Smart TSO-DSO interaction schemes, market architectures and ICT Solutions for the integration of ancillary services from demand side management and distributed generation

D6.2 Evaluation on project results related to a number of models and roadmaps

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About SmartNet

The project SmartNet (http://smartnet-project.eu) aims at providing architectures for optimized interaction between TSOs and DSOs in managing the exchange of information for monitoring, acquiring and operating ancillary services (frequency control, frequency restoration, congestion management and voltage regulation) both at local and national level, taking into account the European context. Local needs for ancillary services in distribution systems should be able to co-exist with system needs for balancing and congestion management. Resources located in distribution systems, like demand side management and distributed generation, are supposed to participate to the provision of ancillary services both locally and for the entire power system in the context of competitive ancillary services markets.

Within SmartNet, answers are sought for to the following questions:

- Which ancillary services could be provided from distribution grid level to the whole power system?
- How should the coordination between TSOs and DSOs be organized to optimize the processes of procurement and activation of flexibility by system operators?
- How should the architectures of the real time markets (in particular the markets for frequency restoration and congestion management) be consequently revised?
- What information has to be exchanged between system operators and how should the communication (ICT) be organized to guarantee observability and control of distributed generation, flexible demand and storage systems?

The objective is to develop an ad hoc simulation platform able to model physical network, market and ICT in order to analyse three national cases (Italy, Denmark, Spain). Different TSO-DSO coordination schemes are compared with reference to three selected national cases (Italian, Danish, Spanish).

The simulation platform is then scaled up to a full replica lab, where the performance of real controller devices is tested.

In addition, three physical pilots are developed for the same national cases testing specific technological solutions regarding:

- monitoring of generators in distribution networks while enabling them to participate to frequency and voltage regulation,
- capability of flexible demand to provide ancillary services for the system (thermal inertia of indoor swimming pools, distributed storage of base stations for telecommunication).

Partners

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List of Abbreviations and Acronyms

Acronym	Meaning
ACER	Agency for the Cooperation of Energy Regulators
AS	Ancillary Services
BEREC	Body of European Regulators for Electronic Communications
BSP	Balance Service Provider
CACM	Capacity Allocation & Congestion Management
CEER	Council of European Energy Regulators
CENELEC	European committee for electrotechnical standardisation
CMP	Commercial Market Parties
CSs	Coordination Schemes (developed by SmartNet)
DAM	Day-ahead Market
DC	Direct Current
DFR	Distributed Flexibility Resources
DSM	Demand Side Management
DSO	Distribution System Operator
EEGI	The European Electricity Grid Initiative
EN	European standard
ENA	Energy Network Association
ENTSO-E	European Network of Transmission System Operators for Electricity
ETIP-SNET	European Technology & Innovation Platform - Smart Networks for Energy Transition
EUI	European University Institute
EV	Electric Vehicle
FAT	Full Activation Time
FCR	Frequency-controlled reserve
FCR-D	Frequency-controlled disturbance reserve
FCR-N	Frequency-controlled normal operation reserve
FRR	Frequency Restoration Reserve
GCT	Gate Closure Time
GEODE	Groupement Européen des entreprises et Organismes de Distribution d' Energie
HV	High Voltage
IAS	Internet Access Service
IDM	Intra-day Market
IEC	International Electrotechnical Commission
ISO	The International Organization for Standardization
LFC	Load-Frequency Control
MCM	Market Coordination Mechanism

MCO	Market Coupling Operator
MDC	Meter Data Company
MO	Market Operator
MOL	Merit Order List
NEMO	Nominated Electricity Market Operator
NMF	Neutral Market Facilitator
NRA	National Regulating Authority
QoS	Quality of Supply
R&D	Research and Development
R&I	Research and Innovation
RA	Reserve Allocator
RES	Renewable Energy Sources
SET	Strategic Energy Technology
SO	System Operator
SOCP	Second Order Conic Programming
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework
VPP	Virtual Power Plant

Executive Summary

This deliverable is one in a series of three reports that are looking into regulatory aspects of implementation of methodologies and coordination schemes developed in the SmartNet project, with the aim to facilitate integration of significant levels of Distributed Energy Resources (DERs) into the network and their participation in provision of AS at both transmission and distribution levels. This requires new market/trading architectures and operational arrangements that will affect networks at both transmission and distributions levels as well as the interface between these networks.

The aim of the SmartNet project is to provide architectures for optimized interaction between TSOs and DSOs in managing the exchange of information for the acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management) from DER located in distribution networks. The main project results include the technical-economic assessment of a set of five TSO-DSO Coordination Schemes (CSs) with their market architecture. This is done through the set-up of a new simulation platform and ad-hoc national scenarios at 2030 aimed at assessing the operation of the proposed schemes so as to feed a cost-benefit analysis. The five proposed CSs are:

- Centralized AS market
- Local AS market
- Shared balancing responsibility
- Common TSO-DSO AS market
- Integrated flexibility market.

The different coordination schemes all have specific benefits and attention points related to the TSO and/or DSO grid operation, other market participants and the functioning of the market in general. In addition, implementation of or transition from one to another Coordination Schemes will require a significant change in roles and responsibilities, which are assigned to the central market actors.

As already mentioned, in order to carry out the technical-economic comparison of the different CSs, a large-scale simulator, has been developed to realistically model the behaviour of complex systems which include transmission and distribution networks, bidding and market processes, as well as fundamental physics behind each flexible device connected to the system. This simulator includes three main layers:

- Market Layer – representing the mFRR market
- Bidding Layer – representing aggregation and disaggregation processes
- Physical Layer – physical network including controls and protections and aFRR regulation

The main objective of this report is to present the regulatory trends and stakeholders' position on several issues, which the project considers to be essential for the definition of a well-functioning TSO-DSO interaction. To facilitate this analysis, we have identified 25 main issues, here referred to as *topics of interest*, which are associated with solutions and assumptions implemented in each of the simulator

layers. These topics have been evaluated in a comprehensive screening study, based on more than 40 different documents such as position papers, strategies, roadmaps and legislation/regulation (EU Directives, Network guidelines, national regulatory Decisions). Table 1 presents a summary of the screening according to the defined topics of interest.

Table 1 Summary of the screening study

Layer	Topic of interest	Conclusion
Market layer	Market sessions timeline	Need for an overall harmonisation process across Europe. Energy to be traded in periods, which are at least as short as imbalance settlement (requirement of 15 min from 2025-01-01). The trade should be moved as close as possible to operation. Non-discriminatory access to the markets and creation of level-playing field.
	Nodal market vs. zonal	Zonal organisation is the preferred model in Europe. The nodal pricing model allows incorporating bottlenecks into the pricing. This type of organization has been successfully applied at several markets in USA.
	Local congestion management by DSOs vs centralized TSO market	DSOs and TSOs to be responsible for handling congestion in their respective grids. Balancing remains under TSOs responsibility. Rules for use of flexibility resources across grids need coordination with a clear framework. Centralised TSO market for procurement of resources is expected to have higher efficiency and liquidity, but an extension to distribution could prove computationally challenging. Local markets could, by contrast be illiquid and prone to exercise of market power.
	Prequalification of resources in distribution networks	Prevailing position is that the "static" prequalification process in the distribution network should be replaced by a coordinated TSO and DSO process.
	Inclusion of constraints (device-related) from distribution grid bidders	No present legal requirements for inclusion of device-related constraints. Proposal for inclusion of certain requirements on portfolio-level are advanced by stakeholders.
	Operation of possible local market	Several key stakeholders including ENTSO-E support creation of a single market place for balancing and solving

		congestions, with that meaning that the different markets (and their relevant responsible) should work in a shared database in order to avoid double awarding of the same bid.
	Management of voltage constraints	Voltage control is formally defined as non-frequency ancillary service and thus shall be allowed to be procured by DSOs in market-based manner (both active and reactive power can be used for voltage control). According to common report TSOs and DSOs should agree on voltage control parameters at the border of the networks.
	Availability of reserve capacity	Legal requirements requesting separate procurement of balancing energy and capacity, separate procurement of up- and down regulation capacity. At present TSOs are responsible for conducting optimal reserve capacity provision through market-based methods (FRR+RR), short term.
	Relationship with previous markets	In the recent European legislative documents [6]" the market participants shall be allowed to bid into balancing markets as close to real time operation as possible, and at least after the intraday cross-zonal gate closure time - at most 1 hour before the delivery", which means even shorter terms
	Pay-as-bid vs. pay-as-clear	EU legislation and guidelines suggest using pay-as-clear pricing model. However, several EU countries are presently still adopting pay-as-bid.
	Optimisation criterion for electricity market design – maximization of social welfare vs. minimum activation costs	Maximisation of the social welfare prevails even if some present real time markets, by contrast, minimize purchase costs of the needed services.
	Roles and Responsibilities in the context of the prequalification, procurement, activation and settlement of AS markets including observability	Gradual evolving of roles and responsibilities, especially for DSOs, towards more active role. This for example includes managing the local flexibility resources to improve operational efficiency (voltage regulation) and solve local congestion. However, balancing market responsibility will stay in TSO hands as stated by the Clean Energy for all

		European package.
Bidding layer	Ancillary services considered in the screened documents	According to the EU Directive on common rules for IEM [5] "...ancillary service' means a service necessary for the operation of a transmission or distribution system including balancing and non-frequency ancillary services but not congestion management".
	Possibility to create "virtual" copperplate bids vs nodal bidding	The recast IEM regulation proposal (Clean Energy for all European package) highlights locational price signals, which are needed for efficient investment into zonal electricity model. No other information was found in the screened documents. Copperplate bidding favours trading whereas nodal bidding provides a more transparent dispatch, with less request of activating countertrade by the TSO.
	Possibility for bidding negative prices in AS Markets	This is issue is not directly discussed on the screened documents. However, the tendency in energy markets is everywhere to enable negative prices to give signals also in case of excess of resources.
	Dimensioning of bidding zones	Recast of Regulation for IEM defines that the bidding zone should be defined on the basis of long-term congestions in the transmission network, and the zones should not have structural congestions. The zones can be modified (splitting, merging and adjusting) but should be the same for all market time frames.
	Incentivisation mechanisms for RES vs price revelation in AS Market	It is argued that larger installations of mature technologies should participate in the markets and phasing out of their subsidies is planned by 2030.
	Minimum bid size and resolution	The screened legal documents do not define min size for the bids. Several stakeholders favour allowing smaller bids for supporting participation of RES in the ancillary services. The issue is to what extent this should be supported by a decrease of the minimum market threshold or rather by the set-up of aggregators for the small DER resources.
P h	Prioritisation of control traffic	Regulation of Open Access to Internet allows traffic

	(support for network slicing) - how prioritisation for ICT control traffic for energy system management is ensured so to guarantee secure system operation.	management for control signals needed for distributed ancillary services as long as this does not reduce quality for other end-users. Otherwise, provision of these services is a subject to a number of conditions.
	Responsibilities and ownership of components and data	New tasks and responsibilities require changes in the rules for data sharing among key market actors. However, an increase of data sharing is the natural consequence of increased coordination needs between TSO, DSO and the other market subjects.
	Energy supply for communication and ICT components (how to ensure sufficient power backup for ICT)	The issue was not covered in the screened documents
	Remote controllability of DER	The new Codes and draft standards define requirements for remote controllability of DER (new units above 1 MW). It is expected that these requirements will be extended towards smaller units.

A general conclusion from the review is that EU regulations are not directly addressing several of the topics identified by SmartNet, i.e. crucial topics for large-scale utilisation of Distributed Energy Resources in ancillary services, as for example timing of the markets. Without common EU regulations different solutions will develop in the distribution areas, the most diverse and non-harmonized solutions will be implemented in agreement between DSOs and adjoining TSO (e.g. nation- or region-wise under influence of TSO). This will not necessarily hamper the utilisation of local flexibility in the transmission grids, but it will certainly make more difficult the development towards cross-border utilisation of distributed energy resources.

The final conclusions and recommendations will be presented in deliverable D6.3.

The preliminary impression is that hardly any of the present or proposed regulation is explicitly in contrast to the hypotheses at the basis of the SmartNet work. However, for one topic, the EU legislation is somewhat different with configuration of SmartNet coordination schemes. For incorporating bottlenecks into the pricing, SmartNet selected to use nodal market organisation for ancillary services, European architectures (unlike the US implementations) implement a zonal organisation.

When it comes to the stakeholders' opinions, currently the situation is that ENTSO-E suggests that all congestion management needs, both for TSOs and DSOs, should be fulfilled by a common bid submission process from providers of distributed flexibility resources [18] in document "Distributed Flexibility and the value of TSO/DSO cooperation". A common process will among other ensure liquidity of the market [18]. ENTSO-E supports a common centralized solution for three system and grid services:

- For electricity balancing from Frequency Restoration Reserves and Replacement Reserves.
- For internal or cross-border congestion management in the transmission network
- For congestion management in the distribution network

Disregarding the selected approach (centralised or not) it is advised by ENTSO-E [18] that the market design should allow both DSOs and TSOs to set limitations and to activate flexibility resources based on the connection point of the resource as it is advised by ENTSO-E.

On the other hand "TSO-DSO data management report[1]" [13] mentions different points of attention coming from DSOs and TSOs, where DSOs are essentially concerned about possible misalignments of actions between TSOs, DSOs and other market players, which could lead to loss of control over the distribution grid and drive inefficient grid expansion. DSOs think that certain balancing actions could be delegated to them to procure balancing services on their network as a subsidiary activity to support TSOs (see page 15 in [13]).

[1] Common publication of ENTSO-E, EDSO for SmartGrids, Eurelectric, GEODE and CEDEC

1 Introduction

This deliverable is one in the series of three reports that are looking into regulatory aspects of implementation of methodologies and coordination schemes developed in the SmartNet project. Therefore, building on work related to evaluation of ancillary services, market architectures, ICT requirements and trials carried out as part of the SmartNet, the three reports seek to carry out the following analysis:

- Summarize lessons learned from evaluation of new operational tools and market models proposed and tested in the SmartNet project
- Evaluate proposed market architectures and planning and operation strategies in relation to current EU and national regulation and roadmaps developed by main industry and research bodies
- Produce a set of regulatory guidelines that reflect learning outcomes of SmartNet project

The main objective of this report is to present the regulatory trends and stakeholders' position on several issues (called *topics of interest*), which the project considers to be essential for definition of well-functioning TSO-DSO interaction.

Additional evaluation of learning from the implementation or SmartNet coordination schemes, as well as policy recommendations will be discussed in the following related deliverables:

- D6.1 "*Conclusions from national tests/simulations and their evaluations*", which will collect the project experience on the same issues
- D6.3 "*Policy recommendations to implement and/or overcome barriers and enable TSO/DSO integration*", which, which will conclude the work package and elaborate on the final guidelines and regulatory recommendations that result from the SmartNet project

The ever-increasing integration of Renewable Energy Sources (RES) constitutes a challenge for the pan-European electricity system, both at the transmission and at the distribution levels. This was recognised by European Commission and National regulators, who looked for possible solutions to enable RESs connections so as to help with overall environmental goals over the last decade or so. In the initial phase, issues with integration were more often related to local connection networks, rather than an overall system operation. Solutions to those issues called for changes in management of RES operation, in particular at distribution levels, but also started to include utilisation of energy storage and demand side management that could help tackling the limitations deriving from network constraints.

Further increase in DER connections has opened additional questions related to how to include them in electricity markets, and allow them, by offering flexibility, to participate in a provision of Ancillary Services (AS). Currently, AS services are mainly purchased from participants at the transmission level by

Transmission System Operator (TSO). However, DERs are also seeking to participate in TSO AS markets, but these trades can be hampered by constraints that may emerge at the distribution network level due to significant increase in a number of DERs, and their influence distribution network operation. To resolve issues at the distribution network level it can be expected that local AS markets might be needed in the future, especially if number of DREs becomes very high. Current European and national regulations are starting to address some of the issues that are emerging with these new arrangements, and the main objective of this report is to present the regulatory trends and stakeholders' position on several issues, which the project considers to be essential for definition of well-functioning TSO-DSO interaction. To that end, the deliverable makes a comprehensive screening of present and forthcoming regulation with respect to some key regulatory issues that were addressed in SmartNet or influenced in some way the work in the project.

1.1 SmartNet in a nutshell

Increased levels of DERs and their participation in provision of AS at both transmission and distribution levels, call for a more advanced dispatching management of distribution systems to transform distribution from a "passive" into an "active" system. Moreover, new market architectures must be developed to enable participation of DERs in energy and AS markets. New operational and trading arrangements will also affect the interface between transmission and distribution networks, which will have to be managed in a coordinated manner between TSOs and DSOs in order to ensure the highest efficiency, effectiveness and security.

The aim of the SmartNet project is to provide architectures for optimized interaction between TSOs and DSOs and help manage the exchange of information for monitoring and acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management), both at national level and in a cross-border context.

This section briefly outlines the main outcomes of the project - a set of novel coordination schemes and the simulator as well as assumptions which were made for development and assessment of these.

1.1.1 SmartNet coordination schemes

SmartNet proposes five coordination schemes (CSs), each presenting a different way of organizing the coordination between transmission and distribution system operators (TSOs and DSOs), when DERs participate in provision of ASs. Here, only a brief outline for each of the CSs is provided, while their detailed descriptions are provided and discussed in SmartNet deliverable D1.1 [50]. Furthermore, market aspects of the CSs are discussed in SmartNet deliverable D2.4 [49].

Each of the CSs is characterized by a specific set of roles assigned to TSOs and DSOs with a comprehensive operational rules and market designs. The main differences between different CSs are related to how, and by whom, coordination of DERs' participation in AS markets or local markets is managed.

The five proposed CSs, developed within the SmartNet, are as follows:

- ***Centralized AS market model,*** (Figure 1), where the TSO operates a market for resources connected both at transmission and distribution levels, without involvement of the DSO.

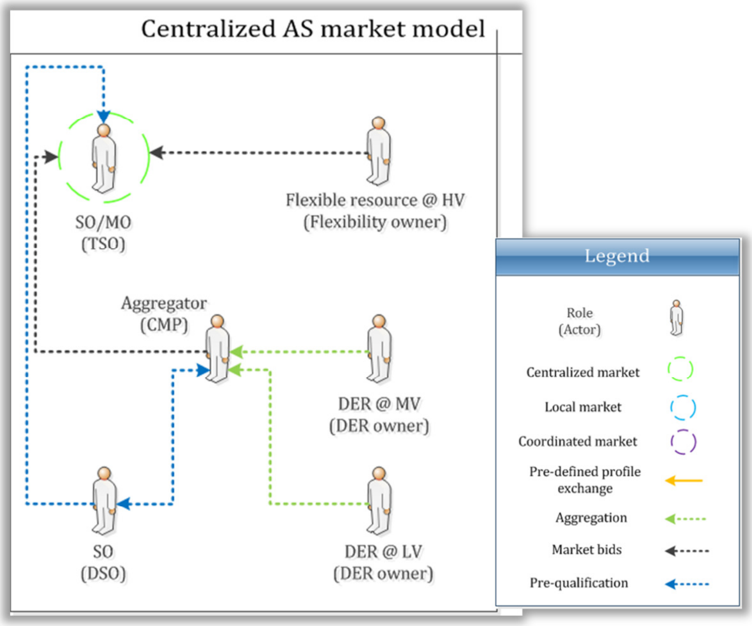

Figure 1 Coordination Scheme Centralized AS. Source: [56].

- ***Local AS market model,*** (Figure 2) where the DSO organizes a local market for resources connected at the DSO-grid and, after resolving local grid constraints, offers the remaining flexibility bids to the TSO for participation in AS markets.

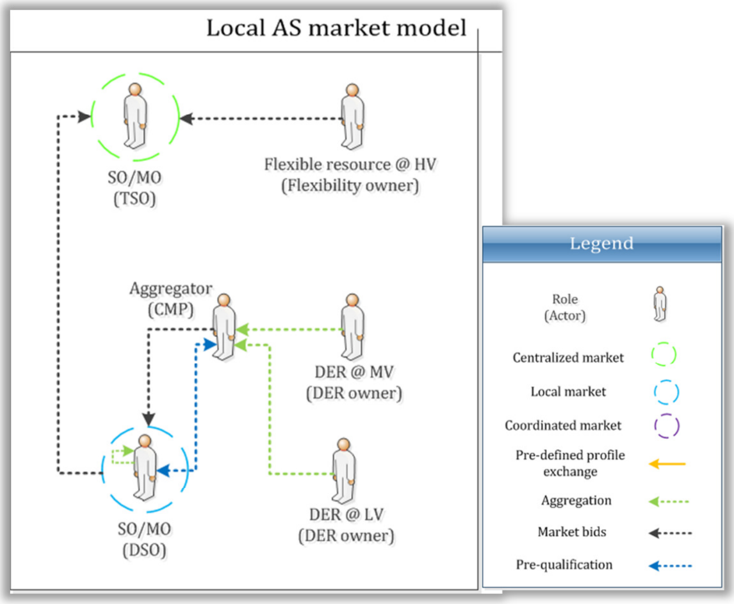

Figure 2 Coordination Scheme Local AS Market Model. Source: [56].

- ***Shared balancing responsibility model,*** *(*Figure 3*)* where balancing responsibilities are divided between TSO and DSO according to a predefined schedule. The DSO organizes a local market to respect the schedule agreed with the TSO while the TSO has no access to resources connected at the distribution grid.

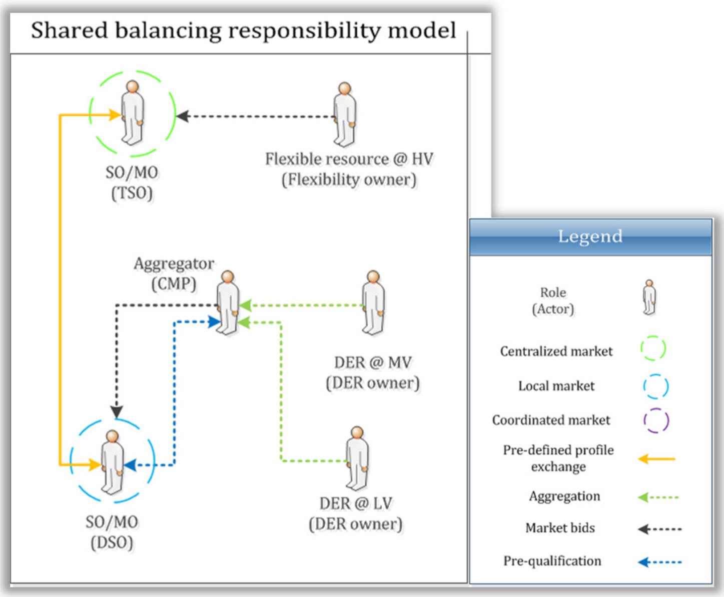

Figure 3 Coordination Shared Balancing Responsibility Model. Source: [56].

- ***Common TSO-DSO AS market model*** *(*Figure 4*),* where the TSO and the DSO have a common objective to decrease costs to satisfy the needs for resources by both the TSO and the DSO. This mutual objective could be realized by the joint operation of a common market (centralized variant) of the dynamic integration of a local market, operated by the DSO, and a central market, operated by the TSO (decentralized variant).

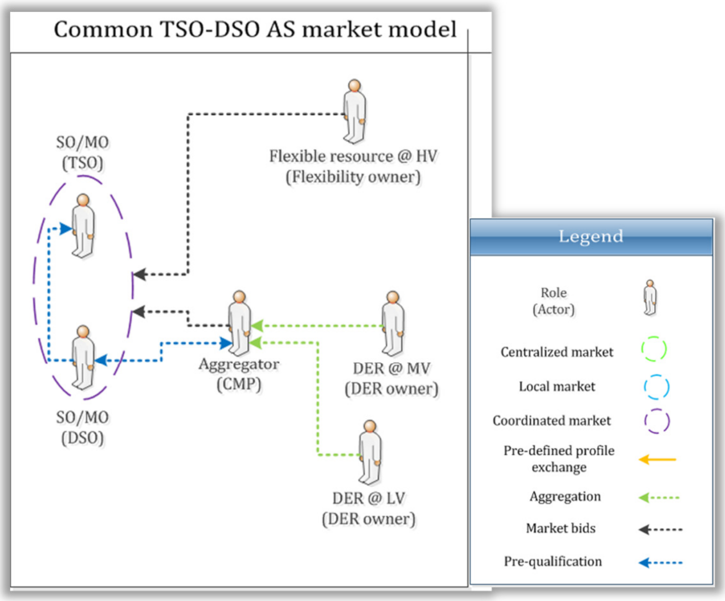

Figure 4 Coordination Common TSO-DSO Market Model. Source: [56].

- ***Integrated flexibility market model*** (Figure 5*), where* the market is open for both regulated and non- regulated market parties, which requires the introduction of an independent market operator to guarantee neutrality.

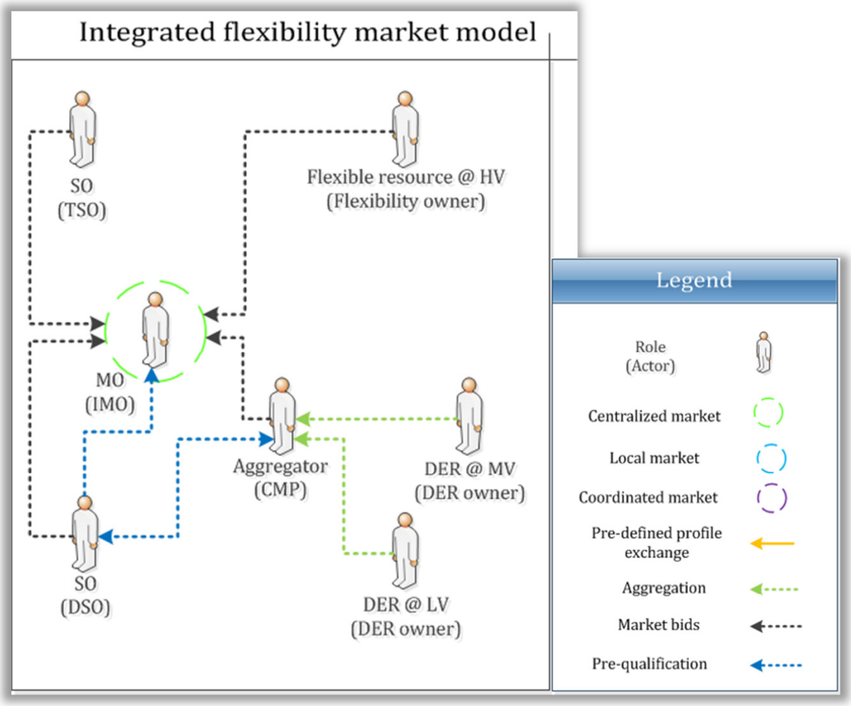

Figure 5 Coordination Scheme Integrated Flexibility Market Model. Source: [56]

The different coordination schemes all have specific benefits and attention points related to the TSO and/or DSO grid operation, market participants and the functioning of the market in general. Main benefits and attention points for each scheme are summarized in the Table 2

In addition, the feasibility of the implementation of each coordination scheme is very dependent upon the regulatory framework. As discussed in [50], *Centralized AS market model* is the most in line with current regulations. The other coordination schemes would require considerable changes with respect to roles and responsibilities of TSOs and DSOs. The implementation of a coordination scheme is also influenced by the national organization of TSOs and DSOs, e.g. the number of system operators (both TSOs and DSOs) and the way they currently interact. In addition, the implementation of certain coordination schemes will have an impact on other markets, such as the Intraday markets. Dependent on the services offered in the AS market, and compared to the Intraday markets (IDM), these markets might be able to co-exist or alternatively, may need to be integrated.

Table 2 Summary of the benefits and attention points for SmartNet Coordination schemes

Coordination Scheme	Benefits	Attention points
Centralized AS market model	• Efficient scheme in case when TSO is the only buyer for the service • Having only one market is low in operational costs and supports standardized processes • The most in line with current regulatory framework	• No real involvement of DSO • DSO grid constraints not always respected
Local AS market model	• DSO has priority in using local flexibility • DSO actively supports AS procurement.	• TSO and DSO markets for services are cleared sequentially • Local markets might be rather illiquid • Need for extensive communication between TSO market and local DSO markets.
Shared balancing responsibility model	• The TSO will need to procure a lower amount of AS • Local markets might create lower entry barriers for small scaled DERs	• Total amount of AS to be procured by TSO and DSO maybe higher in this scheme • BRPs might face higher costs for balancing • Small local markets may not be liquid enough to provide sufficient resources for the DSO
Common TSO-DSO AS market model	• Total cost of AS for TSO and DSO are minimized • TSO and DSO make optimal use of each other	• Individual cost of TSO and DSO might be higher compared to other schemes. • Allocation of costs between TSO

		and DSO could be difficult.
Integrated flexibility market model	• Increased possibilities for BRPs to solve imbalances in their portfolio. • High liquidity and relative low prices due to large number of buyers and sellers.	• Independent market operator needed to operate the grid. • Negative impact on the development and liquidity of intraday markets. • TSO and DSO need to share data with Independent Market Operator (IMO).

1.1.2 SmartNet simulator

A key part of the SmartNet is a large-scale simulator, which is developed to realistically model the behaviour of complex systems which include transmission and distribution networks, bidding and market processes, as well as fundamental physics behind each flexible device connected to the system. As illustrated in Figure 6 the SmartNet simulator comprises of three main layers, briefly describe below.

The Market layer

The core of the simulator is an optimization algorithm responsible for simulating the real-time balancing market clearing process. It is designed to manage large optimization problems including the constraints of all the networks and the different TSO-DSO interaction models. Modelling in this layer includes:

- **Network representation** - the market-clearing algorithm embeds a DC-power flow model for the transmission network and an approximated AC-power flow model (based on convexification of the AC power flow equations) for the distribution grid that includes complex voltages and powers [49]
- **Market products -** typical multi-period and logical constraints of flexibility providers
- **Arbitrage opportunities -** between cascading markets (i.e. day-ahead, intraday, AS market).

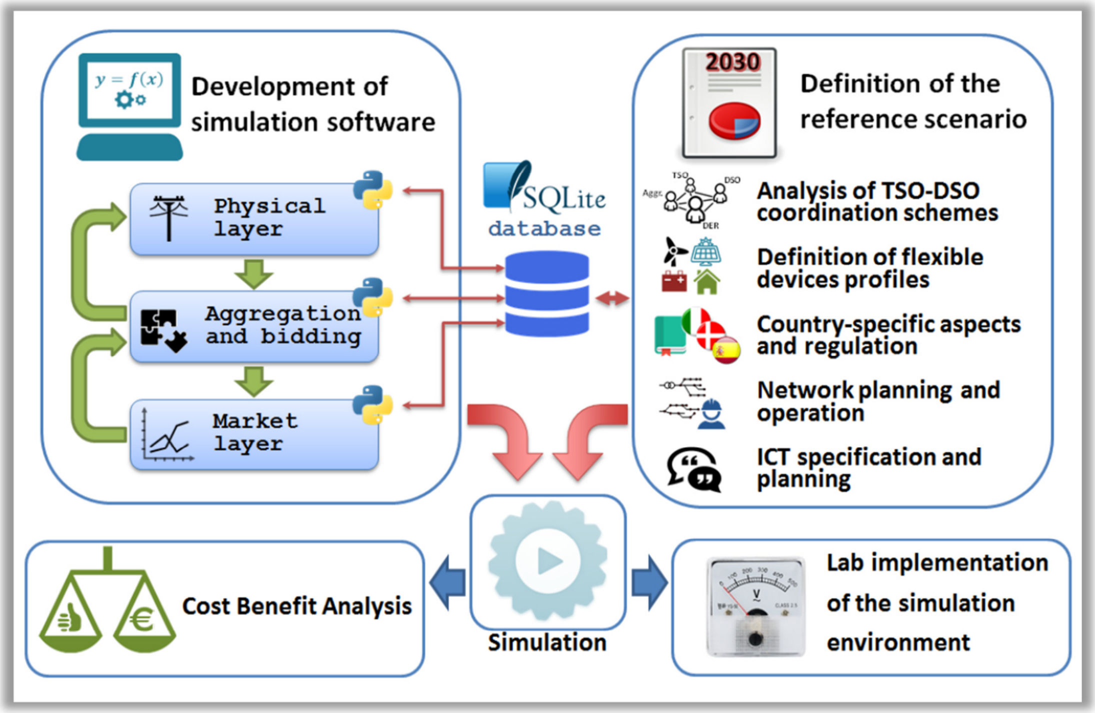

Figure 6 Structure of the SmartNet simulation platform [55]

The Bidding and dispatch layer

The interface between the physical devices and the market (and vice versa) is simulated through aggregation and disaggregation processes aimed at optimally managing the available flexibility from many dispatchable devices. This is done in order to bid the flexible devices by submitting bids that reflect flexibility costs and other constraints of particular technologies while also taking into account the potential arbitrage between different markets.

The Physical layer

The basis of the entire simulator is represented by the physics of the system components. The complex behaviour/characteristics of each network (transmission and distribution), loads, generators and flexible devices (storage, electric vehicles etc) are simulated together with the automatic processes directed by grid operators (state estimation/forecasting, network asset management etc). The processes include voltage regulation, reactive compensation, aFRR and network protections.

1.1.3 SmartNet market dimensions

During the initiation of the project several important assumptions and decisions were made regarding the types of AS, their time-scales, as well as bidding and other technical parameters. These components can be called market dimensions, and in many ways have influenced configuration of the project's final outcomes.

Time-scales of AS considered: the SmartNet is not tied to a particular product (e.g. aFRR, mFRR), but the services would typically [57]:

- Encompass product with the similar time-scale as mFRR/RR
- Do not encompass aFRR (with update of setpoints every few seconds) or FCR (local controller) time frame due to timing reasons

Considered services: balancing and congestion management at transmission (HV) and distribution level (MV), including voltage constraint at MV [55].

Timing Dimension - the project follows a generic approach to test combinations of important timing parameters:

- Time horizon of the market (optimisation window, delivery period): e.g. 30 min
- Time granularity of the market horizon: e.g. 5 min
- Market clearing frequency: e.g. 30 min (The shorter, the better, but limited by optimization problem complexity (market clearing duration)
- Max Full Activation Time (FAT) of the product: e.g. max 10 min
- Max clearing time = Max allowed time for market clearing algorithm to return the decisions: e.g. 5 min
- Gate closure Time (GCT): e.g. 15 min before delivery period starts (10 min FAT + 5 min market time)

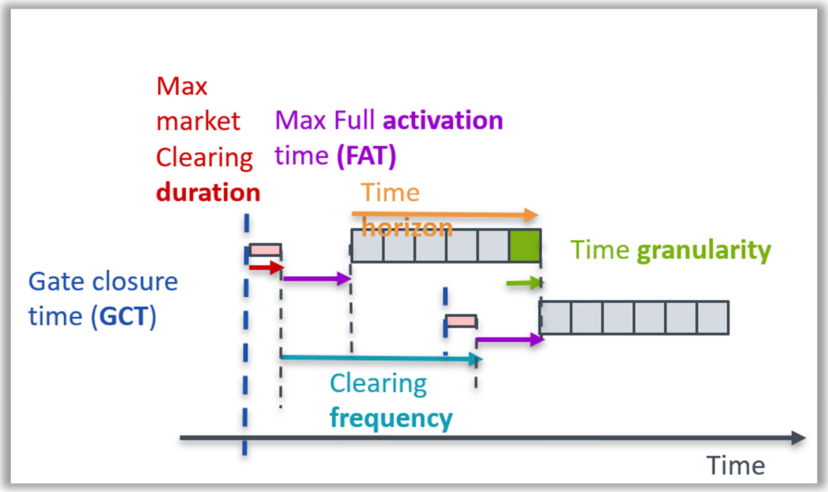

Figure 7: Timing Dimension for SmartNet. Source: [57]

Bidding Dimension – a catalogue of market products is proposed, to allow all flexibility providers to be on a level playing field:

- Bids are energy offers/asks, defined by quantity/price pairs in their simplest form
- Curtailable or non-curtailable bids
- Extension to multi-period bids, when time horizon is larger than the time granularity
- Complex bid constraints, including temporal constraints and logical constraints.

Clearing Dimension - the functional objective of the market clearing is to minimize activation cost (avoiding unnecessary activations)

Pricing Dimension - pay-as-clear chosen over pay-as-bid. Locational" Nodal" marginal price (LMP) has been chosen to remunerate bidders.

- Potentially different prices for each network node (in the model), due to losses and congestions

For detailed explanation of the above see [49].

2 Methodology

The main objective of this report is to present the regulatory trends and stakeholders' position on the issues, which the project considers to be essential for definition of well-functioning TSO-DSO interaction.

To facilitate this analysis, it was necessary to, first, decide which aspects of the project would be important and informative to evaluate against current or planned solutions outlined by various stakeholders. These are referred here as *topics of interest and* are described in detail in subsection 2.1. The second step was to decide on the documents that would be "screened" and against which defined topics of interest would be evaluated. Selection of regulators and stakeholders, as well as selection of their documents that are considered here is discussed in subsections 2.2 and 2.3, respectively. The aim of this evaluation phase is to indicate where the proposed SmartNet solutions stand compared to current and proposed solutions so to take DERs integration and realisation of the SmartGrids to the next level.

2.1 Topics of Interest for the screening

Under each of the three layers described above in the section on the SmartNet simulator, a set of *topics of interest* have been identified. These topics represent either some key assumptions made within the project, or/and some attributes, which can be directly or indirectly decisive for implementation of the project's outcomes. The structural overview for the topics of interest is presented in Figure 8. Presentation and discussion of main findings from screening of present regulation and stakeholders' views is aligned with the corresponding topics of interests. The following Sections 2.1.1-2.1.3 briefly explain selection of the above-mentioned topics and their relevance to outcomes of SmartNet project.

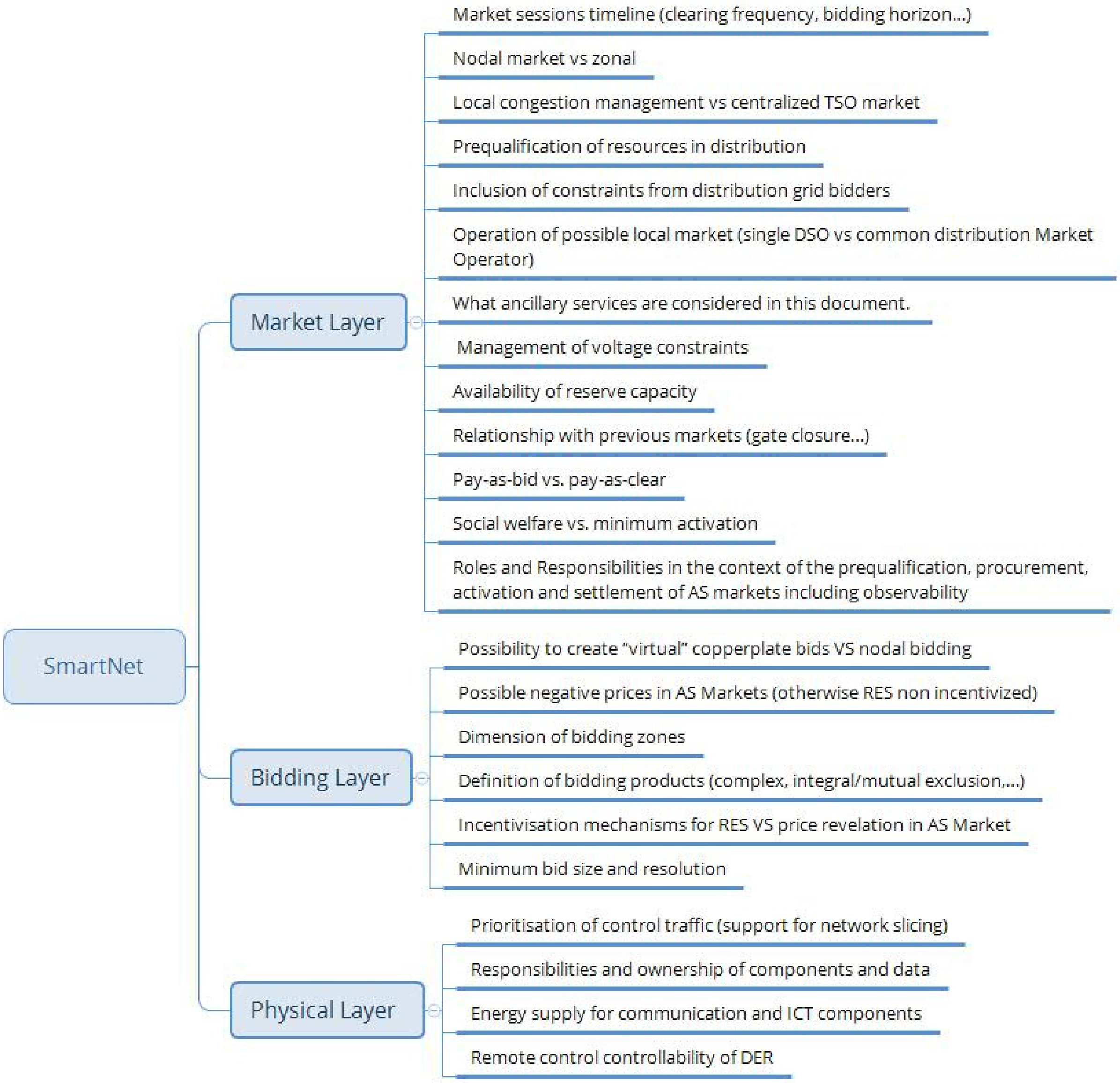

Figure 8 Topic of interest for the screening

2.1.1 Topics of interest for the Market Layer

Market sessions timeline

This topic covers configuration and layout of electricity market sessions especially related to timing and similar parameters. These issues are critical for definition, refinement and later introduction of SmartNet's concepts, since implementation of the concepts will require certain compatibility, making alignment of the key parameters possible.

Nodal market vs. zonal

The aim of this topic is to evaluate different views related to selection of the pricing mechanism for the Internal Electricity Market (IEM) in Europe, which has been one of the ongoing public discussions during the recent years. SmartNet has chosen marginal pricing or "pay as clear" as the pricing approach for balancing energy (see Section 3.1.10 for more details). Since considered power system is not treated as a copper plate, network constraints, both at the transmission and distribution levels, have to be taken into account. Marginal pricing can be adapted to a system with network constraints in different ways [49],, including

- Nodal approach where a price for flexibility is associated to the most granular level in our network representation i.e. to each node of the transmission and distribution grids
- Zonal approach where a price for flexibility is associated to a zone covering different nodes; each zone can have a different price but the nodes in the same zone have the same price.

Local congestion management by DSOs vs centralized TSO market

The main issue to be evaluated is to what extent the DSOs are ready to carry out a local congestion management via a local market, and to what extent this market could be sufficiently liquid.

Prequalification of resources in distribution networks

Prequalification process refers to the process in which a trusted entity (e.g. network operator) verifies the compliance of a balancing capacity provider with the requirements set by the TSOs [6], which could be also extended to the DSOs. The intention has been to clarify presence of rules and regulations defining these processes, e.g. which actor, should be responsible to carry out this, and on basis of which rules.

Inclusion of constraints (device-related) from distribution grid bidders

The main intention of this topic has been to clarify complexities of bids at distribution level, i.e., types of constraints which a bidder at distribution level should be allowed to include. Since SmartNet introduces both intra-bid temporal and inter-bid logical constraints (for details see [49], it is necessary to evaluate how allowing for these complex bids relates to current or already proposed market solutions.

Operation of possible local market

The main question is whether the local market should be operated on a single-DSO level or by a common Market Operator? One can observe that the DSO landscape across Europe is very diverse and fragmented.

Number of national DSOs varies from only few to more than 100 per country. In some cases, small-sized DSOs may have insufficient expertise to operate its own real-time market as well as limited liquidity.

Management of voltage constraints

Here the intention was to analyse to what extend the voltage constraints should be separately enforced or whether the market should take them into consideration.

Availability of reserve capacity

The rationale for this topic is related to definition of : reserve capacity which, according to [6], refers to "*the amount of frequency containment reserves, frequency restoration reserves or replacement reserves that needs to be available to the transmission system operator*". This issue became relevant in Europe during the recent years due to several factors, including the growing share of the renewable generation thanks to various support schemes and stagnating demand due to energy efficiency measures and relatively low economic growth. As a consequence, the electricity prices have been falling, leading to less investments into conventional generation. Higher share of varying RES, combined with low investments in firm capacity, has raised concern about availability of capacity reserves, which would be sufficient to maintain liquidity of the AS market.

Relationship with previous markets

This topic reviews how the outcome of the Intra Day market should be related to the real-time markets, including AS markets. For example, the persistence of uncoordinated and heterogeneous Intra-day Gate Closure Time (GCT), between, but also within, bidding zones, can be an important barrier to the improvement of the liquidity level in intraday markets [53].

Pay-as-bid vs. pay-as-clear

This topic reviews strengths and weaknesses related to two pricing alternatives: pay-as-bid vs. pay-as-clear[2].

- The "Pay as bid" approach where the activated bids simply receive the price corresponding to the activated quantity in the bidding curve. This approach is simple and intuitive for the different market stakeholders. However, it does not give incentive for the market participants to bid using the real cost of flexibility, creating an economic distortion in the activation decision [49].

[2] Use of terminology varies across different documents, so the project group assumes that term "marginal pricing" in case of balancing market means the same as "pay-as-clear".

- The "Pay as clear" or "locational marginal price (LMP) approach" where the activated bids receive the same price per MWh, corresponding to the most expensive activated flexibility. This approach removes the risk of market participant bidding in terms of what they want to receive instead of in terms of their real cost of flexibility [49].

Optimisation criterion for electricity market design - maximization of social welfare vs. minimum activation costs

There are two main choices for the market objective function, namely "minimization of activation costs" and "maximization of social welfare." According to recommendations by ENTSO-E, SmartNet has chosen to use "maximization of social welfare" as the objective function for the Integrated Reserve market, see [49] for a detailed description. It is therefore relevant to evaluate this choice towards other options considered by different stakeholders in Europe.

Roles and Responsibilities in the context of the prequalification, procurement, activation and settlement of AS markets including observability

The intention of this topic is to assess the current and future regulatory considerations regarding TSO and DSO roles, which are specifically relevant to the scope of SmartNet project and in particular to provision of ancillary services.

Ancillary services considered in the screened documents

This topic summarises the ancillary services, which were included in the screened documents.

2.1.2 Topics of interest for the Bidding Layer

Possibility to create "virtual" copperplate bids vs nodal bidding

This topic is related to comparison of two ways of organising market for ancillary services i.e. nodal market vs. zonal. It includes a consideration whether a trader should be entitled to consider a sort of portfolio of services in different locations, which could have certain distance between them and could have some bottleneck in-between.

Possibility for bidding negative prices in AS Markets

The intention of this topic is to assess incentives for involvement into the flexibility market. In case a generator offers energy for downward regulation, it has to buy back energy that it has already sold on the previous markets. Thus, when the down-regulation price goes below the true generator's cost, provision of this flexibility becomes profitable. This is even more so if the price can be negative, increasing a the energy bought back at the flexibility market.

Dimensioning of bidding zones

Due to several reasons, explained above, SmartNet project has chosen nodal organisation of the market. Therefore, dimensioning of the bidding zones is not directly in the scope of the present study. However, it still worthwhile to consider this issue since it can provide us with an insight on the size of the potential bidding zones should be in order to allow traders to be flexible while still maintaining secure system operation.

Definition of bidding products

There are three types of the main market products (or bids), which have been proposed and implemented in SmartNet: the UNIT-bid, the Q-bid, and the Qt-bid (for more details see [49]). These complex bids can be used by market participants, such as aggregators, to leverage the flexibility from a portfolio of resources. One of the project's deliverables [49] describes these resources in detail and the models used to represent them. The topic seeks to compare SmartNet bidding products with those proposed elsewhere, by other stakeholders.

Incentivisation mechanisms for RES vs price revelation in AS Market

This topic considers how the price regulation of the AS markets should exclude incentivisation, or to what extend the incentivisation should continue to exist, so no market distortions are created.

Minimum bid size and resolution

There are several opinions that in order to foster the participation of small units in balancing markets, and achieve more competitive balancing market, a smaller minimum bid size should be required. It is also believed that the aggregation of several units should be facilitated [53]. This topic considers therefore different positions regarding minimum bid size and resolution.

2.1.3 Topics of interest for the Physical Layer

Prioritisation of control traffic (support for network slicing)

The topic discusses how prioritisation for ICT control traffic for energy system management is ensured so to guarantee secure system operation.

Responsibilities and ownership of components and data

Deployment of SmartNet's coordination schemes will require more active interaction between TSO and DSOs, which presumes new responsibilities and ownership of components, models and data.

Energy supply for communication and ICT components

This aim of this topic was to clarify how to ensure sufficient power backup for ICT and also discusses which parties are responsible for its provision.

Remote controllability of DER

This topic considers to what extent DER inverters and similar equipment will include the controllability and related remote-control interfaces needed by services considered in the SmartNet or other FRR type of ancillary services.

2.2 Organisations issuing the screened documents

The documents considered in this study have been issued by several types of stakeholders, including:

- Governmental Organisations
- Organisations working with different aspects of Regulation and Standardisation
- Interest organisations as Industrial Associations and similar
- Other

The key stakeholders, which are considered in this study, are in many ways defined by implementation of the latest changes in the European legislation related to the internal gas and electricity markets i.e. the Third Energy Package (entered into force in 2009). The package established National regulatory authority (NRA) for each member state, and a common Agency for the Cooperation of Energy Regulators (ACER). Following the same process, the European Network of Transmission System Operators (ENTSO-E) was established in 2008 as a common body representing European TSOs. In the scope of the present document, ENTSO-E in fact has a twofold functional role. On one hand it operates as an organisation which represents interest of the Europeans TSOs, and on another it acts as regulatory body which develops the Network Codes (Guidelines).

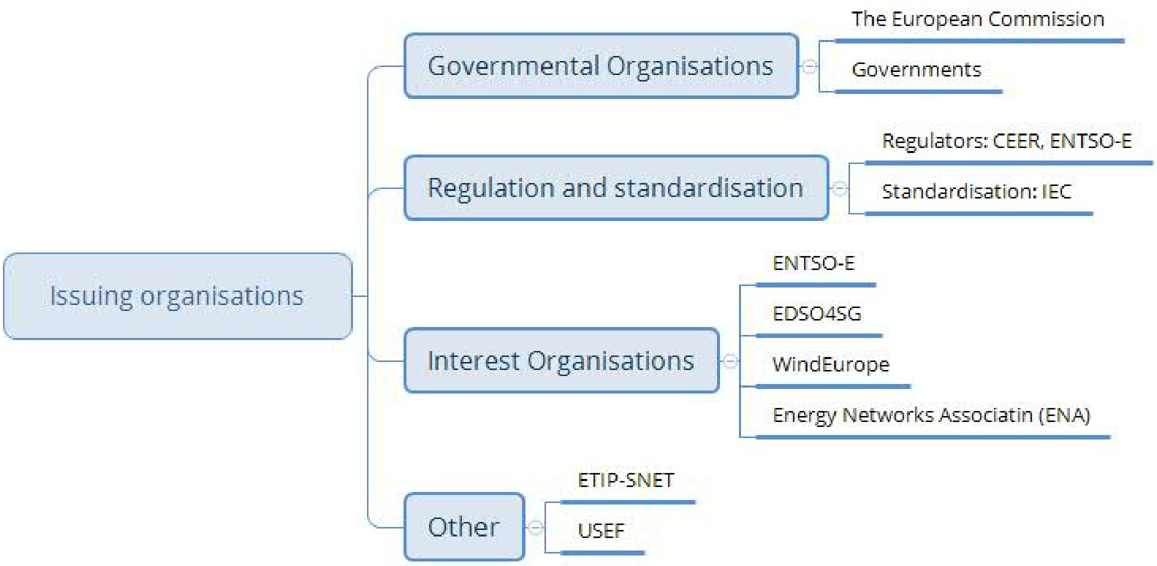

Figure 9 Overview of the issuing organizations

Even though establishment of a similar single organisation for the European DSOs has been suggested by the Clean Energy Package [6], no such organisation exists yet at the time of this writing. Based on the available information it appears that at the moment that there are four active associations: EDSO for Smart Grids, Eurelectric, GEODE and CEDEC (see Annex 1, page 80 for more details). The foreseen tasks for the new EU DSO entity are as follows:

- coordinated operation and planning of transmission and distribution networks;
- integration of renewable energy resources, distributed generation and other resources embedded in the distribution network such as energy storage;
- development of demand response;
- digitalisation of distribution networks including deployment of smart grids and intelligent metering systems;
- data management, cyber security and data protection;
- participation in the elaboration of network codes

The screening includes a document from European Technology & Innovation Platform - Smart Networks for Energy Transition (ETIP-SNET) [3], an organisation that superseded The European Electricity Grid Initiative (EEGI).

2.3 Selection of documents for the screening

The study considered the main outcomes of SmartNet project, based on two dimensions:

- **Stakeholders' views or Replication**, which denotes the property of a system that allows it to be replicated at another location or time [48]. The study looks how outcomes of SmartNet project (see SmartNet deliverable D6.1 [63]) will comply with the overall position and opinions of the key stakeholders, which are expressed via position papers, roadmaps and similar indicative documents. These documents show whether the given stakeholders may accept and even endorse SmartNet's outcomes, and how challenging it may be to replicate these across Europe including which barriers will have to be overcome.
- **Regulatory alignment**, which shows how SmartNet aligns with the regulatory framework that has already been implemented or/and has been suggested for the implementation within a certain number of years. It also aims to give an indication on the potential time frame for certain measures, solutions and outcomes. For this purpose, the study looks into legislative and regulatory documents, although it should be noted that regulation in general is not something static, but a constantly evolving process, required for a gradual step-by-step achievement of certain global targets.

Table 3 Dimensions of the screened documents

Dimension	Source documents
Stakeholders' views (Replication)	Position papers Roadmaps Other
Regulatory alignment (Evaluation)	Legislation Regulation Strategies

The project evaluated all together more than 40 documents, provided in the References section on, page 74. This document also includes brief summaries for each of the screened documents, which are included in Appendix 6.1" Overview of the studied documents (summaries).

2.4 Limitations of the study

There are many interlinked political discussions in the energy domain, which are ongoing at different institutional levels in Europe today. Since the present study has a limited scope to present the regulatory trends and stakeholders' position on selected, above defined, *topics of interest*, it was necessary to make a representative selection of documents, showing position of different involved parties i.e. stakeholders.

The working group for the present activity has observed that some of the documents indicate more or less continuous decision-making process, where several significant corrections were added after release of the document. In addition to this, one can argue that some stakeholders have been adjusting their position over time. Therefore, the present views or the current screening is based on the state of the discussion (documents) at the time of this writing.

Some of the considered documents belong to regulatory or restructuring processes with different time horizons, e.g. some refer to a specific issue in the certain period of time, while others represent a step-wise long-term process. Therefore, some of the statements or positions may simply indicate different steps in a similar process. Also, there may be certain divergence in implementation of the Pan-European legislative acts on national levels.

Moreover, the study concentrated on the documents, which are both official and publicly available.

Finally, whenever possible the study sought to use terms and definitions from official public documents, as for example European Directives and Network Guidelines.

3 The screening study

The following sections were prepared using a common step-wise structure, which included:

- **Step 1:** Overview of the present or/and proposed (not fully implemented yet) legislative acts and definitions using the European Directives, Network Codes/Guidelines etc. as sources.
- **Step 2:** Summary of the stakeholders' opinions have been mapped by using roadmaps, position papers and similar. as sources
- **Step 3:** Reference to the present situation (i.e. status quo), which refers to the existing practices and prevailing regulatory documents
- **Step 4**: Conclusions and reference to SmartNet’s Coordination Schemes, when applicable

Several topics are somewhat interrelated, therefore some of the points can be mentioned repeatedly in the description. Each topic is first introduced with a brief rationale, outlining its importance, which is then followed by a discussion and relevance to the SmartNet project.

3.1 The market Layer

3.1.1 Market sessions timeline

At the time of this writing the latest Proposal for a recast of the Internal Electricity Market Regulation provides several key principles for the organization of the market sessions [6], including the following: Market Operators (MOs) on the Day-ahead Market (DAM) and IntraDay Market (IDM) shall provide the opportunity to trade energy in time intervals, which are at least as short as the imbalance settlement period at these two markets. It also defines that from 2025-01-01 the imbalance settlement period should be 15 minutes in all control areas. This means in practice that from 2025 energy will be traded in 15 min or shorter time intervals.

In documents additional to "Clean Energy for all Europeans" [9], it is stated that the trade should be allowed as close to the real time as possible, and at least after intraday cross-zonal gate closure - at most one hour before delivery. Specifically, for DAM [7] the gate closure time (GCT) is defined as a market that closed at noon the day before. Therefore, the EU is providing a guideline on the maximum time for trade. In this sense, they are setting the upper bound, while the lower bound is to be decided by the involved stakeholders based on the current context and objectives.

According to the European Commission [6], the contracting of the balancing capacity should be done at least one day before provision of the balancing and the contracting period should be maximum one day. In Guidelines on electricity balancing, [15], the time period for imbalance settlement on balancing markets is defined as 15 minutes. This is related to the overall harmonisation process in Europe, which will support trading on IDM and development of trading products with a similar time window. This means that both settlements are being harmonized - DAM/IDM and balancing.

It is difficult to observe very specific opinions from stakeholders, when it comes to organisation and timing of the markets. Both ENTSO-E [18] and WindEurope [14] share position on the necessity to create a level playing field, to ensure non-discriminatory access to all interested providers and in particular when it comes to separate procurement of up- and down-regulation, which is clearly favourable for some of the existing technologies. WindEurope also refers to the design of products with short duration and high granularity as target [14] , [42] in order to increase participation. In addition, WindEurope supports moving GCT for balancing markets as close as possible to real time delivery and reducing the lead time for procurement of balancing capacities since it will encourage involvement of wind power generators. In fact, this complies with the proposal for the recast of IEM regulation [6], which was made more general (i.e., not technology-specific).

Comparing the existing practice in Nordic Countries, Spain and CWE (Belgium, France, Germany, Luxembourg and the Netherlands), the GCT for DAM complies with the above-mentioned requirement of 12:00 (D-1). The IDM in Spain has six discrete trading sessions, the Italian IDM is divided into seven sessions, while the NordPool applies continuous auction until H-1. In general, across Europe there are two designs: discrete and continuous auctions for IDM. Continuous auctions are mostly used across Central and Northern Europe, while discrete is used in the Iberian Peninsula and Italy.

Conclusions and reference to SmartNet

In order to have a compromise between fast reaction and computational effort, SmartNet has proposed a market with a clearing frequency of 15 minutes [49]. It is assumed that within the time step both market clearing and counter-trading are taking place [49]. This time step duration is not definitive (as it is a market parameter) and can be potentially adjusted to help with an implementation of algorithm, if necessary. Note that the common European requirement for the imbalance settlement will be 15 min. as of 2025. In some European countries it is already so, as for example in Italy.

3.1.2 Nodal market vs. zonal

The network constraints, both at the transmission and distribution levels, are of key importance for an ancillary service market ensuring the satisfaction of congestion and voltage constraints. It is therefore natural to encompass these network factors in the price mechanism in the most accurate and economically efficient way. Moreover, ancillary service markets are close-to-real-time market and their outcomes cannot be corrected by a market afterwards. The nodal pricing model incorporates bottlenecks into the pricing. For these reasons, a nodal approach is proposed to be considered for the Integrated Reserve market design [49].

Several legal documents refer directly to zonal organisation as model for electricity system in Europe. This includes the latest recast of Regulation [6] mentioning zonal electricity system in several instances and defining principles for setting bidding zones (i.e. structural congestions) presuming that this is an agreed or preferred model. The Network Guidelines [7] , [15] also stipulate that the pricing mechanism for DAM and IDM is zonal. In [6] it is also highlighted that in a zonal electricity system, locational signals must be provided, as the signals allow the determination of bidding zones, which reflect structural congestion.

The Recast Electricity Regulation [6] highlights that, in order to support a zonal electricity system, correct locational signals are required to ensure efficient network operation and planning. The correct locational signals need reliable definition of bidding zones, which could reflect congestions. The Electricity Balancing Guideline [15] focuses on establishing the rules on electricity balancing markets. Moreover, the statements regarding cross-zonal electricity system in [15] align with that in [6].

The Nordic and Spanish electricity markets are zonal and both the wholesale and the AS market in Spain are zonal [26, 27, 28, 29]. The zone of the Spanish electricity market is defined as the whole peninsula. Please note that there are exceptions (i.e. definition of smaller zones) in the Spanish electricity market. In the case of automatic Frequency Restoration Reserves (aFRR) [27] and [28], this service is provided by the regulation/control zones, which is a group of generator units qualified by the system operator (Red Eléctrica de España). For technical restrictions identified by the system operator, which imply increase/decrease of generation schedule, the system operator will select the most economical solution available for each specific technical restriction [29].

It is confirmed in [7] that the pricing mechanism for both day-ahead market and intra-day market is zonal. In the Spanish wholesale electricity market, marginal price is used for clearing day-ahead and intra-day market [26], [27] and [28].

Conclusions and reference to SmartNet

As the network constraints, both at the transmission and distribution levels, are of key importance for an ancillary service market ensuring the satisfaction of congestion and voltage constraints, it is natural to encompass in the price mechanism these network factors in the most accurate and economically efficient way. The selected nodal organisation of the market allows SmartNet to resolve two different issues at the very same time – "balancing + congestion".

For these reasons, a nodal approach is proposed in SmartNet for the considered Integrated Reserve market to be designed [49]. In addition, through the experience of SmartNet simulations, it has been observed that in most cases nodal market has provided good solutions.

3.1.3 Local congestion management by DSO vs centralized TSO market

The European Commission states in [6] "DSOs can use flexibility to improve efficiencies in the operation and development of the distribution system, including local congestion management". According to recast of the Directive on common rules for the internal electricity market [5], " many DSOs are part of vertically integrated companies, which are also active in electricity supply business". Therefore, regulatory safeguards are necessary to guarantee the DSOs' neutrality in their new functions, e.g. in terms of data management and when using flexibility to manage local congestions. One of the key issues, related to this, deals with electrical storage facilities. The European Parliament states in "The Common rules for the internal market in electricity" [5] that TSOs shall not be allowed to own, manage or operate energy storage facilities, and shall not directly own or indirectly control assets that provide ancillary services. Furthermore, DSOs shall not be allowed to own, develop, manage or operate energy storage facilities. The very same document opens, however, several possibilities for derogation, when certain conditions are fulfilled. This includes, for example, cases when no other actors were interested to own and operate storage facilities through an open tender procedure. Exemptions can be also given by regulatory authorities after assessing necessity for such derogation.

Looking at this issue, from the stakeholders' point of view, The European Distribution System Operators' association for Smart Grids (EDSO4SG) suggest that DSOs could own and operate storage facilities for security and quality of service (QoS) reasons [10]. EDSO4SG in general advocates for DSOs a possibility to deploy, own and operate grid-scale network storage assets, but for technical/network operation purposes only (incl. emergency situations, maintenance, voltage limits preservation and reactive power control management).

The European Technology and Innovation Platform (ETIP) in its Research and Innovation (R&I) Roadmap 2017-2026 [3] for Smart Networks for Energy Transition foresees that TSOs will be responsible for the overall system reliability, while DSOs will keep managing congestions in their local grids [3] with the request/requirement to coordinate the real-time congestion management between TSOs and DSOs. Furthermore, the document suggests a single market place for balancing and congestion management.

Also, EDSO4SG states that DSOs should be allowed to procure system flexibility services not only through market-based solution. In contrast, EDSO advocates for DSOs to deploy, own and operate grid-scale assets for technical operation purposes only.

Reference [13] developed by CEDEC (the European Federation of Local Energy Companies), EDSO for smart grids, ENTSO-E, EURELECTRIC and GEODE (association for European independent distribution companies of gas and electricity) highlights different views of TSOs and DSOs in terms of balancing actions. DSOs agree that some balancing actions can be devoted to them to procure balancing services on their network to support TSOs, while TSOs argue that balancing should be managed on a wider scale because local balancing cannot ensure overall optimisation of the system balancing.

Similarly, to the previous reference, [16] is a cooperation document between ENTSO-E, Eurelectric, EDSO, CEDEC and Geode and specifies that TSOs and DSOs are responsible for congestion management in their grids respectively. However, the cooperating parties in the joint document do not take any specific position related to how solutions can be implemented. The document says that procedures for congestion management at distribution level should be developed and integrated with other market aspects of the current markets design at that level. They suggest that DSOs and TSOs could investigate possible options for coordinating the use of flexible resources across both grids. The two options proposed are a single market place or local congestion markets with high level coordination between TSOs and DSOs.

ENTSO-E proposes to increase the scope of the EU legislation in the Guideline on System Operation by allowing limitation to be set not only on balancing bids but also on congestion bids, considering the geographical location of the bidding asset. The latter is also supported by USEF [35]. ENTSO-E supports inclusion of locational information in bids or internal schedules within an aggregation [18] and [22]. ENTSO-E also suggests that the Single flexibility marketplace collects bids (with locational information) for balancing and congestion management processes. In this marketplace, bids could be different, or it could refer to both (diluting the distinction between balancing and congestion) [22].

CEER (Council of European Energy Regulators) is not specific in its position, presented in the document "CEER Position paper on the future DSO and TSO relationship" [25], about how local congestion management shall be conducted/organised in the future.

WindEurope advices in [14] that DSOs should be enabled to solve local congestions at distribution level by procuring and activating eligible resources to participate to the markets. However, WindEurope does not support formation of local flexibility (DSO) markets which they consider inefficient and limited [14].

In the same vein, it should also be mentioned that measures to avoid negative impacts on the distribution grid are required for an efficient operation. A measure could be the introduction of a traffic light system similar to the one, proposed by USEF in [36].

Conclusions with reference to SmartNet

The discussion on the European level regarding local DSO vs system wide TSO congestion management is still open. DSOs appear to be in need of flexibility, and this is recognised and supported by the recast IEM Directive. Mechanisms that could enhance the current procurement of flexibility (either via common procurement or via market at each grid level) and the framework (since DSOs are regulated entities) for the recognition of costs i.e. incentives for participation in such mechanisms, are still missing. The overall impression is that even when DSOs may take local responsibility for congestion management or/and voltage regulation, these are not intended to cope with balancing, which will remain under TSOs' responsibility. In this sense, SmartNet solutions provides a gradual and modular approach to the implementation of congestion management that fits the different stages of national markets.

3.1.4 Prequalification of resources in distribution networks

Recast of the Regulation [6] makes a general definition of prequalification (see above). It also stipulates that the procurement shall be organised in a non-discriminatory way between market participants in the prequalification process, either individually or through aggregation, while post-qualification is not mentioned. Furthermore [15] defines that each balancing service provider (BSP) intending to provide service, should pass the qualification process defined by TSO and, if necessary, by DSO.

Currently, only TSOs are able to procure flexibility services from resources directly connected to the distribution networks. For the balancing services connected to the distribution network and offered to the connecting TSO, the border between distribution and transmission network is monitored and managed by a pre-qualification process carried out by a DSO [24].

Most of the stakeholders' opinions [16], [18], [22] and [25] on pre-qualification process in distribution network suggests coordinated TSO and DSO process, while there exists a view from USEF [36] that recommends the pre-qualification process to be carried out by aggregators at portfolio level.

The General Guidelines report [16] and the CEER (Council of European Energy Regulators) position paper [25] have the same suggestion. They recommend that TSOs and DSOs jointly define technical requirements for new technologies and ancillary services connected at the distribution network. They also emphasise DSOs need to ensure services quality in their network.

The Guideline on System Operation advocates for TSO and DSO coordination to enable delivery of reserves at distribution level. Also, it expects TSOs and DSOs to define limitations on balancing bids, during pre-qualification or before activation, in order to avoid security issues in their respective networks.

WindEurope [14] considers DSOs as responsible for ensuring coherence between ancillary services and distribution network constraints. Both TSOs and DSOs are regarded as market facilitators, and they should coordinate to activate flexibility resources through market signal/system operator's activation or direct activation by the system operator. Efficient data exchanges are important to achieve this coordination, so that curtailment of Distributed Generators (DGs) and redispatching cost could be minimised.

In order to enable coordinated process between TSOs and DSOs, data management and exchange is a critical part. The TSO–DSO data management [13], produced by both EDSO and ENSO-E, recommends that each TSO develops an agreement with its connecting DSOs. The agreement includes information exchange required for the pre-qualification process of reserves located in distribution networks. These reserves include frequency containment reserve (FCR), Frequency Restoration Reserve (FRR), and replacement reserve (RR). The European University Institute research [24] has a very similar view with [13] that TSOs will need to define the information exchange terms and set up an agreement with its connecting DSOs, for the pre-qualification process for FCR, FRR, and RR. In addition, [13] also specifies that pre-qualification should not lead to grid limitations for those unconstrained networks.

USEF's work [36] concentrates on potential aggregator models that enable the integration of explicit Demand Response (DR) (i.e. incentive-based DR). In the example of aFRR (automatic Frequency Restoration Reserve), it is assumed that this service is delivered from a group of aggregated assets by the aggregator. Part of the TSO contract phase with aFRR is a pre-qualification process. The pre-qualification phase can be done either at individual level or at portfolio level. It is the aggregator's responsibility to register its portfolio, so the relevant DSOs are aware of DR availability in its distribution network. Therefore, USEF recommends allowing pre-qualification to be carried out by aggregators at portfolio level, so that the amount/type of flexibility resources participating in various markets can be increased.

There is no explicit mentioning of pre-qualification process in the EDSO position paper [10]. However, it is emphasized in the paper that DSOs are free to choose the way of procuring flexibility. Guideline on Electricity Balancing [15] requires each DSO to provide essential information associated with pre-qualification to its connecting TSO in due time for performing imbalance settlement, this is to ensure efficient and effective system balancing in a coordinated way.

In Spanish ancillary service markets, two criteria need to be met before the participation, which are: 1) pass pre-qualification test by the TSO (Red Eléctrica de España); 2) minimum bid size of 10 MW, can be the aggregated bids. For the instance of aFRR participation, the tests are established for the corresponding operation procedures. Mandatory information must be sent to the system operator by the service provider. The State Secretary of Energy defines the criteria for the type of technology which may provide ancillary services. Furthermore, before the participants connect to the market operator's (OMI-Polo Español S.A.) computer system, the market operator could verify whether the technical requirement for the participation has been reached, by suggesting and carrying out several tests.

Conclusions and reference to SmartNet

To summarise the above, screening indicates two main topics of the discussion:

- Which actor (-s)/role (-s) should be involved into the pre-qualification process i.e. TSO, DSO individually or in coordinated manner or aggregator
- What should be the qualification level i.e. individual or portfolio (mainly discussed in the USEF's work [36], Section 6.7)

It is proposed in SmartNet that the process of pre-qualification could include two separate processes, which are technical pre-qualification and system pre-qualification. The technical pre-qualification process checks if a unit is qualified to participate in Ancillary Service (AS) market. In SmartNet, DSO is responsible for the system pre-qualification process in all Coordination Schemes (CSs).

In the system pre-qualification process, DSO validates if the participation of flexible resources at distribution network will impose any local grid constraints. For example, in Coordination Scheme (CS) A – centralised AS market model, a separate system pre-qualification process could be carried out to guarantee that activation of flexible resources at distribution network by TSO will not cause additional distribution network constraints.

3.1.5 Inclusion of constraints (device-related) from distribution grid bidders

The present legal documents emphasise non-discriminatory approach [6] that will ensure adequate competition based on a level-playing field between market participants, including demand-response aggregators and assets located at the distribution level. However, no mandatory requirements related to inclusion of device-related constraints have been identified. The existing regulation in Spain provides certain mandatory requirements for the connected devices and in particular power factor [31] and [32].

ENTSO-E supports homogenous access to the market from all participants [18]. Furthermore in [35] various stakeholders argue that requirements should be applied explicitly on portfolio level as for example:

- Ramping rate up and down
- Sustain requirement
- Single side flexibility
- Availability requirements
- Activation frequency

Conclusions and reference to SmartNet

Regarding to SmartNet, it can be concluded that there are no legal requirements for inclusion of device-related constraints. Proposal for least requirements on portfolio level from several stakeholders has been suggested in the framework of Open Networks Project [35].

3.1.6 Operation of possible local market (single DSO vs common distribution Market Operator)

The (recast) Directive on common rules for the internal electricity market [5] advocates that regulatory framework in Member States should give incentives to DSOs to use flexibility services to improve operational efficiency and distribution network development, e.g. congestion management at distribution level. It is also recommended in [5] that DSOs shall procure the flexibility services via market-based procedures.

The 10-year R&I roadmap [3] reviews the coordinated activities between TSOs and DSOs proposed in [15]. The coordinated activities include accessing resources, grid visibility and data, and regulatory framework. Based on these coordinated activities, one of the benefits is enabling market players to provide flexibility services through bidding in a potential single market place. The purpose of the single market place is to manage bids for balancing and solving congestion. ENTSO-E in [18] and [22] explains the above proposed single marketplace in more detail, for the purpose of integrating Distributed Flexibility Resources (DFR). The single marketplace could be applied to collecting and selling DFR services, by allowing DFR service providers to bid in the single marketplace. Both TSOs and DSOs can access the bids and use the bids for balancing and congestion management based on their respective Merit Order Lists (MOLs). TSOs will also forward balancing bids to European-wide MOL for mFRR (manual Frequency Restoration Reserves) and RR (Replacement Reserves) in the common European balancing market. The bids can be the same or different for balancing and congestion management. In addition, to be used for congestion management, the bids would include locational information. The DFR bids can be activated directly by the system operators or by the market. In addition, ENTSO-E also emphasizes that DSOs should avoid acting as intermediate entities between TSOs and the connecting DFR. The proposed single marketplace could ensure market liquidity by allowing service providers to bid, allowing coordinated activities for balancing and congestion management and minimise the bidding processes.

Day-ahead and intraday market operation with capacity allocation is discussed in [24]. It mentions that the CACM (Capacity Allocation & Congestion Management) Guideline introduces Nominated Electricity Market Operator (NEMO), which is a new entity (or role) to perform tasks of day-ahead or intraday market. Market Coupling Operator (MCO) is also introduced to match orders of day-ahead or intraday market from different bidding zones and allocate cross-zonal capacity. This is based on the requirement stated in the CACM Guideline, which requires TSOs couple and operate markets through power exchanges.

To realise the integration of demand response, USEF in [36] and [43] recommends a Market Coordination Mechanism (MCM), which sits on top of the existing market models. The MCM allows all market participants with equal access, therefore, it delivers flexibility services with no limitations and customizations. The aim of the proposed MCM is to optimize the flexibility value, by enabling the flexibility trading across all roles in the energy system.

Referring to today's practice, the common Nordic market for balancing power does not have a dedicated Market Operator at the moment but is operated by national TSOs.

Conclusions and reference to SmartNet's schemes

An important difference between SmartNet's coordination schemes is whether a centralized or decentralized architecture is considered. The following Table 4 shows which architecture is used in each coordination scheme.

Table 4 Types of architecture applied in SmartNet coordination schemes

Centralized architecture	**Decentralized market architecture**
Centralized AS market	Local AS market
Common TSO-DSO AS market (centralized)	Common TSO-DSO AS market (decentralized)
Integrated flexibility market	Shared balancing responsibility model

From screening of the relevant documents, it appears that creation of a single market seems to be the dominating opinion, supporting three SmartNet's coordination schemes, as shown in Table 4

3.1.7 Management of voltage constraints

The recast Directive on internal electricity market [5] defines the steady state voltage control as one of the non-frequency ancillary services. Moreover, it points out that the non-frequency ancillary services shall be allowed to be procured by DSOs in a transparent, non-discriminatory and market-based manner.

With the growth in the penetration of DER, the European ENTSO grid connection codes and related international IEC standards [21] will increasingly require DGs, Battery Energy System (BES), and micro grids to have capabilities to change their active and reactive power outputs, so to help with local voltage control. Currently, possibilities to control active and reactive power outputs directly and via droop settings are included in the draft standards.

The 10-year R&I roadmap [3] mentions that TSOs are responsible for the security and stability of their respective networks, including the system interconnections with other transmission networks. Ancillary services are used by TSOs to manage network, frequency and voltage control. It is proposed in [3] that new ancillary services coming from Renewable Energy Sources (RES) and Distributed Generators (DGs) could be procured to enhance the current ancillary services' procedures and strategies. To increase the integration of small (mainly PV) and medium Distributed Energy Resources (DERs) at distribution network, the roadmap [3] urges the need for automatic monitoring and control system that will help DSOs to better operate their network and maintain power quality at large scale.

When it comes to network planning, voltage control is part of this analysis. The TSO-DSO data management report [13] recommends that TSOs and DSOs should agree on the voltage control parameters at the border between the TSO and the DSO networks. To maintain these agreed parameters, DSOs should be able to use its reactive power sources and to carry out voltage control instructions to large users connected to its distribution network.

In the Spanish electricity system [32], voltage control services are provided by generators (net power > 30 MW (ordinary regime) or > 5 MW (renewable, cogeneration, wastes)) connected to the transmission network, transmission operator (Red Eléctrica de España), qualified customers (contracted power ≥ 15 MW) connected to the transmission network, and distribution network managers. The requirements for the voltage control service providers at transmission level are divided into mandatory and optional. The optional requirements can be required by the system operator when necessary in real time. In Italy the voltage constraints are currently taken into account in the resolution on ancillary service market.

Conclusions and reference to SmartNet

Voltage control is one of the key aspects in managing power system stability, and it is becoming more challenging at the distribution level with the increase levels of DERs In the SmartNet project voltage management is considered one of the key aspects, with the DERs participating in provision of this service[50] both to DSO and to support the voltage at transmission network. Within SmartNet coordination schemes, this service is delivered in several coordination schemes: The Local AS market, Shared Balancing Responsibility, and Common TSO-DSO AS market.

In the Local AS market, DSO offers the amount of reactive power that does not increase the ranges of acceptable losses. TSO chooses which voltage control offers to use, both from the resources connecting at transmission network or from the DSOs, and then notifies the selected offer. In the Shared Balancing Responsibility, a pre-defined schedule profile is shared between TSO and DSO at the border of transmission and distribution network. This pre-defined schedule profile includes definition on voltage set-point, which can be either agreed between TSO and DSO or is determined by TSO only. In the Common TSO-DSO AS market, TSO and DSO share the same objective (i.e. minimize activation costs), so that DSO may provide certain amount of reactive power, even if it increases the ranges of acceptable losses.

3.1.8 Availability of reserve capacity

Both the electricity Directive [5] and the recast of electricity Regulation [6] suggests a focus on strengthening short-term markets by adapting market rules, in order to cope with increasing penetration of Renewable Energy Sources (RES). The electricity Regulation [6] specifically defines that procurement of balancing energy and capacity should be done separately. In addition, procurement of upward and downward balancing capacity should be done separately as well.

The EDSO position paper [10] proposes that contractual agreements with flexible parties may be based on capacity procurement, rather than energy.

The Guideline on Electricity Balancing [15] is reviewed in [24]. It is mentioned in [24] that the Guideline [15] considers the exchange of balancing capacity as potential ways to achieve a more efficient reserve procurement. It foresees the possibility to exchange balancing capacity between TSOs and TSO-BSP, as the way of balancing capacity exchanges are similar. Moreover, TSOs can also share reserves, e.g. Frequency Restoration Reserves (FRR) and Replacement Reserves (RR), to meet their requirements for reserve. To achieve the exchange of balancing capacity and sharing of reserve, it requires inter TSO cooperation on close to real time and forward capacity calculations and updates to determine the capacity that will be used for exchanging or sharing [24]. In addition, as required in the Guideline [15], TSOs need to continuously update the cross-zonal capacity availability.

The Guideline on Electricity Balancing [15] defines the procurement and exchange rules for balancing capacity. Each TSO is asked to conduct optimal reserve capacity provision analysis at minimum costs, considering balancing capacity procurement at the control network, exchange of balancing capacity with neighbouring TSOs, sharing of reserves, and non-contracted balancing energy bids if they are available at the control area or within the European platforms. The balancing capacity should be procured through 1) market-based method for at least the FRR and the RR; 2) a short term and economically efficient process; 3) several contracting periods maybe involved with the contracted volume. In addition, the Guideline [15] also expects separate procurement of upward and downward balancing capacity for at least the FRR and the RR. If TSOs exchange balancing capacity, a proposal is needed for the common rules.

In Spanish electricity system, the automatic Frequency Restoration Reserves (aFRR) is an optional service which is limited to be provided by the regulation zones [27]. For the RR, it is mandatory for the programming units to submit bids for the service. The units have been pre-qualified by the system operator (Red Eléctrica de España) for the service provision. The bids need to include all the available power reserve, including upward and downward availability, and the corresponding energy prices [28]. Energinet as the Danish TSO has agreements with some energy suppliers to ensure the availability of reserve power. The suppliers must enter into a main agreement with Energinet relating to the supply of ancillary services [37]. To ensure sufficient reserve capacity is available on the regulating power market, Energinet has concluded reserve capacity markets [38]. In the regulating power market, market players are paid at a fixed availability payment for being available and submitting bids for upward/downward regulation. The Italian market is based on procurement of energy and not capacity. In order to be compliant with the Network Codes, there are possibilities to price also the capacity.

Conclusions and reference to SmartNet's schemes

The SmartNet project considers four ancillary services (AS), which are: balancing and congestion management, frequency control, and voltage control. For balancing and congestion management, aFRR (automatic Frequency Restoration Reserve), mFRR (manual Frequency Restoration Reserve) and RR (Replacement Reserve) are considered[3]. FCR (Frequency Containment Reserve)/primary reserve is not

[3] Depending upon national classification mFRR and RR can belong to the same regulation - tertiary

considered in SmartNet. On the experience of SmartNet the fact that intraday sessions can fuse with RT markets. This may require a particular attention because TSO and DSO need a clear demand to satisfy and can't cope with a continuous readjustment of the positions by the Commercial Market Parties.

3.1.9 Relationship with previous markets

In the recent European legislative documents [6] the market participants shall be allowed to bid into balancing markets as close to real time operation as possible, and at least after the intraday cross-zonal gate closure time - at most 1 hour before the delivery [9].

Stakeholders' positions do not address directly relationship with previous markets, except for the ENTSO-E's working paper [22], specifying that "balancing market design should be compatible with wholesale markets".

When it comes to the existing practice, e.g. in Denmark, the intra-day market closes 1 hour before the delivery, while the regulating power (balancing) market closes 45 minutes before the delivery [41].

Conclusions and reference to SmartNet's schemes

There are limited requirements or expressed stakeholders' positions regarding the relationship between Intra Day and the real-time market it in the present legislative documents such as directives, network codes or other position papers. The only guideline is that the participants in the balancing markets shall be allowed to bid as close to real-time as possible and at least after the intraday gate closure.

3.1.10 Pay-as-bid vs. pay-as-clear

The recast Regulation on internal electricity market [6] requires that marginal pricing (pay-as-clear) should be used for the settlement of balancing energy. The Guideline on electricity balancing [15] has mentioned that the pricing for balancing energy (energy from activated balancing energy bids) used for the frequency restoration process and the reserve replacement process should be based on marginal pricing (pay-as-clear).

The USEF's work on the integration of Demand Responses (DR) [36] looks into different aggregator models, which could be used to implement the role of aggregator in energy markets. In the framework implementation report [36], USEF recommends a market approach based on a pay-as-bid pricing model for the clearing price when a DSO performs active grid capacity management to solve potential congestion using flexibility services from aggregators. The claim is that pay-as-bid model will lead to lowest costs for the DSO and for society. This is because in a pay-as-bid pricing model, the flexibility providers receive the price bidden if their flexibilities are provided to the DSO, rather than being paid at the most expensive accepted offer (in a pay-as-clear model).

When it comes to the present practice "pay-as-clear" is a preferred pricing for the European electricity wholesale markets [26], [28]. According to [27], in Spain two reserve services are paid at the marginal price, including 1) the regulation power band; and 2) the effective net energy of the Replacement Reserve (RR) that is necessary to be assigned for the replacement of the Frequency Restoration Reserve (FRR). In the Danish electricity market, the primary reserve is cleared at marginal pricing (pay-as-clear), while the others are cleared at their individual bids (pay-as-bid) [37]. It is also confirmed in [41] that pay-as-clear is mainly used in Danish balancing market, except in certain cases. Bids involving limitations (e.g. in time, in volume, and in activation mode), can be activated under special circumstances and are settled at the bid prices (pay-as-bid). The Italian ancillary service markets use pay-as-bid pricing.

Conclusions and reference to SmartNet

EU legislation and guidelines [6], [7] and [15] require using pay-as-clear for balancing energy.

3.1.11 Optimisation criterion for electricity market design - maximization of social welfare vs. minimum activation costs

In the recent legislative documents of the European Union [5] and [6] it is explicitly stated that maximum benefits for the society is the key objective for the current electricity market design. The set of documents "Clean Energy for all Europeans" [9], which combines the assessment for the recast of the Directive and regulation of the IEM, specifies that the main aim is to reduce barriers (e.g. by promoting a balancing market design that takes into account technical capabilities or units, or by championing a minimum product size of 1 MW for DA and ID trading [9]) and market failures in order to increase social welfare via improved market design. CEER in document on DSO-TSO cooperation issues [24] refers to maximising the whole system's efficiency.

The importance of social welfare as the main objective seems to be supported by several stakeholders. ETIP-SNET in [3] mentions the social welfare in several places across the document, stating that new solutions should maximise the social welfare, CBA tools should investigate it and the overarching goal for the whole R&I Roadmap is to optimise the European welfare. This position is further supported by ENTSO-E in several documents, as for example [4], where optimising of the social welfare in the long term is one of the goals of ENTSO-E's strategy scope.

By Moving the focus from high level and rather generic, to more specific, documents, in [13] EDSO argues that both TSO and DSO should contribute to maximisation of social welfare with a fair cost and benefit allocation. When a DSO expands, its network proper assessments have to be made in order to maximise the social welfare. Furthermore in [22] ENTSO-E suggests that the use of distributed flexibility reserves (DFR) should be prioritized in those places, where they provide the highest value for the system. WindEurope in [14] points out that the provision of the reserve capacity should be optimal i.e. based on coherent (considering distribution operational constraints) and coordinated (so that critical data exchanges take place) dispatching orders (NB! not minimal) with minimisation of the costs.

Conclusions and reference to SmartNet

Based on the screened documents, one can conclude that maximisation of the social welfare is the dominating optimisation criterion. SmartNet used objective function of minimisation of activation costs expressed as maximisation of the social welfare.

3.1.12 Roles and Responsibilities in the context of the prequalification, procurement, activation and settlement of AS markets including observability

The present position (i.e. status quo) - reference to the existing regulatory documents

The TSOs and DSOs roles and responsibilities, and their shared responsibilities defined in the regulations and Network Guidelines [5], [6], [15], [27] and [28] are listed below.

<u>TSOs' roles and responsibilities</u>:

- Maintain the balancing of and development of its transmission network, by closely cooperating with neighbouring TSOs and connecting DSOs, in an economic, environmental, and efficient manner. Ensure operational security by procuring ancillary services from market participants, including renewable energy sources, aggregators, demand responses, and energy storage devices. Define technical requirements for market participants. Furthermore, procure balancing services and non-frequency ancillary services (e.g. steady state voltage control), in a transparent, non-discriminatory, and market-based procedure [5].
- In the balancing market, publish close to real time network balancing information, the imbalance price, and the balancing energy price [6]
- In capacity allocation and congestion management, if technically possible, use the line to its maximum (i.e. overrated) capacity to relief the congestion [6]
- May calculate and settle activated volume of balancing energy for frequency containment process, frequency restoration process, frequency replacement process with BSP. Calculate imbalance adjustment, which will be applied to the associated BSPs for each activated balancing energy bid and determine the activated volume of balancing energy. Apply the imbalance settlement period of 15 minutes, after three years entry into the Guideline on Electricity Balancing [15]
- Calculate cross-zonal capacity at least after day-ahead and after intra-day cross-zonal gate closure time [6]. Continuously update the cross-zonal capacity availability, after the intra-day cross-zonal gate closure time [15]. Moreover, allocate available cross-zonal capacity in the next cross-zonal capacity allocation process [6]
- If there is cross-border participation in capacity mechanism, specify required technical functions in capacity mechanism and register capacity providers in the registry as eligible providers, also carry out availability checks [6]
- Provide all necessary information to the operator of an interconnected system [5]

- For LFC (Load-Frequency Control) block, TSOs need to assess and review the reserve capacity requirements regularly [15]
- Collect charges relevant to the transmission system, including access charges and ancillary services charges [5], and clearly state beforehand how the congestion income will be used and report the actual income use [6].

DSOs' roles and responsibilities:

- Maintain the balance of its distribution network and develop its network, in an economic, environmental, and efficient manner [5]
- Comply with unbundling conditions [5]
- Data management of smart meters [5]
- Provide information to the connecting TSO in due time, for the purpose of performing imbalance settlement [15]

TSOs & DSOs joint responsibilities:

- Ensure effective and efficient balancing with BSPs [15]
- Develop a cost method for allocating costs resulting from actions of DSOs, e.g. for prequalification of reserves [15]

In the Spanish electricity grid pre-qualification is carried out by the system operator, Red Eléctrica de España [27] ,[28] .

Evolving of the responsibilities - reference to the existing regulatory documents

The potential responsibilities, proposed in [5], [6] and [21] mainly aim to better integrate Distributed Flexibility Resources (DFRs) and to increase the engagement from aggregators. TSO's future responsibilities do not change significantly, whereas DSOs will see a transition of their roles from merely passive to more active. DSOs might be allowed to procure and manage services at distribution network for network operation and development, including the flexibility resources. The potential changes in responsibilities are as follows:

TSOs' potential responsibilities:

- Ensure efficient participation of all market participants including renewable energy sources, demand response, energy storage facilities and aggregators, in particular by requiring regulatory authorities or transmission system operators in close cooperation with all market participants, to define technical modalities for participation in these markets on the basis of technical requirements of these markets and the capability of all market participants.
- May own, develop, manage or operate storage devices, if it has been granted by the National Regulatory Authority (NRA), or if no interest from commercial entities, or if they are necessary to fulfil obligations. [5]

DSOs' potential responsibilities:

- DSOs could be allowed to manage connected flexibility resources at their respective networks, and use flexibility to improve operational efficiency, including local congestion management [5]
- Define standardised market products for the services procured, exchange necessary information and coordinate with TSOs. Procure energy for covering losses and non-frequency ancillary services in a transparent, non-discriminatory, and market-based procedure. Technical specifications for the service providers need to be defined between the DSO (/regulatory authorities) and all market participants. In addition, DSOs shall remunerate for the service procured adequately [5]
- Define or remotely control the droops or the set points for the DER active and reactive powers (mainly based on the requirements given by the TSO) [21]
- Play an active role in integration of electro-mobility and energy storage devices– own, develop, manage or operate recharging points or storage devices, if it has been granted by the NRA, or if no interest from commercial entities, or if it complies with unbundling conditions [5]

TSOs & DSOs joint responsibilities:

- Cooperate with demand service providers and customers, to define technical specifications of demand side participation. This also includes potential engagement from aggregators [5]
- Use proper methods to guarantee the minimum curtailment or downward re-dispatching of Renewable Energy Sources (RES) and high efficiency co-generation [6]

The stakeholders' opinions

The stakeholders agree with the regulatory documents about the overall division of responsibilities for the SOs: TSOs and DSOs are responsible for maintaining system stability of their respective network. TSOs are responsible for system balancing, and DSOs are responsible for managing voltage and congestion at distribution networks (ETIP-SNET [3], common ENTSO-E, CEDEC, EDSO for SG, Eurelectric and GEODE [13], [16], WindEurope [14], ENTSO-E [18], [22], European University Institute (EUI) [24], CEER [25] and ENA [36]). However, several of the stakeholder documents are more specific about details than the regulatory documents:

TSOs' roles and responsibilities:

- Could access data related to users in the distribution network, through the respective aggregator/ Balancing Service Provider (BSP), or through the connecting DSOs, or directly through the grid users for specific needs. In addition, 2 out of these 3 options may create unnecessary redundancy [18]
- Be aware of when a DFR capacity for balancing is affected, and consider this when procuring balancing capacities, including pre-qualification and dimensioning process [22]
- If there is a contractual relationship with the aggregator/BSP, TSOs need to pay the aggregator/BSP for the delivered flexibility and to correct the perimeter if necessary [36]

DSOs' roles and responsibilities:

- Manage voltage and congestion of their respective networks [3], [14] and [16] with flexible resources under commercial arrangements of connections (i.e. firm and non-firm) [24], as well as imposing restrictions to flexibility bids offered to TSO or commercial players [36] and ensure coherence between system need (i.e. ancillary services) and grid constraints [14]
- Play the role of market facilitator and operate their grids to allow all the resources to provide services in (wholesale and ancillary service) markets [10]
- Monitor the current border of distribution and transmission network via a pre-qualification process, for balancing services connected to the distribution network and offered to the TSO [24]
- Be allowed to access all necessary data to fulfil their grid obligations, and to access a common European data format or a limited 'minimum content's data format [10]
- The USEF work proposes that, for the settlement between DSO and aggregator, DSO is responsible for settling the flexibility acquired from aggregators, including checking whether the acquired flexibility has been delivered based on the agreements [43]

TSOs & DSOs joint responsibilities:

- Allow an efficient system operation [25], neutrally manage their networks, including the secure network operation, congestion management and voltage control [13]. Both are responsible for product definition, procurement, and activation (including setting limitations for product activations) [18], [22]. In addition, optimally allocate the outputs of flexible resources [22].
- Recognise one complete energy system instead of several separate systems, e.g. TSO networks, DSO networks, etc. [13]
- Ensure coherence between DERs connected at distribution network (by TSOs) and distribution network constraints (DSOs) [14]
- Data transfer between DSOs and TSOs should in accordance with the principles of "data parsimony and EU data protection regulation" and align with the cascading principle [10]

SmartNet Coordination schemes relevant for provision of ancillary services

In SmartNet Coordination Schemes (CSs), the major differences between CSs lie in the market arrangement for the procurement of ancillary/system services. The grid operation, pre-qualification, activation, and settlement processes of flexible resources are similar across the CSs. Table 5 summarises grid operation roles, including SO, system balancing responsible party, and data manager, for each CS. Among the CSs, both TSO and DSO are responsible for managing system balance in shared balancing responsibility model, whereas only TSO manages network balance in the other four CSs. As defined in [5], TSO and DSO are responsible for maintaining the balance of their respective network.

For the pre-qualification responsibility, as it was described earlier in Section 0, DSO is responsible for the system pre-qualification process in the SmartNet CSs, and a certified independent actor could be responsible for the technical pre-qualification process.

Table 5 Grid operation roles adoption across coordination schemes

			Coordination Schemes				
		Role	**Centralised AS Market Model**	**Local AS Market Model**	**Shared balancing responsibility model**	**Common TSO-DSO AS market model**	**Integrated flexibility market model**
Domain	**Grid Operation**	System Operator (SO)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)
		System Balance Responsible (GBR)	TSO (Tx; Dx)	TSO (Tx; Dx)	TSO (Tx) DSO (Dx)	TSO (Tx; Dx)	TSO (Tx; Dx)
		Data Manager (DM)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	IMO TSO (Tx) DSO (Dx)

The recast regulation on the electricity internal market [5] requires TSOs to procure balancing services and non-frequency ancillary services (e.g. steady state voltage control etc.), in a transparent, non-discriminatory, and market-based procedure. One of the reasons that SmartNet proposes CSs is to achieve an enhanced operation between TSOs and DSOs. The proposed procurement responsibilities in the SmartNet CSs are listed below and summarised in Table 6.

- In centralised AS market model, TSO is the only buyer of resources, CMPs (commercial market parties) are the only sellers. The centralised market is operated by TSO for the resources connecting at both transmission and distribution network. Aggregation of flexibility resources is carried out by flexibility service providers or aggregators (CMPs) in centralised AS market model.
- In local AS market model, shared balancing responsibility model, and common TSO-DSO AS market model, TSO and DSO can buy flexibility resources, CMPs are the sellers. DSO has priority to allocate flexibility connecting at distribution network in local AS market model, and TSO and DSO manage their respective networks. In local AS market model, in addition to the possibility

that CMPs aggregate flexibility resources, it is also possible that DSO aggregates the resources connecting at distribution network and offers them to TSO.

- In shared balancing responsibility model, TSO and DSO manage their respective networks, and CMPs aggregate the flexibility resources.
- In common TSO-DSO AS market model, TSO and DSO operate the network together, by optimising the market in mutual agreement. CMPs and DSO can aggregate flexibility resources in common TSO-DSO AS market model.
- Since integrated flexibility market model has a common market operated by IMO (independent market operator), both transmission and distribution networks are operated by IMO. Considering CMPs are also allowed to compete equally with TSO and DSO in integrated flexibility market model, CMPs can buy flexibility resources, and SOs can sell contracted flexibility back to the market.

Table 6 Procurement roles adoption across coordination schemes

			Coordination Schemes				
		Role	**Centralised AS Market Model**	**Local AS Market Model**	**Shared balancing responsibility model**	**Common TSO-DSO AS market model**	**Integrated flexibility market model**
Domain	**Procurement**	Reserve Allocator (RA)	TSO (Tx; Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)
		Buyer	TSO (Tx; Dx)	TSO (Tx; Dx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx; Dx) DSO (Dx)	TSO (Tx; Dx) DSO (Dx) CMP (Tx; Dx)
		Seller	CMP (Tx; Dx)	CMP (Tx; Dx)	CMP (Tx; Dx)	CMP (Tx; Dx)	CMP (Tx; Dx) TSO (Tx; Dx) DSO (Dx)
		Market Operator (MO)	TSO (Tx; Dx)	TSO (Tx) DSO (Dx)	TSO (Tx) DSO (Dx)	TSO (Tx; Dx) DSO (Tx; Dx)	IMO (Tx; Dx)
		Aggrega-tor	CMP (Tx; Dx)	CMP (Tx; Dx) DSO (Dx)	CMP (Tx; Dx)	CMP (Tx; Dx) DSO (Dx)	CMP (Tx; Dx)

The most optimum resources are selected after the market clearing for activation and settlement. Table 7 and Table 8 give an overview of the activation and settlement roles in SmartNet CSs.

Table 7 Activation roles adoption across coordination schemes

			Coordination Schemes				
		Role	**Centralised AS Market Model**	**Local AS Market Model**	**Shared balancing responsibility model**	**Common TSO-DSO AS market model**	**Integrated flexibility market model**
Domain	**Activation**	Flexibility Dispat-cher (FD)	TSO, CMP (Tx; Dx)	DSO (Dx) TSO (Tx; Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	IMO and TSO (Tx; Dx) DSO (Dx) CMP (Tx; Dx)

CMPs are involved in the activation process, as they send activation signals to individual DERs connecting at transmission and distribution network. In centralised market, since only TSO manages the network, TSO activates the selected resources. IMO operates the common market in integrated flexibility market model, therefore, IMO is involved in resource activation. The settlement process to verify the activation could be done by SOs. After regulation approval, independent CMP can also measure the activation of flexibility resources.

Table 8 Settlement roles adoption and across coordination schemes

			Coordination Schemes				
		Role	**Centralised AS Market Model**	**Local AS Market Model**	**Shared balancing responsibility model**	**Common TSO-DSO AS market model**	**Integrated flexibility market model**
Domain	**Settlement**	Metered Data Respon-sible (MDR)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)	TSO (Tx) DSO (Dx) CMP (Tx; Dx)

Conclusions and reference to SmartNet

SmartNet has proposed five Coordination Schemes among other to achieve an enhanced operation between TSOs and DSOs. The choice of any particular coordination scheme at any moment in time still allows the possibility to evolve to another coordination scheme in the future. A change from one coordination scheme to another is in principle a question of a change in roles, responsibilities and market design [56].

The major differences between the CSs lie in the market arrangement for the procurement of ancillary/system services. The grid operation, pre-qualification, activation, and settlement processes of flexible resources are similar across the CSs. As defined in the recast regulation on the electricity internal market [5], in the five CS, TSO and DSO are responsible for maintaining the balance of their respective networks. [5] also requires TSOs to procure balancing services and non-frequency ancillary services, in a transparent, non-discriminatory, and market-based procedure. However, the regulation does not specify further how the balancing market shall be organized. There are several ways to organise the market within the regulation.

In the CS "*Centralized AS market model*", the TSO is the buyer of balancing services. But in the other CSs the DSO can also buy balancing services. In one of the schemes, "*Integrated flexibility market*", a Commercial Market Provider can buy balancing services.

EDSO proposes the DSOs as market facilitators. The SmartNet CSs propose different solutions: in the *Centralized AS* market model, the TSO operates the market. In the *Local AS* market, the *Shared balancing responsibility* scheme and in the *Common TSO-DSO AS* market scheme, both the TSOs and DSOs operates the balancing market. In the last CS, the *Integrated flexibility* market model, an Independent Market Operator operates the market. In the "*Shared balancing responsibility model*", balancing responsibilities are divided between TSO and DSO according to a predefined schedule. The DSO organizes a local market to respect the schedule agreed with the TSO while the TSO has no access to resources connected at the distribution grid. Such an organisation of the market means new tasks and responsibilities for the DSO and is not fully in accordance with the present regulation. Furthermore, liquidity may be a challenge in a market limited by a DSO region. As shown in Table 9 "*The Shared balancing responsibility model*" is the only scheme where the DSO is responsible for buying local flexibility for balancing.

Table 9 The role of the DSO in the Coordination Schemes. Source: [52][56].

Coordination scheme	**Role of the DSO**	
Centralized AS market model	• Limited to possible process of prequalification	• Gradual increase of the role of DSO • Increased level of TSO-DSO interaction
Local AS market model	• Organization of local market • Buyer of flexibility for local congestion management • Aggregation of resources to central market	
Shared Balancing Responsibility model	• Organization of local market • Buyer of flexibility for local congestion management and balancing	
Common TSO-DSO AS market model	• Organization of flexibility market in cooperation with TSO • Buyer of flexibility for local congestion management	
Integrated Flexibility market model	• Buyer of flexibility for local congestion management	

Present regulation also states that TSOs & DSOs have joint responsibilities for cooperation with demand service providers and customers, to define technical specifications of demand side participation. This also includes potential engagement from aggregators [5]. The cooperation can be done in many ways, and the regulation does not specify how.

When it comes to present markets/systems, in Spain, pre-qualification is carried out by the TSO (Red Eléctrica de España) [27], [28], while SmartNet recommends the DSO.

3.1.13 Ancillary services considered in the screened documents

In the Directive on common rules for the IEM, the Commission classifies ancillary services (AS) into balancing (frequency related) and non-frequency AS, but not congestion management. The term non-frequency ancillary services is applied for steady-state voltage control, fast reactive current injections, inertia and black start capability [5]. In [6] ancillary services are mentioned without specification, e.g. frequency containment reserves, frequency restoration reserves and replacement reserves. The document refers to the Network codes [15] (Guideline on electricity balancing) and mentions Frequency restoration reserves, frequency containment reserves and replacement reserves.

The ENTSO-E's Research and Development Road Map 2017-2026 [4] mentions faster ramping services, frequency response, inertia response, active and reactive power reserves, flexibility reserves (short-term and long term), voltage control and network restoration. The TSO-DSO data management report [13] mentions Frequency Containment Reserves (FCR), Frequency Restoration Reserves (FRR) and Replacement Reserves (RR). Furthermore, it also mentions fast reserve control, Load-Frequency Control (LFC) and automatic Frequency Restoration Reserves (aFRR). The reference [23] written by Nordic TSOs, mentions the following ancillary services: frequency restoration reserves (FRR), replacement reserves (RR) and frequency containment reserves (FCR).

When it comes to the present position, there is one Spanish document about Automatic Frequency Restoration Reserves (aFRR) [26], one about Replacement Reserves (RR) [27] and one about Voltage control [31]. Voltage control is not an ancillary service based on ENTSO-E definition. Ancillary services mentioned in [37] for Denmark (for DK1 and DK2 zones) are:

- Primary reserves DK1 (FCR)
- aFRR supply ability, DK1+DK2
- Secondary reserve DK1 (aFRR)
- Frequency-controlled normal operation reserve, DK2 (FCR-N)
- Frequency-controlled disturbance reserve, DK2 (FCR-D)
- Manual reserve, DK1+DK2 (mFRR)

3.2 Bidding Layer

3.2.1 Possibility to create “virtual” copperplate bids vs nodal bidding

The Recast IEM Regulation proposal [6] highlights correct locational price signals, which reflect where electricity demand is high, are needed for efficient investments in a zonal electricity system. The process of determining correct locational price signals needs to be transparent. It also requires a reliable and coherent establishment of bidding zones could indicate structural congestions [6]. Structural congestion refers to the predictable congestions in transmission networks, which always occur at the same locations and reoccur frequently under normal network conditions.

In the Spanish electricity system, virtual copperplate bids do not exist [26], [27] and [28]. The programming units, which are defined as the elementary representation units in the Spanish energy markets, allow the integration of individual installations in the Spanish market. One of the functions to be performed by the responsible programming unit is the disaggregation of the assigned schedules into physical generation units. Therefore, the system operator knows the physical units that have been assigned to each operating schedule. In addition, for the provision of this Replacement Reserve (RR) [28], all programming units qualified by the system operator must submit a bid for the whole available RR power, including upward and downward availability, for each programming periods of the following day. The Italian power market is a central dispatch power system. Based on this, the bidding is typically nodal.

Conclusions and reference to SmartNet

In SmartNet, four different aggregation methods are used, one of which is called justified approximation/hybrid approach [49], [62]. The hybrid approach uses a single or limited number of virtual devices to present the aggregated devices. Thus, the number of individual devices is reduced. The approach is used when there is a high number of devices to be aggregated.

3.2.2 Possible bidding negative prices in AS Markets (otherwise RES non-incentivized)

The EU directives or other documents from the Commission., as well as documents from stakeholders do not discus prices for bidding in AS Markets, nor possibilities of the negative price bids.

The exception is Spain [26], [27], where the producer sells energy to the day-ahead market and rebuys it in the balancing markets (downward regulation). In general, the producer pays to the balancing market a price that is lower (but not negative) than the day-ahead market price. Similar definitions of down-regulation are used in Nordic electricity market. Essentially, the producer is motivated to down-regulate as soon as the TSO's offer for the down-regulation is less than the producer's generating cost/loss of subsidies. Furthermore, Italian AS market also does not allow for negative bidding.

3.2.3 Dimension of bidding zones

Bidding zone is the largest geographical area within which market participants are able to exchange energy without capacity allocation. This definition is commonly used and originates from the previous version (2012) of CACM Network Codes (the recent version of the document [7] does not seem to have this definition included). In the scope of the present project, dimension of the bidding zones is important since it should allow the traders to be flexible and support security of operation of the system.

The recast of the Regulation for IEM [6] advocates that the bidding zone borders for capacity allocation should be defined on the basis of long-term congestions in the transmission network, and the zones should not contain structural congestions. Structural congestions refer to the predictable congestions in transmission networks, which always occur at the same locations and reoccur frequently under normal network conditions. In addition, the dimension of each bidding zone should be equal to an imbalance price area. Moreover, the configuration of the bidding zones should also be designed to maximise economic efficiency and cross-border trading opportunities and maintain the security of supply at the same time. The design of bidding zones could help with determining correct locational signals in a zonal electricity system.

The Capacity Allocation & Congestion Management (CACM) Network Guideline [7] highlights that bidding zones must reflect the distribution of supply and demand in order to achieve the full potential of capacity allocation methods. Thus, bidding zones should be defined to ensure efficient congestion management and to guarantee overall market efficiency. The zones can be modified through splitting, merging, or adjusting the zone borders. In addition, the bidding zones should be identical for all market time-frames.

In Spanish electricity system, bids are submitted by the responsible regulation zones, in which programming units are included. The programming units are formed by one or more generation installations that are qualified for service provision. The minimum size of the regulation zones is fixed in 300 MW of installed power. This value could be lower, but must be higher than 200 MW, if the available capacity for regulation is equal to or higher than 75% of the zone size [27]. For the purpose of active participation in the service provision, each generation installation needs to be qualified by the system operator (Red Eléctrica de España) and pass the corresponding tests. Each programming unit must provide a minimum bid capacity of 10 MW [27], [28]. This can be several aggregated installations that belong to the same type of technology, the same programming unit, and the same control centre [28]. In the Nordic countries (ex-NORDEL) the bidding zones are defined by TSOs as a part of managing:

- Major and long-term operational congestions occurring in the regional and central grid system.
- Foreseen energy deficit situations in defined geographical areas.
- In 2018 it was five bidding zones in Norway, four in Sweden, one in Finland and two in Denmark (DK1 area is not synchronous to ex-NORDEL).

Conclusions and reference to SmartNet

The CACM [7] requires that bidding zones reflect on the distribution of supply and demand, in order to allow the full potential of capacity allocation methods. Therefore, the bidding zones need to be designed to ensure efficient congestion management and to guarantee overall market efficiency. The zones can be modified by adjusting the zone borders, e.g. merging or splitting. It should also be identical for all market timeframes.

The recast Electricity Regulation [6] highlights that the bidding zone borders should be defined based on long-term transmission network congestions but should not contain structural congestions. Each bidding zone dimension should be equal to an imbalance price area, and the zones should be defined to maximise economic efficiency and cross-border trading opportunities, as well as to maintain the security of supply. In addition, this configuration of bidding zones could help with the determination of correct locational signals in a zonal electricity system.

In the introductory part in Section 0 it was already mentioned that this issue has very limited relevance for the SmarNet. The SmartNet's market clearing makes nodal prices taking into account the grid constraints. That always ensures efficient congestion management.

3.2.4 Definition of bidding products (complex, integral/mutual exclusion…)

The recent legislative acts, which have been studied in the scope of the present activity do include specifically quantified requirements related to configuration of bids on the balancing markets. In [15] it is, however, mentioned that standard bidding products for balancing energy and balancing capacity should at least include the following characteristics:

- preparation period;
- ramping period;
- full activation time;
- minimum and maximum quantity;
- deactivation period;
- minimum and maximum duration of delivery period;
- validity period;
- mode of activation.

These are not necessarily required, but rather allow for possibilities to develop more complex bids. The same document sets framework for introducing of specific products by each TSO, provided that standard products are insufficient and that the use of these is to be minimised subject to economic efficiency.

When it comes to other requirements, related to configuration of bids, in [6] it is mentioned that balancing energy should be procured separately from balancing capacity and the procurement of upward and downward balancing capacity should be done separately i.e. as separate bids. With relation to DAM and IDM it is mentioned that the minimum bid size should be 1 MW, but this does not necessarily bring any immediate implications to configuration of bids on the balancing market.

There is no explicit mentioning of design for the bids on the stakeholder side either. ENTSO-E in [22] hints that the bidding process should fulfil needs for both distribution and transmission networks and that network operators could select bids based on their compliance with restrictions/network limitations so that security criteria is ensured. WindEurope in [14] points out that configuration of bids should allow products to be adapted to different technologies entering the mix e.g. products with short duration, lead delivery tie and higher granularity. The latter is a measure that reduces market discrimination or said differently improves market participation and hence, liquidity. This, in fact complies with the above-mentioned requirement from the Commission.

The present practice at balancing market in Spain [26], [27] is prevailing simple bids, however the thermal groups can submit complex bids although. this contradicts the present intention for non-discrimination of specific technologies. Requirements for regulating power market in Nordic countries define simple bids with minimum duration of one hour and minimum bid size of 10 MW.

Conclusions and reference to SmartNet

Introduction of complex bids in SmartNet was intended to support involvement of different DER technologies into provision of ancillary services and thus increase the overall liquidity of the market. Regarding bids defined and proposed in SmartNet, the above-mentioned requirements, especially in [15] do not necessarily support introduction of complex bids. At the very same time it allows introducing new type of bids by TSOs. It can be however a challenge to elevate bids, proposed by SmartNet to a level of so-called "standard products", as it is required by ENTSO-E.

3.2.5 Incentivisation mechanisms for RES vs price revelation in AS Market

The Clean Energy for All Europeans [8] emphasizes that the regulatory framework should ensure participation of RES in market in a transparent and non-discriminatory way. It also mentions the need to develop shorter term trading in the wholesale market, as the close to real time trading will reward flexibility for generation (including RES (Renewable Energy Resource)), demand, or storage. Furthermore, priority dispatch will still apply to existing small-scale renewable generation, and the curtailment of renewable power should be kept to a minimum level. To cover high capital costs of renewables and to minimise market distortion, the renewables directive contains principles that support renewables after 2020 by ensuring subsidies.

The recast of Electricity Regulation [6] therefore promotes:

- reducing market barriers for RES participation (by lowering the bid size)

It is proposed in [6] that small bid sizes with a minimum size of 1MW or less should be allowed to trade in day-ahead and intraday markets, with the objective to achieve effective participation of Demand Side Responses (DSR), small-scale renewables and energy storage. These measures are expected to decrease the system operation costs and increase the level of integration for renewable generation.

- priority of dispatch for RES and high-efficiency technologies below a threshold (capacity)

It is also highlighted in [6] that TSOs should give priority to Renewable Energy Resource (RES) or high-efficiency cogeneration with a generation capacity lower than 500 kW, when dispatching electricity generation installations. If the installed generation capacity for priority dispatching is higher than 15% of the total installed capacity, RES or high-efficiency cogeneration less than 250 kW will be dispatched first. From 2026, the priority will apply for RES or high-efficiency cogeneration less than 250 kW, and it will be 125 kW if the penetration is larger than 15%. In any case, priority dispatch should not impact the security of supply (i.e. no supply interruptions).

- optimal redispatching and curtailment of RES and high efficiency technologies

When it comes to redispatching and curtailment, the Recast Electricity Regulation [6] advocates TSOs and DSOs to take appropriate measures and guarantee optimal curtailment and downward redispatching of RES and high-efficiency cogeneration. For instance, it is recommended in [6] that redispatching and curtailment of RES and high efficiency cogenerations should not exceed 5% of the installed (RES and high efficiency cogenerations) capacity.

The 2030 Energy Strategy [1] mentions that although subsidies for energy technologies, including RES, distorts markets, they are still needed for 1) mature technologies, subsidies will be phased out by 2030; and 2) for new and developing technologies which could contribute to RES penetration.

WindEurope [14] proposes that wind power producers should have non-discriminatory access to balancing and ancillary services markets, and system operators should procure technology-neutral services regardless of the technology used. WindEurope [14] also advocates the need of new connection approaches to allow flexible connections and to achieve economic efficient network operation. Moreover, it lists options to reduce the risk of curtailment of DGs and flexible connections (including renewables and energy storage). The options are 1) introduction of market mechanisms to reduce curtailment cost, 2) introduction of caps to limit the risk of curtailment, 3) compensation for the lost revenue due to curtailment, and 4) more transparent data regarding curtailment and redispatching activities.

ENTSO-E in a working paper [22] promotes that suitable products should be defined by TSOs and DSOs jointly, considering both system operators' needs and flexibility providers' interests. ENTSO-E also advocates [22] that the solutions for using distributed flexibilities (including renewables) should be consistent with EU market design principles and be guided by economic efficiency principles at an early stage. Distributed flexibilities should not cause market fragmentation and competition distortion, while respecting neutrality, confidentiality, and transparency. In addition, the use of distributed flexibility should align with the security criteria in the system.

In Spanish electricity system [26], [27], [28] currently, new RES generation units can either be installed without any subsidies or bid into the auctions organised by the government. Periodically, the government opens an auction, where the amount of capacity to be installed is fixed. RES promoters bid for the subsidies they want to receive. The last auction was held in July 2017, and the resulting price was zero. Therefore, the assigned project will not receive public support. Despite this, the assigned promotions are guaranteed at a minimum price in the pool market considering market oscillations. A new Feed-In Tariff (FIT) was introduced in 2007. Specifically, the regulated price to be received by PV for each kWh produced was very high. This motivated a massive deployment of this kind of installations. Thus, the mechanism had to be modified for new installations in 2008. This leads to only installations executed until that moment having the right to receive such a high remuneration. In 2012, the subsidies were removed for new installations. Finally, in 2013, the retributions still in force was modified and a new concept of reasonable profitability was introduced.

In Denmark RES generation has several technology-dependent support schemes [53]:

- loan guarantees: Energinet.dk guarantees the loans before constructing wind power plant
- net metering: Net metering plants are exempt from paying the public service obligation or part of it

- Feed-in premium tariff: Electricity generated from renewable energy is paid through premium tariff, which includes a bonus payment

In Norway, grid operators are required to connect renewable energy without discrimination. A quota system is used to incentivise renewable introduction. The system includes a certificate trading system, in which grid operators prove the percentage of supplied energy is generated from renewable energy.

Conclusions and reference to SmartNet

The SmartNet bids should include information on if they are representing renewable energy or high efficiency co-generation. When there is no preference between two bids, if both represents renewable energy, the one represents high efficiency co-generation is preferred. Since renewable energy and high efficiency co-generation are distinguished from other resources. This enables higher penetration of renewable and high efficiency co-generation.

3.2.6 Minimum bid size and resolution

The considered documents from European Parliament and the Council do not mention minimum bid size for ancillary services. The recast of Regulation documents [6] mentions minimum bids sizes for day-ahead markets and intraday markets.

According to WindEurope [42] the Balancing Guideline foresees movement towards smaller balancing products (1 MW for mFRR vs currently typically 5MW). It should also be mentioned that WindEurope argues in [42] for aggregation of smaller units offering balancing services, rather than reduction of the minimum bid size, as aggregated forecasts are more accurate, leading to a more reliable participation of wind power in balancing markets.

According to [23], currently the mFRR (manual Frequency Restoration Reserves) minimum bid size limit is 10 MW in Norway/Denmark/ most areas in Sweden., while the mFRR minimum bid size is 5 MW in Finland. Similarly, the minimum bid size for aFRR in Spain is 10 MW [27].

Conclusions and reference to SmartNet

In local markets it is necessary to have small size bids and resolution in order to enable adequate liquidity. SmartNet does not limit the minimum bid size, nor the optimal resolution (it is parameterized), however during the course of the project it was decided that bids below 1 kW should not be forwarded to the market. It also necessary to keep in mind that in SmartNet the bidding happens per Each node. The Italian case, for example, includes approximately 10 000 nodes in the network. This value differs significantly from the above-mentioned requirement of 1 MW and one can conclude that nodal architecture allows to introduce lower bids, which should enhance liquidity of the market and support participation from RES.

3.3 The Physical Layer

3.3.1 Prioritisation of control traffic (support for network slicing)

The Regulation of Open Access to Internet [19] stipulates that traffic management needed to enable, for example, the low latency high reliability multicasting of small real time control signals needed by the distributed ancillary services (AS) will be allowed as long as it does not reduce the quality of the normal Internet access of the end users.

The BEREC guidelines [20] clarify the interpretation of the above-mentioned regulation [19]. The clarifications are in line with the assumption that traffic management needed to enable the low latency transmission of small real time control signals will be allowed as long as it does not reduce the quality of the normal Internet access of the end users and network capacity is assured. The provision of special services, including communication for power grid automation and ancillary services, is subject to a number of conditions, namely i) the network capacity is sufficient to provide the specialized service in addition to any Internet Access Service (IAS) provided, ii) specialized services are not usable or offered as a replacement for IAS, iii) specialized services are not to the detriment of the availability or general quality of the IAS for end-users.

The SmartNet concept requires that the control signals are always very reliably transmitted to the DER in less than 0,5 - 1 minute. That is why it is necessary to have prioritisation, if Internet access connections are used for the purpose. The interpretation of "specialized services" will have impact on implementations of SmartNet control traffic by allowing the new network slicing methodology in software defined networking.

3.3.2 Responsibilities and ownership of components and data

The TSO-DSO data management report [13] discusses different concerns from DSOs and TSOs. DSOs are concerned about possible misalignment of actions between TSOs, DSOs, and other market players, which could lead to a loss of control of the distribution grid and drive inefficient grid expansion. On the other hand, TSOs are more concerned with their ability to perform efficient balancing of the overall electricity system, to ensure security of supply and fair market functioning. Also, TSOs and DSOs have different visions on balancing actions:

- DSOs' position is that certain balancing actions could be delegated to them to procure balancing services on their network as a subsidiary activity to support TSOs
- TSOs' position is that balancing actions should be managed on a wider scale, as local balancing cannot ensure an overall optimisation.

As for the new legislative definitions (not fully implemented yet), such as the Directives, Network Codes and similar, the recast Electricity Directive [5] states that 'eligible parties' (defined as customers, suppliers, TSOs and DSOs, aggregators, energy service companies, and other parties which provide energy or other services to customers) may have access to data of the final customer with their explicit consent. The data can include metering data, consumption data, and data required for consumer switching. Access to this data should not carry any additional costs to end customers, and regulated entities should not profit from providing data services. The data management model should be independent of that applied in each member state and ensure equal access. To ensure equal access, DSOs shall have specific measures to exclude discriminatory access to data from eligible parties. DSOs also need to comply with unbundling conditions when involved in data management of smart metres. TSOs are responsible to provide sufficient information to the operator of an interconnected system.

It is defined in the recast Electricity Regulation [6] that TSOs are responsible for publishing relevant real and forecasted data. For example, estimated available transfer capacity of each day, actual and forecasted demand, etc. Moreover, TSOs and DSOs need to exchange necessary information and data regarding the performance of generation assets and Demand Side Response (DSR) participants, the daily operation of their networks, and the long-term plan of network investments. Both TSOs and DSOs need to ensure cost-efficient network development whilst maintaining a secure and reliable network.

The EDSO position paper [10] promotes DSOs as Data Manager (DM) to access and handle necessary data. It is recommended that DSOs have access to data needed to fulfil their obligations (e.g. Neutral Market Facilitator (NMF) and grid operation), and ii) assess the common European data format based on the cost and benefit, or alternatively limit it to a common "minimum content". DSOs also require being fully involved in the smart metre developing processes and in the administration of the measured data. On the collaboration between TSOs and DSOs, EDSO requests that data transfer between TSO and DSO conform to subsidiarity and communication cascade. The communication cascade principle assigns all data and control flows to the connecting grid operator.

The joint DSO responses [11] states that network operators own the data related to their systems. Based on the consultation results, DSOs have the willingness to exchange data and limit the data to a minimum content. For example, if the DSOs network data is critical for the provision of fundamental services, an equivalent or simplified network model is needed. Furthermore, DSOs argue that Common Grid Model (CGM) should not be kept confidential but made transparent.

The TSO-DSO data management report [13] discusses that each system operator (TSOs and DSOs) is responsible for its own IT system and data communication networks, organised by the system operator, as long as the highest security of supply standard is guaranteed. DSOs are responsible to provide relevant data to TSOs for grid operation, in the case when TSOs require data from a user connected at the distribution network and the data is related to technical needs or specific ancillary service product. Different options proposed in the report: i) TSOs access the required data from a DSO connected grid user through an aggregator/BSP (Balancing Service Provider); ii) DSOs pass the required data to TSOs; or iii) TSOs access the required data via a direct technical solution.

ENTSO-E [18] proposes options for TSOs for accessing data related to users connected to the distribution network, the options are i) via the respective aggregator or BSP; ii) via the connecting DSOs; or iii) directly via the grid user for specific needs. It is also emphasised by ENTSO-E that using 2 out of 3 options may create redundancy.

CEER position paper [25] suggests that TSOs and DSOs should not only share information and consult with each other, but also share information with the market and consult with other market participants, to achieve better network management.

USEF [36] discusses a Meter Data Company (MDC) role, who is responsible for collecting, modifying, and distributing data to eligible parties (e.g. DSO) for calculation and/or verification processes. It also proposes different methods for data collection, including i) aggregator collects data and shares the data with MDC or MDC has access to sub-meters, if the sub-meters are installed by aggregators; ii) aggregator has access to sub-meters, if they are installed by MDC. In addition, the USEF work recommends aggregators share basic technical information (e.g. available power, ramping rates, type of flexibility services) to the connecting TSOs and DSOs, after signing a contract with a prosumer.

Conclusions and reference to SmartNet

The Table 5 has previously summarized grid operation roles, including SO, system balancing responsible party, and data manager, for each SmartNet coordination scheme. Each network operator manages its own data. For the purpose of network balancing and congestion management, relevant data may need to be available and communicated between TSO and its connecting DSO.

3.3.3 Energy supply for communication and ICT components

Electricity supply is not included in the scope of the existing European network codes that set controllability requirements for demand [44] and for generation [45]. Based on the draft standards considered in IEC TC8 [21] this may change in the future.

3.3.4 Remote controllability of DER

The ENTSO-E Network Codes and the related European (EN) and other draft standards considered in IEC TC8 [21] set requirements for remote controllability of Distributed Energy Resources (DERs). To fulfil the target of high penetrations of remotely controllable DERs in 2030, the requirements must be implemented within the next few years. Only the new DERs will be required to meet the new codes. There must be a long transition time (approx. 10-15 years) for the existing DERs. The requirements are being developed now in order to give a more accurate view of situation in 2030. It is also obvious in [21] that the existing controllability and remote control interface requirements are very likely to gradually extend to smaller units. Eventually, all inverter-based grid connections of significant size may be included.

Requirements for remote controllability for Virtual Power Plants (VPPs) are included in the Electric Vehicle (EV) to grid communication related draft ISO 15118 standard [46].

The new grid connection codes [44], [45] in Europe require remote controllability by DSOs for all generators and electricity storages that are type B or above. The sizes of the types vary from country to country. In central Europe, type B means all units that have at least 1 MW peak power. Type A refers to all units that are smaller than type B with a minimum size of 0.8 kW. For type A units, it requires control functions, but remote control interface is not necessary. Extending the control interface requirement to type A in a reasonable long transition time (roughly the normal lifetime of the equipment, which is 10 -15 years) would reduce the implementation costs of Demand Response (DR) services.

In addition, it is necessary to define adequate requirements for the measurement and control dynamics (e.g. response duration, reliability, and immunity to disturbances) of DER technologies in the grid connection codes, preferably via standardisation. Otherwise, the risks and costs of engaging the functionalities for ancillary service provision may be too high. Standardisation would also reduce the implementation costs of distributed flexibility and ancillary services, if the grid connection codes require communication interfaces with a common data structure and communication protocol. Therefore, DERs must provide services to the DSO or the VPP using remote control signals. Moreover, the EV related standard ISO 15118 [46] should use the same communication protocols as the rest of DER remote control automation, for communicating with the VPP.

The present situation in EU is that voltage droops are not required, and the frequency droop requirement does not apply to electric energy storage nor Electric Vehicles (EV). The requirement for the frequency droop control is in The Network Code on Requirements for Generators [45]. The Network Code for Demand Connection [44] does not include such requirements.

In the draft standards (such as prEN 50549 [47]) considered in the IEC TC8 there are requirements for both frequency and voltage droops for Distributed Generation (DG), electricity storage, microgrids and electric vehicles for type A and bigger, and remote controllability by DSO for type B and bigger. In the future, such requirements are likely to appear also in the European grid connection codes for DER. The draft standards do not yet include such requirements for loads although there are reasons to do that, too.

The joint DSO reply [11] states that DSOs agree with exchanging network information aimed at making TSOs aware of the amount of flexibility that can be guaranteed from DERs. WindEurope [14] suggests active power management (upward or downward dispatching) of distributed wind generators can be realised through the generators by following signals from the market and/or System Operator (SO), or through activating by the SO directly. In addition, ENTSO-E [22] recommends that each SO (not only the connecting SO) has direct access to Distributed Flexibility Resource (DFR) technically (direct activation) and contractually (direct bid submission and settlement). In addition, ENTSO-E proposes to avoid implementations where DSOs act as the interface of DFR to TSOs.

The USEF [36] introduces possible aggregation models. Based on the document, although not explicitly discussed in [36], one can infer that the control responsibility of the flexible asset is done by the aggregator. However, since the prosumer has the final control over its assets, aggregator's control needs to satisfy prosumer's comfort level. This is expected to vary according to the targeted services. It [36] also assumes a standardised setup and interface between the aggregator, the prosumers, and DERs (defined as active demand & supply in [36]), to ensure low cost to connect and to serve.

In Spanish electricity system [31], installations of renewable resources, cogeneration, and waste with power higher than 5 MW, or a group whose total power is larger than 5 MW, must be assigned to a generation control centre. This will be the interlocutor with the SO (Red Eléctrica de España), who sends the installations information in real time and executes convenient instructions, in order to guarantee the electrical system reliability. Installations with power higher than 1 MW, or a group with a total power larger than 1 MW, must send tele-measurements in real time to the SO. The tele-measurements can be sent by the installation owner, its legal representative, or through the distribution company control centre. The DSOs will have access to the real time tele-measurements of the installations connected to their respective networks. The costs of the control centre installation and maintenance, including installation and maintenance of communication channels with the SO, will be borne by the generators assigned to it.

Conclusions and reference to SmartNet

Remote controllability of DER is an important enabling technology supporting involvement of DER in provision of ancillary services. It is particularly important for implementation of outcomes from SmartNet project since it is supports submission of small and complex bids. The screening study indicates that requirements for remote controllability for generators and storages for type B and above are already stipulated in the grid connection codes. The remote control interface for type A is still not necessary. It is clear that establishing of infrastructure for controllability of smaller units will require substantial capital expenditures. Therefore, extension of the control interface requirement to smaller units (type A) would reduce the overall implementation costs of Demand Response (DR) services.

If the grid connection requirements will be extended to cover different types of DER and smaller DER in the future, abundant flexibility becomes ubiquitously available for the distributed provision of ancillary services. That could mitigate or even remove the liquidity problems related to local distributed markets, if the markets are designed accordingly. That would also increase the relevance of the market architectures developed and compared in SmartNet.

3.4 Summary of the findings from the screening

This section summarises the results from the above review of EU legislation relevant for topics of interest identified in the SmartNet project and described in Section 2.1.

3.4.1 Market layer

- In the issue related to priority of doing local congestion management by DSO vs centralized TSO market: neither the Commission nor the CEER do express any clear position about market solutions. There are, however, very several clear preferences from the stakeholders. It appears that mechanisms for the procurement of flexibility (either via common procurement or via market at each grid level) and the framework (since DSOs are regulated entities) for the recognition of costs is still missing.
- Prequalification of resources in distribution networks: screening indicates two main topics of the discussion: i) Which actor (-s)/role (-s) should be involved into the pre-qualification process i.e. TSO, DSO individually or in coordinated manner or aggregator ii) What should be the qualification level i.e. individual or portfolio. Recast of the Regulation of the European Parliament and the Council on the internal market for electricity makes a general definition of prequalification. It also stipulates that the procurement shall be organised in a non-discriminatory way between market participants in the prequalification process, either individually or through aggregation. Guideline on electricity defines that each balancing service provider intending to provide service, should pass the qualification process defined by TSO and if necessary, by DSO.
- Operation of possible local market (single DSO vs common distribution Market Operator): recast of the Directive on common rules for the internal market in electricity only advocates that regulatory framework in the Member States should give incentives to DSOs to use flexibility services to improve operational efficiency and distribution network development, e.g. congestion management at distribution level. The same document also recommend that DSOs shall procure flexibility services via market-based solutions.
- Relationship with previous markets including GCTs: the only requirement for this in present legislative documents is that the participants in the balancing markets shall be allowed to bid as close to real-time as possible and at last after the intraday gate closure.

3.4.2 Bidding layer

- Possibility to create "virtual" copperplate bids versus nodal bidding: the regulation focuses on correct local price signals and transparency in the process of determining the locational signal. The review did not identify any legislation about copperplate versus nodal bidding.
- Definition of bidding products: the legislative acts do not require but open the possibility to develop complicated bids.
- Minimum bid size and resolution: Currently, in practice the size of minimum bid is between 5-10MW, but a movement towards smaller balancing products (1 MW for mFRR vs currently typically 5MW) can be expected

- Incentivisation mechanism for RES vs price revelation: while in most national markets there are legacy Incentivisation mechanisms for RES, there is longer term strategy to apply this only to smaller installation or less mature technologies. It is argued that larger installations of mature technologies should participate in the markets and phasing out of their subsidies is planned by 2030.

3.4.3 Physical layer:

- Prioritisation of control traffic: the SmartNet concept requires that the control signals are always very reliable transmitted to the Distributed Energy Resource in less than 0.5-1 minute. There is no regulation ensuring this requirement. The regulation is the other way around: traffic management need to allow low latency transmission of small real time control signals will be allowed as long as it does not reduce the quality of normal internet access of the end users.
- Responsibility and ownership of components and data: the recast electricity Directive states that "eligible parties" (defined as customers, suppliers, TSOs and DSOs, aggregators, energy service companies etc) may have access to data of the final customer with their explicit consent. The review did not identify any legislation about ownership of components.
- Remote controllability of Distributed Energy Resources: The Network Guidelines [44] and [45] require remote controllability by DSO for all new generators and electricity storage that are of type B and above. In Central Europe, type B means all units that have at least 1 MW peak power. For other parts of Europe, the size of type B varies from country to country. In addition, it is necessary to define adequate requirements for the measurements and control dynamics (e.g. response duration, reliability and immunity to disturbances) of Distributed Energy Resources. The present situation in EU is such that voltage droops are not required, and the frequency droops requirement does not apply to electric energy storage nor electric vehicles.

The following topics are covered in the present or proposed European legislation:

- Market layer: Market session timeline, Nodal market vs zonal, Management of voltage constraints, Availability of reserve capacity, Pay-as-bid vs pay-as-clear, Optimisation criterion for electricity market design - maximisation of social welfare vs minimum activation costs,
- Bidding layer: Dimension of bidding zone.

4 Conclusions

The “recast for Directive of the European Parliament and of the Council on common rules for the internal market in electricity" [5] writes in its introduction:

> “Short-term electricity markets which allow trading RES-E across borders are key for successful integration of RES-E into the market…… The creation of markets which allow participation at short notice before actual delivery (so-called "intraday" or "balancing" markets) are a crucial step to enable RES-E producers to sell their energy at fair terms and it will also increase liquidity in the market. Short-term markets will provide new business opportunities for participants to offer "back-up" energy solutions at times of high demand and scarce renewable generation. This includes the possibility for consumers to shift their demand ("demand response"), storage operators or flexible generators. While dealing with variability in small regions can be very expensive, aggregation of variable production over larger areas could help consumers save significant amounts of money. Yet, integrated short-term markets are still missing.”

The project SmartNet aims at providing market, data exchange and ICT architectures for optimized interaction between TSOs and DSOs for the acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management).

The SmartNet project proposes five coordination schemes:

- Centralized AS market
- Local AS market
- Shared balancing responsibility
- Common TSO-DSO AS market
- Integrated flexibility market.

The schemes are briefly explained in Section 1.1.1, while more detailed explanation can be found in [50]. The different coordination schemes all have specific benefits and attention points related to the TSO grid operation, the DSO grid operation, other market participants and the functioning of the market in general.

This deliverable makes a comprehensive screening of the present and proposed regulation with respect to key regulatory issues of interest for SmartNet. The investigated topics are structured into three categories: market, bidding and dispatch and physical, called "layers" in SmartNet. For each of these categories, a number of specific topics are identified and investigated. For more detailed explanation of the topics, see Section 2.1. The documents considered in this report have been issued by several types of stakeholders including:

- Governmental Organisations (European Commission, Governments)
- Organisations working with different aspects of Regulation and Standardisation (Regulators, CEER, ENTSO-E, IEC etc)

- Interest organisations as Industrial Associations and similar (ENTSO-E, EDS4SG, WindEurope, Energy Network Association)
- Other (ETIP-SNET, USEF)

The following Table 10 shows some results and conclusions derived from this documents screening.

Table 10 Summary of the screening study

Layer	Topic of interest	Conclusion
Market layer	Market sessions timeline	Need for an overall harmonisation process across Europe. Energy to be traded in periods, which are at least as short as imbalance settlement (requirement of 15 min from 2025-01-01). The trade should be moved as close as possible to operation. Non-discriminatory access to the markets and creation of level-playing field.
	Nodal market vs. zonal	Zonal organisation is the preferred model in Europe. The nodal pricing model allows incorporating bottlenecks into the pricing. This type of organization has been successfully applied at several markets in USA.
	Local congestion management by DSOs vs centralized TSO market	DSOs and TSOs to be responsible for handling congestion in their respective grids. Balancing remains under TSOs responsibility. Rules for use of flexibility resources across grids need coordination with a clear framework. Centralised TSO market for procurement of resources is expected to have higher efficiency and liquidity, but an extension to distribution could prove computationally challenging. Local markets could, by contrast be illiquid and prone to exercise of market power.
	Prequalification of resources in distribution networks	Prevailing position is that the "static" prequalification process in the distribution network should be replaced by a coordinated TSO and DSO process.
	Inclusion of constraints (device-related) from distribution grid bidders	No present legal requirements for inclusion of device-related constraints. Proposal for inclusion of certain requirements on portfolio-level are advanced by stakeholders.
	Operation of possible local	Several key stakeholders including ENTSO-E support creation of a single market place for balancing and solving

	market	congestions, with that meaning that the different markets (and their relevant responsible) should work in a shared database in order to avoid double awarding of the same bid.
	Management of voltage constraints	Voltage control is formally defined as non-frequency ancillary service and thus shall be allowed to be procured by DSOs in market-based manner (both active and reactive power can be used for voltage control). According to common report TSOs and DSOs should agree on voltage control parameters at the border of the networks.
	Availability of reserve capacity	Legal requirements requesting separate procurement of balancing energy and capacity, separate procurement of up- and down regulation capacity. At present TSOs are responsible for conducting optimal reserve capacity provision through market-based methods (FRR+RR), short term.
	Relationship with previous markets	In the recent European legislative documents [6]" the market participants shall be allowed to bid into balancing markets as close to real time operation as possible, and at least after the intraday cross-zonal gate closure time - at most 1 hour before the delivery", which means even shorter terms
	Pay-as-bid vs. pay-as-clear	EU legislation and guidelines suggest using pay-as-clear pricing model. However, several EU countries are presently still adopting pay-as-bid.
	Optimisation criterion for electricity market design – maximization of social welfare vs. minimum activation costs	Maximisation of the social welfare prevails even if some present real time markets, by contrast, minimize purchase costs of the needed services.
	Roles and Responsibilities in the context of the prequalification, procurement, activation and settlement of AS markets including observability	Gradual evolving of roles and responsibilities, especially for DSOs, towards more active role. This for example includes managing the local flexibility resources to improve operational efficiency (voltage regulation) and solve local congestion. However, balancing market responsibility will stay in TSO hands as stated by the Clean Energy for all

		European package.
Bidding layer	Ancillary services considered in the screened documents	According to the EU Directive on common rules for IEM [5] "...ancillary service' means a service necessary for the operation of a transmission or distribution system including balancing and non-frequency ancillary services but not congestion management".
	Possibility to create "virtual" copperplate bids vs nodal bidding	The recast IEM regulation proposal (Clean Energy for all European package) highlights locational price signals, which are needed for efficient investment into zonal electricity model. No other information was found in the screened documents. Copperplate bidding favours trading whereas nodal bidding provides a more transparent dispatch, with less request of activating countertrade by the TSO.
	Possibility for bidding negative prices in AS Markets	This is issue is not directly discussed on the screened documents. However, the tendency in energy markets is everywhere to enable negative prices to give signals also in case of excess of resources.
	Dimensioning of bidding zones	Recast of Regulation for IEM defines that the bidding zone should be defined on the basis of long-term congestions in the transmission network, and the zones should not have structural congestions. The zones can be modified (splitting, merging and adjusting) but should be the same for all market time frames.
	Incentivisation mechanisms for RES vs price revelation in AS Market	It is argued that larger installations of mature technologies should participate in the markets and phasing out of their subsidies is planned by 2030.
	Minimum bid size and resolution	The screened legal documents do not define min size for the bids. Several stakeholders favour allowing smaller bids for supporting participation of RES in the ancillary services. The issue is to what extent this should be supported by a decrease of the minimum market threshold or rather by the set-up of aggregators for the small DER resources.
P h	Prioritisation of control traffic	Regulation of Open Access to Internet allows traffic

	(support for network slicing) - how prioritisation for ICT control traffic for energy system management is ensured so to guarantee secure system operation.	management for control signals needed for distributed ancillary services as long as this does not reduce quality for other end-users. Otherwise, provision of these services is a subject to a number of conditions.
	Responsibilities and ownership of components and data	New tasks and responsibilities require changes in the rules for data sharing among key market actors. However, an increase of data sharing is the natural consequence of increased coordination needs between TSO, DSO and the other market subjects.
	Energy supply for communication and ICT components (how to ensure sufficient power backup for ICT)	The issue was not covered in the screened documents
	Remote controllability of DER	The new Codes and draft standards define requirements for remote controllability of DER (new units above 1 MW). It is expected that these requirements will be extended towards smaller units.

A general conclusion from the review is that EU regulations are not directly addressing several of the topics identified by SmartNet, i.e. crucial topics for large-scale utilisation of Distributed Energy Resources in ancillary services, as for example timing of the markets. Without common EU regulations different solutions will develop in the distribution areas, the most diverse and non-harmonized solutions will be implemented in agreement between DSOs and adjoining TSO (e.g. nation- or region-wise under influence of TSO). This will not necessarily hamper the utilisation of local flexibility in the transmission grids, but it will certainly make more difficult the development towards cross-border utilisation of distributed energy resources

The present and proposed European regulation points to the Members States for providing relevant framework, e.g. in "The recast for Directive of the European Parliament and of the Council on common rules for the internal market in electricity"[6]:

> Member States shall provide the necessary framework to allow and incentivise distribution system operators to procure services in order to improve efficiency in the operation and development of the distribution system, including local congestion management. In particular,

regulatory framework shall enable distribution system operators to procure services from resources such as distributed generation, demand response and storage……

Furthermore, the same document requires that transmission system operators shall cooperate with others, e.g.:

- In procuring ancillary services from market participants to ensure operational security, the transmission system operator shall …. and cooperate as necessary with neighbouring transmission system operators
- The transmission system operator shall ensure that the procurement of balancing services and …. non-frequency ancillary services ensure efficient participation of all market participants including renewable energy sources, demand response, energy storage facilities and aggregators, in particular by requiring regulatory authorities and transmission operators in close cooperation with all market participant, to define technical modalities for participation in these markets ……

The decision shall be done by each Member State and each regulator and in cooperation between transmission system operators. Without more common and comprehensive basis of EU regulation, a number of non-harmonized solutions will develop, and this will delay if not completely hamper the development of an internal European market related to ancillary services. Aggregators that wants to act on markets in several countries will have to adapt to different solution.

This includes the latest "Recast for Regulation of the European Parliament and of the council on the internal market for electricity" [6] defining principles for setting bidding zones presuming that zonal organisation is the agreed and preferred model. SmartNet argument for selection of nodal market organisation is that grid constraints will be considered during the market clearing process.

When it comes to the stakeholders' opinions, currently the situation is that ENTSO-E suggests that all congestion management needs, both for TSOs and DSOs, should be fulfilled by a common bid submission process from providers of distributed flexibility resources [18] in document "Distributed Flexibility and the value of TSO/DSO cooperation". A common process will among other ensure liquidity of the market [18]. ENTSO-E supports a common centralized solution for three system and grid services:

- For electricity balancing from Frequency Restoration Reserves and Replacement Reserves.
- For internal or cross-border congestion management in the transmission network
- For congestion management in the distribution network

Disregarding the selected approach (centralised or not) it is advised by ENTSO-E [18] that the market design should allow both DSOs and TSOs to set limitations and to activate flexibility resources based on the connection point of the resource as it is advised by ENTSO-E.

On the other hand "TSO-DSO data management report[4]" [13] mentions different points of attention coming from DSOs and TSOs, where DSOs are essentially concerned about possible misalignments of actions between TSOs, DSOs and other market players, which could lead to loss of control over the distribution grid and drive inefficient grid expansion. DSOs think that certain balancing actions could be delegated to them to procure balancing services on their network as a subsidiary activity to support TSOs (see page 15 in [13]).

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6 Appendix

6.1 Overview of the studied documents (summaries)

Document: 01. 2030 Energy Strategy
The 2030 energy strategy documents set out the EU-wide climate and energy objectives and targets to be achieved by 2030, provide and discuss policy framework to achieve them, and provide key indicators that will be used to measure the progress. Two documents for the website have been looked at for the SmartNet (others related to efficiency were omitted).

Doc 1a: A policy framework for climate and energy in the period from 2020 to 2030
Main objectives of the EU policy framework include:

- greenhouse gas emission reduction,
- improved competition and integration of internal energy market
- improving energy security through integrated markets, integration of renewables, infrastructure investments, energy savings improvement and research and innovation
- flexibility on the national level to develop best national plans to achieve common EU goal, while strengthening cooperation among Member States

Key elements of the policy framework based on experiences form the implementation of the current framework include:

- possible re-evaluation of the GHG targets and reforming of the Emission Trading System,
- further strengthening of competitive internal energy market,
- ensuring availability of affordable energy to customers on competitive bases,
- maintaining security of energy supply by facilitating the transformation of energy cross-border interconnections, storage potential and smart grids to manage demand,
- improving energy efficiency.

Main relevance for the SmartNet: emphasis of the framework on integration of renewables, competitiveness of energy markets, flexibility of national plans to choose best course of action, emphasis on customers' choice of energy supplier and ability to produce, role of Smart Grids to help achieve sustainable energy systems, encouraging R&I and new technology solutions, as well as new approaches to state aid for new technology but with a need not to distort competition.

Doc1b: Impact Assessment
The impact analysis document looks into potential scenarios under the proposed policy framework, therefore, benefits of meeting the 2030 energy strategy are analysed based on results obtained from modelling the scenarios. This is a supporting document for targets discussed in Doc 1a, and it is not of an interest for analysis in T6.2
The 2030 energy strategy documents outline problems that the energy system will face, considering the current progress towards the 2020 targets. Four major general challenges that the 2030 framework aims to address is emphasised, which are greenhouse gas reduction, medium to long-term security of supply, balancing between long investment cycle in energy infrastructure and utilisation of current facilities, and a more sustainable and economical energy system. To address these problems, the 2030 climate and energy targets are set out. Since the series of the 2030 energy strategy documents provide general energy system guidelines for the period between 2020 and 2030, the outcomes of SmartNet project are relevant for the progress on the climate and energy 2030 targets.

Document: 02. Energy Roadmap 2050
It is a Low-Carbon economy roadmap of 2050, which studies the main challenges to achieve the EU decarbonization objective of 2050, meanwhile keeping the energy supply competitive and secure.

It states that to make this energy system transition possible and the main target achievable, the EU needs to take urgent actions already today. Decisions being taken today are already shaping the energy system of 2050.
It distinguishes ten challenges/conditions/steps which should be met to achieve this new energy system transition and hit the desired target of decarbonization.

- Prioritize the fully implementation of EU Energy 2020 strategy
- To be more energy efficient in all aspects/layers
- Continuous increase in RES (Renewable Energy Sources), first achieving the 20 % renewable energy target for 2030
- Technological innovation
- Well-designed energy market which allows new ways of cooperation
- New investment will be needed throughout the energy system
- Collective responsibility
- Safety and security should be respected
- More coordinated international energy relation
- Member-States and investors need concrete milestones

Document: 03. Final 10-year ETIP SNET R&I roadmap covering 2017-26
The Research Innovation Roadmap (RIR) of ETIP SNET is constructed with three main building blocks. The first building block is a mapping of the main guidelines of the EU climate and Energy Union policies: this analysis yields a set of impacts of these policies on the future energy system, with a focus on the power system for the decade to come. The impacts are then translated into the main and most probable evolutions of the power system in the decade to come, as a result of the "policy push" framework. These evolutions are listed in terms of issues related to generation, loads, network infrastructures, digitalisation of the network, cooperation between network operators, technologies, integration within the energy system and market.
The second building block is the definition of the future challenges for the network operators as a result of the evolutions of the power system. Four major challenges mentioned in the report are:

- More intermittent generation
- New loads
- Integration of the pan-European electricity network
- Internal energy market

The third building block is a mapping between the future challenges to be addressed by network operators, together with the other stakeholders of the power (energy) system, and the structure of the RIR.
The document does not provide direct answers, but rather points out the key areas for the future R&I.

Document: 04. R&D Roadmap 2017-2026
This R&I roadmap published by ENTSO-E focuses on R&I activities to support TSOs with integration of different technologies (e.g. demand responses, energy storage, etc.), and to improve interaction between TSOs and DSOs.
In this regard, ENTSO-E promotes vertical and horizontal cooperation:

- Vertical cooperation - TSOs should collaborate with universities, industries, generation companies, DSOs, market entities
- Horizontal cooperation - tends to enhance the TSO-TSO cooperation which is aiming to fulfil common targets.

Functional objectives of TSOs' R&I activities are maintained and updated under five categories, including

- power system modernisation,
    - Optimal grid target
    - Smart Asset management
    - New materials and technologies
    - Environmental challenges and Stakeholders

- security and system stability,
  - Grid Observability
  - Grid controllability
  - Expert systems and tools
  - Reliability and resilience
  - Enhanced ancillary services
  - power system flexibility,
  - Storage integration
  - Demand response
  - RES forecast
  - Flexible grid use
  - Interaction with non-electrical energy networks
- power system economics and efficiency,
  - Market-grid integration
  - Business models
  - Flexible market design
- ICT and digitalisation of power system.
  - Big data
  - Standardisation and data exchange
  - Internet of things
  - Cybersecurity

The document lists the impacts and benefits of the R&I roadmap:

- Sustainable: enables RES integration and decarbonization targets
- Secure and Competitive: High system flexibility and security with a strong transmission network
- European resource synergies: maximizes the outcomes while reducing the standard costs
- European leadership in technology

The roadmap also updates and assesses the current progress of R&I activities. Based on the current progress, it reviews gaps and thus recommends three R&I areas with high priorities, which are asset management, joint TSO and DSO activities, and market design. Barriers and recommendations of regulatory framework for R&I activities are proposed in the roadmap as well.
Outcomes of SmartNet project should align with the proposed expected outcomes of the functional objectives. In addition, the roadmap highlights that joint TSO and DSO activities is one of the high priority R&I area, and SmartNet looks into the coordination schemes that interact between TSO and DSOs. Therefore, SmartNet need to demonstrate that, as a research project, its outcomes are able to support TSOs with utilisation of various technologies, and to improve TSOs and DSOs interactions.

Document: 05. "DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity"
The Directive proposal is an update of the rules for the internal market of electricity. The document aims to pursue the goal of creation the internal energy market and reduce application of fragmented national rules and uncoordinated policies. The Directive covers several areas, where the following are most relevant for the present project:

- Lays down the main principles ensuring that the EU electricity market is competitive, consumer-centred, flexible and non-discriminatory
- Reinforces the existing and introduces the new rights for the customers, including free choice of suppliers or aggregators, ability to engage in Demand Response, self-generation and self-consumption.
- Highlights the role of independent aggregators and demand response principles.
- Clarifies tasks for DSOs, especially procuring of network services to flexibility and integration of EVs and data services.
- Summarises the general rules applicable to TSOs, largely based on the existing text.
- Sets rules for unbundling as developed in the 3rd Energy Package.

- Describes rules related to establishment, powers and duties of the independent energy regulators.

Document: 06. "REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the internal market for electricity"
The document proposes common rules for the internal electricity market. In general, the proposal defines frames for the concept in the SmartNet project:

- It focuses on involving the demand side in balancing the supply
- It is setting fundamental principles for integrated markets which facilitate aggregation of distributed demand and supply.
- Underlines the need for cooperation between distribution and transmission system operators for coordinated access to resources such as distributed generation, energy storage or demand response since those resources may support particular needs of both the distribution and the transmission system.
- Improves pre-existing rules on the consumers' possibility to share their data with suppliers and service providers by clarifying the roles of the parties responsible for data management and by setting a common European data format to be developed by the Member States.

The proposal is at a more general level than the information specified in the SmartNet scheme.
There are three documents:

1. The main document. Most of the below information is from this document
2. Annex document about "Functions of regional operational centre" (Annex 1)
3. Correlation table (Annex 2)

Document: 07. Capacity Allocation & Congestion Management
The 2015/1222 EU CACM Regulation (Capacity allocation and Congestion management), which establishes the guidelines on capacity allocation and congestion management, entered into force on 14 August 2015.
Unlike other European regulations adopted so far, which are configured as "Network Codes" and therefore provide a complete set of rules ready to be implemented at national level, the CACM is an "orientation" of the European Commission, which contains harmonization rules de minimis and refers to subsequent acts of regulation the definition of some "terms and conditions or methodologies" necessary to fully implement its objectives.
These "terms and conditions or methodologies" must be developed in concert by all the network operators (TSOs) and the appointed market operators (NEMO) and approved by all the national regulatory authorities of the Member States through their own deliberative acts.
In this regard, regulators set up a platform (European Regulatory Forum, ERF) on a voluntary basis to facilitate the adoption of joint decisions on approval processes under the CACM
Article. 9 of the CACM Regulation describes the procedures for adopting the "terms and conditions or methodologies" and the related fields of applications. For 13 areas, the approval procedure involving all national regulators will be necessary, for another 8 areas will be called to jointly approve only the regulators of the same electric region and finally for 6 areas the independent approval of each individual regulator will be necessary, for a total of 27 areas of intervention.

Document: 08 Clean Energy for all Europeans (communication)
The document starts by reminding the reader on the targets for energy efficiency (30% by 2030) and renewables (27% by 2030) set by the commission. It continues by emphasizing the overarching commitment of the present legislative proposal: set a level playing field for all technologies across domains and timeframes relevant in European power systems.
In short, the main messages provided by this communication (which are relevant to the SmartNet project) are:

- Market rules should be adapted to facilitate market access to distributed resources, while managing variability and ensuring security of supply (SoS).
- Rules should allow shorter term trading (reflecting characteristics/necessities of RES)
- Allow participation of renewables to all market segments (incl. system services)

- Priority of dispatch will remain for small scale renewable installations/demonstrations
- Consumers will be able to offer demand response directly or through aggregators
- No messages/position on DSO-TSO cooperation

Document: 09. Clean Energy for all Europeans - additional set of documents (recast IEM regulation & recast IEM directive)
This document clarifies and proposes rules/approaches for electricity markets across all timeframes. The proposed rules/approaches have an impact on inter-linked subjects such as (but not limited to):

- Market participation: supporting aggregation, promoting a level-playing field, emphasizing responsibility of all market participants, …
- Trade & prices: minimum bid size (1 MW or lower), alignment of product design and generation/load mix characteristics, removing electricity price limits (or set it to VOLL), …
- Dispatching, re-dispatching and curtailment: keeping priority of dispatch (selected technologies), supporting market-based mechanisms for re-dispatching, advocating for curtailment limits and compensation, …
- Incentives, network access & congestion management: supporting market-based solutions for solving congestions, endorsing the provision of incentives to DSOs to procure services, …
- Cooperation DSO-TSO: on relevant information sharing and on coordinated access and use of resources.

Document: 10. EDSO position paper on the Clean Energy Package
The document explains the position of DSOs with respect to the points proposed by the clean energy package. They focus on few very specific aspects such as the role as market facilitator, the possibility of owning flexible devices, the ownership/availability of the data and their willingness to be privileged stakeholders of regulatory consultations.
Particularly interesting are the aspects related to the procurement and use of flexibility by DSOs (suggesting DSOs could own and operate storage and other devices) for non-commercial activities, but only for the management of network critical situations. In this regard, EDSO advocates for a sound framework allowing the recovery of related costs.

Document: 11. Joint DSO Reply to consultations on Generation and Load Data Provision Methodology v.2 and Common Grid Model Methodology v.2
The document reports the feedback of CEDEC, EDSO4SG, EURELECTRIC and GEODE to two public consultations on the data (including grid model) exchange between TSO-DSO, as proposed by ENTSO-E. The document includes in a schematic way the various feedback of this consultation to 9 different points. Some interesting point on DSO voltage level competency and DSO willingness of providing data can be deduced.

Document: 12. Strategic Energy Technology (SET) Plan

The SET plan reviews the future trends of energy system and policy, including

- Energy system decarbonisation
- Security of energy supply
- Competitive and sustainable energy system
- Improving energy efficiency
- Diverse and cost-effective technologies for energy supplies
- Requirement of further solutions from innovations

Four key challenges to achieve secure, competitive and sustainable energy system are proposed in the plan, with sub themes under each challenge.
Challenge 1: Active customers engagement

- Better understanding, information exchanges and market adaption to active customers
- Enable engagement through innovative technologies, products and services

Challenge 2: Increase energy efficiency

- In buildings
- In heating and cooling sector
- In industry and services

Challenge 3: System optimisation (with various energy carriers, e.g. energy storage)

- Development of smarter European power network and improve synergies between member states
- Integration of energy storage and other energy carriers (e.g. hydrogen and fuel cell vehicles)
- Providing flexibility, secure and cost-effective solutions to the energy system
- Development of local/urban level system optimisation (smart cities/communities)

Challenge 4: Secure, cost-effective, clean and competitive supply

- Integration with renewable energy resources
- Enabling carbon capture storage technologies and increasing efficiency of fossil fuel generators
- Safe and efficient nuclear system operation
- Developing sustainable biofuels for the European transportation energy sector (e.g. hydrogen and fuel cell vehicles)

In addition, there are cross cutting aspects between the energy system transition and the impacts on European societies, which requires 1) better education and training, 2) the definitions of policy to support the social, the environmental and the economic aspects of the energy system, and 3) persistent innovation funding for energy efficiency and energy supply.

Potential R&I activities to address these challenges are categorised under 9 sub-themes. Themes 1, 2, 6 and 8 are relevant to SmartNet project.

Document: 13. TSO–DSO DATA MANAGEMENT REPORT
This report aims at sharing recommendations on common European principles and criteria for data and information exchanges between TSOs and DSOs. The work is divided into four core topics:

- establish a common understanding of terms;
- define context and objectives of data management;
- define key principles of data management;
- define needs and uses for data management.

Main outcomes of five use cases are mentioned in this report, and the use cases' details are given in the Appendix 1. The use cases are:

- Congestion management
- Balancing
- Use of flexibility
- Real-time control and supervision
- Network planning

Document: 14. WindEurope Views on the TSO-DSO coordination - Enabling flexibility from distributed wind power
The document touches upon relevant open issues (barriers) affecting TSO-DSO coordination and proposes options to deal with these issues.
In general, the document acknowledges that DSOs are not encouraged to implement innovative solutions to operational challenges due to the shortcomings of current regulatory framework. In the same line, it states that TSOs are not able yet to access flexibility resources directly connected to the distribution grid due to the limitations of current DSO-TSO coordination schemes.
To tackle those issues, the document suggests that more efforts are done in respect to DSO-TSO coordination, aggregation strategies and facilitation of market access. More specifically, the document:

- Asks for a clear definition of roles and interaction for DSOs and TSOs
- Promotes the use of a common centralized marketplace for AS, where all types of resources are able to participate.
- Promotes a technology neutral procurement of services without disregarding grid requirements and needs at all levels.
- Suggest exploring new connection approaches (non-firm grid connections).
- Propose a set of principles to enhance DSO-TSO cooperation
  - Equal rights and opportunities to all resources, which requires a coordination model that allows the procurement of AS services at Dx in a clear, easy to understand, reliable, cost-efficient and fast manner.
  - Only one responsible for system balancing; the TSO.
  - Services should be procured to solve distribution congestions; by the DSO.
  - Ensure coherence between dispatching orders (TSO) and distribution operational constraints (DSO)
  - AS procurement and distribution services should be market-based, transparent, non-discriminatory and neutral

Document: 15. Guideline on Electricity Balancing (EB)
This regulation, which applies to the EU transmission networks and interconnections, sets out rules that guide the functioning of electricity balancing market for

- The procurement of available balancing capacity
- The activation of balancing energy
- The financial settlement of balancing responsible parties.

The aim of proposing this regulation is to achieve optimal operation of the EU transmission electricity network, together with increasing integration with renewable resources and providing benefits to customers.
The target model is an exchange of TSO-TSO resources using offers for different products collected and sorted according to economic merit order list. There is a great absence in balancing markets it is not possible to accept a bid/offer for congestion management. For each resource the NC EB envisages the development of a centralized platform that collects the offers of the various control areas and allows the procurement of the various TSOs. Within one year (December 2018) the TSOs must develop a price proposal based on the marginal price and exclude offers for other uses and by eliminating any price limits (cap and floor)
The TSOs that manage central dispatch systems can certify themselves as such with the approval of the National Regulatory Authority; as a consequence, a number of specific provisions apply to these systems which protect their specificity.
Since SmartNet project looks into TSO-DSO interaction market schemes and procurement of ancillary services, the TSO operation of balancing market should comply with this regulation.

Document: 16. GENERAL GUIDELINES FOR REINFORCING THE COOPERATION BETWEEN TSOs AND DSOs
This general guideline starts from reviewing the challenges that TSOs and DSOs are facing with. Based on the challenges, it highlights the need of cooperation between TSOs and DSOs in order to ensure security and stability of power systems. Three opportunities are identified for the interactions between TSOs and DSOs, which are

- Coordinated access to resources,
- Regulatory stability,
- Grid visibility and grid data.

By close cooperation between TSOs and DSOs, it will benefit

- Customers with lower energy cost and security of supply,
- Markets with integration of demand responses and renewable energy,
- The decision-making progress between TSOs, DSOs, and grid uses with better and easier solutions,

- The grid with economical reinforcement costs,
- Grid resources with efficient long-term lifetime.

For the aim to achieve better TSOs and DSOs cooperation, three areas are anticipated to be improved. These areas are

- TSOs and DSOs roles and responsibilities,
- Procurement of flexibility in the market,
- Technical requirements that enable integration with DERs and new technologies, and network planning and operation.

At last, TSOs and DSOs need to work together on knowledge sharing and understanding, together with NRAs and European Commission, to realise the TSOs/DSOs close cooperation.
This report provides preliminary guidelines for the cooperation between TSOs and DSOs, with the advent of various energy technologies and flexibilities. A brief review of potential areas where the TSOs and DSOs need to work together are included in this guideline report. Moreover, the TSOs/DSOs interactions should comply with the guidelines in this report.

Document: 18. Distributed Flexibility and the Value of TSO/DSO Cooperation
The document postulates ENTSO-E's key recommendations for the integration of distributed flexibility resources (DFR) into the internal energy market.
Key recommendations:

- Products: Joint (DSO & TSO) definition of a limited set of DFR products
- Congestions: DSOs & TSOs should be able to set limitations or activate DFR (close to real time) considering the geographical location of the assets in a bid.
- Balancing: availability of contracted balancing reserves must be ensured.
- Use: Activation should be such that it gives the highest value to the flexibility provider.
- Market: Single marketplace for collecting and mutually coordinate activations of distributed flexibility

Document: 19. "REGULATION (EU) 2015/2120 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL measures concerning open internet access"
The EU regulation 2015/2120 aims that all internet access connections give open, non-discriminatory and equal access to the internet. The principle of technological neutrality means that the regulation neither impose nor discriminate in favor of the use of a particular type of technology. It does not allow prioritization of traffic, but service level differentiation of specific categories of traffic in terms of latency, for example, is allowed in order to optimise the overall quality and user experience. Reasonable traffic management measures, to differentiate the quality of service e.g. new machine-to-machine communication services are allowed by providers of internet access services, but they should be transparent, non-discriminatory and proportionate, and should not be based on commercial considerations. The regulation aims at removing the problem that a significant number of end-users are affected by traffic management practices which block or slow down specific applications, services or terminal equipment due to commercial reasons.

Depending on the interpretations, the EU regulation 2015/2120 may promote or hinder the prioritization of grid communications. The intention seems to be that traffic management needed to enable the low latency transmission of small real time control signals will be allowed as long as it does not reduce the quality of the normal internet access of the end users and network capacity is assured. It would be good to make sure that this possibility is not removed in the future development and interpretation of the EU regulation 2015/2120.

Document: 20. BEREC Guidelines on the Implementation by National Regulators of European Net Neutrality Rules
The BEREC guidelines aim to clarify the interpretation of the regulation (EU) 2015/2120. The clarifications are in line with the assumption that traffic management needed to enable the low latency

transmission of small real time control signals will be allowed as long as it does not reduce the quality of the normal Internet access of the end users and network capacity is assured. Such reliable low latency transmission of small real-time control signals in necessary for the activation of the SmartNet ancillary services. The ancillary services need that the control signals are sent to very many DER simultaneously.
BEREC uses the term "specialised services" as a short expression for "services other than internet access services which are optimised for specific content, applications or services, or a combination thereof, where the optimization is necessary in order to meet the requirements of the content, applications or services for a specific level of quality" (ref. Article 3(5)). This topic is important for SmartNet. If the new network slicing methodology of software defined networking is considered either as "specialised services" or as a technology allowed in the implementation of "specialised services" such as distributed ancillary services for power systems, commercial networks may provide services that are similar to today's dedicated (separate) networks.

Document: 21. IEC TC8 System aspects of electrical energy supply
The IEC TC8 is a technical committee preparing and coordinating, in co-operation with other TC/SCs the development of international standards and other deliverables with emphasis on overall system aspects of electricity supply systems. Thus, it prepares and coordinates very many draft documents. Among other things it provides a good view on the development of grid connection requirements. The draft standards are not available outside the standardization committees. The drafts are also evolving, and this review was done in March 2018.
Grid connection requirements include requirements on controllability for DER (now mainly for different generators and electric energy storage systems and but in the future most likely also for microgrids and flexible loads) and related communication interfaces of DER for enabling services to support the power system. These requirements include

- possibility to control via an external communication interface
    - active power
    - reactive power
    - drop of the local voltage and frequency control loop
- minimum size limit of these requirements.

Thus grid connection requirement documents and drafts tell what local control functions and remote controllability can be required to readily exist in DER in 2030 thus enabling SmartNet systems to control the devices without additional local costs of connecting DER controllability to the ancillary services.

Document: 22. Distributed Flexibility and the value of TSO/DSO Cooperation (working paper)
In this working paper ENTSO-e discusses potential uses of distributed flexibility resources (DFR), as well as a market design for the procurement of services based on these resources and responsibilities of actors within the proposed design.
In their view, such a marketplace should,

- Collect bids (with locational information) for balancing and congestion management processes
- Allow TSOs and DSOs to manage their own merit order lists (MOLs)
- Enable the activation of bids either directly by SOs or by the market
- Prioritize the use of DFR based on "where they provide the highest value to the whole system"

In respect to responsibilities, ENTSO-e suggest actions to be performed by balancing service providers (BSPs) and system operators (SO)

Document 23. Unlocking Flexibility: Nordic TSO Discussion paper on third-party aggregators
The aim of the discussion paper is to develop harmonized solutions for integrating aggregators in the Nordic electricity markets. Increasing the share of the renewable energy sources increases the need of the balancing power; flexibility from both supply and demand side. One way to increase flexibility in the market is enabling the smooth integration of aggregators as a new market entity. This might require a new market design, which allows fair and competitive solutions providing socio-economic efficiency. Hence, the paper studies possible approaches/models to integrate aggregators from a TSO viewpoint.

The paper focuses on the role of aggregator as the key role allowing smaller resources to participate in the market and relates on some models of aggregation experimented in Nordic pilots. The debate on aggregation is polarized: new actors point out there are electricity markets hold barriers preventing them to enter, whereas conventional ones lament lack of profitability.

The main challenges of integrating aggregation seen from a TSO side are the followings:

1. The Nordic balancing market is for larger units/consumers; There is a need to apply an EU standard of 1MW for FRR, it means there is a need to lower the bid size. Lowering bid size requires from all market actors to develop solutions for electronic bid activation ordering. Bringing down equipment cost would help. Data hubs for smart meters are being developed by Nordic TSOs. However, privacy issues are to be safeguarded for date from connection point and consumer.
2. Online metering for resources participating in balancing markets is needed. Online metering for a smaller resource is considered costly and challenging for the aggregator business model.
    - The following major issues/rules are discussed in developed models for integrating aggregation.
    - Balance responsibility- all market actors have to be balance responsible
    - Polluter must pay (if there are several BRPs on one node, other BRPs should be aware of the change in resource owner's behaviour.
    - Independency (aggregators don't need to associate to resources owners)

Four different models allowing aggregation are developed and tested/to be tested in Pilots. Two of the models aim to test the independent aggregation concept. In the third model BRP (Balance Responsible Party) and the aggregator are the same entity. In the fourth model several BRPs are allowed on the same connected point.
The paper discusses the advantages and the disadvantages of the developed modes.

- Finally, it concludes that four topics should be looked into:
- Lower minimum bid size
- Allow aggregation of generation and demand in one bid
- Information exchange toward TSO
- Geographical issues and requirements for activation.

Document: 24. DSO-TSO cooperation issues and solutions for distribution grid congestion management

This paper first reviews the major congestion management methods based on energy system states (i.e. green, orange, and red, corresponding to the timeframe of day-ahead markets, balancing/congestion management and last resort curtailment). The congestion management approaches mentioned in the paper are congestion pricing (including explicit auctioning and implicit auctioning), redispatching, and curtailment. Following the review of the congestion management methods, current inter-TSOs cooperation on balancing and capacity allocation under each state of the energy system is presented. Moreover, the possible TSO-DSO cooperation is reviewed and presented in this paper, under by making reference to the same time frames (green, orange and red).
With the increasing flexibility resources connected to the power grid, DSOs are becoming more active in managing the congestions at the distribution networks. This requires closer cooperation between TSO and DSO, especially considering capacity allocation at their borders.
The main interest for the SmartNet is the orange (and possibly red) system state which is related to re-dispatch and possible curtailment (although in our case curtailment can be voluntary and thus regarded as somewhat part or the re-dispatch. In the reality SmartNet doesn't treat the case of a curtailment carried out outside market mechanisms - but this would be more typical for the red time frame i.e. as a last resort when no market mechanisms have functioned properly). The paper covers a number of approaches used by TSO but also discusses their applicability or possible solutions for DSO and TSO-DSO cooperation. It also includes discussion on pricing approaches to include management of capacity currently used by TSO and discusses its applicability to DSO.
What the paper doesn't provide is a judgement of the different methodologies, which is mostly left to the reader (so it is more a review paper than a policy paper)

Document: 25. CEER Position Paper on the Future DSO and TSO Relationship
The document studies possible ways the TSO-DSOs might cooperate in order to provide more efficient system solutions, addressing the current market challenges like increased RES integration, demand side management, low -carbon generation target and so on. CEER suggests the following principles, which should serve as bases of the future TSO-DSO relationship:

- Overarching principles

According to CEER, TSOs and DSOs should construct mutually respectful relationship and that the effective cooperation among system operators, competitive markets can result optimal system outcomes.

- Governance

Continuous consultation among TSO, DSO and stakeholders should take place for a corresponding task.
It is significant that, the TSO-DSO cooperation create incentives for both of them to optimize system outcomes as a whole.

- Network Planning

It is important to have shared information between TSO-DSO related to the network status to ensure least cost solutions, to avoid over and under investment.
Strong TSO-DSO cooperation is crucial to long term network planning

- System Operation

Strong TSO-DSO cooperation can lead to increase the efficiencies in the system operation.
Increased information share will give the possibility for TSO, DSO to have better knowledge of their networks, to investigate who has to act where in order to unbundle system flexibilities and support the system as a whole.
It is important that the regulatory arrangements will support all mentioned above points.

Document: 26. "Day-ahead and intraday markets – Operating Rules - Resolución de 23 de diciembre de 2015, de la Secretaría de Estado de Energía, por la que se aprueban las Reglas de funcionamiento de los mercados diario e intradiario de producción de energía eléctrica."
Definition of the operating rules for the Spanish day-ahead and intraday markets.

Document: 27. "System Operator's Operating procedure 7.2 – Automatic Frequency Restoration Reserve."
Spanish System Operator's operating procedure. Definition of the ancillary service "Automatic Frequency Restoration Reserve".

Document: 28. "System Operator's Operating procedure 7.3 – Replacement Reserve"
Spanish System Operator's operating procedure. Definition of the ancillary service "Replacement Reserve".

Document: 29. "System Operator's Operating procedure 3.2 – Technical Restrictions"
Spanish System Operator's operating procedure. Definition of the ancillary service "Technical restrictions".

Document: 30. "System Operator's Operating procedure 3.1 – Generation scheduling"
Spanish System Operator's operating procedure. Definition of the generation scheduling.
In this document the relationships between the existing markets can be identified: Gate closures, publication of requirements, assignation of bids, etc.

Document: 31. "System Operator's Operating procedure 9.0 – Exchanged information by the System Operator"

Spanish System Operator´s operating procedure. Definition of the exchanged information by the System Operator.

Document: 32. "System Operator's Operating procedure 7.4. Voltage control at transmission network"
Spanish System Operator's operating procedure. Definition of the ancillary service "Voltage control".

Document: 33. "Real Decreto 413/2014, de 6 de junio, por el que se regula la actividad de producción de energía eléctrica a partir de fuentes de energía renovables, cogeneración y residuos"
Spanish Royal Decree 413/2014, of 6 June, which regulates the electricity production with renewable resources, cogeneration and wastes.

Document: 34. DCO 354/2013-DCO 557/2013 - DCO 298/2016
This is an overview of the Italian power system and thus different documents have been analysed: DCO 354/2013, DCO 557/2013, DCO 298/2016, Italian network code, DCO 368/2013,DCO 300/2017, DCO 798 2016, DCO 557/2013

Document: 35. Open Networks Project: Opening Markets for Network Flexibility 2017 achievements and future directions

This report first sets out current background and challenges of the UK power system. It then briefly introduces the Open Networks project and its scope, including the achievements in 2017 and objectives to be achieved in 2018. It then emphasises that the project considers a whole electricity system context for both transmission and distribution network. The project is consist of 5 work streams, which are

- Customer experience, that groups customers into different categories, reviews the current customer connection process, and etc.
- Transition from DNO to DSO, that defines DSO and its functions, and potential markets that enable DSO services developed on the basis of SGAM.
- Short-, Medium-, and long-term improvements and changes of transmission and distribution processes, e.g. investment planning and statement of works, based on current process.
- Whole system charging reform with the transition from DNO to DSO,
- Communications with stakeholders

In addition, several case studies of projects carried out by system operators are briefly introduced in relation to the work of each stream.

Document: 36. "USEF: WORKSTREAM ON AGGREGATOR IMPLEMENTATION MODELS: Recommended practices and key considerations for a regulatory framework and market design on explicit Demand Response"
The document introduces and articulates seven aggregator implementation models: Integrated, Broker, Contractual, Uncorrected, Corrected, Central settlement, and Net benefit (a specific variant of the central settlement). Each of these models is described in terms of contractual relationships, balance responsibility, perimeter correction and transfer of energy.
The study covers the commercial, industrial and residential segment. For the residential segment, where DR takes place on a daily basis, the study introduces a new set of models: reference profile models. These models have at their core the objective to ease the split of balance responsibility (by means of a separate baseline -likely different from the baseline to check delivery performance- to identify imbalance volumes).
The document concludes with recommendations (advice that could be incorporated into a standardized contract) and considerations (options and implications) towards identified complexities for the implementation of these models. Such complexities are:

- Measurement and validation
- Baseline methodology
- Information exchange and confidentiality

- Transfer of energy price methodology
- Relationship between implicit and explicit DR
- Rebound effect
- Portfolio conditions

More detailed explanations and specifications (including use cases) of the USEF framework are covered in two additional documents:

- USEF: The Framework Explained
- USEF: The Framework Specifications.

Please note: Unless specified otherwise, the form summarises the document 'USEF: Workstream on Aggregator Implementation Models: Recommended practices and key considerations for a regulatory framework and market design on explicit Demand Response' (the version updated in Sept. 2017). A few learnings are coming from the document 'USEF: The Framework Explained' and 'USEF: The Framework Specifications', and that is explicitly mentioned.

Document: 37. ANCILLARY SERVICES TO BE DELIVERED IN DENMARK TENDER CONDITIONS
The document is describing the tender conditions relevant for a specific type of ancillary service in Denmark, specifically in Western Denmark (DK1) and Eastern Denmark (DK2). It is important to mention that the ancillary services mentioned in this document are provided by the individual players who have concluded an agreement about reserve capacity with Energinet.dk.
So, this document does not consider a player who can refrain from concluding such an agreement, instead entering regulating power bids as he sees fit (using real-time trading).
Energinet (Danish TSO) buys ancillary services to ensure access at all times to such resources as are necessary to ensure the stable and reliable electricity system operation. The ancillary services presented in the document are the followings;

- Primary reserve, FCR
- aFRR supply ability
- Secondary reserve, aFRR
- Manual reserve, mFRR
- Frequency-controlled disturbance reserve, FCR-D
- Frequency-controlled normal operation reserve, FCR-N

Document: 38. MARKET REGULATIONS: Regulation A Principles for the electricity market
The document describes the main principles for the Danish electricity market model, stating the main players in the electricity market, market places, the TSO's commercial transactions and TSO's tariffs.

Document: 39. MARKET REGULATIONS: Regulation B Terms of electricity market access
The document is describing all terms and conditions to access the electricity market for both consumers and producers. In addition, it includes a description of Energinet' s electricity tariffs for producers and consumers.

Document: 40. MARKET REGULATIONS: Regulation C1_Terms of balance responsibility
The document summarizes the Danish regulation on and terms of balance responsibility. The regulation is primarily aimed at market participants that have already signed or want to sign an agreement with Energinet.dk in order to become a balance responsible party (BRP). The regulation is also aimed at all parties which are basically qualified to become BRPs, balance suppliers, grid companies and electricity generators, as well as balance suppliers in general.
Finally, the regulation also defines which information is required in order for Energinet.dk to carry out its tasks in relation to balance responsibility and which the market participants are therefore obliged to provide to Energinet.dk on request; see Section 84(5) of the Danish Electricity Supply Act2.
This document does not cover those topics based on which we want to make the review for SmartNet.

Document: 41. BALANCING MARKET: Regulation C2 The balancing market and balance settlement, Adjustment of market regulations

The document defines the balancing market and summarizes the regulations and rules related to the market players participation in the regulated power market. The Danish balancing market is grouped into a regulating power market and a balancing power market.
In the regulated power market Energinet buys/sells the regulated power from/to players in the delivery hour.
In the balancing power market, Energinet buys/sells balancing power from/to the market players to counterbalance imbalances incurred by them.

6.2 Organisations currently representing DSOs

CEDEC	CEDEC represents the interests of more than 1500 local and regional energy companies from ten European countries, serving 85 million electricity and gas customers and connections. These predominantly medium-sized local and regional energy companies have developed activities as electricity and heat generators, electricity and gas distribution grid and metering operators and energy (services) suppliers. The wide range of services provided by local utility companies is reliable, sustainable and close to the consumer. Through their high investments, they make a significant contribution to local and regional economic development.
EDSO for Smart Grids	European Distribution System Operators for Smart Grids (EDSO) gathers leading European electricity distribution system operators (DSOs) cooperating to bring smart grids from vision to reality. The development of smart grids is a prerequisite to reaching the EU's ambitious energy, climate, security of supply and internal market objectives. EDSO and its members are committed to taking on this huge challenge, while at the same time ensuring the reliability of Europe's electricity supply to consumers and enabling them to take a more active part in our energy system. EDSO is a key interface between the DSOs and the European institutions, and is focused on RD&D, policy and member state regulation to support this development.
EURELECTRIC	EURELECTRIC represents the power sector in over 30 European countries, speaking for more than 3,500 companies in power generation, distribution, and supply. We also have affiliates and associates on several other continents. We stand for carbon-neutral electricity by 2050, competitive electricity for our customers, and continent-wide electricity through a coherent European approach.
GEODE	GEODE represents the interests of 1200 private and public energy companies for both electricity and gas from 16 European countries, serving more than 100 million customers. These small and medium-sized companies are bringing intelligence to the grids and making thereby a major contribution to achieve Europe's climate and energy policy goals. GEODE promotes fair and competitive conditions for network operators giving them a strong voice to secure core values - namely providing a customer-focused service, with a high quality of supply and energy efficiency to homes, businesses and local communities.

This paper reflects only the author's view and the Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.