6. **Regulatory compliance** with relevant frameworks is crucial for in replicability and scalability of IEGSA. Regulatory evolutions might also require IEGSA's adaptability when deemed necessary.

To conclude, it is recognised that a successful undertake of the replicability and scalability pathways will require increasing collaborative efforts across member states, national organisations and industry associations which will unlock the full potential of flexibility provisions across Europe, enabling the inclusion of new flexibility products which could be tested and deployed by a future pan-European IEGSA architecture.