TSO-DSO Coordination

BRIDGE Regulation WG and

Data Management WG

December 2019

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List of Acronyms and Abbreviations

AI	Artificial Intelligence
AMQP	Advance Message Queuing Protocol
API	Application Programming Interface
BRP	Balance Responsible Parties
BMS	Building Management System
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CEP	Clean Energy Package
CG-SEG	Coordination Group Smart Energy Grid (CEN-CENELEC-ETSI)
CGMES	Common Grid Model Exchange Specification
CIM	Common Information Model
CSV	Comma-Separated Values file
DB	DataBase
DEP	Data exchange platform
DER	Distributed Energy Resources
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
E.DSO	European Distribution System Operators
ebIX	european forum for energy business Information Exchange
EC	European Commission
EFET	European Federation of Energy Traders
EG	Expert Group
EMS	Energy Management System
ENTSO-E	European Network of Transmission System Operators for Electricity
ESB	Enterprise Service Bus
ESMP	European Style Market Profile
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
GDPR	General Data Protection Regulation
HEMRM	Harmonized Electricity Market Role Model
HEMS	Home Energy Management System

HTTPS	HyperText Transfer Protocol Secure
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
IT	Information Technology
LCE	Low Carbon Energy
MQTT	Message Queuing Telemetry Transport
NIST	National Institute of Standards and Technology
P2P	Peer to Peer
P2DSO	Peer to DSO
QUIC	Quick UDP Internet Connections
RES	Renewable Energy Sources
REST	REpresentational State Transfer
SAREF	Smarty Appliances REFerence ontology
SGAM	Smart Grid Architecture Model
SGTF	European Smart Grids Task Force
SLA	Service Level Agreement
TBD	To be defined
TLS	Transport Layer Security
TSO	Transmission System Operator
UDP	User Datagram Protocol
UML	Unified Modelling Language
USEF	Universal Smart Energy Framework
VPN	Virtual Private Network
VPP	Virtual Power Plant
VSP	Virtual Storage Plant
WAN	Wireless Area Network
WG	Working Group
XML	Extensible Markup Language

Executive Summary

BRIDGE report on TSO-DSO Coordination attempts to map the interactions between the network operators (TSOs & DSOs), either between the same type of operators or between TSO and DSO. The focus lies on market design and data exchange between the aforementioned actors and the way that this is implemented.

15 projects responded to the Regulation WG questionnaire. All projects deal to some extent with the development of products and services and consequently, impact the underlying market design and the necessary coordination between system operators. The questionnaire focused on three core aspects: (1) the development of products and services, (2) different coordination models, and (3) the implications for roles and role models. The answers from the survey highlight the challenges observed at technical, economic and regulatory level to implement innovations in both product development and coordination models. Recommendations will be provided to support replicability of the solutions proposed by different projects.

14 projects responded to Data Management WG questionnaire. Not all of them are actually involved in studying the TSO-TSO, DSO-DSO and/or TSO-DSO data exchanges. Nevertheless, their insights are still valuable, as data exchanges between the rest of the actors of the energy value chain are still important and require standardization and further research. The complexity of the data exchanges in the modern markets implies not just bilateral data exchanges, but multilateral instead. The usage of existing and planned data platforms was investigated in the context of growing needs and volumes of data exchanges. The ‘landscape’ of existing and planned platforms implemented in different projects indicates different focus points of data exchanges. Based on projects’ answers, the report further provides insights into different data types exchanged, data roles, models and frameworks, data access, functionalities and performance of platforms, and interoperability.

Main findings in regulation side are as follows:

- Projects have developed a wide range of products, services and coordination models for only TSOs, only DSOs or for both TSOs and DSOs.
- Most projects focus on the development of services for congestion management and frequency control.
- The services developed unlock a wide range of value propositions for several stakeholders, e.g. reduction in curtailment, reduction of imbalance, avoidance of grid investment, increase of hosting capacity of RES.
- Coordination models between system operators are primarily explored in the operational planning/real-time timeframe.
- The flexibility mechanisms to acquire flexibility are mainly market-based and most market places developed focus on local and distributed markets (P2P).
- The main barriers for the realization of market concepts for coordination and flexibility procurements are regulatory barriers, however, some technical and economic barriers remain relevant.

Main findings in data management side are as follows:

- There are few dedicated platforms for energy data exchanges existing or developing.
- Half of the projects demonstrate interoperability between platforms, while only few demonstrate cross-sector interoperability.

- Half of the projects apply standardized approach to use case description and majority of the projects are in favour of having access to a use case repository.
- Some new data roles have been proposed.
- CIM standard is not addressing all aspects implicitly relevant for TSO-DSO coordination.

Summary of recommendations for regulation:

- DSOs should be actively incentivized to use flexibility.
- Standardization of products is ongoing, but should take into account some degree of flexibility.
- Detailed products for congestion management should be developed.
- The link between market-based mechanisms for flexibility and other mechanisms (regulatory, technical...) should be further analyzed and should avoid conflicting set-ups.
- The increased coordination between system operators should continue, focusing not only on the operational timeframe but also on other fields such as network planning.
- Decentralized and distributed market design options should be further explored in the field of existing and new system services.
- The role of market operator and the degree of regulation should be assessed and clarified.

Summary of recommendations for data management:

- Develop conceptual European data exchange model, involving elements like functionalities, governance, data access, open source, standardisation needs.
- Define “interoperability of platforms” and identify platforms with European ambition and potential for replicability and scalability.
- Ensure GDPR compliance and data owner's control over their data.
- Cooperate while developing use cases and an easily accessible use case repository.
- Elaborate new data roles, harmonize approach to role definitions and recommend these to be included in HEMRM.
- Apply CIM standards in TSO-DSO coordination as well as cooperate in suggesting extensions to CIM.

1. Introduction

This is the common report by BRIDGE Regulation WG and Data Management WG. Both groups launched separate surveys and collected the answers from participating projects in July-September 2019. The report provides an analysis of these surveys' outcomes to highlight TSO-DSO cooperation challenges.

The Regulations WG identifies regulatory issues faced by the H2020 RD&I projects and provides recommendations to the European Commission to tackle these challenges:

- As regards to **energy storage**, the regulatory framework needs to provide clear rules and responsibilities concerning ownership, competition, technical modalities and financial conditions, for island and mainland cases
- In terms of **smart grids**, regulatory challenges arise regarding the incentives for demand-side response, commercial arrangements, smart meter data, etc.

The Data Management WG aims to cover a wide range of aspects ranging from the technical means for exchanging and processing data between interested stakeholders to the definition of rules for exchange, including security issues and responsibility distribution in data handling. Accordingly, the WG has identified 3 areas of collaboration around which mutual exchange of views and discussions have been set:

- **Communication Infrastructure**, embracing the technical and non-technical aspects of the communication infrastructure needed to exchange data and the related requirements;
- **Cybersecurity and Data Privacy**, entailing data integrity, customer privacy and protection;
- **Data Handling**, including the framework for data exchange and related roles and responsibilities, together with the technical issues supporting the exchange of data in a secure and interoperable manner, and the data analytics techniques for data processing.

2. Description of the panel of projects

2.1 Introduction

This report attempts to map the interactions between the network operators (TSOs & DSOs), either between the same type of operators or between TSO and DSO. The focus lies on market design and data exchange between the aforementioned actors and the way that this is implemented.

For data exchange, the objective is to examine standards and frameworks in an effort to identify most popular ones and provide recommendations accordingly to all projects involved in this domain. Apart from trying to recognize the most commonly utilized models, standards and frameworks that could assist the TSO-TSO, DSO-DSO and TSO-DSO data exchanges, the questionnaire that was disseminated to all participants of the Data Management WG of the BRIDGE Initiative aims to identify and highlight the gaps that act as barriers for the materialization of the objectives. In addition, recommendations by the projects were requested, which could act as drivers for the more efficient coordination between the operators. Enhancements, additions and changes to the standards and frameworks are examined so that concrete suggestions can be forwarded to the responsible parties (policy makers, regulators, etc.).

For market design, we focus in the survey on following three dimensions: (1) the development of products and services, (2) different coordination models, and (3) the implications for roles and role models. The survey will highlight the challenges observed at technical, economic and regulatory level to implement innovations in both product development and coordination models. Recommendations will be provided to support replicability of the solutions proposed by different projects.

2.2 Preliminary analysis of the projects' scope

The analysis of the questionnaire and of the responses that were received will follow in Chapter 3. In this section we will present a preliminary mapping of the projects' scope, trying to identify:

- How many projects developed services and products for TSO and DSO.
- Which coordination topic is considered in their project (TSO-TSO, DSO-DSO or TSO-DSO).
- How many projects actually address the communication and data exchange between the operators and more specifically, which interactions they focus on.

Questionnaires were disseminated to the projects that participate in the Data Management and Regulation WG (one questionnaire per WG).

On **Data Management** side, table 1 gives an overview of the projects that responded to the questionnaire regarding the data exchanges that they are examining[1].

Table 1 Overview of the data exchanges where the projects focus on

Project Name	Data Exchanges
OSMOSE	TSO-TSO data exchanges
SMILE	No data exchanges between operators
E-LAND	No data exchanges between operators
INVADE	No data exchanges between operators
TDX-ASSIST	TSO-DSO data exchanges
InteGrid	TSO-DSO data exchanges

1 In addition, project MUSE GRIDS provided one specific comment later in drafting phase.

MERLON	DSO-DSO data exchanges. Additionally, exchanges between DSO and other actors
INTERRFACE	TSO-DSO, DSO-DSO, TSO-TSO data exchanges
EU-SysFlex	TSO-DSO, DSO-DSO, TSO-TSO data exchanges
GIFT	No data exchanges between operators
CROSSBOW	TSO-DSO, TSO-TSO data exchanges
InterFlex	No data exchanges between operators
GOFLEX	No data exchanges between operators
CoordiNET	TSO-DSO, DSO-DSO data exchanges

Figure 1 provides a summary of the results of Table 1.

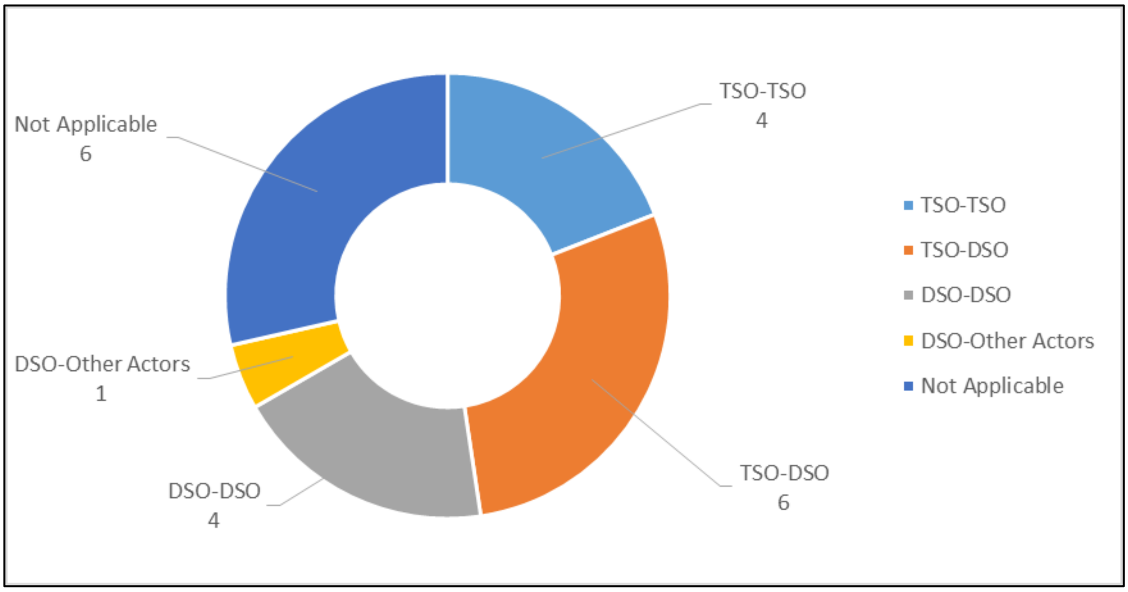

Figure 1: Number of projects dealing with the data exchanges that are being studied

It is obvious in Figure 1 that not all the projects that provided their feedback to the questionnaire are actually involved in studying the data exchanges of interest. In particular, 6 out of 14 projects are not dealing with those data exchanges. Nevertheless, their insights are still valuable, as data exchanges between the rest of the actors of the energy value chain are still important and require standardization and further research. To be more specific, one of the projects deals with DSO-Aggregator data exchanges, as well as the data exchanges at the interface between the DSO and consumers. The complexity of the data exchanges in the modern markets necessitated the establishment of proper guidelines and recommendations for addressing data platforms and exchanges between not just two entities but many of them, multilateral instead of bilateral. Therefore, the DSO-Aggregator exchanges (for example) are also quite relevant for the definition and shaping of the data management and data exchange standards and requirements.

In addition, the data exchanges and the coordination between the TSO and the DSO are examined by 6 projects, which shows the imminent need for more efficient coordination schemes and data exchange procedures and standards. Finally, 4 projects are dealing with DSO-DSO data exchanges, while the TSO-TSO interaction is studied by 4 projects.

The usage of existing and planned data platforms was investigated in the context of growing needs and volumes of data exchanges. It is explained in more details in section 3.4 but figure 2 provides a summary of the platforms' landscape. It is relevant to keep in mind that 'data platform' does not stand here for ‘TSO-DSO coordination platform’. It is platform for any data exchanges between any stakeholders/actors. As an emerging topic the role of platforms should be investigated further.

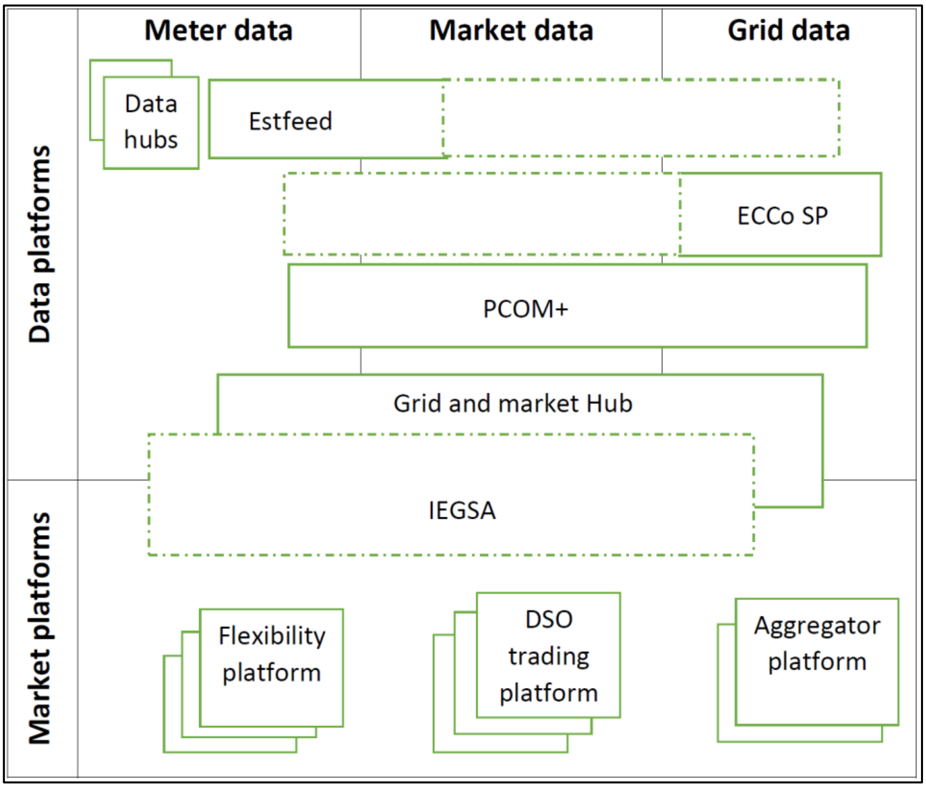

Figure 2: Landscape of existing and new energy sector specific data platforms brought forward by the projects

When designing options for data management the projects can build on several policy documents and study reports like EC communications on European interoperability framework and on European data space, EC study on interoperability for enabling demand side flexibility, Smart Grids Task Force report on interoperability for data access and exchange, ENTSO-E and DSO associations' reports on data management and on integrated approach to active system management, ENTSO-E report on state of play of data exchanges in Europe, ASSET study on data format and procedures, etc. Projects should also refer to existing standards (e.g. CIM) and role models (e.g. HEMRM, USEF).

Specifically, many recommendations in the European Smart Grids Task Force Expert Group 1 report were used as the basis to develop the questionnaire for this study. Namely:

- Recommendation #1. Building on available role models, adopt and use a common European role model.
- Recommendation #2. To facilitate interoperability adopt and use a common information model for semantics, for example consider building on the available IEC CIM model.
- Recommendation #3. Adopt and use a core process model, which should allow for national specificities and stay open for further interoperability over time.
- Recommendation #4. Business requirements shall be the basis for interoperability and must remain technology-neutral.
- Recommendation #5. Adopt and use available European standards as a basis to improve interoperability.

On **Regulation** side, 15 projects are represented in the questionnaire answers:

- CoordiNet
- CROSSBOW
- EU-SysFlex
- FLEXITRANSTORE
- GIFT
- GOFLEX
- InteGrid
- InterFlex
- INTERRFACE
- INVADE
- MIGRATE
- MUSE GRIDS
- OSMOSE
- Store & Go
- WiseGRID

All those projects are developing services for DSO or TSO or both, except one (Store&Go).

Most projects have developed services for Distribution System Operators.

It should be noted that even the projects developing service only for one type of operator may be addressing some coordination aspects.

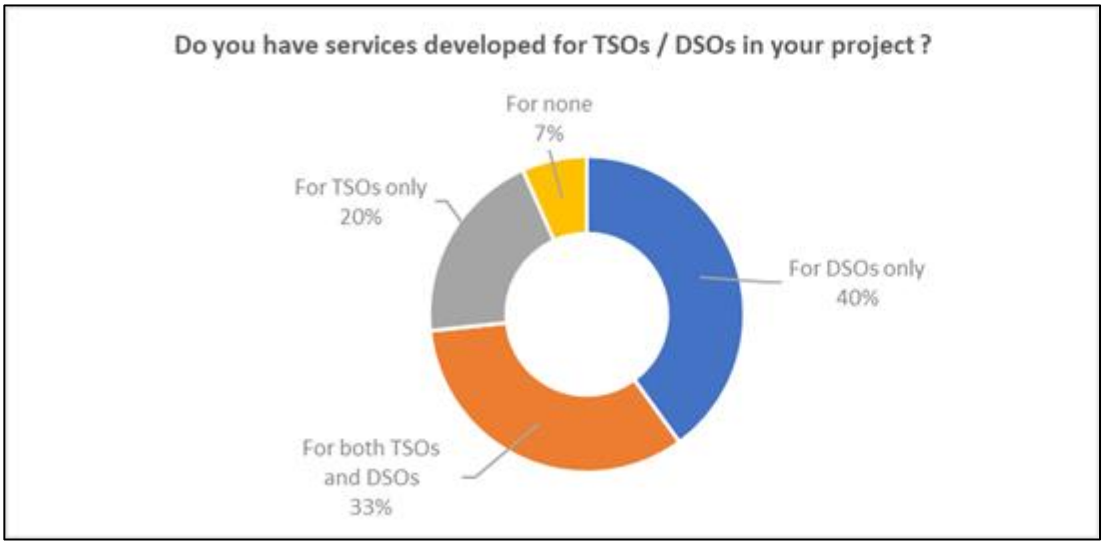

Figure 3: Projects developing services for TSOs / DSOs

Concerning coordination models, three projects do not consider any coordination model: InterFlex, MUSE GRIDS and GIFT.

From the projects that do consider coordination models, the TSO-TSO and TSO-DSO models are the most widely addressed. Also, a considerable set of projects consider more than one model (InteGrid, INTERRFACE, CROSSBOW and WiseGRID).

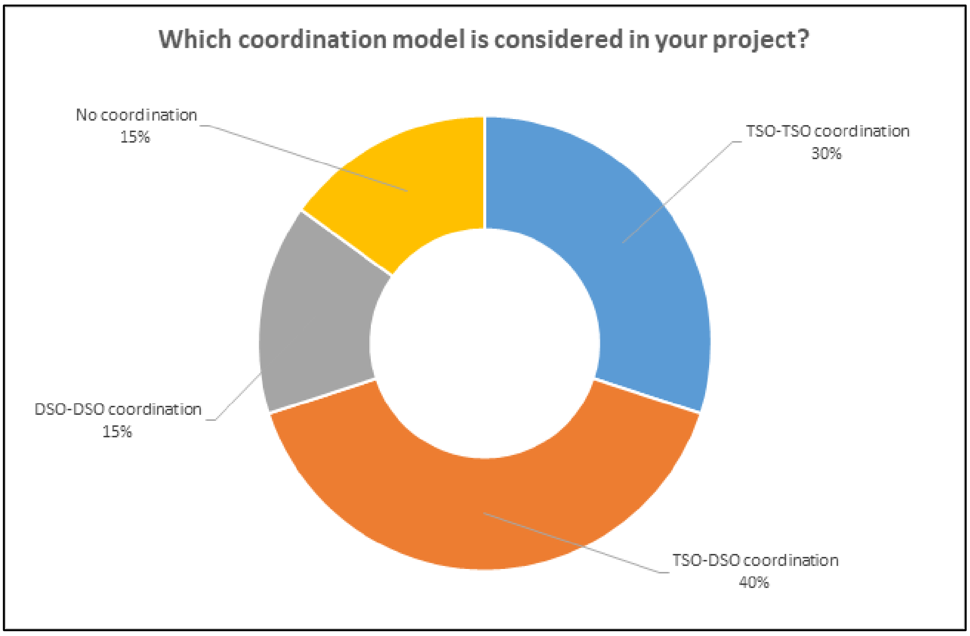

Figure 4: Coordination model considered by the projects

Not all questions from the survey dealing with regulatory aspects are further discussed in detail:

- Only one project (FLEXITRANSTORE) is proposing novel planning models for networks to meet future demands.
- Question regarding transfer of energy was not well understood and no concrete answers were provided.

3. Main findings

3.1 Services and products

3.1.1 Services developed

Services developed for TSO and DSO are diverse. Congestion management is widely proposed for both operators. However, whereas reactive power provisioning is a major TSO offer, it is less favoured for DSO where the active power provisioning is more addressed.

Other major focuses are, for TSO, secondary and tertiary controls, and for DSO, grid capacity management and voltage control.

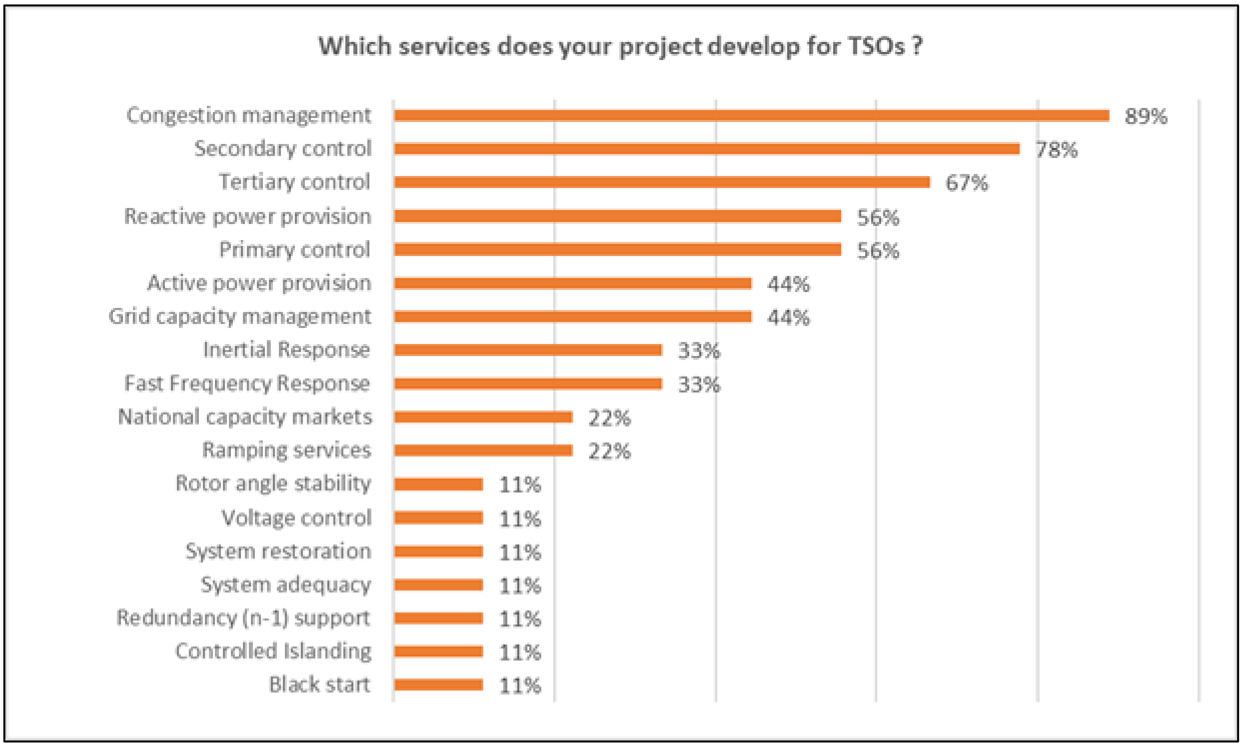

Figure 5: Services developed for TSOs by the projects *(share of projects among those answering the survey and providing services for TSOs)*

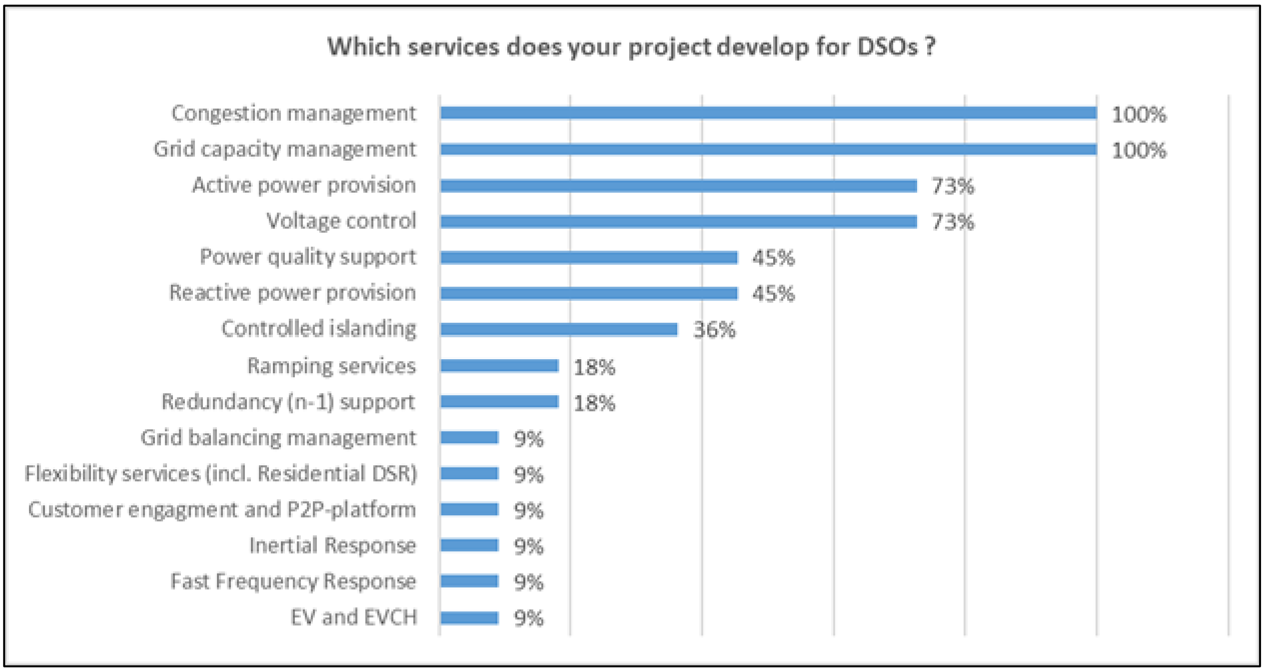

Figure 6: Services developed for DSOs by the projects *(share of projects among those answering the survey and providing services for DSOs)*

Some projects specify that services are defined as requirement for connection not as remunerated service for providers.

3.1.2 Products designed to provide the services

The level of maturity for technical specifications definition differs from one project to another. Some are still in the process of clarifying those characteristics (INTERRFACE, FLEXITRANSTORE), others have already detailed theirs.

The Nice Smart Valley project, for example, which is one of InterFlex demos, developed a flexibilities product with the following characteristics:

Seasons	Summer		Winter		Mid-season	
Days	Week	Week end	Week	Week end	Week	Week end
Time slot	10-16h 18h-20h	10-16h 18h-20h	19h-6h	19h-6h	6h-10h 16h-18h	6h-10h 16h-18h
Process	J-1	J-1	J-1	J-1	J-1	J-1
Minimum duration	30 min	30 min	30 min	30 min	30 min	30 min
Maximum duration	2h	2h	2h	2h	2h	2h
Max. time between activations	2h	2h	2h	2h	2h	2h
Max number of activation/day	2	2	2	2	2	2
Max number activation per year	60					

Figure 7: Example of a product developed by a BRIDGE project: InterFlex

Another example is the Fast Frequency Response product developed by the CoordiNet project, which aims at influencing the system response following a disturbance within the timeframe of inertial response. This is achieved through a fast injection of energy. The following attributes were defined by the project:

Attribute	Value
Preparation period	n/a[13]
Ramping period	Defined in terms and conditions for FSPs[14] [15]
Full activation time	< 2 seconds[16]
Minimum quantity	1 MW or 0.1 MW[17]
Maximum quantity	Defined based on system needs
Deactivation period	< 2 seconds
Granularity	0.01 MW
Minimum duration of delivery period	8 seconds
Maximum duration of delivery period	n/a[18]
Validity period	Defined in terms and conditions for FSPs
Mode of activation	Automatic
Availability price	Yes
Activation price	Possible
Divisibility	Divisible and indivisible bids are allowed
Location	LFC area
Recovery period	n/a (continuous activation within validity period)
Aggregation allowed	Yes
Symmetric / asymmetric product	No symmetry required

Figure 8: Example of a product developed by a BRIDGE project: CoordiNet

[13] The product needs to be available continuously within the validity period.

[14] The mention "Defined in terms and conditions for FSPs" means these are the requirements established by each TSO and/or DSO for procuring services within their control area.

[15] The sum of the ramping period and preparation period cannot be greater than the full activation time.

[16] However, incentives could be in place to promote faster responses. For instance, In Ireland service providers receive incentives to provide a response in 150 milliseconds (EIRGRID, 2019b).

[17] MW delivered within the requested period. Note that the energy impact is expected to be minor since the product would be required for a short time span (up to a few minutes).

[18] Maximum duration of the delivery period may vary in respect to the type of event being tackle (Alan Finkel et al., 2017)

3.1.3 Clean Energy Package compliance

Most projects are compliant with the Clean Energy Package:

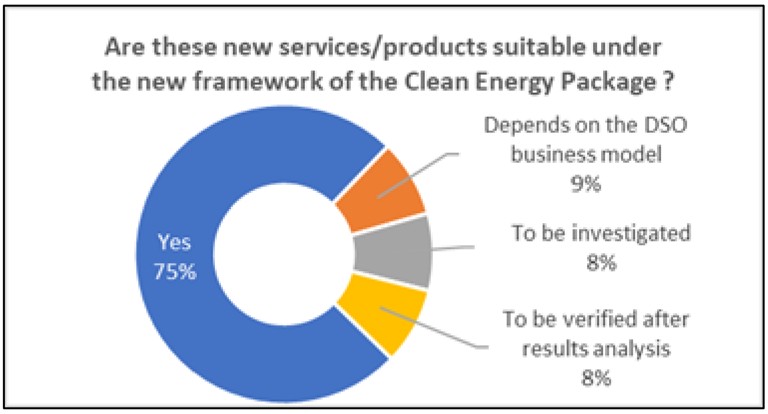

Figure 9: Projects compliancy with the Clean Energy Package *(share of projects among those answering the survey and providing services to TSOs or DSOs)*

The GOFLEX project compliance depends on the DSO Business model. The project specifies that the spread of use/scope of deployment depends on the business model of DSO, which is dependent on the repartitioning of responsibilities and network fee between TSO and DSO.

Within InterFlex French demo, the compliance with the Clean Energy Package is questioned for some use cases around storage. Notably, the islanded operation of a MV network based on battery storages requires the DSO to be able to control its protection plan, the wave quality and the balance between production and consumption. This leads to the necessity for the DSO to operate a minimum sized storage. Thanks to the wireless system developed in the project, storage operators or aggregators can complete the energy needed, whereas the DSO storage is used by the DSO only for islanding. Most of the time, a contract between the DSO and an aggregator is used for the aggregator to valorize the DSO asset (with a fixed compensation to the DSO). Clarification is required on whether or not that counts as an exception in which the DSO can operate a storage.

The INTERRFACE project will define the suitability verifications during the project and the results analysis.

3.1.4 Simulations / demonstrations of the services and/or products developed

All projects answering the survey are carrying-out simulations / demonstrations of their services and products (except for Store & Go, which does not propose services for TSO / DSO).

The main challenge for demonstrations' replicability on a larger scale is the evolution of regulation:

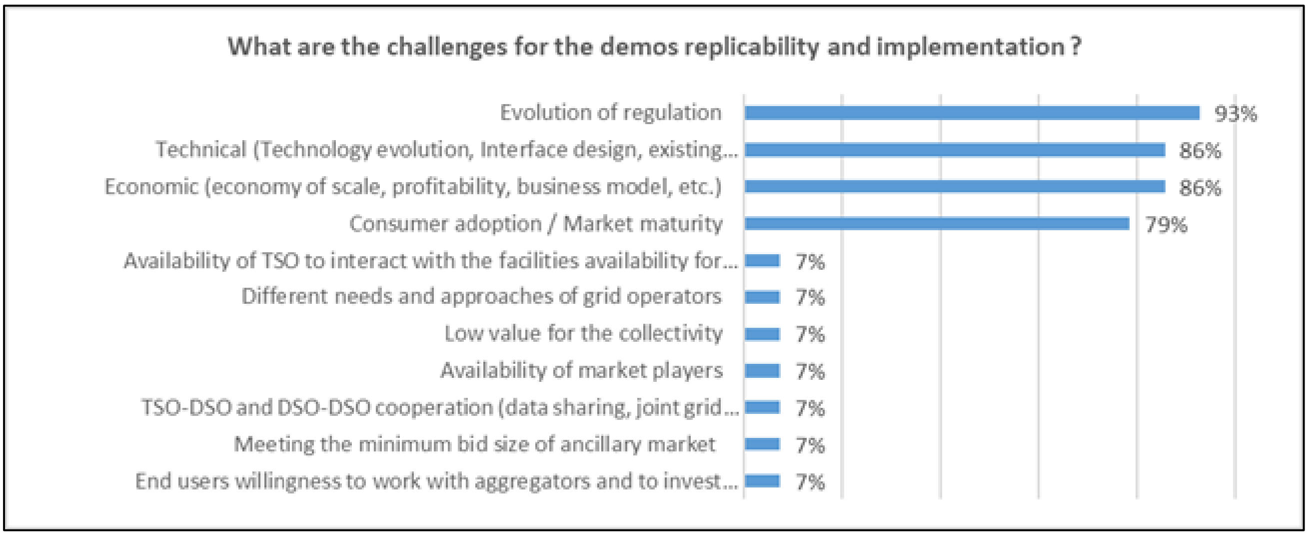

Figure 10: Challenges faced by the projects for demos' replicability and implementation *(share of projects among those answering the survey and running simulations / demonstrations)*

The EU-SysFlex project provided details on the *Evolution of regulation* challenge:

- There are differing stages of regulatory development and approaches for specific markets across Europe (for example, differing maturity levels of System Services market in different jurisdictions). The inadequate remuneration for the incentivisation of the necessary system services and flexibility is also an issue: money should shift from energy and capacity to services as they will be essential for the future pan European system, largely dependent on non-synchronous, intermittent technology such as wind and solar.

- Evolution in the regulation is needed for technical aggregation of flexibilities from lower to upper voltage levels by respective system operators; in order to reduce flexibility limitations in operators' coordination processes, operators need schedules of connected grid users first for time efficient coordination process, technical standardisation e.g. CIM (the only technical challenge), explicit definition of operators' responsibilities to select flexibilities connected to own grid.

- DSO need an evolution of regulation to be able to ask for flexibility provision from private distributed resources ("local flexibility services" are currently not allowed/remunerated).

InterFlex highlights that some collectivities do not express any need for grid operation since there is no flexibility value where grid congestions are very rare. The availability of market players like aggregators and the end users' willingness to work with these players and to invest in, for instance, a local battery, also represent a challenge.

CROSSBOW project presents the specificity of being located in a region which comprises both EU and non-EU countries. It therefore takes a wider perspective on regulation (the levels of implementation of EU regulation for non-EU countries, the level of markets maturity, the practices of TSOs for ancillary services), the expected evolution of regulation in the region, and the extension of EU rules and practices to EU immediate neighbouring countries.

3.1.5 Value pockets of services and beneficiary actors

The services proposed by the different projects unlock a wide range of value pockets. They allow notably for a reduction in the curtailment of distributed generation, a reduction of imbalance and CO_2 emissions, avoid grid investment and increase grid hosting capacity for distributed generation:

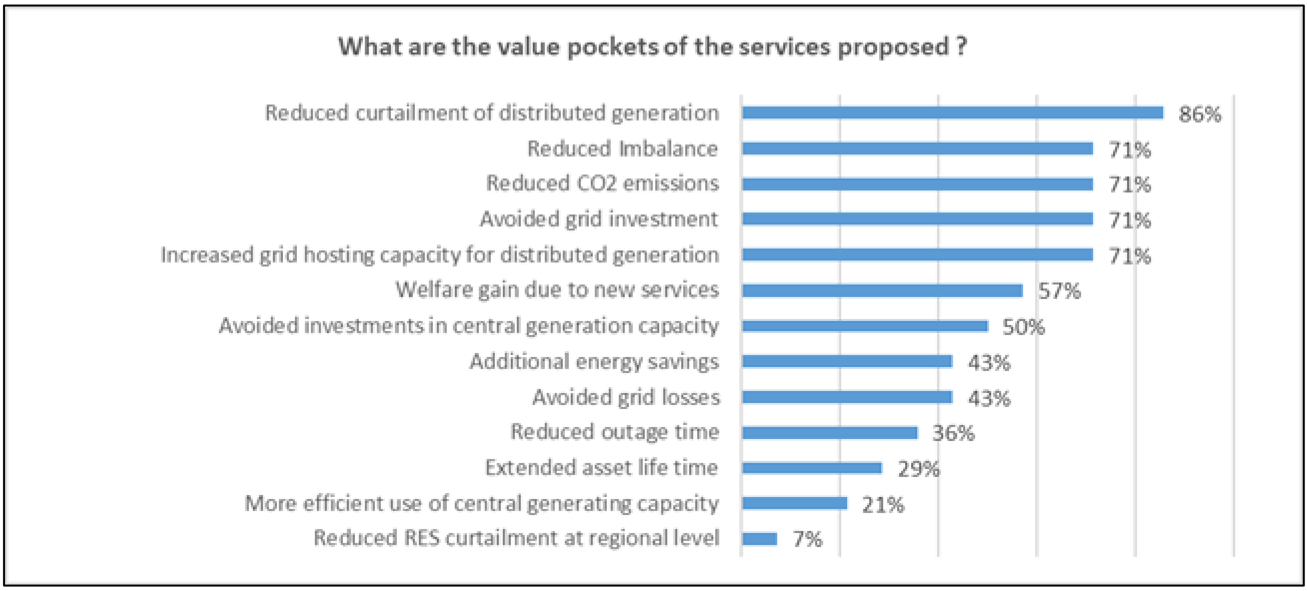

Figure 11: Value pockets unlocked by the services developed *(share of projects among those answering the survey and developing services for TSO / DSO)*

Projects services benefit to a wide range of actors:

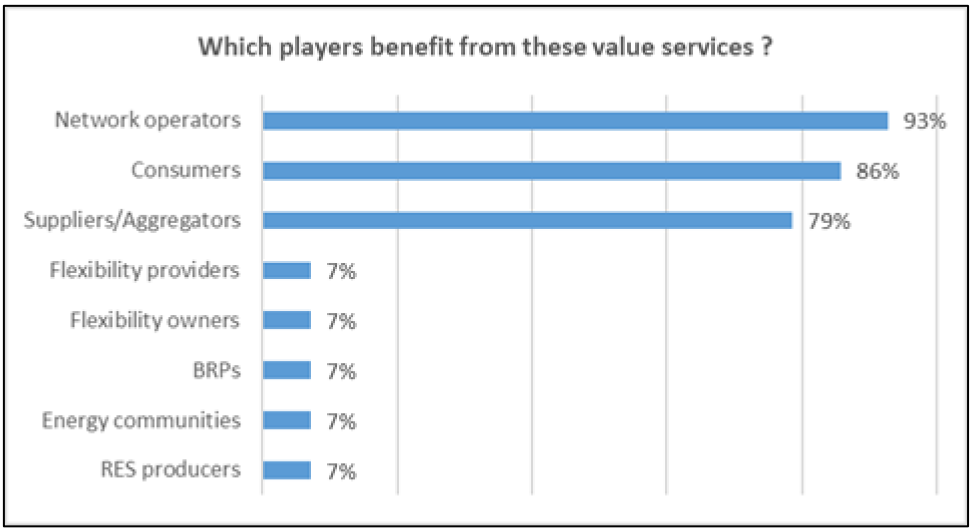

Figure 12: Players benefiting from the value services *(share of projects among those answering the survey and developing services for TSO / DSO)*

10 projects over the 14 developing services for TSO / DSO provide services for both Suppliers/Aggregators, Network operators and Consumers.

Most projects have defined KPIs to quantify the benefits provided by their services. There is a very wide set of KPIs proposed, among which the avoided energy curtailment, the reduction of system peak load and of voltage limitations, the improvement of supply security and the consumer acceptance and involvement are recurrent KPIs.

The WiseGRID project, for instance, defined the following KPIs, aiming at quantifying the added value of Research & Innovation results compared to the existing practices:

KPIs	Compliance with EU energy policy goals		
	Sustainability	Market competitiveness	Security of supply
A.1. Increased network capacity at affordable cost	✓	✓	✓
A.2. Increased system flexibility at affordable cost	✓	✓	✓
B.1. Increased RES and DER hosting capacity	✓	✓	✓
B.2. Reduced energy curtailment of RES and DER	✓	✓	✓
B.3. Power quality and quality supply	✓	✓	✓
B.4. Extended asset life time			✓
B.5. Increased flexibility from energy players		✓	✓
B.6. Improved competitiveness of the electricity market		✓	
B.7. Increased hosting capacity for EVs and other new loads	✓	✓	✓

Figure 13: Example of a set of KPIs developed by a BRIDGE project: WiseGRID

3.1.6 Forecasting models definition

Most projects define new forecasting model to predict frequency issues/voltage issues/congestion issues/other system scarcities:

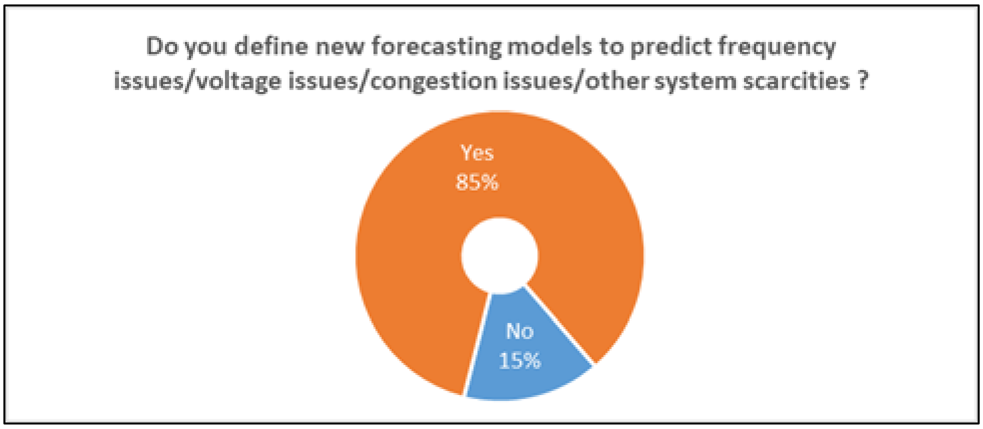

Figure 14: Projects defining new forecasting models to predict frequency/voltage/congestion issues or other system scarcities *(share of projects among those participating in the project and providing answer to the question)*

3.1.7 Voltage level

Most projects have medium voltage within their scope:

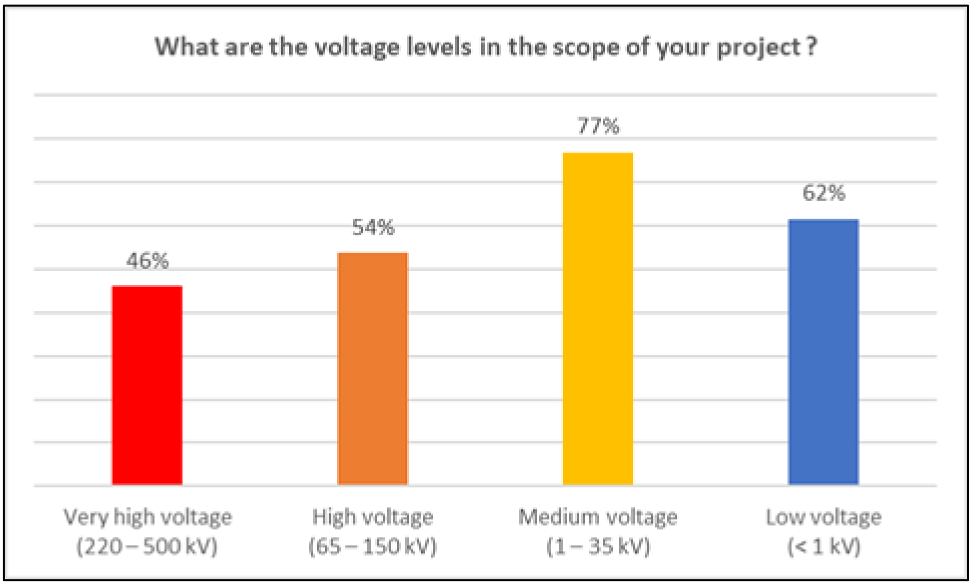

Figure 15: Voltage levels in the scope of the projects *(share of projects among those participating in the project and providing answer to the question)*

3.2 Market design

3.2.1 Coordination models considered

All coordination models are considered among surveyed projects. However, different preferences are observed. Some projects focus on only one model, while others opt for a combination of models. The preferred combination is TSO-TSO & TSO-DSO. Combinations including the DSO-DSO model were less explored.

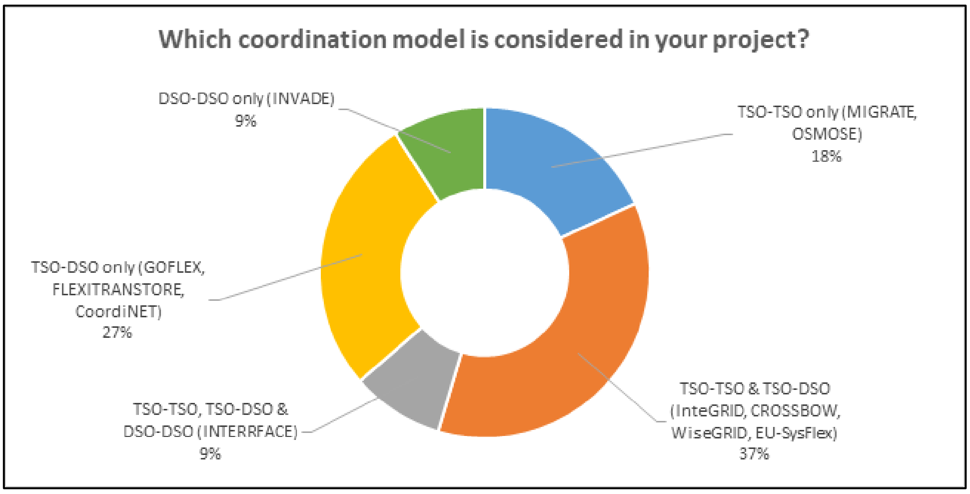

Figure 16: Share of coordination models in the scope of surveyed projects

3.2.2 Timeframes in scope

The vast majority of projects focus on the operational planning and real-time operation timeframes. Network planning is only explored in projects that consider all three timeframes (InterFlex, WiseGRID, MIGRATE and FLEXITRANSTORE).

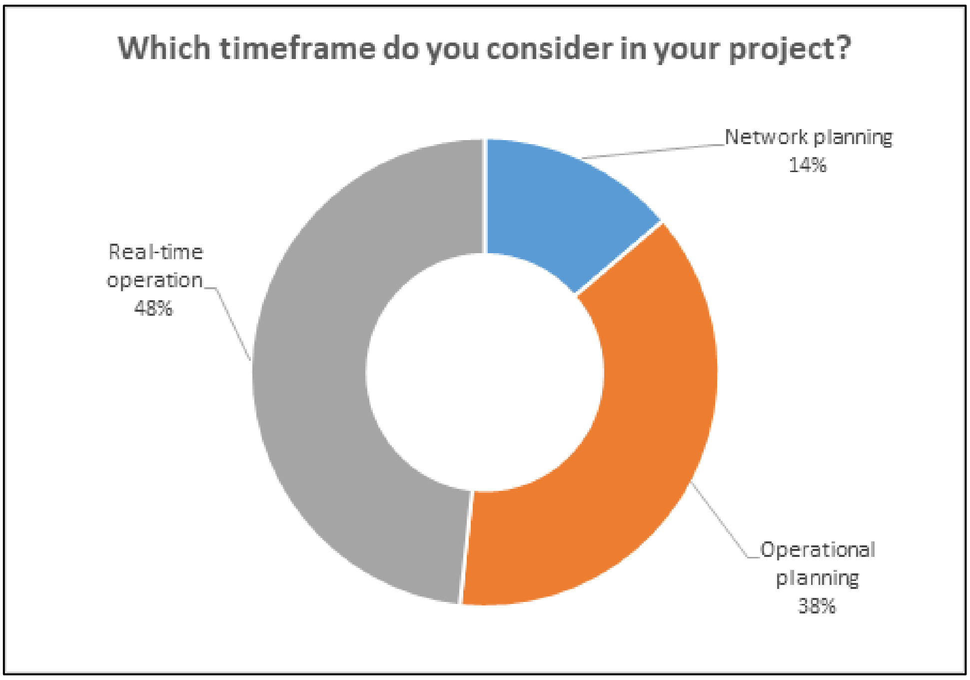

Figure 17: Share of timeframes in the scope of surveyed projects

Cross-referencing with projects that consider a coordination model yields the following:

- Only one project (INTERRFACE) considers operational planning and real-time operation across all three coordination models.
- No project considers all timeframes across all coordination models.

Real-time operation is always considered (exclusively or in coordination with other timeframes) for all three coordination models (TSO-TSO, TSO-DSO and DSO-DSO). In contrast, exclusive consideration of network and/or operational planning is not observed for any coordination model, suggesting a preference for real-time operation across projects.

3.2.3 Mechanisms developed

All projects develop at least one mechanism to cover the needs for the timeframes in scope. Market-based solutions are the preferred option.

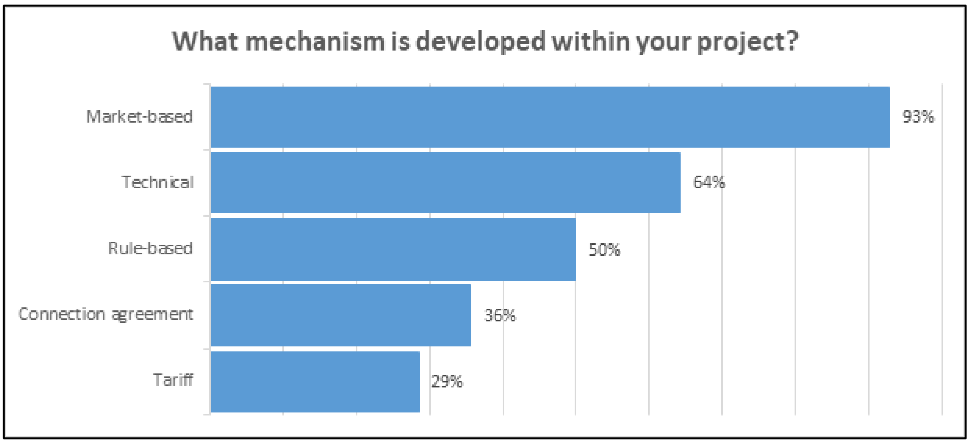

Figure 18: Mechanisms developed within the projects

The CROSSBOW project develops the following solutions for operational planning and real-time operation timeframes:

Table 2: CROSSBOW project solutions for operational planning and real-time operation timeframes

<table>
<tr><th></th><th>Operational planning</th><th>Real-time operation</th></tr>
<tr><td rowspan="6">Technical solutions</td><td>RES generation forecast</td><td>Regional low frequency oscillation detection</td></tr>
<tr><td>Dynamic line rating forecast</td><td>Voltage monitoring</td></tr>
<tr><td>Capacity calculations</td><td>Dispatching of RES units</td></tr>
<tr><td>Congestion management algorithms</td><td>WAMAS based remedial actions</td></tr>
<tr><td>Short-term regional adequacy assessment</td><td>Temporary storage of surplus of energy</td></tr>
<tr><td></td><td>Frequency and voltage regulation, and congestion mitigation by coordination of either distributed storage resources, VSP or DSM</td></tr>
<tr><td rowspan="3">Market-based solutions</td><td>RES participation on secondary (reserves) market</td><td>Market based RES curtailment</td></tr>
<tr><td colspan="2">RES dispatchable units participation on ancillary markets</td></tr>
<tr><td>Regional intraday block-chain based electricity market</td><td>Regional block-chain based peer to peer market for flexibility</td></tr>
<tr><td rowspan="2">Rule-based solutions</td><td></td><td>RES curtailment strategies</td></tr>
<tr><td></td><td>Minimum curtailment of flexibility resources</td></tr>
</table>

Few projects deal with e-mobility (INVADE, WiseGRID, GOFLEX and MUSE Grids) and half of them (INVADE and GOFLEX) implement dynamic tariffs.

3.2.4 Market concepts developed

Options for marketplace concepts provided within the survey may be classified in three groups based on the scope: Central, Local and Distributed. Options within the central market concept group are regional markets, central markets for TSO & DSO and markets for system operators and BRPs. The local market concept group refers to separate local markets for one DSO, local market for multiple DSOs and local market for one DSO and multiple BRPs. The group for distributed market concepts includes P2P and P2DSO.

Most projects develop concepts for market places with either a local or a distributed scope.

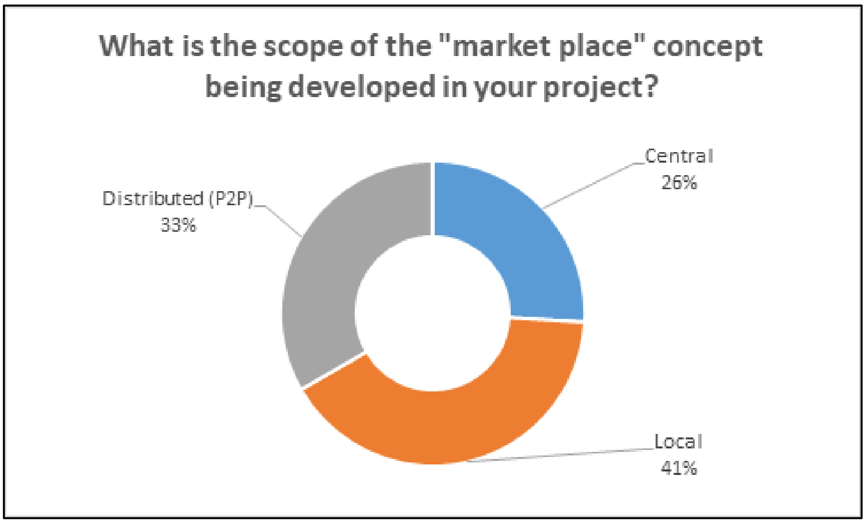

Figure 19: Share of marketplace concepts scopes found in surveyed projects

Also, within surveyed projects a variety of market place concepts are implemented.

For instance, DEMOs in the GOFLEX project consider (i) a separate local market for one DSO, (ii) a market for one DSO and BRPs, and (iii) a peer-to-peer (P2P) market for local energy community.

P2P is tested within the borders of a community and also, at regional level. In this regard, the CROSSBOW project implements a regional P2P market (for intraday and balancing energy trading).

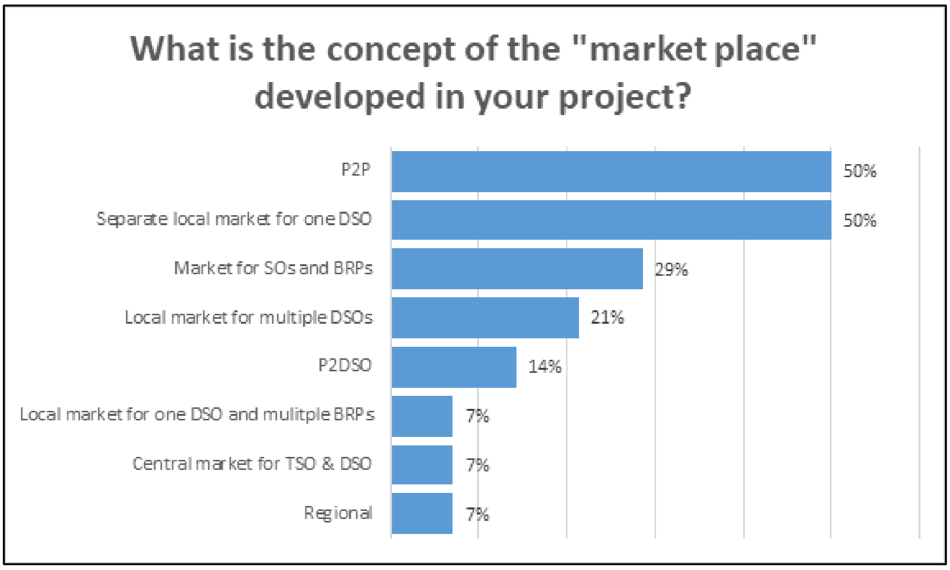

Figure 20: Marketplace concepts in the scope of surveyed projects

3.2.5 Roles of stakeholders

Stakeholders that assume the role of market operator vary in respect to the market place in scope. For market places with a local scope, this role is, in most cases, assumed by the DSO. The TSO, in contrast, assumes this role (alone or jointly with other System Operators) in market places that focus on a wider control area.

3.2.6 Pricing rule

Most projects are exploring the use of pay-as-bid (PaB) as pricing rule for the procurement of services.

Other pricing rules were also observed. For instance, the CoordiNet project considers a combination of free/mandatory provision. In InteGrid project, participation may become mandatory if the system operator expects "insecure conditions" for grid operation. Concerning non-market-based pricing, the InterFlex project, for the islanding use case, implements contracts between DSO and aggregators. The GOFLEX project considers short-term prediction of the need for services (based on operational state of the grid).

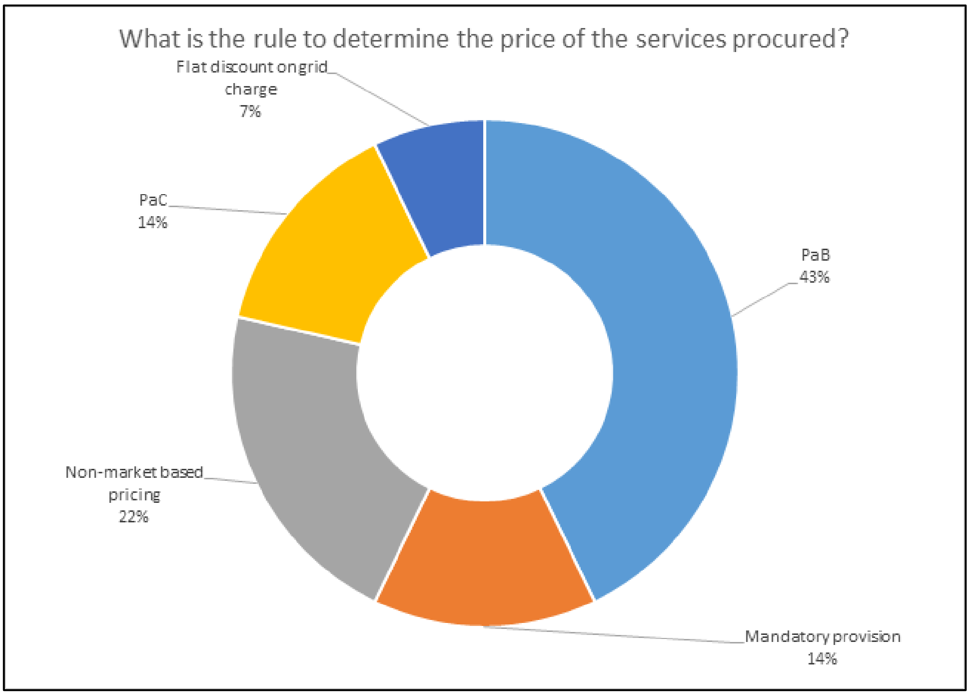

Figure 21: Share of pricing rules for services in the scope of surveyed projects

3.2.7 Allocation principle

No a priori allocation of priority seems to be the preferred allocation principle among surveyed projects. *Based on collected responses, this allocation principle is considered in eight projects*. Allocating *priority to the DSO* is the second most used principle. It is worth noting that 4 projects test more than one principle. The pair of principles most used is *no a priori allocation of priority* and *priority to DSO*.

Also, in projects that use *non a priori allocation of priority* no clear preference for either *minimisation of costs* or *highest willingness to pay* is observed. In fact, at least half of them test both principles.

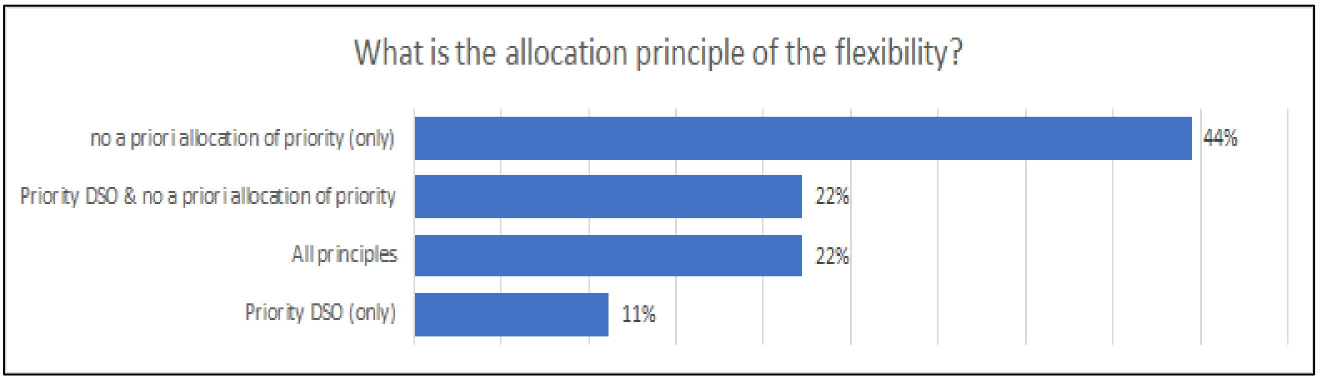

Figure 22: Allocation principles in the scope of surveyed projects (based on collected responses)

3.2.8 Consideration of grid constraints in coordination models

There are three projects that do not explore coordination models: InterFlex, MUSE GRIDS and GIFT. These projects are not considered for this question.

Grid constraints are mainly considered during clearing. Some projects (InteGrid, EU-SysFlex and INVADE) consider them during prequalification. Also, the EU-SysFlex project considers some post-dispatch measures based on security constrained optimal power flow (OPF).

Table 3 shows approaches used to consider grid constraints.

Table 3: Approaches used to consider grid constraints

Approach	Prequalification	Clearing	Post-dispatch
Technical validation of flexibility offers	✔		
Inclusion in the OPF		✔	
Common regional AC power flow model		✔	
ATC		✔	
Transmission and distribution models		✔	
Implicit transfer capacity		✔	
Security constrained OPF (incl. cross-border flows)			✔

3.2.9 Barriers for the realization of concepts

Barriers for the realization of concepts (see sections 3.2.3 and 3.2.4) were balanced among all areas (technical, economic, regulatory), with a bit more emphasis on regulatory barriers.

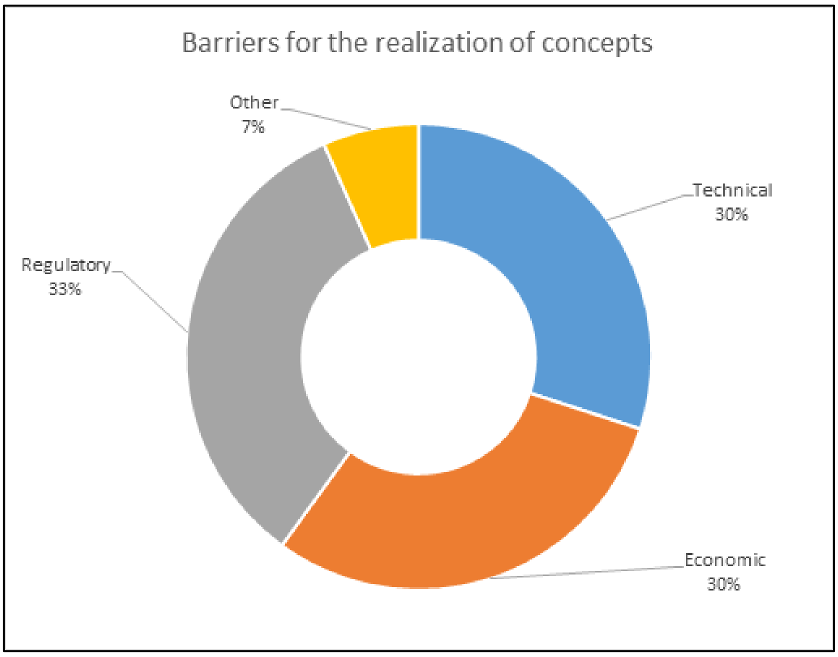

Figure 23: Share of barriers for the realization of concepts in the scope of surveyed projects

For technical barriers, “availability and accessibility of flexibilities” was the most mentioned. In this regard, the Interflex project highlights the importance of looking “within the various timeframes bound to the DSO needs.”

As highlighted by GOFLEX and GIFT projects, “economic boundary conditions are strongly dependent on regulatory constraints.” Among the economic barriers, the following were found:

- *Incentive rules*: New incentive rules are needed. Specially, for the combo RES & storage.
- *Existing tariff requirements*: A revision of these requirements is needed. Specially, for electric vehicles.
- *Financial viability*: Difficult to define flexibility offers that provide a financially viable base due to low value and rare use.

The following regulatory barriers were highlighted:

- The time lag between developing a new solution and defining a framework that supports it. Also, the different timetables for the harmonization of EU legislation. Specially, countries of the SEE region.
- Lack of common rules for the calculation and allocation of cross-border capacity.
- Fuzzy (not so clear) regulatory framework for storage.
- Pace of the market coupling process.
- Lack of standard market products.
- Introduction of balancing responsibility for RES.
- Lack of dynamic pricing.
- Lack of market place for services: e.g., reactive power market.

3.2.10 Possible market distortions

Lack of liquidity and market power are by far the most likely market distortions expected by surveyed projects (8 projects out of 14). Other possible market distortions are strategic gaming behaviour, immature market structures and lack of regional market integration.

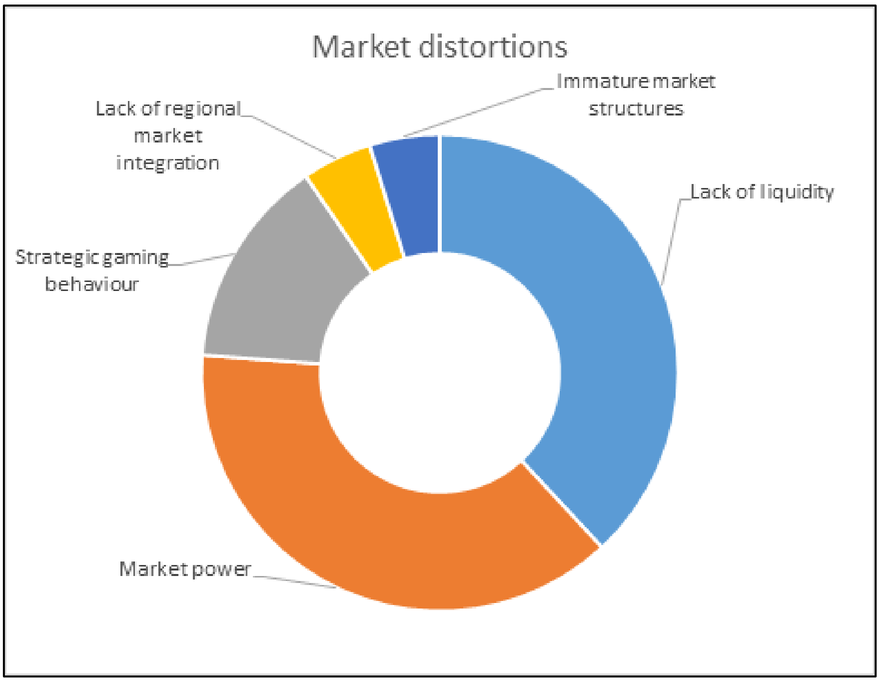

Figure 24: Share of expected market distortions in the scope of surveyed projects

As potential mitigation measures to these distortions, the EU-SysFlex project highlights the following:

- Against mitigation of market power and strategic gaming, use opportunity cost compensation for generators.
- Against lack of liquidity, use mandatory participation.

3.2.11 Joint procurement

Joint procurement of services is being explored in two projects: CoordiNet and EU-SysFlex.

The CoordiNet project will jointly procure the following services:

- Grid congestion management for both the TSO and DSO
- Voltage control for the TSO and DSO

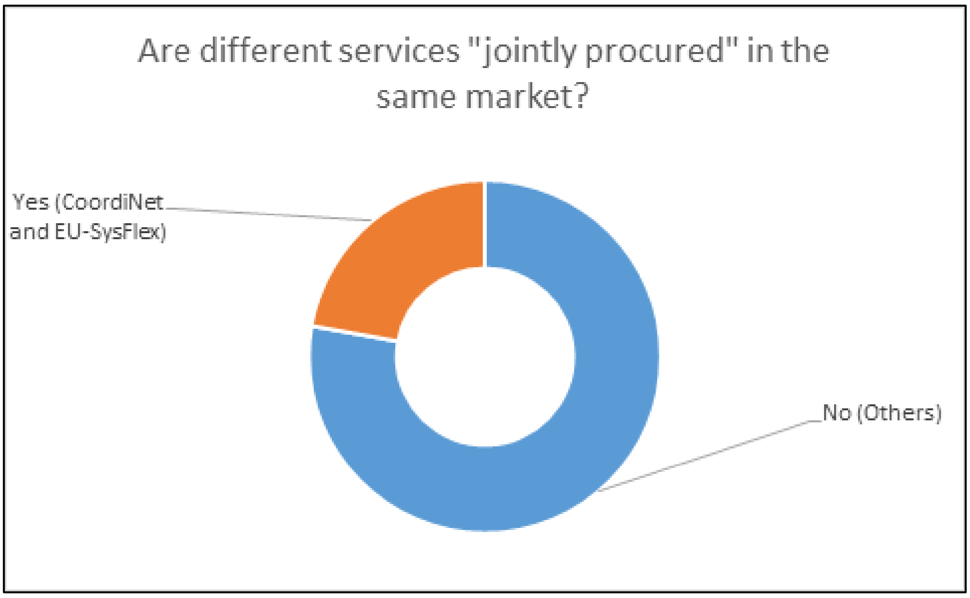

Figure 25: Share of projects exploring joint procurement of services

3.3 Role models

3.3.1 Market roles

More than half of the projects developed a role model for the description of Business Use Cases.

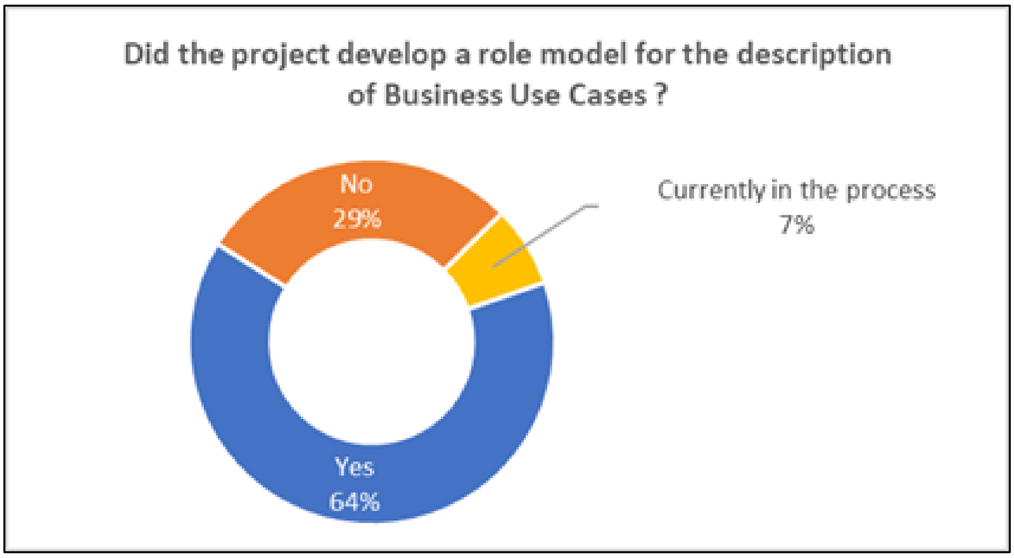

Figure 26: Projects developing a role model for the description of business use cases *(share of projects among those participating in the project and providing answer to the question)*

Roles used by the projects are based on existing models or defined independently to address specific needs of the demos. The projects mentioned the following sources for roles definition:

- Model based on the Harmonized electricity market roles model (HEMRM) in Europe (by ENTSO-E, EFET and ebIX)

- Roles defined based on Grid Codes
- Standardised IEC Use Case modelled in UML
- Role model of French utility EDF
- USEF

3.3.2 Data roles

6 projects out of 14 follow HEMRM in explaining data roles. By following the basic concept of a role model we are not saying in this report which role should be assumed by which actor.

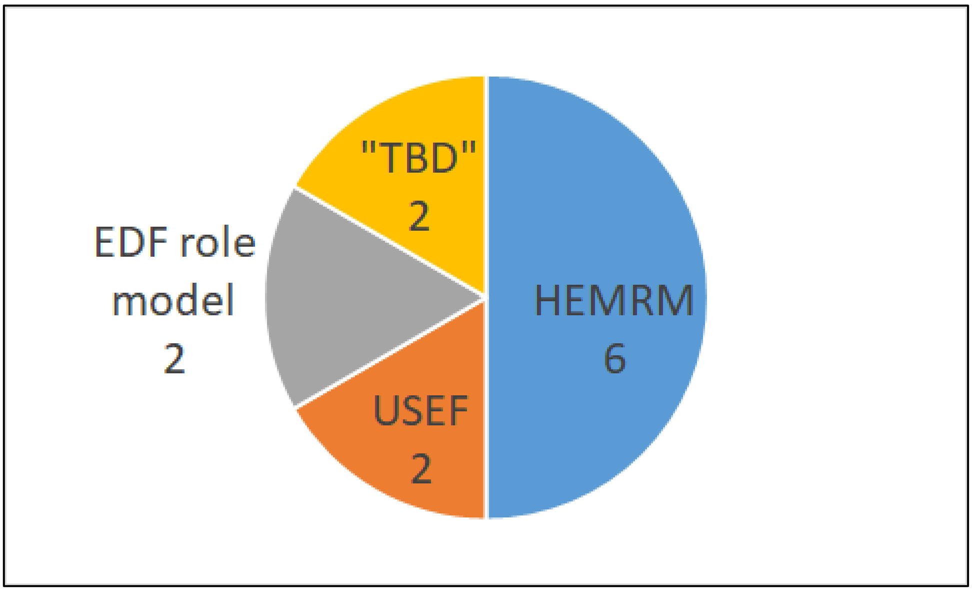

Figure 27: Role models used for data management

Projects were questioned have they identified new roles from data management perspective.

One project (EU-SysFlex) is operating with several new "pure" data roles:

- Data Hub Operator
- Authentication Service Provider
- Data Exchange Platform Operator
- Customer Portal Operator

Some projects mention further roles which are rather market than data roles:

- Flexibility Platform Operator
- Flexibility Operator (aggregator with additional tasks to cover)

- Local Energy System Operator (this role requires data from various type of infrastructure located at customer's premises – e.g. BMS, EV Charger)
- Regional Security Coordinator
- Storage Owner

It should be noted that some of the roles above are in fact existing already here and there and are "new" only in the meaning of not covered by role models yet.

3.4 Data exchanges

3.4.1 Main challenges

Before diving into the detailed analysis of the questionnaire it would be interesting to present the main challenges that have been identified by the projects in terms of data exchanges. 10 projects provided feedback regarding the greatest challenges that they faced regarding data exchanges. Table 4 summarizes the responses gathered.

Table 4: Main challenges regarding data exchanges

Project	Identified Challenges
OSMOSE	Data harmonization
E-LAND	Accessing data from legacy systems of end-users
INVADE	Receiving data in a timely fashion and in good quality
TDX-ASSIST	Compatibility of available simulation tools with the types of the data received by both TSOs and DSOs in order to perform the same simulations at the same time for both operators.
MERLON	- Data harmonization/interoperability - Data ownership issues
INTERRFACE	- Data harmonization/interoperability - Data ownership issues
EU-SysFlex	Common understanding of responsibilities of roles including access and sharing of grid data
CROSSBOW	- Having relevant data centralized and analysed - Aiming towards TSO-DSO coordination - Handling and management of data
InterFlex	- Cybersecurity when interfacing IT with OT - Lack of standard for certain interfaces (e.g. aggregator with appliances)
GOFLEX	Interfacing with legacy DSO systems

The feedback that is summarized in Table 4 identifies the 2 most important challenges:

1. Interoperability:
    a. Interfacing with other systems (either legacy systems or between new platforms)
    b. Lack of standards for certain interfaces (e.g. aggregator with appliances, etc.)
2. Data handling:
    a. Data ownership and data access

b. Data quality

c. Data Harmonization

More challenges were identified but the ones described above are the common ground where most of the challenges can be grouped. It is therefore really important to focus on these two broad domains and invest in research towards further standardization, seamless access to data with specific access rights according to the clearance level of each actor, and ensuring interoperability of systems in a way that interfacing between actors and systems is facilitated. Finally, even though it was only highlighted in one of the responses, cybersecurity should be carefully addressed, as it will be a vital part of the future digital power system[2].

3.4.2 Data types

The breakdown of the data that is currently being collected across the various projects is shown in this sub-section. These graphs are included to give a better and more holistic view of data types, roles and data attributes that are currently being used. In terms of project data types, the most common data types to be used are meter, flexibility and sub-meter data. Detailed answers from projects about their data usage are presented in Annex II.

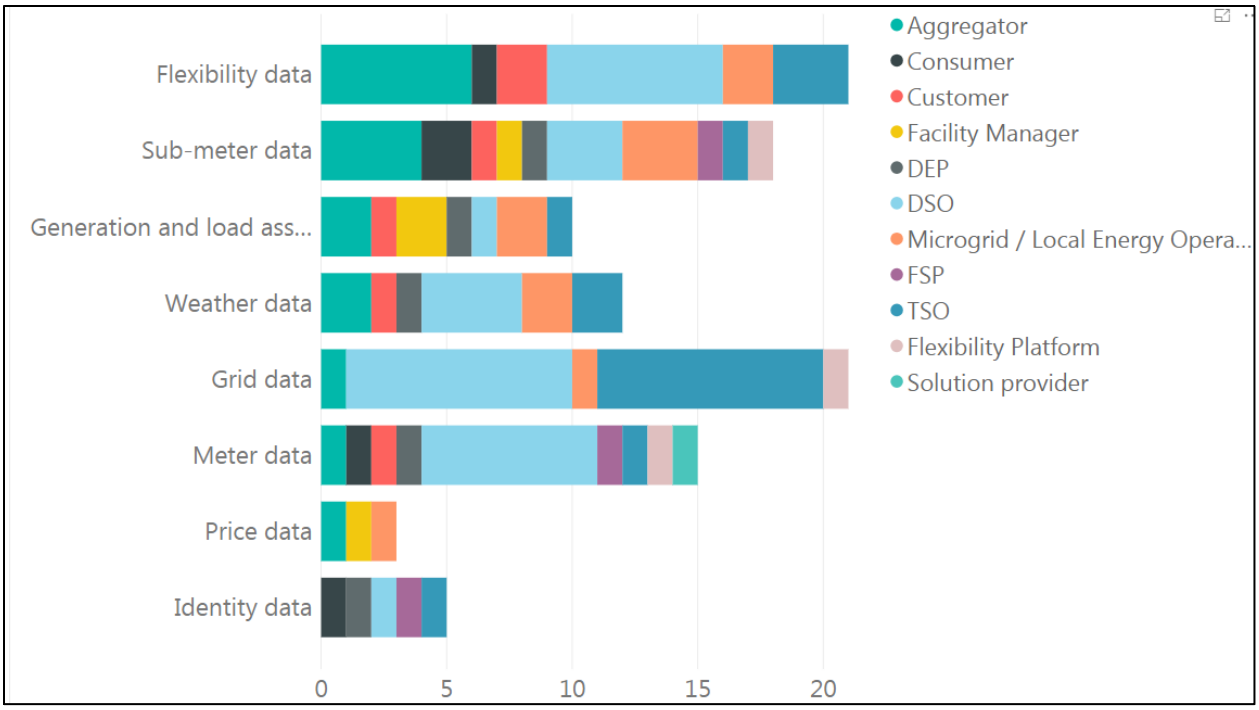

Figure 28: The number of projects by data type

Below are the projects' roles that are involved, the most prevalent roles are the DSO, Aggregator and TSO roles. The roles include both business roles and system roles. E.g. 'Flexibility Platform' is a system role but the corresponding business role would be 'Flexibility Platform Operator' which is essentially 'Market Operator'.

2 Cybersecurity was not in the focus of this questionnaire while in parallel another BRIDGE report was dedicated to cybersecurity issues.

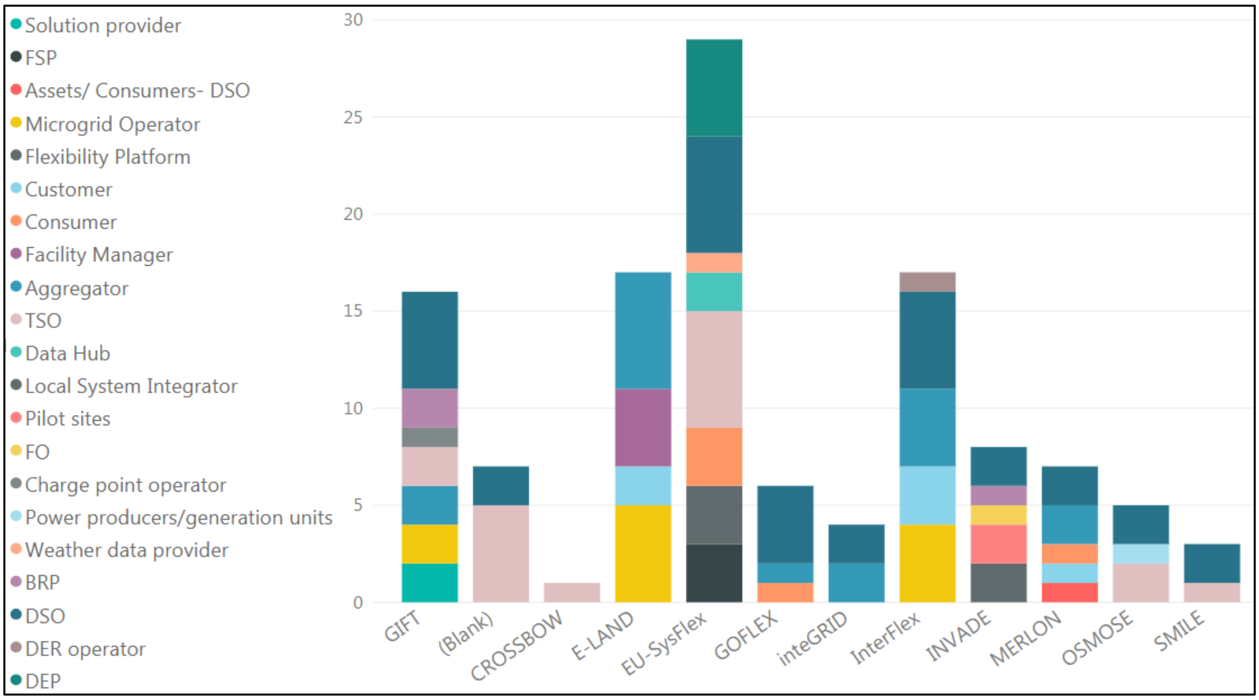

Figure 29: Roles/stakeholders/systems involved in data exchanges

Below is the frequency at which data is generated, this is an important consideration from a cybersecurity perspective as the instantaneous nature of real time data creates another layer of complexity when securing the data.

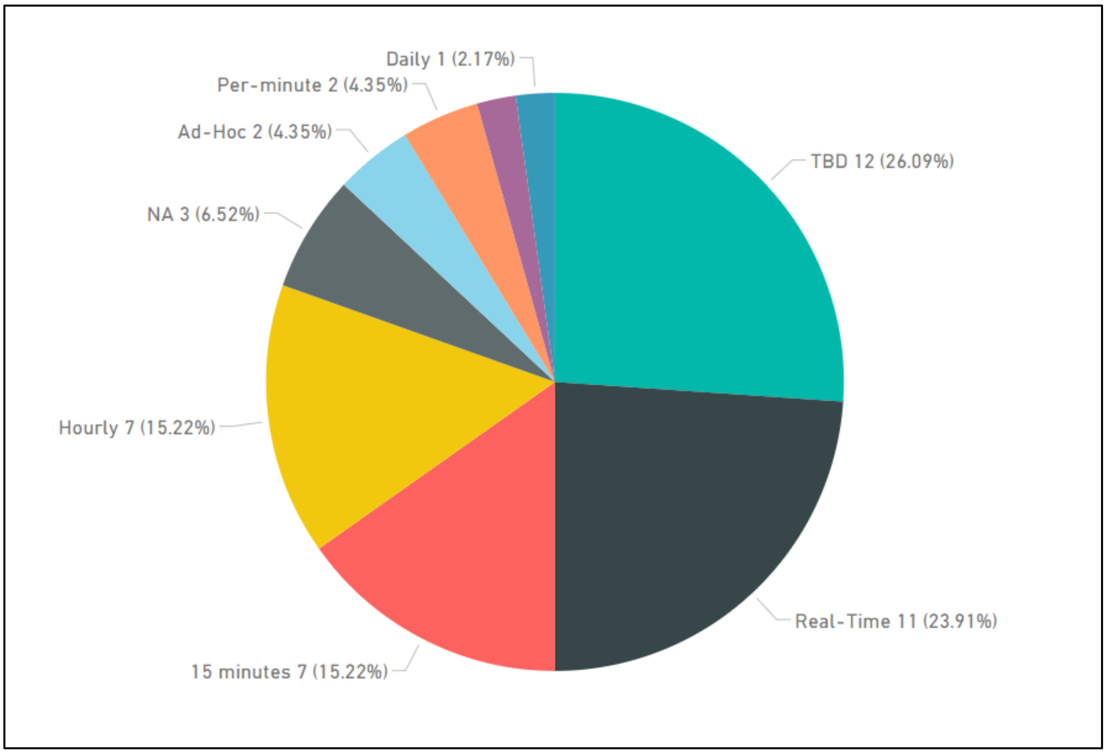

Figure 30: Frequency of data generation

Below is frequency at which data is exchanged. Hourly data is the most common and real-time data exchange is just over 10%, these figures represent the data exchanged as a percentage of other projects (this is not a percentage of volume given that a large project and small project are being treated equally for this assessment).

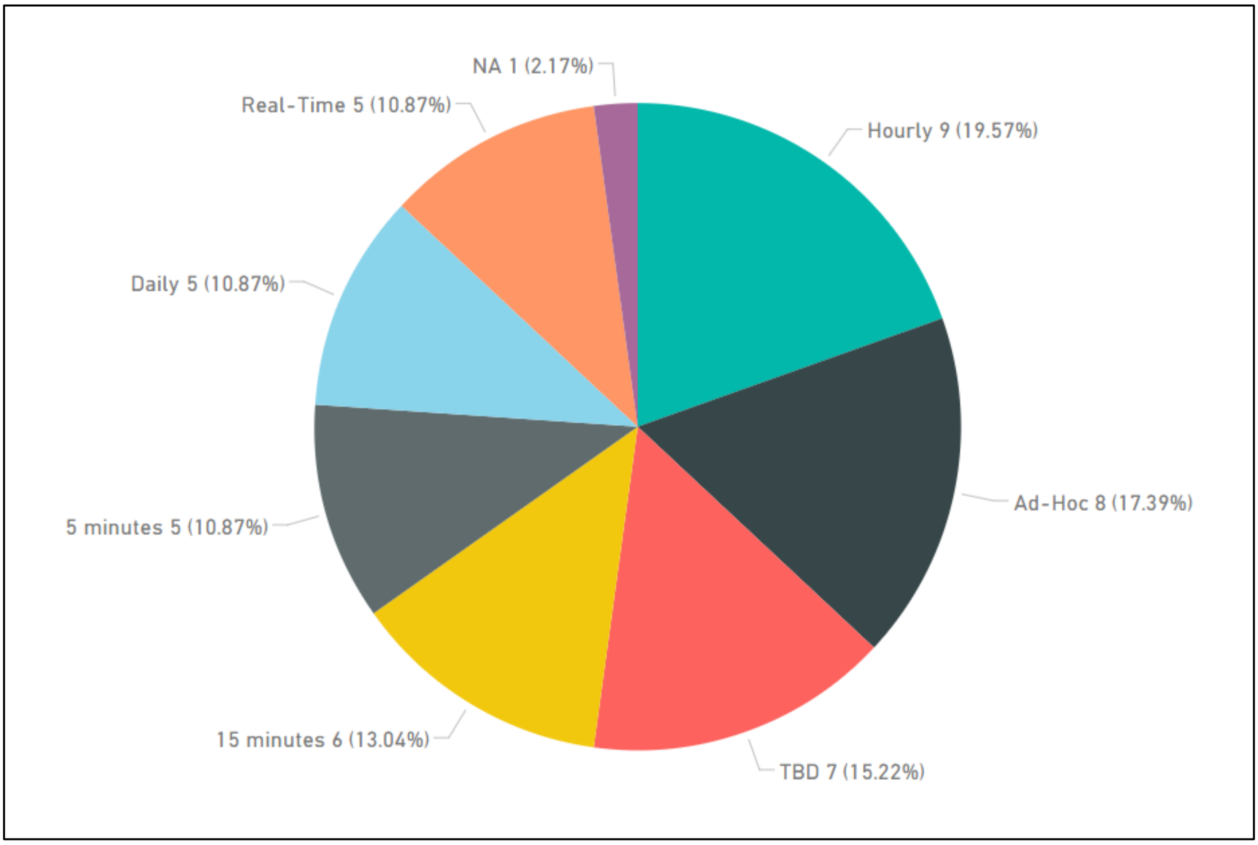

Figure 31: Frequency of data exchange

There was no assessment of the issues that projects encountered acquiring data but this could be an area which could be looked into more in the future. Sharing data across multiple projects or having a register of data owners could help with access to data.

3.4.3 SGAM approach

All projects answering the survey apply SGAM (Smart Grid Architecture Model) to describe TSO-DSO, TSO-TSO and DSO-DSO data exchanges (in case they have such exchanges in the project).

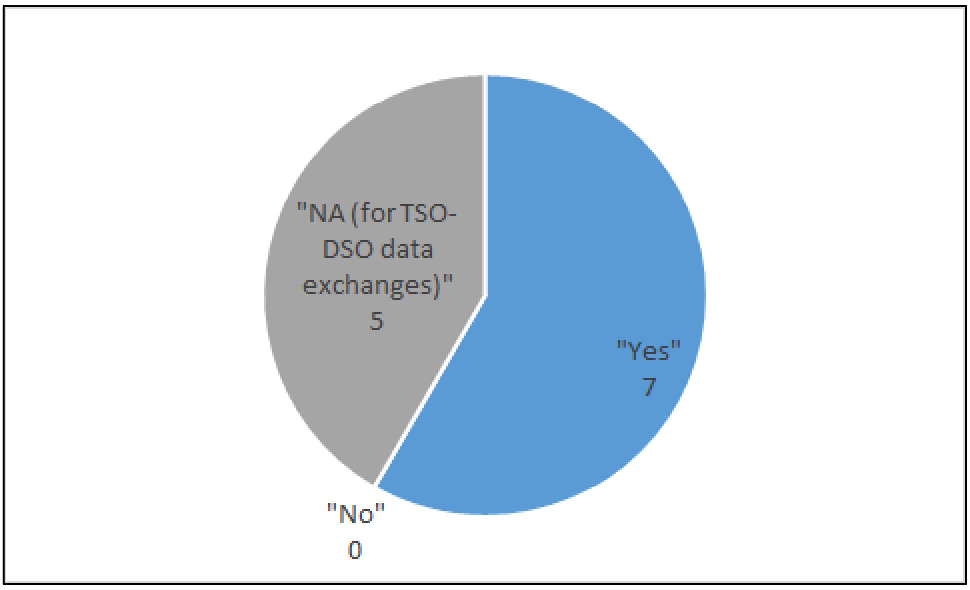

Figure 32: Application of SGAM model in projects

- OSMOSE: Central EMS specification and design planning. The EMSs will be based on the IEC Common Information Model (CIM) and SGAM standards.
- TDX-ASSIST: From the overall business layer perspective, the main aspect to be addressed is twofold: the TSO-DSO interaction, as well as DSO interaction with third party market participants. The TSO-TSO data exchange is well represented nowadays through consolidated standards like CGMES and ESMP. To integrate TSO-DSO data exchange, use cases are mapped onto the SGAM models which will be the basis for documentation of data interaction. DSO-DSO is not considered since all use cases present TSO-DSO or DSO-Market interactions.
- InteGrid uses SGAM to represent the demo architecture (links and components) and to describe the exchange between the different stakeholders (not only TSO-DSO). The SGAM is the basis of our methodology on the scalability and replicability of ICT systems.
- MERLON: SGAM is considered as the means and tool to define the different standards related to information exchange.
- EU-SysFlex: has a dedicated task to propose a model for energy data exchange for Europe based on SGAM approach. Business use cases and system use cases for data management are being described to address business and function layers of SGAM.
- CROSSBOW uses SGAM to define the data flows in the project use cases, and the role of the different actors. For each data flow, the data models and protocols are identified.
- InterFlex and GIFT: SGAM is used for architecture and use case description. However, no TSO-DSO, TSO-TSO nor DSO-DSO data exchange is planned in the project.

Most of the projects applying SGAM also do or plan to do some kind of visual mapping against SGAM, for example:

- EU-SysFlex: Modsarus tool of EDF has been used for modelling use cases. Then SGAM Toolbox (https://sgam-toolbox.org/) as Enterprise Architecture ad-on is used to describe, incl. visually all SGAM layers based on information provided in system use cases.

- CROSSBOW: Diagrams of SGAM model are created in Enterprise Architect and included in relevant deliverables.
- TDX-ASSIST: The visual mapping includes graphical presentation of the new UML profiles proposed by the project and the exchange of data between different stakeholders that include TSOs-DSOs-Market interaction. Also, IEC 62913-1 (Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach), standard for Use Case elaboration implements the visual mapping of actors interactions, with the use of tools like Enterprise Architect and Modsarus for this visual mapping.

3.4.4 Data models, formats and communication protocols

It has been asked to the projects the list of data models that they are using for:

a. Appliances

b. Platforms/markets

c. TSO-TSO, TSO-DSO, DSO-DSO exchanges

Firstly, it has to be noted that, in the received answers, there is a general confusion between communication protocols (e.g. Zigbee, HTTP), data formatting (e.g. JSON, XML) and data models (e.g. CIM), in particular for the appliances domain. It often reflects specific or proprietary data models.

Then, there is a real disparity between the appliances (a.), where many different solutions are mentioned, and the platforms/markets and TSO/DSO interfaces (b. and c.) where CIM has a strong majority.

Appliances

For appliances connection, Modbus is the most used. However, Modbus is an applicative messaging protocol but the definition of the data is free and not standardized. IEC 60870 is also mentioned several times (mostly IEC 60870-5 part, which is SCADA oriented). Finally, many proprietary or specific data models are being used.

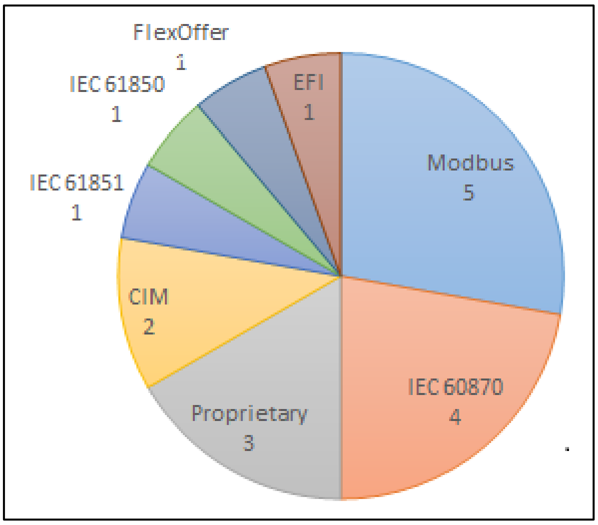

Figure 33: Data models for data exchange at the level of appliances

Platforms/markets

For platforms/market connection, CIM is widely used. However, several new options are being considered, such as USEF, FlexOffer, EFI.

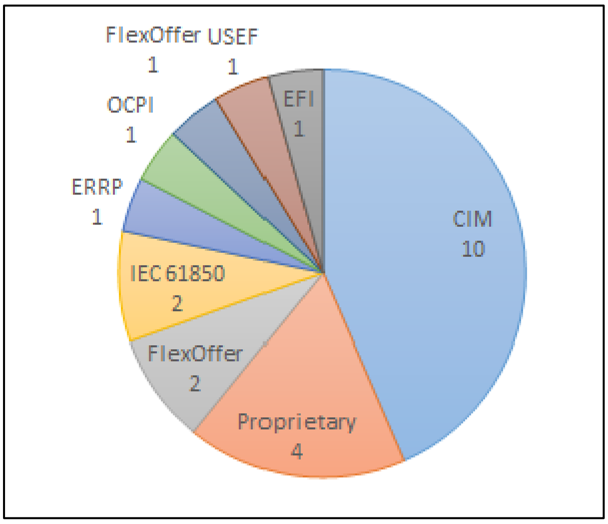

Figure 34: Data models for data exchange at the level of platforms/markets

TSO/DSO interfaces

For TSO/DSO interface, CIM has a strong majority. TASE.2 (IEC 60870-6) is also used.

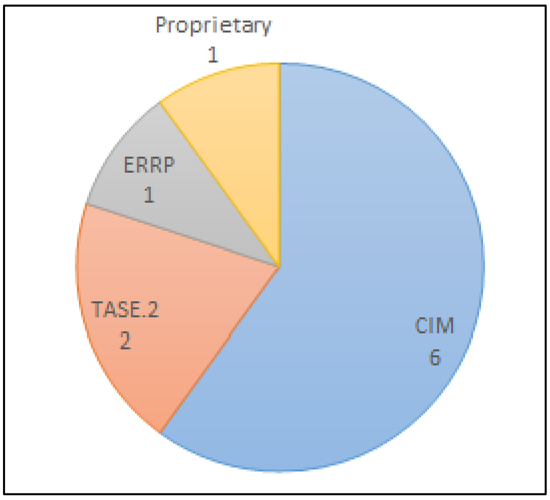

Figure 35: Data models for data exchange at the level TSO/DSO

However, it has been raised by the projects that the current CIM standard does not cover enough Energy forecast, DER, Flex data and TSO-RSC interface.

3.4.5 Focus on CIM

CIM Canonical Model

5 projects declared to be working with the CIM Canonical Model.

Enterprise Architect was presented as the most common environment/tool for handling CIM Canonical Model. Some projects are not able to define it in the beginning of the project.

CIM Canonical model is used mainly for the analysis of the data model, when some new profile is proposed to exchange. The current CIM canonical model compiles three different versions of the following profiles:

- 61970 CIM17 v34 (WG 13 of TC-57 Committee)
- 61968 CIM13 v12 (WG 14 of TC-57 Committee)
- 62325 CIM3 v17 (WG16 of TC-57 Committee)

The aggregated model for the three above mentioned profile is now known as **CIM100**[3].

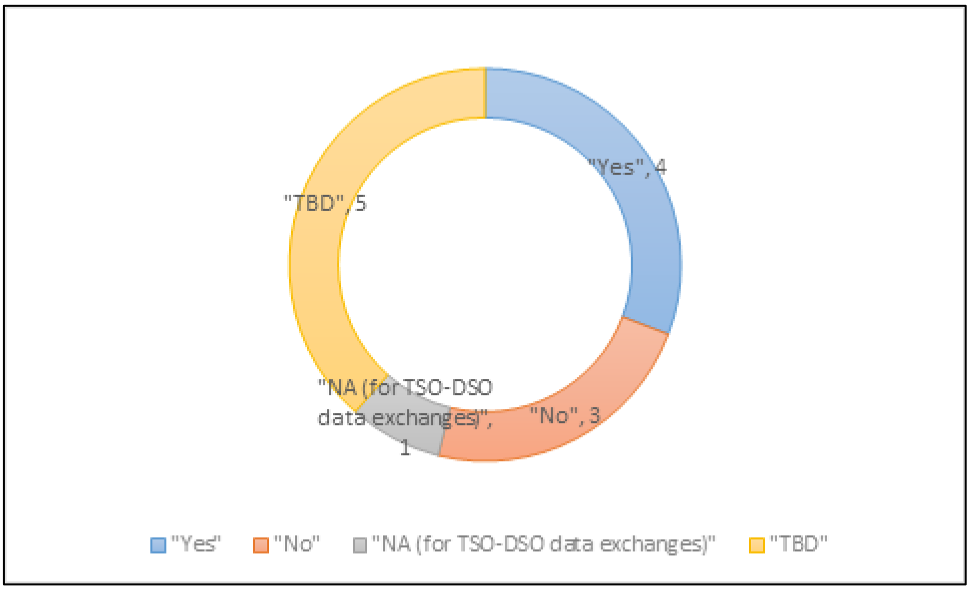

Figure 36: Canonical Model management by participants

CIM Data Model between actors

Application of CIM for TSO-TSO, TSO-DSO and DSO-DSO data exchange. 6 projects informed the use of CIM Data Model for data exchange between these actors. It is largely used by TSOs, but it is not the case for DSOs.

4 projects informed they use CIM from vendor products. One project requested for certification processes as well as extensions.

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3 It has to be noticed that CIM evolves on a regular basis, and mainly due to the fact that CGMES profiles have been consolidated (CGMES 2.4.15). In December 2019, CIM100 is based on IEC 61970 CIM17 v36, IEC 61968 CIM13 v12, IEC 62325 CIM03 v17a.

The current status from the three CIM profiles must work for the contribution of data exchange's evolution between CIM actors.

- CIM 61970: CIM100 is frozen for CDV submission stage of publishing. Documents to be published depend on the current version, although a new version is under preparation. ENTSO-E extensions under work.

- CIM 61968: Also current changes under analysis.

CIM 62325: There are currently two style profiles under use, and “European Style” and “US” Style market profile. Next step is the coordination with EU, NA and environmental teams for the update. ebIX works on retail market.

In TDX-ASSIST some use cases leveraged existing CIM market related profiles.

It was proven that some existing profiles can be reused, adapted, to support new business requirements.

CIM at appliance level

2 projects work with CIM on appliance level. 9 projects work with CIM on platform/market levels.

In one of the projects, TDX-ASSIST, tools from non-TSO actors have tested the implementation of CIM for the data exchange with TSOs. For these cases, a small adjustment in the files had to be done to be compliant with the CIM, since the vendor's tool was not prepared for some CIM profiles. In other demo, the profiles were applied successfully in the appliance level to data exchange.

The graph below shows the use of data models (even those which uses a different one then CIM).

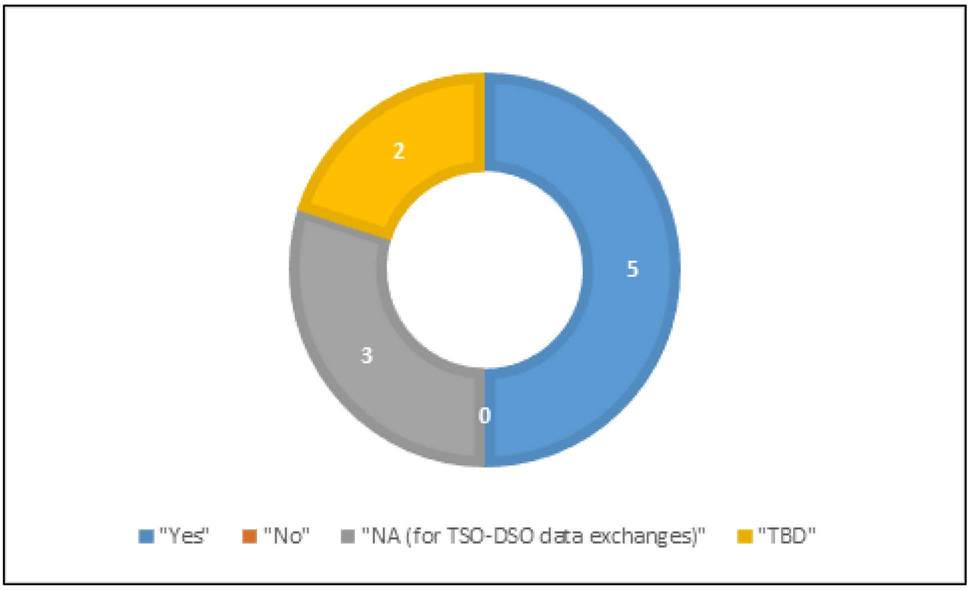

Figure 37: Answers from standardized data models use from projects

CIM Harmonization with IEC 61850 and Extensions

Only one project needs harmonization between CIM and IEC 61850. Another two projects declared necessity for IEC CIM extensions for their projects.

Topics like observability Area, which is the responsibility of each area managed by TSOs and DSOs, can be considered through harmonization and extensions.

CIM harmonization with IEC 61850, through mappings to associated CIM classes or other options, are more and more demonstrated as fundamental in the industry for the capacity of connecting TSOs/DSOs/ data centres with substations/real time data.

3.4.6 Data platforms

There are few dedicated platforms for energy data exchanges, some of these used as input in the projects, some others even (further) developed as part of the projects. In addition, there are some data platforms not specific to energy data but rather vendor products for any data exchanges. The answers revealed that the borderline between data platforms and market/trading platforms is always not very clear. Also, it should be distinguished between platforms and other tools/systems.

"Pure" data platforms:

- Meter data derived from data hubs of Energinet, Elering. These data hubs are primarily for centrally collecting and storing data from smart meters but also to facilitate some business processes like supplier switching and imbalance settlement.
- ECCo SP data exchange platform by ENTSO-E. Primary aim is to facilitate grid data exchange (grid models) between TSOs but can support other data exchanges also. For instance, some TDX-ASSIST partners used ECCo SP to demonstrate information exchange between different participants (TSO, DSO, market participant).
- Estfeed data exchange platform by Elering. is capable to connect any data source and any data user (consumers as well as 3rd party applications) enabling exchange of personal and commercially sensitive data based on data owner's consent. This includes any data relevant for TSO-DSO, TSO-TSO and DSO-DSO exchanges – e.g. connecting data hubs for meter data or for grid data as data sources or connecting applications relevant for TSO and DSO processes that need access to data.
- IEGSA - new data platform to be developed by one project (INTERRFACE – project started in 2019 and there is not detailed information available yet).
- The grid and market Hub, a cloud-based platform - has been developed by a project to enable various data exchanges, e.g. between aggregators and DSOs for the validation of flexibility products offered by a commercial Virtual Power Plant (VPP), or for the booking and activation of flexibility offers or for the activation of flexibility between the flexibility sources (HEMS) and the DSOs.
- PCOM+ is capable to connect any data source and any data user (e.g. forecast provider) enabling exchange of personal and commercially sensitive data based on data owner's consent. This includes any data relevant for TSO-DSO, TSO-TSO and DSO-DSO exchanges.
- Cloudera, Predix, openESB Linux/Windows, EDF Platform – all these platforms are intended to be used for data exchange by one and the same project. They are not energy data specific, any type data can be exchanged through them.
- Prometheus platform by RTE – allows sharing market models between TSOs. It is an industrial software release based on the past FP7 project OPTIMATE. PROMETHEUS is a simulation platform of different types of market design but is not a market platform software.

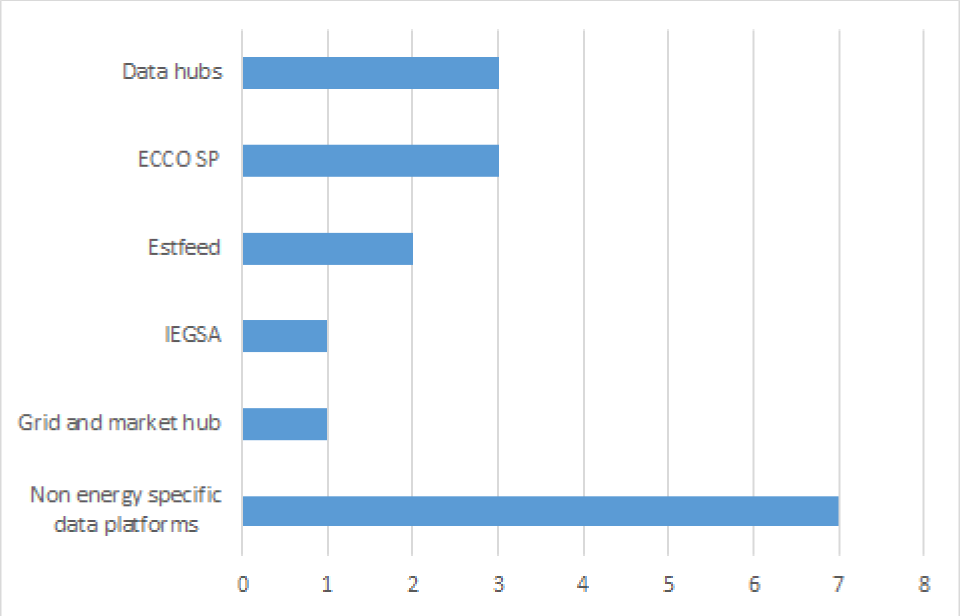

Figure 38: Number of projects using data platforms

Not explicitly TSO-DSO data exchange related platforms and/or not "pure" data platforms:

- Flexibility platform operated by market operator (3 projects)
- DSO operated trading platform (3 projects)
- Aggregator's platforms (2 projects)
- Toolbox that will enable exchange of information within a Local Energy System (e.g. microgrid) and eventually to external entities among different stakeholders (e.g. Consumers, EV Owners, DER Owners)
- Regional Security Platform that will communicate will all TSO to coordinate actions
- For the market data, a platform based on blockchain have been developed providing REST-access to market participants

Beside platforms projects apply several specific tools (systems, softwares) like grid optimization tools, forecasting tools, aggregation tools, AI tools, etc.

Performance

Performance of platforms can be assessed in several ways – e.g. 1000 simultaneous connections, availability (24h/24, 7 days a week), failure rates (8h for the Maximum Tolerable Period of Disruption).

Explanations provided by the projects:

- OSMOSE: We are looking for 24/7 availability. That is why we will be running two platforms in parallel to secure constant availability. We do not expect high number of simultaneous connections, but for scalability purposes this might be also important.
- SMILE: Between EEM and Prsma the expected performance is 1 request every 15 minutes, since that's the update frequency of the requested data. After the data is provided by the EMS, the system is prepared to handle a high number of simultaneous requests (>1000) and operate

24/7. No failure rates requirements were defined. Every time a failure is detected, EEM is informed about it, and it employs the appropriate solution

- INVADE: Generally, the pilot cases have been limited in the number of participating end points, hence the requirements to run the pilots are quite different to being able to run flexibility management in a full market place implementation. There may be 10,000+ simultaneous connections to feed/exchange data, typically with 24/7 availability, with near zero down time so the flexibility can be provided on demand.
- InteGrid: Connectivity between the gmhub platform and third party systems/applications is provided through encrypted APIs and SAP's cloud connector. Stress testing has taken place with peaks of 2500 requests/second being recorded. The system availability SLA for all SAP cloud services is 99.9% per month. The gmhub platform should follow this availability of 99.9% per month as per the standard Service Level Agreement for SAP Cloud Services[4]Level. As for failure rates, SAP follows an ISO standardized approach in its problem resolution process. It starts with 24/7 proactive monitoring with a goal of catching problems before they happen. If any alerts are detected during the monitoring phase, SAP has a 24/7 support team that tries to resolve the incident depending on the priority. In case the gmhub platform is down with a serious business impact, response times are very aggressive. For any other failures, support services are geared to support around the clock and the response time is up to 4 hours.
- EU-SysFlex:

- Estfeed, as a national platform today, is designed for transporting hourly data from around 800 thousand metering points. Estfeed is available 24h. Estfeed is a distributed system, and it has no central nodes (servers), so its performance is limited by the performance of the connected members. Estfeed is an asynchronous system - when some/most nodes go offline, platform is not affected.

- German demo: Roughly 20 thousand data sets (4GByte) every 5 minutes are transferred as CIM and csv via PCOM+, the platform is designed to transfer much more than is used in the EU-SysFlex field test.

- CROSSBOW: 24/7 availability is required.
- GOFLEX: Cloud based services are highly available, > 95% uptime, and scalable to support many parallel MQTT, AMQP connections.
- TDX-ASSIST: EDF tested ECCo SP while sending large amount of data. For example, 1000 messages in a row were sent with different delay between each message (from 10 to 200 ms). In all cases none message was lost. For each case number of messages that waited more than 90s to be received was identified.

Platform functionalities

Table 5 presents some data exchange related functionalities. The cases in table are for projects only which apply "pure" data exchange platforms. Obviously, similar functionalities exist in many other projects.

[4] http://go.sap.com/about/agreements/cloud-services.html?search=Service

Table 5: Data exchange related functionalities in three projects

	EU-SysFlex	TDX-ASSIST	InteGrid
Data collection	X	X	
Data transfer/sharing	X	X	X
Authentication of data users	X		X
Consent management	X		X
Personal data handling	X		
Data logs	X		
Service provider integration	X		X
Data source integration	X		
Flexibility activations	X	X	X
Flexibility bidding	X	X	X
Flexibility prequalification	X	X	
Flexibility verification	X		
Flexibility baseline	X		
Flexibility prediction	X	X	

7 projects apply IEC 62559 standard template to describe the functionalities as use cases. Majority of the projects (12 projects) would be in favour of having access to a Use Case repository expressing TSO-TSO, TSO-DSO, DSO-DSO use cases.

3.4.7 Interoperability

TSO-DSO interoperability

8 projects demonstrate interoperability between platforms in terms of interoperability with other DSOs/TSOs.

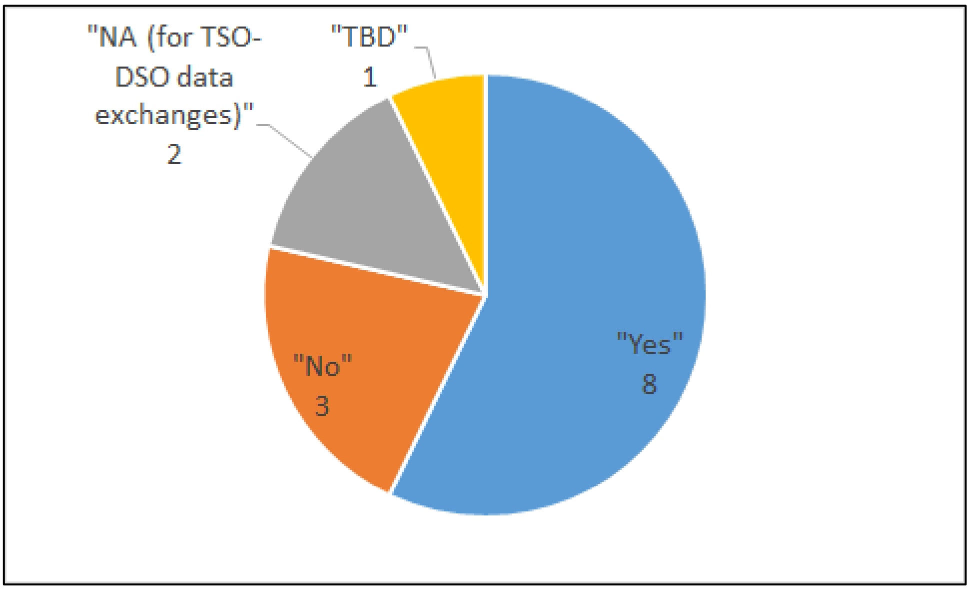

Figure 39: Interoperability between platforms in terms with other TSOs/DSOs

- OSMOSE: Lab Testing of the Flexibility Scheduler. The impact of the actions optimised by the Flexible Scheduler tool will be assessed through real-time simulations of both networks (TSO and DSO).
- Within the INVADE pilots: all participants send and receive data via several different pilot cases in 5 countries and all exchange data using the same formats.
- InteGrid: gm-Hub is deployed in two demo sites (Slovenia and Portugal), therefore we demonstrate the interoperability with other DSOs.
- EU-SysFlex: Existing platforms are capable of every needed data exchange as well as through connecting with platforms. They can connect any TSO and DSO application which either provides or consumes data. By doing this data format does not matter. In a variety of demos (flexibility) market operator's applications and system operator's applications are connected either directly or via platforms, such as PCOM+ and Estfeed. In one of the EU-SysFlex demos, the interoperability between Estfeed and ENTSO-E's data exchange platform will be tested. In the German demonstration the data exchange via the PCOM+ platform between the DSO and forecast providers, flexibility providers and TSO is being tested.
- GOFLEX replicates the same platform across different DSOs, but they don't interoperate.
- CoordiNET: the aim is to define common data models for the information exchange between the different agents using the platform
- TDX-ASSIST demonstrates interoperability by applying best practices proposed by IEC. These best practices are leveraging SGAM interoperability layers and IEC System Committee system approach:
    - Develop Business Use Cases using Business Roles from Harmonized Electricity Market Role Model and define Business Objects which have to be defined between Roles (IEC 62559 and 62913-1 standards);
    - Develop associated System Use Cases which are going to be implemented in TDX-ASSIST demonstrators and define associated business objects which have to be exchanged between system and/or business roles (IEC 62559 and 62913-1 standards);
    - Use IEC Common Information Model to model business objects (or other IEC Core SmartGrid information models like IEC 61850 and COSEM);
    - Try to reuse and adapt existing IEC CIM profiles following IEC 62361-103 profiling methodology;
    - Choose adapted communication protocols to support information exchanges;
    - Adopt Security standards like IEC 62351 and/or rely on Cyber-Secure Data Exchange Platforms (like ECCo SP, MADES);
    - Develop and maintain a Use Case repository, with associated business objects, and associated profiles;
    - Disseminate interoperability results by proposing feedback to Standardisation bodies like IEC TC57, CEN-CENELEC-ETSI CG-SEG.

Interoperability with other sectors

Only 3 projects demonstrate interoperability between platforms in terms of interoperability with other markets (e.g. mobility, health or home-security services).

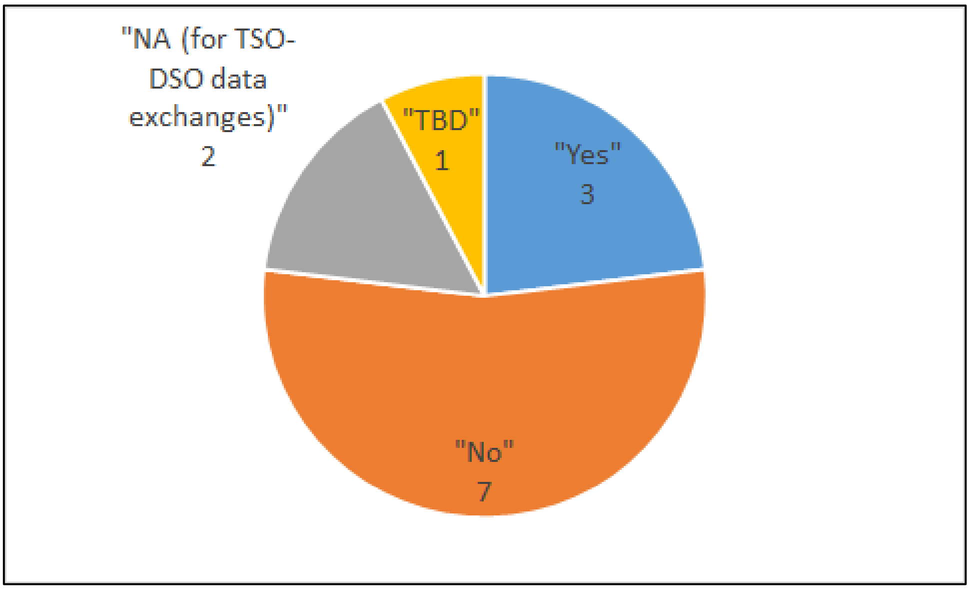

Figure 40: Interoperability between platforms in terms with other markets

- OSMOSE: Interoperability for replication and standardization. This task will address the interoperability issues for what concerns the optimal management and standardized interfaces between the technology components developed in WP6.
- SMILE: Madeira: There is interoperability between EEM (DSO and TSO) and the platform developer, specifically for monitoring the EVs mobility schemes in joint operation with the electric grid (charging/de-charging) (Prsma). The platform monitors and aggregates real-time data relevant to electricity production/consumption; this data is stored and then provided by Prsma to the affected partners in SMILE. From the EEM (Madeira's DSO) site the dispatch center provides in an API which is updated every 15m with information regarding the real-time energy production. The information is divided between the different production groups (e.g. thermal, or wind). The service also provides a prediction of production for the next 6h in 30 minutes intervals. On Prsma (SMILE partner) side a webscrapper requests the data every 15 and stores is in a local database.
- EU-SysFlex: Potentially any data source and data requesting application can be integrated either directly or via platforms, such as PCOM+ and Estfeed. As part of the demonstrations some residential devices will be connected for data exchange (maybe EVs?).

Interoperability tests

Projects were asked:

a) Would you be interested to participate in interoperability tests to demonstrate TSO/DSO, DSO/DSO compliancy?

b) Do you have data models representing TSO or DSO networks that could be used in interoperability tests? With which CIM profiles your data sets are compliant with?

7 projects would be interested to participate in such tests. As TDX-ASSIST said this would be a good opportunity to test the proposed UML Profiling scenarios considering the data exchange between TSOs and DSOs.

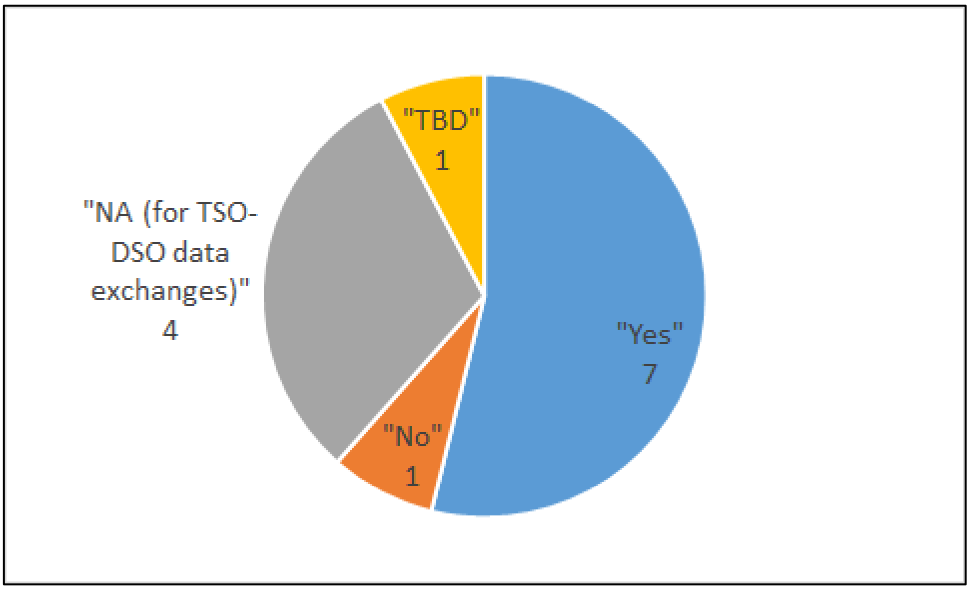

Figure 41: Projects' willingness to participate in interoperability tests

Only 3 projects would be possibly able or willing to share data for interoperability tests:

- TDX-ASSIST: CGMES and CDPSM compliant data sets and ESMP related data sets.
- EU-SysFlex: In case the purpose and objectives are defined clearly, Mitnetz could share a model grid, based on real grid data.
- CROSSBOW: CGMES

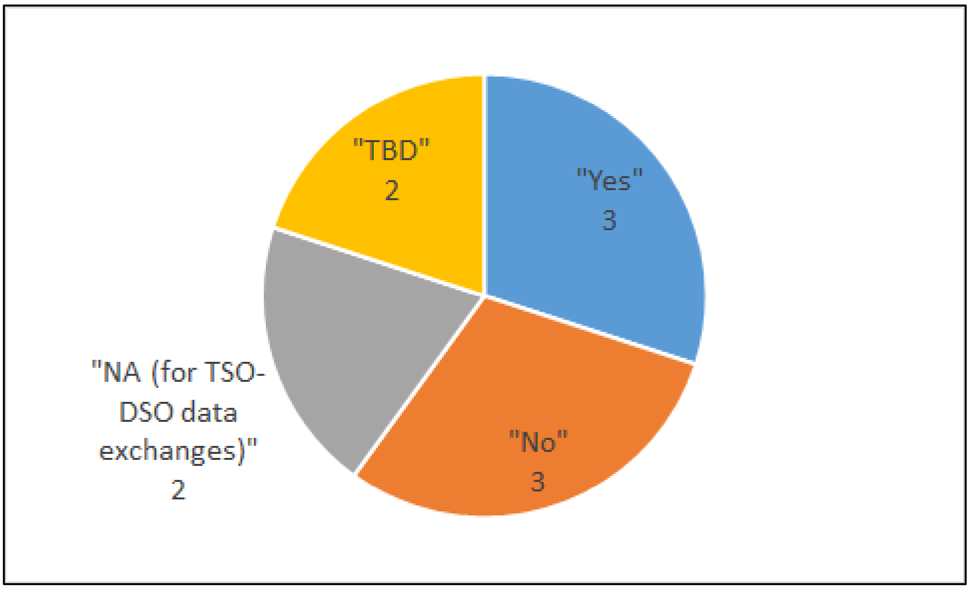

Figure 42: Projects' willingness and capability to share data for interoperability tests

3.4.8 Transparency and data access

Projects were asked how they would ensure transparency and non-discrimination to access to data (including sharing of personal and commercially sensitive data). Some confusions seem to have been in answering this – data sharing between project partners vs access to data beyond project. However, the answers cover full range of options for access:

- Based on consent
- Anonymization
- Restricted access
- Public

Detailed answers from the projects are indicated below:

- SMILE: In Samso demonstrator supply and demand data are not publishable. Weather data are open access. In Madeira demonstrator only the affected and authorized partners have access to the collected data.
- E-LAND: Data will be shared using a common platform, which will handle sensitivity issues accordingly.
- INVADE: Each data item should be exchanged via non "person data identified". A common key e.g. a GUID or common unique identifier is used. The platform also has the capability of exchanging data based on the counterparts' identification scheme (here a cross reference is established between an external system unique key and an internal key (GUID)) used by the platform.
- MERLON: A Security framework will be established complementarily to the data management platform incorporating the security/privacy requirements defined in the project
- INTERRFACE: A vertical Cyber-Security / Data Privacy Layer will assure end-to-end secure data exchange and manipulation from the moment the datasets leave the IT infrastructures of the different operators, during their processing and handling in the data governance tier, until they are promoted back to the tools and applications but also the involved stakeholders. This layer keeps all communications in encrypted channels, and supplemented by need-to-know basis data-encryption. This also manages the users' authentication and authorisation as well as keeps the audit trails and logs of all user and system actions.
- DEPs in EU-SysFlex are designed for transporting personal and commercially sensitive data. They are GDPR compliant. (Estfeed is operated by Elering – ownership unbundled electricity and gas TSO of Estonia, thus ensuring independence from market interests. PCOM+ is operated by DSO and DSO has to ensure transparency and non-discriminatory access by regulation.)
- GIFT: An access policy has been defined for each type of data handled by the project. In case of sensitive data, it has been defined that detailed data can be shared only with the full consent of the data owner. Otherwise, only aggregated data or anonymous data can be shared.
- CROSSBOW: This is a TSO-oriented project with no personal data involved. Due to the market-sensitive nature of some information (e.g. level of water reservoirs), access to data is actually restricted to the signature of NDAs.

- MUSE GRIDS[5]: Weather data are open access. A policy has been defined for each type of data generated during the project. Aggregated data and anonymous data could be shared. Sensitive data will be shared just with a written approval of the data owner.

Projects were also asked about the design patterns selected for the data exchanges (design patterns may include e.g. API gateways, Enterprise Service Bus, web services). Their feedbacks are listed below:

- API gateways, RESTful API (MQTT, QUIC)
- API's and web services
- ESB and web services (mostly REST). Not fully defined yet.
- Web API and/or intefacing via Microsoft Event Hub.
- Web services
- Enterprise Service Bus
- A RESTful service layer (web APIs) for encrypted communication with HTTPS (Certificate based authentication at session level); strong password policy; Role/permission checks on system calls; Anti-DOS calls with source traffic validation
- API gateways, MQTT/AMQP, web services, DB schemas are considered for the design of the platform
- Hybrid model
- File-based data exchanges (e.g. XML, CSV), webservices, enterprise service bus
- API gateway for market participation, enterprise service bus for data exchange and security-related remedial actions
- Various (6 demos)
- GOFLEX uses serverless design patterns for cloud services.

5 Muse Grids project did not answer the questionnaire but provided this comment in a later phase.

4. Conclusion and recommendations

4.1 Conclusions from the Regulation working group

4.1.1 Recommendations

Topic	DSO role
Findings	The evolving role of the DSO is considered as a major challenge for demos' replicability.
Recommendation	Beyond allowing DSOs to use flexibility, it is advised to actively incentivize the DSOs to use flexibility via: • Remuneration mechanisms (OPEX/CAPEX) • Regulatory sandboxing • Promotion of good examples from projects where the use of flexibility is considered cost efficient.

Topic	Products standardization
Findings	The standardization of products decreases complexity for flexibility buyers and increases price transparency. However, a more flexible approach could be a better trade-off and respond better to countries' specificities
Recommendation	Products ranges could be defined instead, or even moving away from products towards a definition of flexibility as a set of technical parameters.

Topic	Product development for system services
Findings	The need for new or additional services in the field of congestion management is considered highly important by both TSOs and DSOs.
Recommendation	The detailed design for products providing congestion management services should be developed and implemented, taking into account: • The link with products developed for balancing services – in particular assessing if and how these services could be jointly procured • The role of both active and reactive power • The implications for the coordination between system operators

Topic	Flexibility Mechanisms
Findings	Most projects investigate market-based flexibility mechanisms. However, other mechanisms (technical, rule based, tariff based, connection agreements) remain also relevant and could complement market-based mechanisms.
Recommendation	When designing different types of flexibility mechanisms, the link between different mechanisms should be clear and no conflicting set-ups should be installed.

Topic	Coordination models between system operators
Findings	Coordination between system operators (TSO-TSO, TSO-DSO, DSO-DSO) has been in the heart of the debate for the last years. Current research has focused to a large extent on organizing the coordination between system operators in the operational planning phase. Less attention has been paid so far to explore novelties in coordination in the field of network planning.
Recommendation	Due to the increasing role of flexibility as a trade-off for capital investments, further research should focus on coordination between system operators during network planning

Topic	Market Design
Findings	Besides centralised marked design options, decentralized and distributed design options are actively explored for specific services for system operators.
Recommendation	The emergence of new market design concepts should go hand in hand with • Analysing the impact on coordination between system operators • Ensuring interoperability between different platforms implementing different market design concepts

Topic	Market Operator – regulated versus commercial
Findings	The role of the market operator is essential for the well-functioning of each market concept that provides energy, flexibility and system services. Dependent on the market, service or country, the role of market operator is taken up by a regulated entity or by a commercial party.
Recommendation	In order to ensure harmonisation and integration of both local, national and cross-border market models, it is advised to analyse which of the activities taken up by a 'market operator' should stay regulated and which activities should become or remain part of the commercial domain.

4.1.2 Next steps

Further work is required on some regulatory topics:

- In the field of network planning, coordination between TSO and DSO, and the inclusion of flexibility should be improved.
- Many projects that use role models start from the Harmonized Electricity Market Role Model (developed by ENTSO-E and the associated organisations EFET and ebIX) and adapt these models further to the particular needs of the project in order to describe their innovations. It is advised to map the changes made by the different projects: this information could be used for future revisions of the HEMRM, and shared with the projects at their start to facilitate a definition of roles common to all demos.
- The market operator role should be clarified (regulated or non-regulated role): it is advised to follow up with the projects what are the arguments developed in favour or against commercialization of certain activities related to market operation.

4.2 Conclusions from the Data management working group

Significant gaps were identified in relation to : existing standards and guidelines (such as IEC, CIM, SGAM, HEMRM); and data exchange (protocols, data types, data models, validation of the data, etc). Existing standards and guidelines were recognised as insufficient to address the most significant data management challenges. It was concluded that there are many standards and guidelines that have potential to be further improved in order to address many challenges such as TSO-DSO data exchange, flexibility, and data platform interoperability. Changes and additions (such are for example CIM extensions) to the existing standards were examined so that concrete suggestions can be forwarded to the responsible parties (policy makers, regulators, etc). Nevertheless, some methodology to improve interoperability are existing and some projects demonstrated their adding-value.

4.2.1 Recommendations

Topic	**New roles proposed for data management**
Findings	One project is operating with several new “pure” data roles (e.g. Data Exchange Platform Operator). Some projects mention further roles which are rather market than data roles. 6 projects out of 14 follow HEMRM, 2 projects USEF and 2 projects EDF’s role model
Recommendation	• Projects should share the role definitions between themselves and align where possible. • While identifying new roles projects should recommend these to be included Harmonized Electricity Market Role Model (HEMRM). • Projects by themselves and/or jointly should identify gaps between USEF and HEMRM, between EDF and HEMRM, etc.
Link to SGTF EG1[6] recommendations	Recommendation #1. Building on available role models, adopt and use a common European role model.

Topic	**Data models**
Findings	For the interface to smart appliances, several standards or initiatives exist. However, none of them are sufficiently implemented by the solutions/market yet. CIM is extensively used for TSO and DSO interactions. However, the current CIM standard does not cover enough Energy forecast, DER, Flex data and TSO-RSC interface.
Recommendation	• On-going efforts on smart appliances interoperability, such as SAREF and InterConnect (DT-ICT-10-2018-19) Horizon 2020 project should be pursued in order to reach an industrial maturity of this technology and its wide implementation by the solution providers. • Projects should bring their needs and suggestions to CIM standardization groups. This could be done via BRIDGE by defining a BRIDGE CIM data model and/or suggesting CIM extensions.
Link to SGTF EG1 recommendations	Recommendation #2. To facilitate interoperability, adopt and use a common information model for semantics, for example consider building on the available IEC CIM model. Recommendation #5. Adopt and use available European standards as a basis to improve interoperability.

[6] SGTF EG1 refers to European Smart Grids Task Force Expert Group 1 report on Towards Interoperability within the EU for Electricity and Gas Data Access & Exchange, March 2019

Topic	Focus on CIM
Findings	Five projects declared to be working with the CIM Canonical Model. Application of CIM for TSO-TSO, TSO-DSO and DSO-DSO data exchange. Six projects informed the use of CIM Data Model for data exchange between these actors. It is largely used by TSOs, but it is not the case for DSOs. Four projects informed used CIM from vendors products. One requested for certification processes as well as extensions. Two projects work with CIM on appliance level and nine projects work with CIM on platform/market levels. Only one project needs harmonization between CIM and IEC 61850. Also another two projects declared necessity for IEC CIM extensions for their projects.
Recommendation	• Keep the support from tools for the development of the CIM Canonical model. More participation of CIM users during the CIM WG meetings. • Certifications could be obtained through interoperability tests and it is an important step for vendors to participate with their products in the projects. • Vendors can be encouraged to participate into interoperability tests for appliance levels. • CIM harmonization to englobe TSO-DSO data exchange, since both uses different tools and solutions from different vendors; • CIM extensions to integrate new concepts like observability area between actors and to involve more actors during data exchange.
Link to SGTF EG1 recommendations	Recommendation #2. To facilitate interoperability, adopt and use a common information model for semantics, for example consider building on the available IEC CIM model.

Topic	Data platforms
Findings	There are few dedicated platforms for energy data exchanges, some of these used as input in the projects, some others even (further) developed as part of the projects. In addition, there are some data platforms not specific to energy data but rather vendor products for any data exchanges. More than one project mentioned platforms like data hubs, ECCo SP and Estfeed.
Recommendation	Next step for BRIDGE Data Management WG could be dedicated to joint elaboration conceptual European data exchange model, involving elements like functionalities of data platforms, governance of those platforms, data access, open source, standardisation needs
Link to SGTF EG1 recommendations	Recommendation #3. Adopt and use a core process model, which should allow for national specificities and stay open for further interoperability over time. Recommendation #4. Business requirements shall be the basis for interoperability and must remain technology-neutral. Recommendation #5. Adopt and use available European standards as a basis to improve interoperability

Topic	Use case based approach and functionalities
Findings	Some projects provided detailed list of data exchange functionalities they are describing as use cases and/or demonstrating. Seven projects apply IEC 62559 standard template to describe the use cases. Majority of the projects (12 projects) would be in favour of having access to a Use Case repository expressing TSO-TSO, TSO-DSO, DSO-DSO use cases.
Recommendation	• Projects should apply IEC 62559 for use case description and could also leverage 62913-1 (Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach). • Projects should cooperate while developing use cases. • Use case repository containing in a structured way use cases from different projects is required. Repository should be public and freely accessible so that use cases can be reused and improved. In cooperation with CEN-CENELEC-ETSI CG-SEG projects could contribute to development of IEC's Use Case Repository.
Link to SGTF EG1 recommendations	Recommendation #3. Adopt and use a core process model, which should allow for national specificities and stay open for further interoperability over time. Recommendation #4. Business requirements shall be the basis for interoperability and must remain technology-neutral.

Topic	Interoperability
Findings	Seven projects demonstrate interoperability between platforms in terms of interoperability with other DSOs/TSOs. Only three projects demonstrate interoperability between platforms in terms of interoperability with other markets (e.g. mobility, health or home-security services). Seven projects would be interested to participate in interoperability tests. But only three projects would be possibly able or willing to share data for interoperability tests.
Recommendation	• While working on conceptual European data exchange model (see above) "interoperability of platforms" has to be defined, interoperability of platforms to be ensured and platforms with European ambition and potential to be identified for replicability and scalability. • Cooperation with other sectors is required – e.g. through appropriate Horizon2020 calls. • Projects should elaborate ways how to share data between themselves enabling cross-project interoperability tests.
Link to SGTF EG1 recommendations	Recommendation #3. Adopt and use a core process model, which should allow for national specificities and stay open for further interoperability over time. Recommendation #4. Business requirements shall be the basis for interoperability and must remain technology-neutral.

Topic	Transparency and data access
Findings	Projects were asked how they would ensure transparency and non-discrimination to access to data (including sharing of personal and commercially sensitive data). The answers cover full range of options for access: • Based on consent • Anonymization • Restricted access • Public
Recommendation	While developing conceptual European data exchange model (see above) easy access to data (CEP), GDPR compliance and data owner's control over their data has to be ensured.

4.2.2 Next steps

As next steps for BRIDGE Data Management WG actions towards "European data exchange model" are suggested. For this aim practical implementation of Smart Grids Task Force Expert Group 1 task force recommendations would be a good starting point, so called Reference Core Model/Framework including elements such as:

1. Data platforms
    a. Classification of platforms
    b. Basic principles
    c. Governance
2. Describe use cases, incl. for flexibility trading
    a. Business processes (business use cases)
    b. Functionalities (system use cases)
    c. Use case repository
3. Propose role model updates (HEMRM)
4. Design data/information model(s) (based on CIM)
5. Identify gaps in standards and propose new where appropriate
6. Taking the best out from the findings and show cases of Horizon2020 projects

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Annex I. Glossary

Term	Definition	Source*
Data exchange platform	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. information about security logs, cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs. Several DEPs may exist in different countries and inside one country.	EU-SysFlex
Data format	Data format in the meaning of file format is a standard way that information is encoded for storage in a computer file. It specifies how bits are used to encode information in a digital storage medium.	Wikipedia
Data hub	An information system which main functionality is to store and make available measurements (e.g. meter data, operational data) and associated master data. Data Hubs are not necessarily centralized in a country or in a region.	EU-SysFlex
Data model	An abstract model that organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities.	Wikipedia
Information model	A representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. Typically it specifies relations between kinds of things, but may also include relations with individual things. It can provide sharable, stable, and organized structure of information requirements or knowledge for the domain context.	Wikipedia
Interoperability	The ability of two or more devices to exchange information and use that information for correct cooperation to perform the required functions. In other words, two or more systems are interoperable, if they are able to perform cooperatively a specific function by using information that is exchanged.	SGTF EG1, IEC61850-2010
Ontology	A representation, formal naming and definition of the categories, properties and relations between the concepts, data and entities that substantiate one, many or all domains of discourse.	Wikipedia
Protocol	Communication protocol is a system of rules that allow two or more entities of a communications system to transmit information via any kind of variation of a physical quantity. The protocol defines the rules, syntax, semantics and synchronization of communication and possible error recovery methods. Protocols may be implemented by hardware, software, or a combination of both.	Wikipedia
(Reference core) process model	A representation of harmonised processes for information exchange within the energy sector so that these processes may be implemented as such or as the basis for a customised version according to regional/national business needs.	SGTF EG1

(Reference) information model	A representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for the energy sector.	SGTF EG1
Role model	A model representing core functions/responsibilities in the energy sector and their interdependence.	SGTF EG1
Semantics	Understanding of the concepts contained in the message data structures. Understanding of the information that needs to be accessed/exchanged. The semantic aspect refers to the meaning of data elements and the relationship between them. It includes developing vocabularies and schemata to describe data exchanges, and ensures that data elements are understood in the same way by all communicating parties.	SGTF EG1, European Interoperability Framework
Syntactics	Understanding of data structure in message exchanged between systems. Technical aspects (e.g. formats, technologies used) of the information that needs to be accessed/exchanged. The syntactic aspect refers to describing the exact format of the information to be exchanged in terms of grammar and format.	SGTF EG1, European Interoperability Framework
Use case	A list of actions or event steps typically defining the interactions between a role (known in the Unified Modelling Language (UML) as an actor) and a system to achieve a goal. The actor can be a human or other external system.	Wikipedia

* SGTF EG1 refers to European Smart Grids Task Force Expert Group 1 report on Towards Interoperability within the EU for Electricity and Gas Data Access & Exchange, March 2019

Annex II. Matrix of data usage

Data analysis below is based on the answers to the question:

Which data, and for what purpose, do you share between TSOs and DSOs as well as with other parties (e.g. supplier, aggregator, customer, etc.) if relevant for TSO-DSO, TSO-TSO and DSO-DSO processes? Data should be presented in functional terms (e.g. power grid descriptions, consumption/production forecasts, flexibility needs). They should be characterized with requirements on data types (e.g. real-time/near-real-time/slower data, time series, graphs, master data, sensitive data) and technical requirements (e.g. frequency of data exchanges and amount of exchanged data).

	Project	Specific data	Partners involved in data exchange	Associated business process(es)	Data type (e.g. real time, hourly, master, ...)	Frequency of data exchange	Volume of exchanged data
Meter data	EU-SysFlex	Measurements from certified meters and associated master data – consumer's ID, location, etc.	TSO, DSO, Data Hub, DEP, Flexibility Platform, FSP, consumer	Data access, data sharing, flexibility market functioning	Hourly	Uploaded in Data Hub by SOs once a day	Ca 750 thousand metering points in Estonia
	GIFT		DSO, Solution provider	Grid modelling, state estimation	Not defined yet	Not defined yet	Not defined yet
	GOFLEX	Meter data - energy, power, voltage	3 DSOs	Flexibility Markets	15 min energy and voltage profiles, near real-time power and voltage	5 minutes – daily	~ 300,000 measurements across 3 DSOs daily
	InterFlex		DSO, customer	Metering	Daily index, hourly load profile	Once a day	< 1kB per day
	INVADE		Pilot sites, local system integrator	Receive site main meter readings	Reading at point of sending (can also be sent as batch of readings)	Once every 5 – 15 minutes	Depends on pilot size, typically for 50, 1500 sites x 5 pilots
	MERLON		Assets/ Consumers-DSO	Billing, DSO operations, Demand Response	Real time	15-minutes	TBD
	SMILE		Samso: DSO		Samso: kWh, import and export	Samso: Read access: 15 min resolution	
Sub-meter data	EU-SysFlex	Sub-meter measurements and	TSO, DSO, DEP, Flexibility	Data access, data sharing, flexibility	Very-near-real-time (1-2 minutes)	Very-near-real-time exchanges	

		associated master data	Platform, FSP, consumer	market functioning			
	ELAND		Aggregator, Microgrid Operator, Facility Manager, Customer	Optimization of operation of a Local Energy System, optimal sizing of a future investments	Hourly time series, sensitive	Hourly	~KB/meter/day
	GIFT		Charge point operator, DSO, BRP, Aggregator, Microgrid operator	EV-based flexibility, congestion management, grid operation	Not defined yet	Not defined yet	Not defined yet
	InterFlex		DSO, DER operator, microgrid controller, aggregator, …	DER monitoring, load monitoring	Various	Various	< 1kB per day
	INVADE	Sub-meter data (e.g. for PV, controllable loads, batteries)	Pilot sites, local system integrator	Receive asset meter reading (e.g. for PV, controllable loads, Batteries)	Reading at point of sending (can also be sent as batch of readings)	Once every 5 – 15 minutes	Depends on pilot size, typically for 50, 1500 sites x 5 assets per site x 5 pilots
	MERLON		Assets/ Consumers - Aggregators	Demand Response	Real time	TBD	TBD
	SMILE		Samso: Compusoft (external platform developed by Compusoft) Madeira: prsma, M-ITI, EEM	Samso: Payment system for boats	Samso: kWh Madeira: kWh every minute	Samso: Minutes Madeira: Minute	Samso: Large Madeira: every request to the EMS heights approx. 280 bytes. There are approx. 50 devices sending data every minute
Grid data	EU-SysFlex	Results of grid impact assessments	DSO, TSO, DEP, Flexibility Platform	Flexibility market functioning: prequalification, bidding, activation	Real-time data	Every few minutes	
		Grid topology, current, grid state estimations, installed capacities (only data	TSO, DSO	Grid planning, congestion management	Real-time data, structural data, forecasts	Every few minutes	

		addressed in SOGL)					
	CROSSBOW	Grid data (energy flows, topology)	TSO-TSO	Real time Cross-border Congestion identification	Real time	3-5 seconds	?
		Grid data (energy flows, market information, topology)	TSO-TSO	Cross-border Congestion forecast	Hourly forecast	hourly	?
		Grid data (energy flows, market information)	TSO-DSO	Distributed generation forecast	hourly	Hourly	?
		Corrective action, network data	TSO-TSO	Enhance network resilience	Corrective actions	depends	depends
		Grid data (energy flows, market information)	TSO-TSO (through RSC)	Cross-border Sharing of reserves	Daily forecast	daily	?
	GIFT		DSO, Solution provider	Grid monitoring, grid visualization	Not defined yet	Not defined yet	Not defined yet
	GOFLEX	Active power load, reactive power load, voltage	3 DSOs	DSO grid observability	Near real-time active/reactive power load, voltages	5 minutes – 1 hour	~ 100,000 measurements across 3 DSOs daily
	inteGRID		Aggregator (commercial VPP) and the DSO (operating the Traffic Light System)		NA	Every hour or on request (depending if it's ex ante or post-activation)	
	InterFlex		DSO, microgrid controller	Grid monitoring	Real time	Various	< 10 kB per day
	SMILE		Samso: DSO Madeira: DSO & TSO, prsma	Samso: Sale and purchase Madeira: Production information	Samso: kWh Madeira: MWh every 15 minutes	Samso: Hourly Madeira: Every 15 minutes	Samso: 24 h x 365 days/year Madeira: 24 h x 365 days/year
Flexibility data	EU-SysFlex	Activation requests, needs, potentials, forecasts, schedules, baselines, bids, calls for tender	TSO, DSO, DEP, Flexibility Platform, FSP, consumer	Flexibility market functioning: prediction, prequalification, bidding, activation, verification	Real-time data, structural data, forecasts	Event-driven – based on need	
	ELAND	Flexibility needs etc.	Aggregator, Microgrid Operator,	Optimization of operation of Local	Hourly/15 minutes	Hourly (or less)	~KB/day

			Grid Operator	Energy System	interval time series		
	GIFT	Flexibility bids	DSO, BRP, Aggregator, Microgrid operator	Flexibility negotiation and activation	Not defined yet	Not defined yet	Not defined yet
	GOFLEX	Flexibility bids	3 DSOs, prosumers and aggregators	Flexibility Markets	15 min FlexOffer	15 mins	10,000 per day
	inteGRID		Aggregator (commercial VPP) and the DSO (operating the Traffic Light System)		Ex-ante: Flexibility bids that need to be evaluated are sent every hour by the VPP and contains the bids for the next 24 hours. Ex-post activation: Flexibility bids activated are sent directly to the TLS		
	InterFlex		DSO, aggregator, customer, microgrid controller	Flexibility	Real time	Various	< 10 kB per day
	INVADE	Baseline, delivery note, flexibility offer, flexibility request, flexibility offer acceptance	BRP, DSO, FO	Send Base Line notices, delivery notes, flex offers Receive flex request, flex offer acceptance	15-minute resolution for Day worth of data, send day ahead and within day typically	Baseline once every 15 minutes, delivery note once a day	Low volume message per BRP area, DSO Zones and Sites, typically 100-500 per day max.
	MERLON		DSO-Aggregators, Aggregators-Customers	Demand Response, Demand Response Remuneration	TBD	TBD	TBD
Weather data and forecasts	EU-SysFlex		Weather data provider, DSO, TSO, DEP	Flexibility market functioning: prediction, verification (baseline calculation)	Real-time data, forecasts	Every few hours	
	InterFlex		DSO, aggregator, customer,	Grid forecast	Various	Various	< 10 kB per day

			microgrid controller				
	INVADE	Weather forecast	Montel (via Energy Quantified)	Weather forecast data local to pilot area	Typically hourly	Typically once a day	Messages per hour at hourly level for 2 days of data x 20 areas
	SMILE		Samso: data from tools developed by RouteMonkey, Libal Madeira: Routemonkey		Samso: Temperature, wind Madeira: Routemonkey	Samso: Hourly	Samso: 24 hours
	GIFT	Weather historical and forecast data	DSO, Aggregator, Microgrid operator	Production and consumption forecast, grid operation	Not defined yet	Not defined yet	Not defined yet
	GOFLEX	Weather historical and forecast data	3 DSOs	Grid prediction services	24 hour energy predictions	15 mins	1000 per day
	ELAND		Aggregator, Microgrid Operator, Facility Manager	Optimal sizing of future investments, optimization of operation of a Local Energy System	Hourly/15 minutes interval time series	Hourly (or less)	~ MB/day
Price data	INVADE	Spot price	Montel (via Energy Quantified)	Spot price data local to pilot market	Typically hourly	Typically once a day	Low volume typically for prices: messages per day at hourly level for 2 days of data x 5 markets for pricing
	ELAND	Market signals (e.g. day-ahead price)	Aggregator, Microgrid Operator, Facility Manager	Optimal sizing of future investments, optimization of operation of a Local Energy System	Hourly/15 minutes interval time series	Hourly (or less)	~ MB/day
Identity data	EU-SysFlex	Authentication information, representation rights, data access permissions, data logs	Data Hub, DEP, consumer, data requesting application (supplier, ESCO, FSP, DSO, TSO)	Data access, data sharing		Event-driven – based on need	

Generation and load asset data	EU-SysFlex	Structural data of generation and load assets (e.g. planned maintenance)	Asset owner, TSO, DSO, DEP	Network planning, congestion management	Structural data	Exchanged if changes in data occur	
	ELAND	Storage schedules, EV user charging preferences	Aggregator, Microgrid Operator, Facility Manager, Customer	Optimization of operation of a Local Energy System	Hourly/15 minutes interval time series, sensitive	Hourly (or less)	~KB/asset/day
	SMILE	Madeira: Driving routes	RouteMonkey, prsma		GPS coordinates	Realtime	24h x 365 days/year
	INVADE	Characteristics of assets - location, controllability, min/max capacity Contract information, incl. pricing - contracts between DSO, BRP, FO	Pilot sites, local system integrator	New Assets, Sites	master	As required ad-hoc	Low volumes, when new sites added to pilot or new assets within sites. Infrequently for pilots, but was required initially to set up the base configuration.
	ELAND	Characteristics of DER	Aggregator, Microgrid Operator, Facility Manager	Optimal sizing of future investments	Fixed, sensitive	Occasional	~MB

Annex III. Regulation WG questionnaire

SERVICES & PRODUCTS

1) Do you have services developed for TSOs in your project? Please indicate which services by ticking the boxes:

☐ Primary control
☐ Secondary control
☐ Tertiary control
☐ National capacity markets
☐ Congestion management
☐ Grid capacity management
☐ Redundancy (n-1) support
☐ Controlled Islanding

2) Do you have services developed for DSOs in your project? Please indicate which services by ticking the boxes:

☐ Congestion management
☐ Voltage control
☐ Grid capacity management
☐ Controlled islanding
☐ Redundancy (n-1) support
☐ Power quality support

3) What are the products (including product specifications and values) designed to provide the services as listed in the previous question? Specifications are for example activation time, duration, reliability, ramping constraints, minimum size, rebound effects,…

4) Are these new services/products suitable under the new framework of the clean energy package? Please explain in the "other" box.

5) Do you simulate/demonstrate these services and/or products in your project ? If Yes, which one, specify under the "other" box

6) What are the challenges for their replicability and implementation?

☐ Consumer adoption / Market maturity
☐ Evolution of regulation
☐ Technical (Technology evolution, Interface design, existing infrastructure, standardization, interoperability, network configuration, etc.)
☐ Economic (economy of scale, profitability, business model, etc.)
☐ Other: ……………………………………………………………

7) What are the value pockets of such services (qualitative assessment)?

☐ Avoided grid investment
☐ Avoided grid losses
☐ Avoided investments in central generation capacity
☐ More efficient use of central generating capacity
☐ Additional energy savings

☐ Reduced Imbalance
☐ Welfare gain due to new services
☐ Reduced CO2 emissions
☐ Reduced outage time
☐ Reduced curtailment of distributed generation
☐ Increased grid hosting capacity for distributed generation
☐ Extended asset life time
☐ Other (please explain): …

8) Which players benefit from these value services?

☐ Consumers
☐ Suppliers/Aggregators
☐ Network operators

☐ Other (please explain): …

9) What are the KPIs proposed in your project to quantify these benefits? What is the result of the KPI analysis? (quantitative assessment)

10) Do you define new forecasting models to predict frequency issues/voltage issues/congestion issues/other system scarcities? Please Explain.

11) What are the voltage levels in the scope of your project and are these grids owned/operated by TSO/DSO/…? Please provide a value.

COORDINATION MODELS

1) Which coordination topic is considered in your project :

☐ TSO-TSO coordination

☐ TSO-DSO coordination

☐ DSO-DSO coordination

2) Which timeframe do you consider in your project:

☐ Network planning
☐ Operational planning
☐ Real-time operation

3) In case the answer on the previous question is 'Network planning' - do you propose novel planning models for networks to meet future demands? Please explain under "other" box

4) What is the mechanism developed in your project to cover the needs for the different timeframes (question above)

☐ technical solutions (e.g. reconfiguration of grid topology, ...)
☐ tariff solutions (dynamic grid tariff f mechanisms,...)
☐ market based solutions (market based activation of flexibility procured via a tender, bilateral contract, flexibility market,....)
☐ connection agreement solutions (dynamic connection agreements/...)

☐ rule-based solutions (curtailment, mandatory provision of flexibility by generators, other rules available in network codes,...)

Special question: For projects dealing with e-mobility: do you use dynamic tariffs for smart charging, and if so, what is the business case for such services

Special question: For projects dealing with e-mobility: do you use dynamic tariffs for smart charging, and if so, what is the business case for such services

5) In case you indicated as mechanism 'market-based solutions' - what is the concept of the 'market place' developed in your project: regional market, central market for TSO and DSO, separate local market for one DSO, local market for multiple DSOs, peer-to-peer market, market for SOs and BRPs,.... Please Explain

6) What are the roles of the stakeholders in the concept explained in the previous question (Who is operating the market (TSO, DSO, independent operator,…), What is the role of the TSO and the role of the DSO in different market phases (prequalification, procurement, activation, settlement))? Please Explain

7) Starting from your answers to the last questions (mechanism and concept), list the existing barriers for the realisation of these concepts. Please explain under the "other" box.

8) Again, starting from your answers to the last questions (mechanism and concepts), what are possible market distortions encountered in your project and what are possible mitigation measures developed in your project ? Please explain under "other" box

9) What is the rule to determine the price of the services procured (continuous auction versus discrete auction - pay as bid/pay as clear - mandatory provision (free) - …)?

10) What is the allocation principle of the flexibility? (priority TSO, priority DSO, exclusive use of flexibility by TSO or DSO, no a priori allocation priority - minimisation of costs, no a priori allocation - highest willingness to pay, other). Explain.

11) How are grid constraints (transmission and distribution) incorporated in your coordination model? When are constraints considered (not/prequalification/in the market clearing algorithm, post-redispatch activity, other) - please explain

12) How is the Transfer of Energy organised (in case of activation of flexibility by a DSO, or by a neighbouring TSO)? Please Explain.

13) Are different services 'jointly procured' in the same market or how is the link between different services organised within your project?

ROLES AND RESPONSIBILITIES

1) Did the project develop a role model for the description of Business Use Cases ?

2) What is the role model used for the description of the Business Use Cases? List both the 'role name' and a short 'definition'

3) What were the sources to define this role model (existing role model, discussion in the project,…)

OPEN QUESTIONS

1) What other aspects related to 'Coordination' are relevant and should be further investigated based on the findings in your project?

2) What are other main research questions (besides 'coordination') which are relevant for the Bridge Regulation WG on which your project could contribute (which were not discussed during previous WG sessions/which are not captured in this survey)

Annex IV. Data Management WG questionnaire

This data management questionnaire on TSO-DSO, TSO-TSO and DSO-DSO topics as it follows should be considered in the context of parallel survey conducted by Regulation WG. Projects should coordinate internally when answering these questionnaires.

DATA MODELS

1) Whether and how do you apply SGAM (Smart Grid Architecture Model) in your project to describe TSO-DSO, TSO-TSO and DSO-DSO data exchanges? Have you done or do you plan to do some kind of visual mapping?
2) What standardized data models (for example IEC CIM, Data exchange for meter reading DLMS/COSEM, IEC 61850, IoT data models, national models, etc.) do you use for communication and data exchange in your project:
    a. at the level of appliances?
    b. at the level of platforms/markets?
    c. specifically for TSO-DSO, TSO-TSO and DSO-DSO data exchanges (like flexibility market functioning, network planning, etc.)?
3) What role models (for example Harmonized Role Model) do you use in your project? Have you identified new roles from data management perspective?
4) What further efforts should be made in standardizing data models? Where do you see gaps, missing use cases, especially in the field of TSO-DSO, TSO-TSO and DSO-DSO data exchange?

CIM SPECIFIC QUESTIONS

5) If you use vendor products, are they CIM compliant? With which CIM version are they compliant with (CIM16, CIM17, other)? Which CIM profiles are they compliant with (CGMES 2.4.15, ESMP related profiles, 61968 related profiles, other)?
6) Are you using some CIM Interfaces in your environment? If yes, for which purpose?
7) What would be your requirements in terms of CIM compliancy for vendor products?
8) Do you manage an internal canonical data model based on CIM (CIM with some extensions)?
9) If you manage an internal canonical data model, do you manage it using a UML environment? If yes, which one?
10) Do you use tools to derive CIM based profiles? If yes, which tools are you using?
11) Do you think your extensions could be part of the official IEC CIM model?
12) Do you think that harmonization between CIM and 61850 is requested to support some use cases associated to TSO-TSO, TSO-DSO, DSO-DSO information exchanges? If yes, for which use cases?
13) Do you think that harmonization between CIM and COSEM or 61850 and COSEM is requested to support some use cases associated to TSO-TSO, TSO-DSO, DSO-DSO information exchanges? If yes, for which use cases?

DATA PLATFORMS AND SYSTEMS

14) What data exchange platforms are you using in your project for TSO-DSO, TSO-TSO and DSO-DSO data exchanges (like for flexibility market functioning, network planning, etc.)? How do these platforms facilitate TSO-DSO, TSO-TSO and DSO-DSO data exchanges? Which other parties can use the same platform? Who are (will be) the operators of these platforms?
15) Do you demonstrate interoperability between platforms:
    a. in terms of interoperability with other DSOs/TSOs?

b. in terms of interoperability with other markets (e.g. mobility, health or home-security services)?

16) What are the functional requirements of these platforms? Do you describe data exchange functional requirements as use cases in your project (using standard template)?
17) What is the performance of these platforms (e.g. 1000 simultaneous connections)? What is the availability of these platforms (e.g. 24h/24, 7 days a week)? What are the requirements on failure rates (e.g. 8 h for the Maximum Tolerable Period of Disruption)?
18) What specific systems (tools, applications, data hubs, …) do you use in your project to facilitate TSO-DSO, TSO-TSO and DSO-DSO data exchanges?

TSO-DSO, TSO-TSO and DSO-DSO DATA

19) Which data, and for what purpose, do you share between TSOs and DSOs as well as with other parties (e.g. supplier, aggregator, customer, etc.) if relevant for TSO-DSO, TSO-TSO and DSO-DSO processes? Data should be presented in functional terms (e.g. power grid descriptions, consumption/production forecasts, flexibility needs). They should be characterized with requirements on data types (e.g. real-time/near-real-time/slower data, time series, graphs, master data, sensitive data) and technical requirements (e.g. frequency of data exchanges and amount of exchanged data). Use the table below to characterize data types, feel free to add additional rows.

Data (in functional terms)	Partners involved in data exchange	Associated business process(es)	Data type (e.g. real time, hourly, master, etc.)	Frequency of data exchange	Volume of exchange data
Meter data (measurements from certified meters)					
Sub-meter data (device level measurements – e.g. heat pump, EV, etc.)					
Grid data (e.g. energy flows, outages, etc. – please specify!)					
Flexibility data (e.g. activation requests, flexibility bids, etc.)					
Other data (e.g. prices, weather data, etc. – please specify!)					
…					

20) How would you ensure transparency and non-discrimination to access to these data (including sharing of personal and commercially sensitive data)?
21) What standardized communications protocols, data formats, equipment do you use for data exchange?
22) What kinds of design patterns are selected for the data exchanges (e.g. API gateways, Enterprise Service Bus, web services)?
23) Have data exchange systems been developed with model-driven engineering methods that can be used to generate code from structural models (e.g. data models) and behavioral models (e.g. sequence diagrams)?
24) To validate your data sets, do you use a specific tool? If yes, which one?

OTHER

25) What have been the two biggest challenges from a data perspective on this project? Are they related to TSO-DSO, TSO-TSO and DSO-DSO co-ordination/ownership? Could it be overcome on this project?
26) Would you be in favor of having access to a Use Case repository expressing TSO-TSO, TSO-DSO, DSO-DSO use cases?
27) Would you be interested to participate in interoperability tests to demonstrate TSO/DSO, DSO/DSO compliancy?
28) Do you have data models representing TSO or DSO networks that could be used in interoperability tests? With which CIM profiles your data sets are compliant with?

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