European Commission

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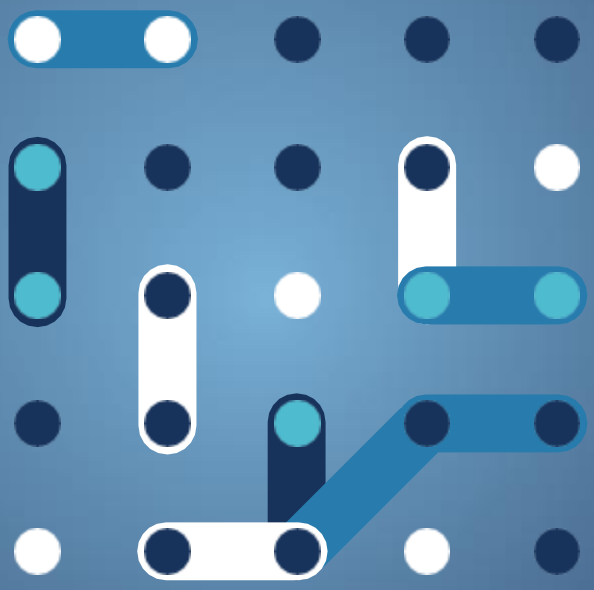
TSO - DSO Cooperation

Case study #4



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1. Increased TSO-DSO-Market cooperation for more renewable energy integration and benefits to the whole EU electricity system value chain

1.1 Context

The transition to a "Carbon neutral Europe in 2050" imposes profound changes in energy systems: deeper electrification and digitalisation, further renewable energy integration in a context of climatic and societal resilience while ensuring energy affordability and security of supply, which creates increased flexibility needs for system operators (TSOs and DSOs) to fulfil their missions.

Several sources[1] defined flexibility as the *modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) to provide a service within the energy system*. Such increased flexibility needs will thus require the integration of additional flexibility resources in the electricity system considered as a whole and the setting-up of the right coordination and data exchange mechanisms among the electricity value chain stakeholders.

1.2 Benefits

It is expected that an increased collaboration between TSOs and DSOs and consumers will contribute to the development of a smart, secure and more resilient energy system: DSOs and TSOs, by acting in a coordinated manner, can provide favourable cooperation conditions to all market players and thus remove barriers to the participation of consumers and smaller market players.

Such increased collaboration will have multiple positive direct and indirect effects resulting from the facilitation of a market playing field for agents: fostering competition and new services, reducing congestion due to a market-based allocation of flexibility services, integrating more renewable energy into the electricity system, increasing engagement of energy consumers / prosumers, paving thus the way to the common EU electricity market.

1.3 Pending challenges

However, the cooperation schemes among these stakeholders must remain compliant with the local technical grid constraints and regulations. Multiple market configurations can be considered in a spectrum of options ranging from the most fragmented to the most integrated ones with different degrees of market liquidity for grid services.

The recent ASM report of CEDEC et al, published in 2019[2] proposed a framework for mapping grid services and standard products for the exchange of grid services as well as of coordination schemes and related market models with a focus on balancing and congestion management. This framework is already considered as a pivotal reference to further mapping efforts of such coordination schemes by R&I projects.

[1] 2015 EG3 report 'Regulatory Recommendations for the Deployment of Flexibility' reported in the ASM report, CEDEC et al, 2019
[2] TSO – DSO report: an integrated approach to active system management with the focus on TSO – DSO coordination in congestion management and balancing, CEDEC, ENTSOE et al , 2019.

More generally, the demonstration of the value of data sharing and of coordinated / common schemes between TSO and DSO can only be achieved by dedicated demonstrations involving the whole value chain of system operators and the market on specific system services.

Implementing new sources of flexibilities in the power system implies to answer to the following questions:

- How to define standardised products and services?
- How to establish coordinated schemes between TSO and DSO and with the market agents?
- Which format for data exchanges?

The present document illustrates how some recent projects in the BRIDGE initiative contributed to answering these questions.

2. Prerequisites for more TSO-DSO-market coordination

Identifying coordination schemes first requires common understanding on the terminology on products and services. A second prerequisite is the compatibility among the classification approaches considering the respective perspectives and roles of TSO, DSO and market. Last, a third topic refers to the interoperability of data and means of facilitation of their exchanges.

- **Harmonised products and system services** to decrease complexity for flexibility buyers and to increase price transparency while keeping some degree of flexibility, starting with congestion management and balancing services.
- Design, selection and testing **of Coordination schemes (CS)** between TSO-DSO.
- **DATA exchange for enhanced TSO/DSO/market coordination:** identification of limits and gaps on data exchange in various H2020 projects and recommendations for updating the Harmonised Electricity Market Role Model and for a new structure and governance for sharing CIM formats.

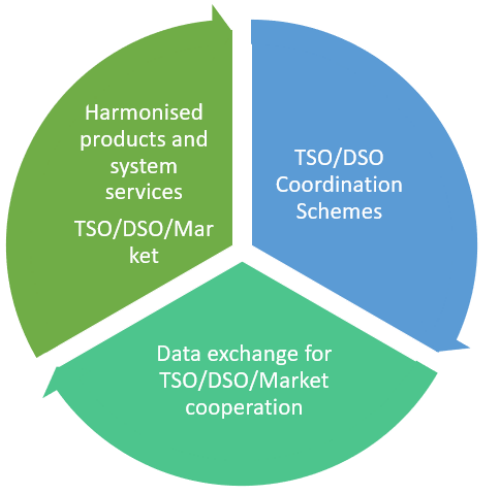


Figure 1: The 3 building blocks to enhance TSO-DSO-Market coordination

This case study focuses on four H2020 projects that address those buildings blocks complementarily:

- **CoordiNET** – call LC-SC3-ES-5-2018-2020 (TSO DSO Consumer) : demonstrating how DSO and TSO shall act in a coordinated manner to procure and activate grid services in the most reliable and efficient way through the implementation of three large-scale demonstrations.
- **INTERRFACE** – call LC-SC3-ES-5-2018-2020 (TSO DSO Consumer) TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system.
- **OneNet** – call LC-SC3-ES-5-2020 - TSO-DSO cooperation. One Network for Europe. Creating the conditions for a new generation of grid services able to fully exploit demand response, storage and distributed generation while creating fair, transparent and open conditions for the consumer.
- **TDX Assist** - call LCE-05-2017 - Coordination of Transmission and Distribution data eXchanges for renewables integration in the European marketplace through Advanced, Scalable and Secure ICT Systems and Tools.

3. Harmonisation of products and system services to enhance TSO-DSO-Market cooperation

This section deals with definitions and mapping of the products and services that will be designed and used to enhance TSO-DSO-Market cooperation with the goal to decrease complexity for flexibility buyers and to increase price transparency. The scope covers congestion management and balancing services[3].

3.1 The definitions of system services and products, a prerequisite for cooperation, are converging

- **OneNet** project analysed fifteen H2020 projects dealing with system services and product designs. Only a few of them proposed explicit definitions: Coordinet, EUniversal, EU-Sysflex, Flexitranstore [OneNet project deliverable D2.1]

Definition of system services:

- **Coordinet** project defined them as 'services provided to DSOs and TSOs to keep the operation of the grid within acceptable limits for the security of supply and are delivered mainly by third parties [CoordiNet project deliverable D 1.3].
- **EU-SysFlex** project formulated a definition as 'the physical action, be it the provision of active or reactive power and/or energy, which is needed to mitigate a particular technical scarcity or scarcities' [EU-SysFlex project deliverable D3.2]
- **Flexitranstore** project defined them as 'a need from the system operator that can be supplied by the market participants by bidding their flexibility capacity in the flexibility market.' [OneNet project deliverable D2.1]
- Among the various formulations, a common feature emerges around the scarcity or need by the network operator as the driver of the service.

Definition of products:

- Regarding the definition of 'Products', **EU-SysFlex** project proposed the following formulation: "A product, contrary to the service, is the 'option' that is purchased and remunerated, where the service is what is actually delivered, and the service defines exactly what is needed once a particular option is called upon. For example, manual frequency restoration reserve (mFRR) is a product, while the covered system service is the provision of active power to restore the system frequency following a frequency deviation" [EU-SysFlex project deliverable D3.2].
- In **OneNet** project, a product is defined as a 'tradable unit' that the network operator acquires from flexibility providers and that entails the option to deliver a service in case of activation (this activation can be automatic). [OneNet project deliverable D2.1].

The qualification of 'standard products' refers to such tradability. **Coordinet** project retained the formulation of EU 2017/2195, i.e. "harmonized products for the exchange of grid services with common characteristics across Europe". [Coordinet project deliverable D1.3].

Classification of products

[3] in line with the scope of the recent CEDEC report previously mentioned.

- **INTERRFACE** project proposed a classification of products into four categories: balancing services as part of TSO responsibility, congestion management, non-frequency ancillary services, and adequacy.

- **CoordiNet** suggested the addition of voltage control, controlled islanding, inertial response and blacks start in the portfolio of services (the two latter not part of demonstration). Considering these additions as non-frequency ancillary services enables to bridge the gap between the respective DSO led and TSO led perspectives.

  - **Congestion** was defined in Coordinet project as a condition where one or more constraints (thermal limits, voltage limits, stability limits) restrict the physical power flow through the network. The service of congestion management refers to the process of mitigating grid congestion issues by avoiding the crossover of network capacity (CoordiNet 2019, deliverable D1.3). Therefore two different products are proposed: **Congestion management reserved**[4] or **non-reserved**[5]**.**
  - **Congestion services** were addressed in INTERRFACE project through three sub-categories defined according to time line and TSO planning processes: **Long-Term Planning congestion management, Short-Term Planning congestion management, Operational congestion management.**

- In **INTERRFACE**, specific attention was paid to the participation of distributed resources in balancing services, as a feature related to Market Design rather than to product specifications (e.g., coordination and transparent settlement).

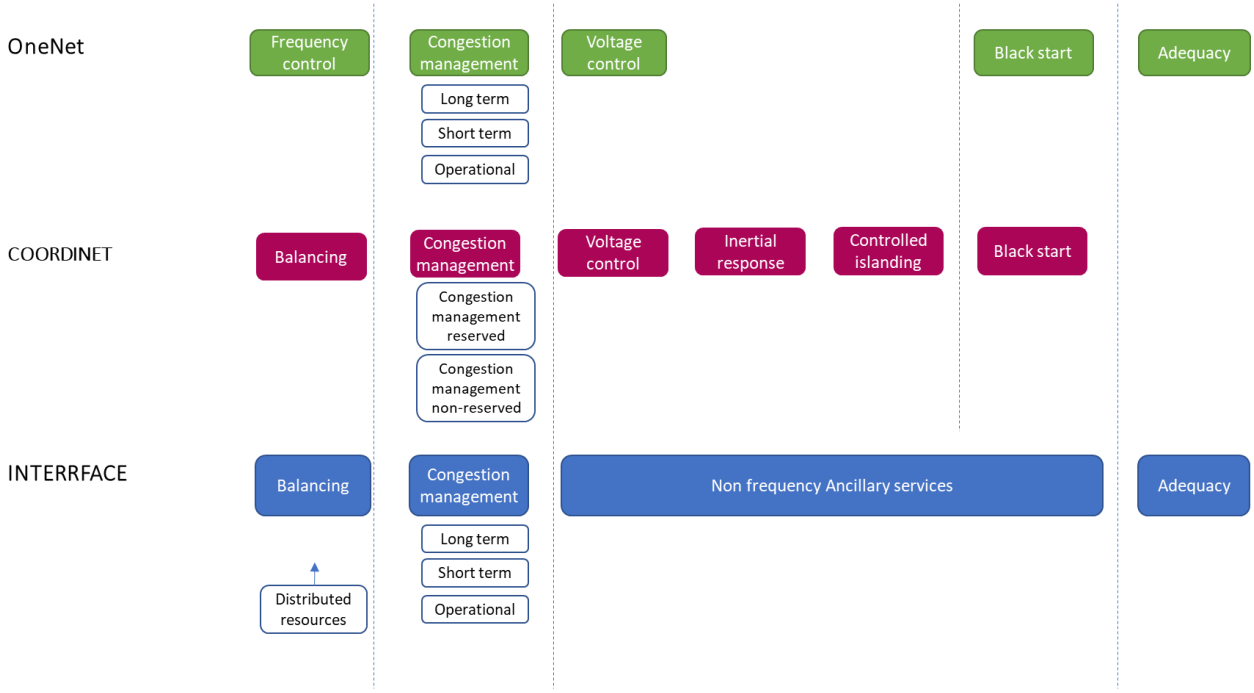


Figure 2: Classification of services in OneNet, Coordinet and Interrface projects

3.2 Harmonisation efforts enable to identify products that are common to TSOs and DSOs

Standardisation vs. harmonisation

[4] i.e., a capacity-based product procured at a certain availability price and activated when the service is needed and called upon by the system operator - typically to deal with structural constraints
[5] an energy-based product addressing less predictable sporadic constraints.

- **CoordiNet** project grouped the products into 'standard products and specific products'. **Standard products** are then "harmonized products for the exchange of grid service(s) with common characteristics across Europe (i.e., shared by all TSOs or by all DSOs or by all TSOs and DSOs)", [...] while **specific Products** are "products different from standard products". (Location)-specific situations could call for the need to define specific products [CoordiNet project deliverable D 1.3].

- **OneNet** distinguishes between the concepts of harmonisation and standardisation: "**Harmonisation** involves a reduction in variations, while **standardisation** entails moving towards the eradication of any variation. Indeed, harmonisation avoids a one-size-fits-all approach. It makes the trade-off between too many and too few product standards and avoids inconsistencies between standards. Harmonisation allows service providers (in this case, FSPs) to understand the minimum requirements of the service markets. This in turn enables these providers to offer products for those markets" [OneNet project deliverable D2.2].

Towards common TSO-DSO products

- **OneNet developed a methodology** for the harmonisation of products and the identification of similar products to TSOs and DSOs. The approach leads to a distinction between frequency products, responsibility of the TSOs only[6], and non-frequency products. **OneNet** project evaluated the similarities between the products considered by both TSOs and DSOs. Results show that **products using active energy are those most frequently identified by both TSOs and DSOs**. [OneNet project deliverable D2.2].

Table 1: Number of TSOs and DSOs using non-frequency harmonised products *(Source: One Net D2.2)*

Harmonised Products	TSOs using these products	DSOs using these products
Corrective Local Active	9	9
Predictive short-term local active		14
Predictive Long-term local active	8	5
Corrective Local Reactive	7	3
Predictive short-term local reactive		4
Predictive Long-term local reactive		4

- A strong message from **OneNet**'s demonstrators is that when considering these products, it will be important to **ensure interoperability with frequency products** so that flexibility can be used efficiently between different services. For example, some TSOs indicated that they would use a modified version of mFFR product including location for congestion management, which might be a barrier for DSOs if the product is defined too strictly.

- **OneNet**'s demonstrators' partners also clearly stated that the definitions of the different products should allow for **a product to be used in more than one service**. For instance, the products defined by TSOs and DSOs in the Greek and Portuguese demonstrators are both procured to address congestion management but they could also be used to provide voltage stability. The products being procured in these countries are the same: thus, besides the harmonisation between both System Operators, alignment will be achieved between two countries in distant geographical locations.

- **Products based on reactive power** also appear to be a **common interest** for TSOs and DSOs. The related products have become more complex with increasing DER penetration and the shift from

[6] and for which a number of projects are working towards harmonisation – e.g., PICASSO or MARI

radial networks to meshed topologies. TSO-DSO coordination is especially needed in the provision of these products as reactive power actions carried out by DSOs can affect the TSOs (or other DSOs) and vice versa. Some of that coordination can be done via the definition of the products. For example, in the Greek and the Czech demonstrator partners, the DSOs use a predictive long-term local reactive product, to regulate voltage according to the requirements of DSO to achieve voltage stability in the distribution grid system and reactive power flows at the primarily TSO/DSO substation [OneNet project deliverable D2.2].

4. Design, selection and testing of TSO-DSO Coordination Schemes (CS)

4.1 Complementary theoretical approaches were designed to qualify the various potential coordination schemes

- The **Active System Management report** elaborated by CEDEC, Eurelectric, GEODE, E.DSO and ENTSO-E formulated a general framework for the TSO-DSO coordination with a focus on congestion management and balancing. The report supposes three main market models, **depending on the management of the merit order list of flexibility bids**. The selection among these three options is guided by three main questions:
    1. *Is locational information available?*
    2. *Is it possible to use balancing bids for congestion management in the distribution system? and*
    3. *Is there a combined market for TSO and DSO congestion management?*

- The three resulting options of market designs are designed as follows:
    - Option 1 considers a separated TSO and DSO congestion management.
    - Option 2 considers a combined TSO and DSO congestion management.
    - Option 3 assumes combined balancing bids and congestion management.

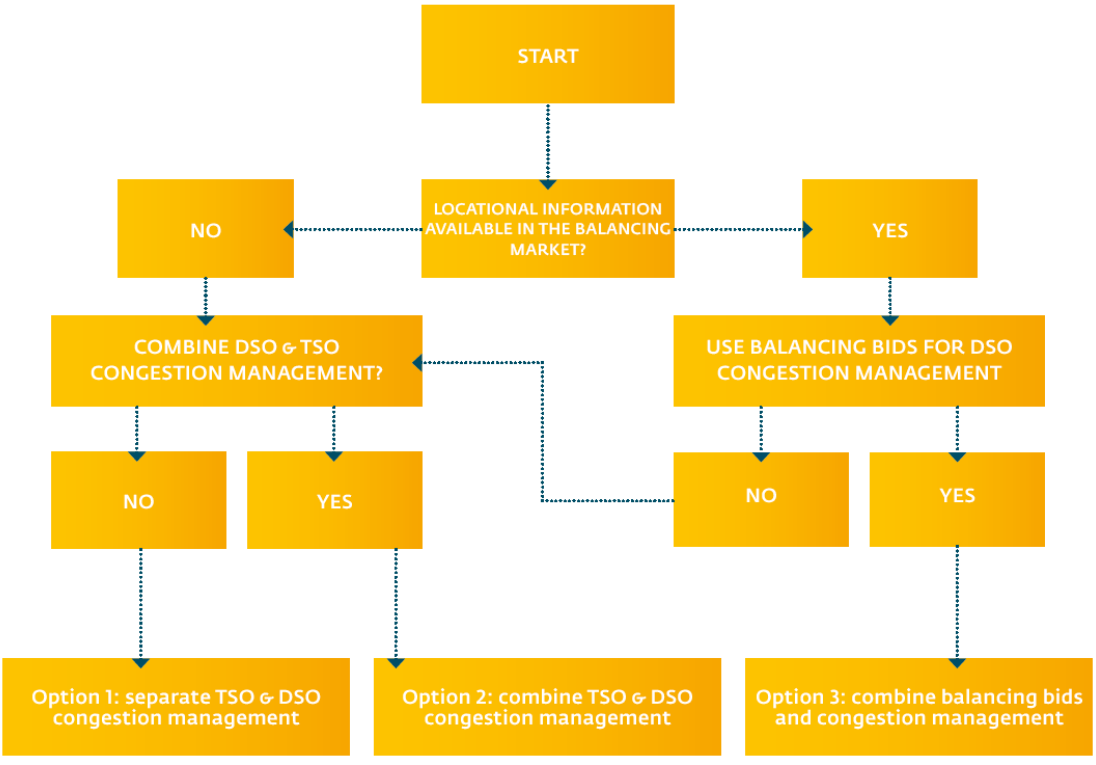


Figure 3: The three possible models for market coordination (ASM report, CEDEC et. al, 2019)

- **INTERRFACE** used the ASM framework as a base for the development of their coordination schemes. However, the project considered necessary to complement such framework with a further analysis of

the various approaches to **coordinating or integrating the Merit Order Lists (MoLs) of flexibility bids**. It therefore proposed four complementary degrees of MoL integration: A/ Separated MoLs with coordination; B/ Overlapping MoLs; C/ Subset MOLs; and D/ Fully integrated MoLs. Thus, starting from separated markets, where bids are only used on one of the markets, up to a fully integrated market with only one common MoL, all different variations are possible and are labeled 1A to 3D in INTERRFACE project.

- **COORDINET** project started from a different perspective, i.e. the framework developed within the SmartNet project proposed three alternatives for the needs of the TSO and the DSO to be satisfied in a coordinated manner: the Common Market Model (CMM); the Multi-level Market Model (MMM - variation of the CMM, in which each system operator uses its own market in a sequential order, rather than through a single market); and the Fragmented Market Model (FMM) in which the TSO has no access to DERs. On this basis, **COORDINET** defined market options following this questioning:

    1. *The needs of which system operator will be addressed?*
    2. *Which stakeholder(s) can buy the flexibility to answer to a certain need?*
    3. *How many markets are considered?*
    4. *Does the TSO have access to DER?*

- The next table shows how the two projects position their respective market model options compared to the ASM approach.

Table 2: Coordination Scheme in Coordinet and INTERRFACE compared to the ASM report *(Source: Coordinet D7.2.3 - common position)*

ASM	Coordinet	INTERRFACE
Option 1 (separated TSO and DSO congestion management)	▪ Multi-level Market Model ▪ Fragmented Market Model ▪ Central Market Model ▪ Local Market Model	▪ Option 1 with separated MoLs with coordination ▪ Option 1 with overlapping MoLs ▪ Option 1 with subset MOLs
Option 2 (combined TSO and DSO congestion management)	▪ Common Market Model ▪ Integrated Market Model	▪ Option 2 with separated MoLs with coordination ▪ Option 2 with overlapping MoLs
Option 3 (combined balancing bids and congestion management)	▪ Common Market Model ▪ Integrated Market Model	▪ Option 3 with separated MoLs with coordination ▪ Option 3 with overlapping MoLs ▪ Option 3 with subset MOLs ▪ Option 3 with fully integrated MOLs
Out of scope	▪ Local Market Model ▪ Distributed Market Model ▪ Central Market Model	

- The **OneNet** project in its market design task proposed a **theoretical market framework,** for market-based procurement of flexibility with the goal, to comply to efficiency, scalability and integration objectives. The project observed that no similar approach on market design was adopted by H2020 projects. The theoretical market framework is simultaneously a descriptive tool of existing market schemes and a prescriptive tool to develop novel markets. It consists in 5 pillars, the two first

two focusing on architecture and the next three centred on how the clearing of the market takes place (source: ISGAN webinar[7]).

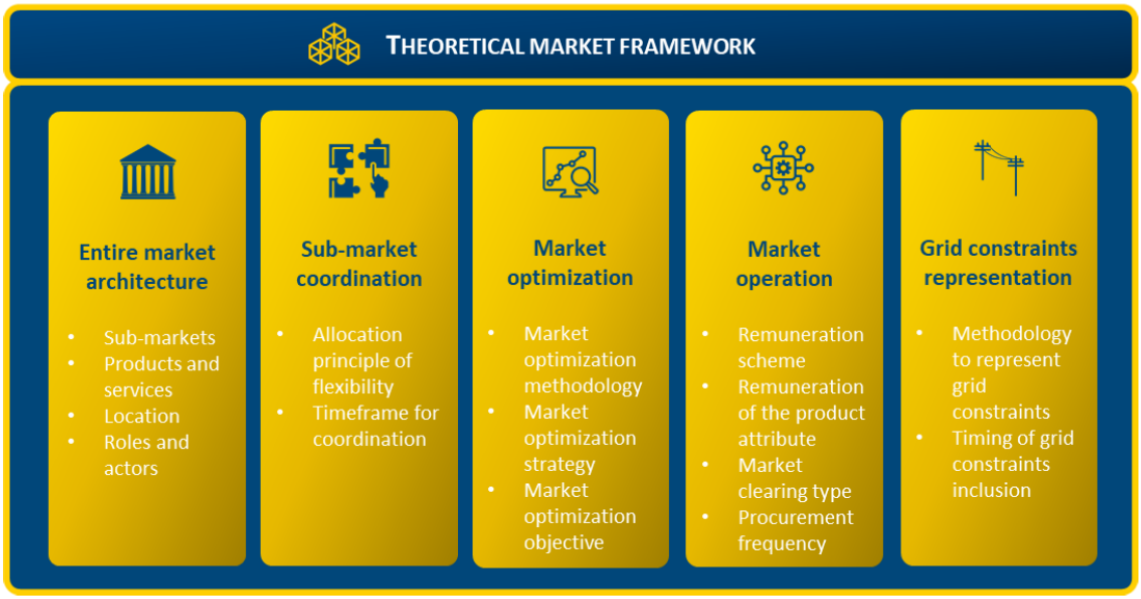


Figure 4: The five pillars of the theoretical market framework proposed by OneNet *(Source: OneNet D3.1)*

4.2 The criteria for the selection of coordination schemes in demonstrators remain however very pragmatic and locally specific

- In their common position paper, **INTERRFACE** and **COORDINET** concluded that **existing markets constituted a decisive criterion in the selection of coordination models for their respective demonstrators.** [Coordinet project deliverable D7.2.3].

- **INTERRFACE** project noticed different preferences in criteria depending on whether demonstrations were TSO- or DSO-focussed or involve both network operators. The DSO-focussed demonstrations opted for coordination models with separated markets, while the demonstrations including TSOs took interest in combined markets with the aim to increase their liquidity. The preference of DSO-led demonstrators for separated markets might be explained by a less extensive experience of organisations in market-based procurement of services, and the heterogeneity of national processes for procurement. The limited prior experience in those pilot projects with market-based procurement of services favours solutions with limited complexity, while alignment with existing markets as well as with other network operators is avoided. Demonstrators integrating TSOs tend to be more familiar with the topic of market-based procurement of services and energy markets in general.

- In **CoordiNet** project, all demonstrations were led by DSOs in close collaboration with the TSOs and established markets at local level to address some of the DSOs' local needs.

- Based on the **CoordiNet** project experience, all the choice for application of coordination schemes depended on national characteristics, including the grid levels operated between TSO-DSO, the network topology, the impacts of the flexibility activations on the TSO-DSO that are related with the

[7] ISGAN - Webinar - Open exchange on TSO-DSO coordination activities, approaches, and solutions (iea-isgan.org

meshed/radial network characteristics, and the characteristics of the flexibility resources. [Coordinet project deliverable D7.2.3 – common position paper].

4.3 Economic assessment concludes on no "one-size-fits-all" Coordination Scheme, and a lack of profitability for flexibility providers

- **CoordiNet** project performed an economic assessment of the coordination schemes tested in their demonstrators in Spain, Sweden and Greece. The demonstrations addressed the coordinated procurement of system services by DSOs and TSOs from flexibility service providers (FSPs) and other Distributed Energy Resources (DER). The analysis performed is based both on demonstration results and simulations.

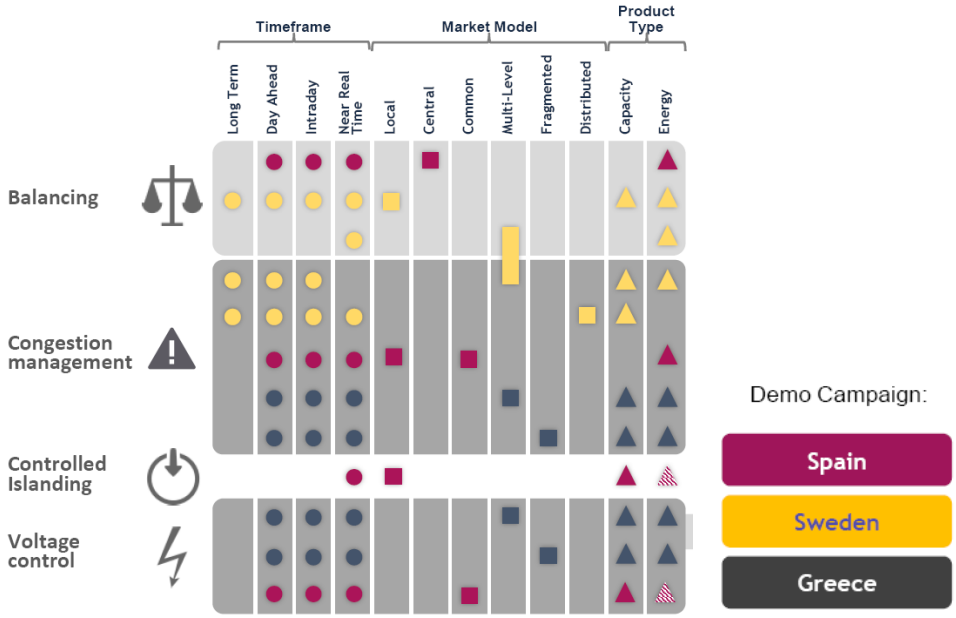


Figure 5: Synthesis of Coordinet demonstrations *(Source: Coordinet D2.1)*

- The economic assessment study focused on the procurement of **congestion management** and was based on three pillars: 1) compare the procurement of flexibility services versus Business-as-Usual alternatives; 2) evaluate the economic impact at system level of the flexibility solution, and 3) evaluate the profitability for the flexible services providers (FSPs).
- When comparing flexibility services procurement versus Business-as-Usual (BaU), grid reinforcement or remedial actions were considered as BaU for Spain and Greece, while the payment of subscription penalties by the DSO was retained in Sweden. For both national contexts, **the flexibility solution demonstrated to be cheaper and more effective than remedial actions in all** the simulated **cases.** More specifically:
  - in case of **occasional congestions**, **flexibility may be more cost-efficient** than reinforcing the grid or take costly remedial actions like the use of diesel generators. Hence, the activation of flexibility from FSPs connected at distribution level could help solve unforeseen congestions via short-term market mechanisms in the most economically and efficiently manner.
  - In the case of **structural congestions**, where flexibility needs to be procured are higher and/or more frequent, **long-term markets may be recommended** to ensure enough available flexibility (i.e., via bilateral contracts), until there is enough liquidity in short-term markets to procure it.

- When evaluating the most cost-effective ways of coordinating the procurement of system services between TSOs and DSOs (including the cost of developing the platforms necessary to do so), results concluded that there is **no one-size-fits-all coordination scheme**. The existing market structure and legacy systems have a strong impact on the efficiency of the different coordination schemes, together with other issues such as the local and regional needs, the role of each agent, the maturity levels of services and products, and type of Flexibility Service Providers among countries.

- **When evaluating the profitability for flexible services providers** (FSP) to provide flexibility services, **results are mitigated**. The business model for the flexibility sellers (aggregators, flexibility providers, distributed resources, prosumers, etc.) seems to be still uncertain and risky under the simulated cases in all countries, because the **high entry costs** (platform development, communication infrastructure and maintenance, prequalification, market participation fee or other allocated costs) disincentive their participation until the congestions are more frequent. Additionally, **the revenue of providing flexibility is difficult to estimate**, due to the immaturity of flexibility markets, uncertainty and disparity of prices, uncertainty of system needs, the mechanism established for flexibility procurement, the available liquidity, the technology mix providing flexibility, etc.

- The business model also **lacks attractiveness** when the solution is **only** implemented in **one specific location**. The annual remuneration for the procurement of a given need is not enough to recover the costs of deploying the flexibility solution by the FSPs. The **scalability** of the business model will make it more attractive and cost-efficient in case of **more widespread congestions**. Moreover, DSOs could also establish local market models to exploit the flexibility of small DERs to solve congestion issues at distribution level. These local markets seem to be more accessible and attractive for small DERs, as the communications and reliability requirements and costs may be lower, as well as being a highly valuable service for the DSO at local level. [Coordinet project deliverable D6.3].

4.4 A clear agenda is proposed to facilitate TSO-DSO-Market coordination

- **A common position paper** Coordinet – Interrface was jointly formalised at the end of both projects. [Coordinet project deliverable D7.2.3, June 2022]. It reflected the project willingness to cooperate and propose joint policy recommendations to deploy the solutions elaborated by the two projects.

- Common recommendations formulated by both projects set the agenda for enhanced coordination TSO-DSO-Market.

Table 3: Overview of the INTERRFACE - CoordiNet common policy recommendations divided by topic (*Source: Coordinet D7.2.3*)

Roles and Responsibilities
1. A harmonisation of the nomenclature and definition of roles is required to enable flexibility markets across the EU. The attribution of such roles and responsibilities should be based on thorough impact analyses.
2. Amidst the rising complexity of flexibility markets, the distribution of costs among procuring entities must be a core element for future regulatory design.
3. Awareness must be raised considering that there is no one-size-fits-all technical solution supporting decision-making for all flexibility market stakeholders.
Requirements for information sharing
1. Improved data sharing frameworks for all stakeholders are necessary to cover emerging information needs for the establishment of flexibility markets.

2. The development of increasingly complex frameworks for data sharing between all market stakeholders should be consistently safeguarded via, e.g., GDPR, data privacy and ownership policies.
Requirements of prequalification process
1. Prequalification processes of flexibility markets should be harmonised and simplified at product level across flexibility services and market platforms to lower entry barriers for FSPs and increase market liquidity.
2. A level playing field should be created to ensure non-discriminatory prequalification processes that grant access to flexibility markets, while a technology-neutral approach is guaranteed.
Requirements for the settlement process
1. Guidelines for telemetry and time-granularity requirements should be harmonised at the European level while considering time characteristics of the flexibility products to ensure the broader harmonisation of settlement processes in European flexibility markets.
2. To increase trust among all stakeholders, transparency in data exchanges necessary for the settlement process in flexibility markets should be ensured.
Geographical scope and network representation
1. Adequate requirements for network information sharing should be chosen to ensure the optimal operation and selection of bids in flexibility markets while those must not hinder grid security and the core responsibilities of SOs.
2. Guidelines on observability requirements should be developed to promote an accelerated deployment of monitoring and measurement tools to improve digitalisation and grid observability.
Consumer engagement
1. Clear and reliable information for FSPs and independent aggregators on markets, including services, products, and coordination schemes, should be promoted.
2. Measures should be taken to ensure transparency in and across flexibility markets, including market operations and bid selection processes, to increase the confidence and interest of FSPs and future independent aggregators in emerging business use cases.
3. Policies tackling flexibility markets should consider incentives to attract new FSPs, strengthen their role, and endorse long-term planning to safeguard business sustainability and security of operation for FSPs and interacting stakeholders.
Scalability and replicability
1. Product and process harmonisation should be regarded as means to facilitate the emergence of tailored business cases and models.
2. Knowledge sharing and cooperation between TSOs and DSOs should be promoted as enablers of the scaling up and replication of flexibility solutions.
3. Barriers posed by national regulation to the implementation of market-based flexibility solutions should be addressed with paramount importance.

- **OneNet** project in its deliverable D2.5 formulated its recommendations for the **Harmonised Electricity Role Model** as a reference document describing the relationship and responsibilities among the various actors in the electricity system. It emphasized in particular the necessity to **distinguish the role and an actor** (which assumes a specific role or a set of role) and proposed to integrate more market participants. This recommendation will be further discussed in next section on data exchange cooperation.

5. Data exchange for TSO-DSO-market cooperation

The volume of data exchange between System Operators and the market is steadily increasing. At the data level, challenges include the standardisation of data format and exchange protocols. For supporting TSO-DSO data exchange, the **common grid model exchange standard** (CGMES) has proven its strong potential as illustrated in a recent paper based on **TDX Assist**, **EU-SysFlex** and **INTERRFACE** projects[8]: it is indeed based on IEC CIM, which is not transmission grid specific. Another advantage results from the degree of details needed: TSO-DSO data exchanges do not need to go in the details of the unbalanced modelling of the concerned part of power system.

5.1 Limits and gaps are identified with regards to TSO-DSO data exchange in recent EU projects

- **CoordiNet** project identified the data exchange requirements between TSOs, DSOs and managers of markets for system services (TSOs or DSOs) and flexibility providers for the procurement of system services and provided recommendations for the evolution of the CIM [source: Bridge TF R&I report].

- **Gaps in TSO-DSO data exchange and interfaces** have been analysed in **TDX Assist**, **EU-SysFlex** and **INTERRFACE** projects with a particular focus on two types of services: Congestion Management and Voltage Control. Authors confirmed the need to rely on standard-based solutions when performing TSO-DSO data exchange. All three projects have commonly used CIM as information model and formulated recommendations for designing future CIM CGMES models [source: "A Review on TSO-DSO Data Exchange, CIM Extensions and Interoperability Aspects", 2022].

Table 4: Example of gap analysis related to data exchanges and interfaces performed in EU-SysFlex, TDX-Assist and OneNet *(Bytyqi et al., 2022)*

Application case (EU SysFlex)	**Gaps identified with respect to CIM**
▪ Managing flexibility bids ▪ Activation of flexibility asset ▪ Verification and settlement	▪ Current CIM coverage for flexibility services and products not sufficient for congestion management ▪ Structural data (mainly location) of aggregated DS-connected assets required for ensuring the operational security of the distribution system
▪ Calculation of baseline (quantifying the performance of FSPs towards TSO or DSOs)	▪ All of the data flows which are required for baseline calculation not covered by CIM
▪ Transferring energy data (portability) ▪ Anonymizing energy data ▪ Aggregating energy data	▪ Comprehensive CIM coverage required
Application case (TDX Assist)	**Gaps identified with respect to CIM**
▪ Consumption and production of historical profiles for long - term planning Consumption and production forecast for operation planning purposes	▪ Insufficient classes and attributes for BOs for TSO-DSO data exchange in CIM/CGMES
Application case (OneNet)	**Gaps identified with respect to CIM**

[8] A Review on TSO-DSO Data Exchange, CIM Extensions and Interoperability Aspects Arsim Bytyqi, Siddhesh Gandhi, Eric Lambert, and Nejc Petrovič. Journal of modern power systems and clean energy, Vol. 10, NO. 2, March 2022. Access

▪ Managing active power flexibility to support congestion management and voltage control	▪ Current CIM CGMES header and metadata models not sufficient enough to cover all TSO/DSO needs ▪ CGMES header required to include information about metering data operator and reference data ▪ Exchange of difference model required to be described

- Concrete actions have been carried out for extending the CIM. For example, **TDX-Assist** project highlighted that Business objects in application cases were not or only partially covered in the existing CGMES profiles and recommended CIM CGMES-extensions[9]:

  - **TDX Assist** formulated the concept of **'observability area'** to ensure efficient TSO-DSO data exchange including a definition and a few design principles such as transparency, privacy and security, non-discriminatory, access, and cost effectiveness. The project recommended that the observability area should have a number of CIM-supported attributes: timestamp of real-time information collected by DSO, unique IDs of data signals, data types, data units, numeric data value.
  - The project also recommended to describe each Business Object with data on the **'activation status'** of the generation unit, active power and voltage violation in the distribution network. New classes referring to "Violation Status" have thus been proposed in the CGMES extension.

5.2 Bridge recommends new Harmonised Electricity Market Role Models as well as a structure and a governance to share CIM extensions

- In 2021, the **BRIDGE Data Management Working Group** released a report on European energy data exchange reference architecture, providing an analysis of data exchange practices in European R&D projects, accompanied with recommendations.[10]

- Based on the analysis of feedback from a dozen of EU projects, the report highlights, among other, that:

  - While each project has a different focus area and various applications, there is **a common need to connect versatile actors**, existing legacy and newly developed systems and devices in a way that allows the seamless **exchange of data** in a **standardised and technology agnostic way**.
  - BRIDGE projects are using **several data exchange business roles** which are **missing** in the Harmonised Electricity Market Role Model. It should be ensured that consistent sets of business roles (both role names and definitions) are used by projects.
  - Projects are using a **variety of data formats** and communication protocols for data exchange
  - BRIDGE projects are increasingly using **business process agnostic data platforms** (e.g. ECCo SP, Estfeed, IEGSA, Atos FUSE, Enterprise Service Bus, Cloudera).

Table 5: Data Exchanged Platforms explored by the responding EU projects (extracted from BRIDGE report)

Project name	Data exchange platform
INTERRFACE	IEGSA Platform, enabling coordination and the more robust operation of the power systems
EU-SysFlex	Platform scaling and replicating Estfeed distributed solution and agnostic to specific business processes

[9] F. Marten, I. Hammeneister, J. Ringeistein et al., "CIM CGMES-extensions for the TSO-DSO data exchange in the EU-project TDX-ASSIST," in Proceedings of International ETG-Congress 2019, Esslingen, Germany, May 2019, pp. 1-6.
[10] European energy data exchange reference architecture, BRIDGE, 2021.

FLEXIGRID	FLEXIGRID DEP based on Atos FUSE
GIFT	Enterprise Service Bus based DEP
InterConnect	Platform focusing on semantic interoperability
PLATOON	PLATOON DEP – COSMAG compliant
SYNERGY	SYNERGY Big Data-driven Energy-as-a-Service (EaaS)
CoordiNet	CoordiNet Platform grid monitoring & operation, market operation and aggregation & disaggregation
BD4OPEM	DEP that leverages smart grid big data
TDX-ASSIT	Cloudera and ECCo SP platforms

- We already mentioned above the recommendations of One-Net and TDX-Assist for the Harmonised Electricity Role Model. The report developed by the BRIDGE Data Management Working Group proposes specific **updates to the Harmonised Electricity Market Role Model (HEMRM)** based on BRIDGE projects practices. These updates include some **adjusted definition of existing roles**, but also the **addition of new roles** such as Data Owner, Data User, Data Consumer, Data Delegated Third Party, Data Hub Operator, Data source, etc.

Table 6: Example of new definitions proposed for the Harmonised Electricity Market Role Model

Business role	Description
Data Owner	Any physical person or legal entity that owns data and can give authorization to other parties to access them. He can create data and / or execute control over them. Every role in the model can be a data owner (it can be also meant as a specification of the role).
Data Delegated Third party	Any natural person or legal entity who has received representation rights from data owner.

- To promote reusability among European projects, a **CIM repository structure** is proposed, **to collect and share data between EU projects** regarding their definitions of Business Objects and CIM Profile. A **governance mechanism** would then be necessary to update these repositories based on projects' feedback, as well as mechanism to make available these repositories to European projects and educate them about CIM.

6. KEY TAKE AWAYS

Section 3: Harmonisation of products and system services to enhance TSO-DSO-Market cooperation	
☑	A common terminology framework with converging definitions enable to map possible services and define common TSO-DSO products.
☑	Harmonisation efforts enable to identify products that are common to TSOs and DSOs. Depending on the type of non-frequency harmonized products, it appeared that 7 to 9 TSOs and 4-14 DSO are already using them.
☑	Products based on reactive power also appear to be a common interest for TSOs and DSOs.
💬	It is recommended that the different products shall be designed to be used in more than one service.

Section 4: Design, selection and testing of TSO-DSO Coordination Schemes (CS)	
☑	An agenda for more TSO DSO cooperations is based on complementary theoretical approaches to qualify the various potential coordination schemes and to select valuable CS in future demonstrations, considering the local constraints.
☑	When evaluating the most cost-effective ways of coordinating the procurement of system services between TSOs and DSOs, results concluded that there is no one-size-fits-all coordination scheme, because of a strong impact of the existing market structure and legacy system, combined with other issues related to the local value chain of flexibility provision.
💬	Profitability and business models for flexible services providers (FSP) requires a strong attention due to structural issues such as the relative immaturity of flexibility markets, the uncertainty on energy prices, etc.

Section 5: Data exchange for TSO-DSO-market cooperation	
☑	Gaps analysis for data exchange between TSO and DSOs allows to identify routes for extending CGMES.
💬	Bridge recommends new Harmonised Electricity Market Role Models as well as a structure and a governance to share CIM extensions.

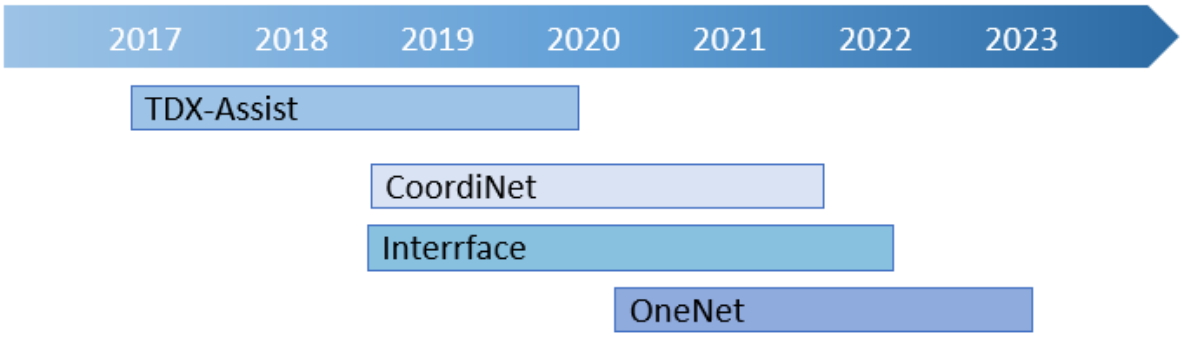
Legend of pictograms:

☑ statement from projects' results and findings

💬 recommendation formulated by the projects (directly or through the Bridge initiative).

References

Timeline of the projects studied



Projects information

Bridge project	Call	Goal	Website	Coordinator / Contact
coordiNET	call LC-SC3-ES-5-2018-2020 (TSO DSO Consumer)	Demonstrating how DSO and TSO shall act in a coordinated manner to procure and activate grid services in the most reliable and efficient way through the implementation of three large-scale demonstrations	https://coordinet-project.eu	Marco Baron marco.baron2@enel.com
INTERRFACE	call LC-SC3-ES-5-2018-2020 (TSO DSO Consumer)	TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system	http://www.interrface.eu/	George Boultadakis george.boultadakis@eurodyn.com
ONENET one network for Europe	call LC-SC3-ES-5-2020 - TSO-DSO cooperation.	One Network for Europe. Creating the conditions for a new generation of grid services able to fully exploit demand response, storage and distributed generation while creating fair, transparent and open conditions for the consumer.	https://onenet-project.eu/	Prof. Antonello Monti, antonelo.monti@fit.fraunhofer.de
TDX-ASSIST	call LCE-05-2017 Tools and technologies for coordination and integration of the European energy system	Coordination of Transmission and Distribution data eXchanges for renewables integration in the European marketplace through Advanced, Scalable and Secure ICT Systems and Tools	http://www.tdx-assist.eu/	Professor Gareth Taylor gareth.taylor@brunel.ac.uk

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