



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

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## Architectures for Optimized Interactions between TSOs and DSOs: Experiences and learnings from the SmartNet

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- Increased reserve needs due to explosion of variable RES
- Opportunities from new DER in distribution?
- Five key questions:

Which ancillary services could be provided from entities located in distribution networks	How the architectures of dispatching services markets should be consequently revised
Which optimized modalities for managing the network at the TSO-DSO interface	What ICT on distribution-transmission border to guarantee observability and control
Which implications on the on-going market coupling process	

*“Some actions can have a negative cross-network effect. For instance, TSO use of distributed resources for balancing purposes has the potential to exacerbate DSO constraints. Equally, whilst DSO use of innovative solutions, such as active network management, can deliver benefits to customers, if not managed properly they may in some cases counteract actions taken by the TSO”* (CEER Position Paper on the Future DSO and TSO Relationship – Ref. C16-DS-26-04 – 21.09.2016)

*Article 32*

**Tasks of distribution system operators in the use of flexibility**

1. Member States shall provide the necessary regulatory framework to allow and incentivise distribution system operators to procure services in order to improve efficiencies in the operation and development of the distribution system, including local congestion management. In particular, regulatory frameworks shall enable distribution system operators to procure services from resources such as distributed generation, demand response or storage and consider energy efficiency measures, which may supplant the need to upgrade or replace electricity capacity and which support the efficient and secure operation of the distribution system. Distribution system operators shall procure these services according to transparent, non-discriminatory and market based procedures.

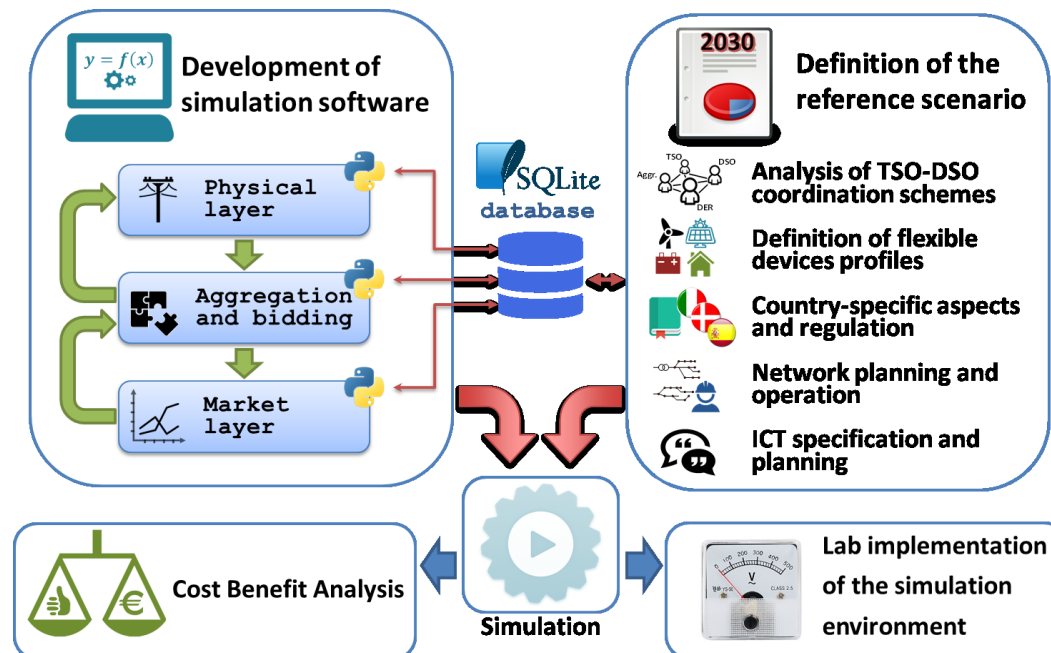
Distribution system operators shall define standardised market products for the services procured ensuring effective participation of all market participants including renewable energy sources, de  
 operators shall exchange all n  
 system operators in order to  
 secure and efficient operation

EC (2016) Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity

Winter package assigns a role to DSOs for local congestion management, but not for balancing

Project video: <https://vimeo.com/220969294/73d98edde6>

- architectures for optimized interaction between TSOs and DSOs in managing the purchase of ancillary services from subjects located in distribution.
- three national cases (Italy, Denmark, Spain);
- *ad hoc* simulation platform (physical network, market and ICT)
- CBA to assess which TSO-DSO coordination scheme is optimal for the three countries.
- use of full replica lab to test performance of real controller devices.
- three physical pilots to demonstrate capability to monitor and control distribution by TSO and flexibility services that can be offered by distribution (thermal inertia of indoor swimming pools, distributed storage of radio-base stations).

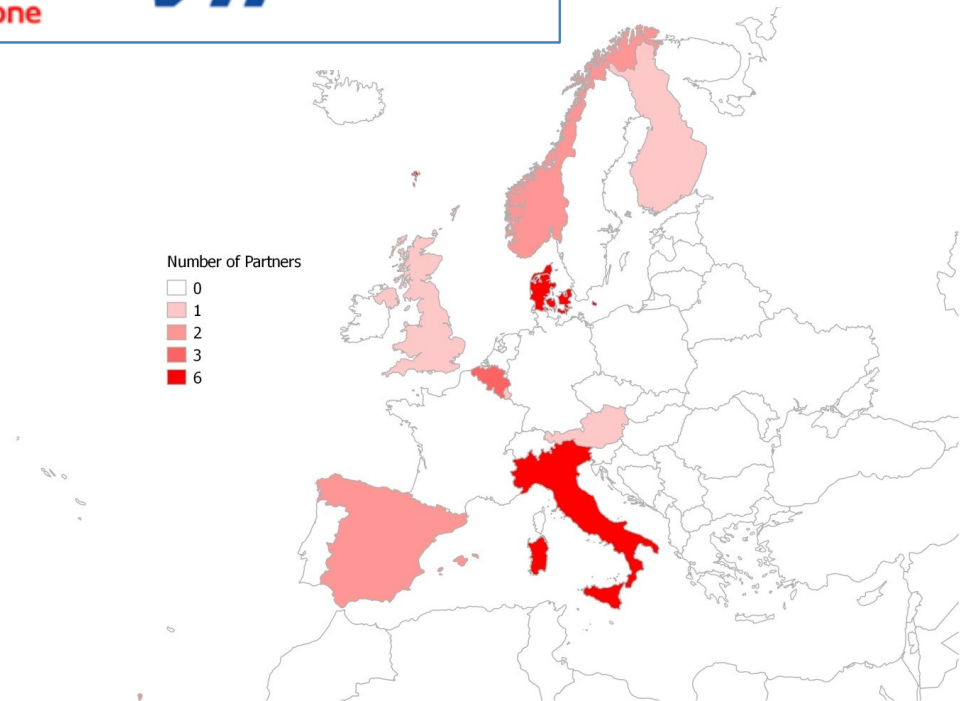
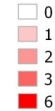


# The SmartNet project



<http://SmartNet-Project.eu>

Number of Partners

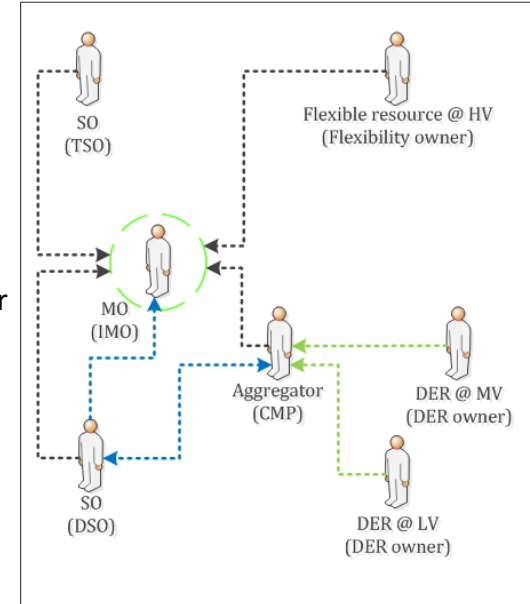
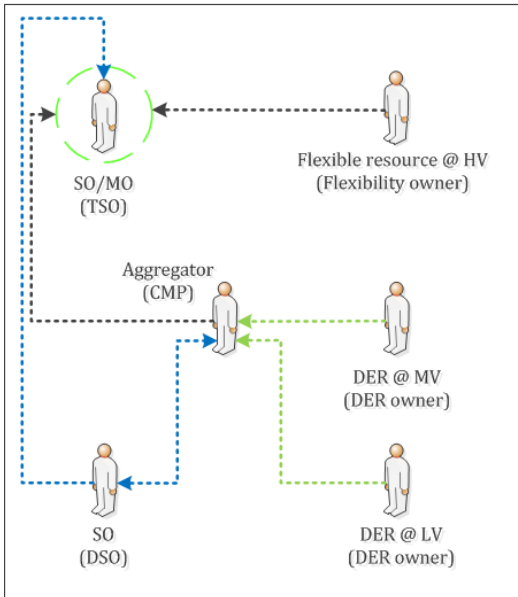


# TSO-DSO coordination schemes

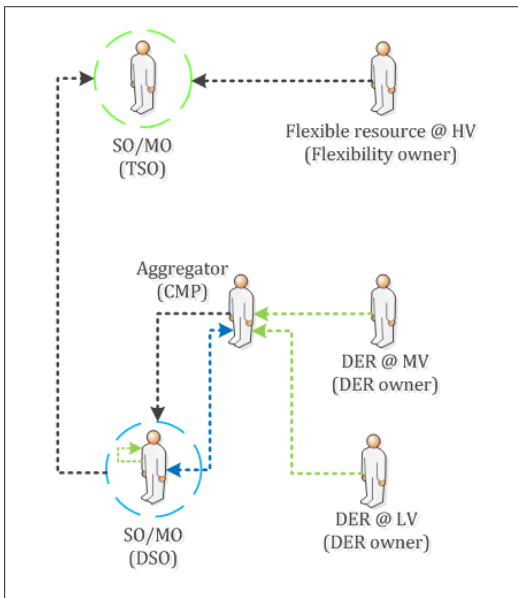
## 5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

- A. Centralized AS market model
- B. Local AS market model Local DSO re-balance after congestion management
- C. Shared balancing responsibility model
- D. Common TSO-DSO AS market model
- E. Integrated flexibility market model

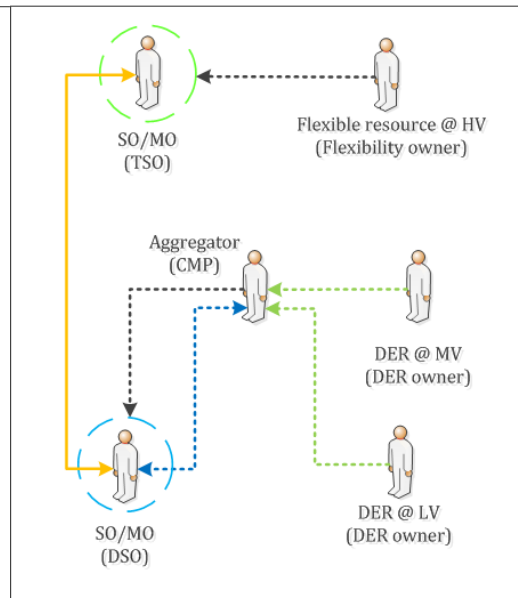
Centralized AS market model



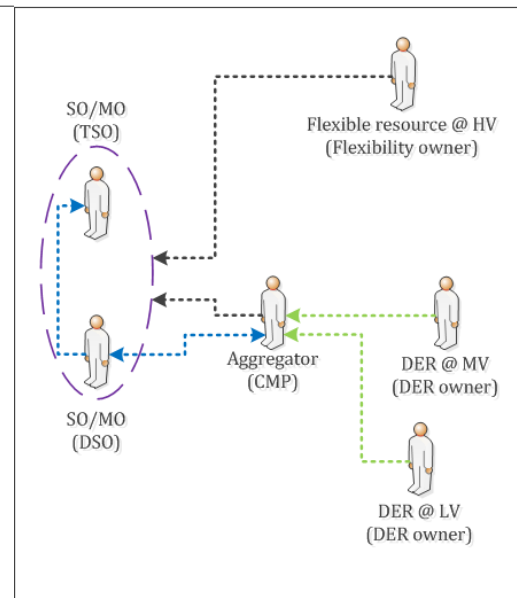
Local AS market model



Shared balancing responsibility model



Common TSO-DSO AS market model



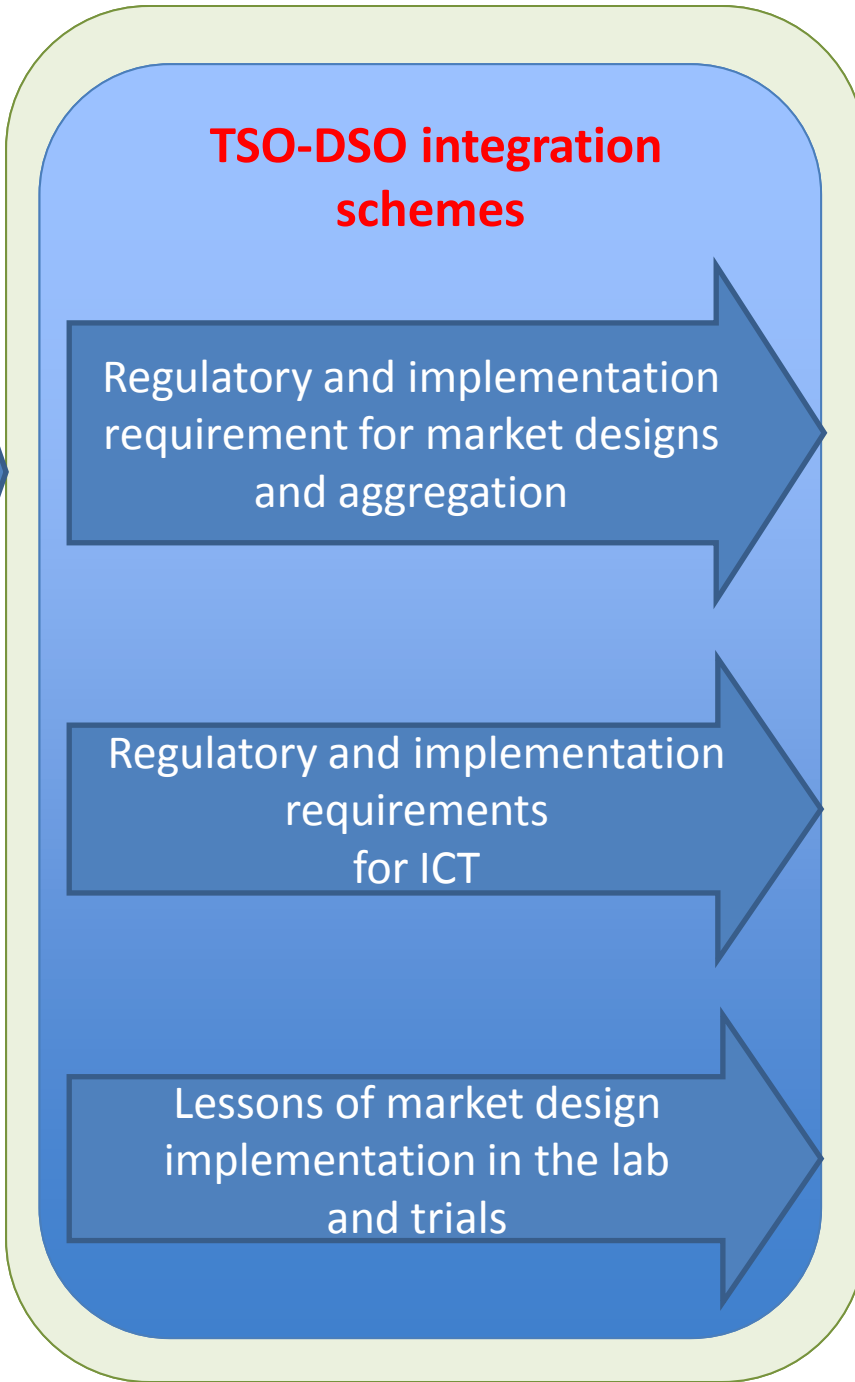
Legend	
Role (Actor)	
Centralized market	
Local market	
Coordinated market	
Pre-defined profile exchange	
Aggregation	
Market bids	
Pre-qualification	

# TSO-DSO coordination schemes: a comparison

Coordination Scheme	Benefits	Attention points
Centralized AS market model	<ul style="list-style-type: none"> <li>▪ Efficient scheme in case only the TSO is a buyer for the service</li> <li>▪ A single market is low in operational costs and supports standardized processes</li> <li>▪ Most in line with current regulatory framework</li> </ul>	<ul style="list-style-type: none"> <li>▪ No real involvement of DSO</li> <li>▪ DSO grid constraints not always respected</li> </ul>
Local AS market model	<ul style="list-style-type: none"> <li>▪ DSO has priority to use local flexibility</li> <li>▪ DSO supports actively AS procurement</li> <li>▪ Local markets might create lower entry barriers for small scaled DER</li> </ul>	<ul style="list-style-type: none"> <li>▪ TSO and DSO market cleared sequentially</li> <li>▪ Local markets might be rather illiquid</li> <li>▪ Need for extensive communication between the TSO market and the local DSO markets</li> </ul>
Shared balancing responsibility model	<ul style="list-style-type: none"> <li>▪ The TSO will need to procure a lower amount of AS</li> <li>▪ Local markets might create lower entry barriers for small scaled DER</li> <li>▪ Clear boundaries between system operation TSO and DSO</li> </ul>	<ul style="list-style-type: none"> <li>▪ Total amount of AS to be procured by TSO and DSO will be higher in this scheme</li> <li>▪ BRPs might face higher costs for balancing</li> <li>▪ Small local markets might be not liquid enough to provide sufficient resources for the DSO</li> <li>▪ Defining a pre-defined schedule methodology agreed by both TSO/DSO might be challenging</li> </ul>
Common TSO-DSO AS market model	<ul style="list-style-type: none"> <li>▪ Total system costs of AS for the TSO and local services for the DSO are minimized</li> <li>▪ TSO and DSO collaborate closely, making optimal use of the available flexible resources</li> </ul>	<ul style="list-style-type: none"> <li>▪ Individual cost of TSO and DSO might be higher compared to other schemes</li> <li>▪ Allocation of costs between TSO and DSO could be difficult</li> </ul>
Integrated flexibility market model	<ul style="list-style-type: none"> <li>▪ Increased possibilities for BRPs to solve imbalances in their portfolio</li> <li>▪ High liquidity and competitive prices due to large number of buyers and sellers</li> </ul>	<ul style="list-style-type: none"> <li>▪ Independent market operator needed to operate the market platform</li> <li>▪ Negative impact on the development and liquidity of intraday markets</li> <li>▪ TSO and DSO need to share data with IMO</li> </ul>



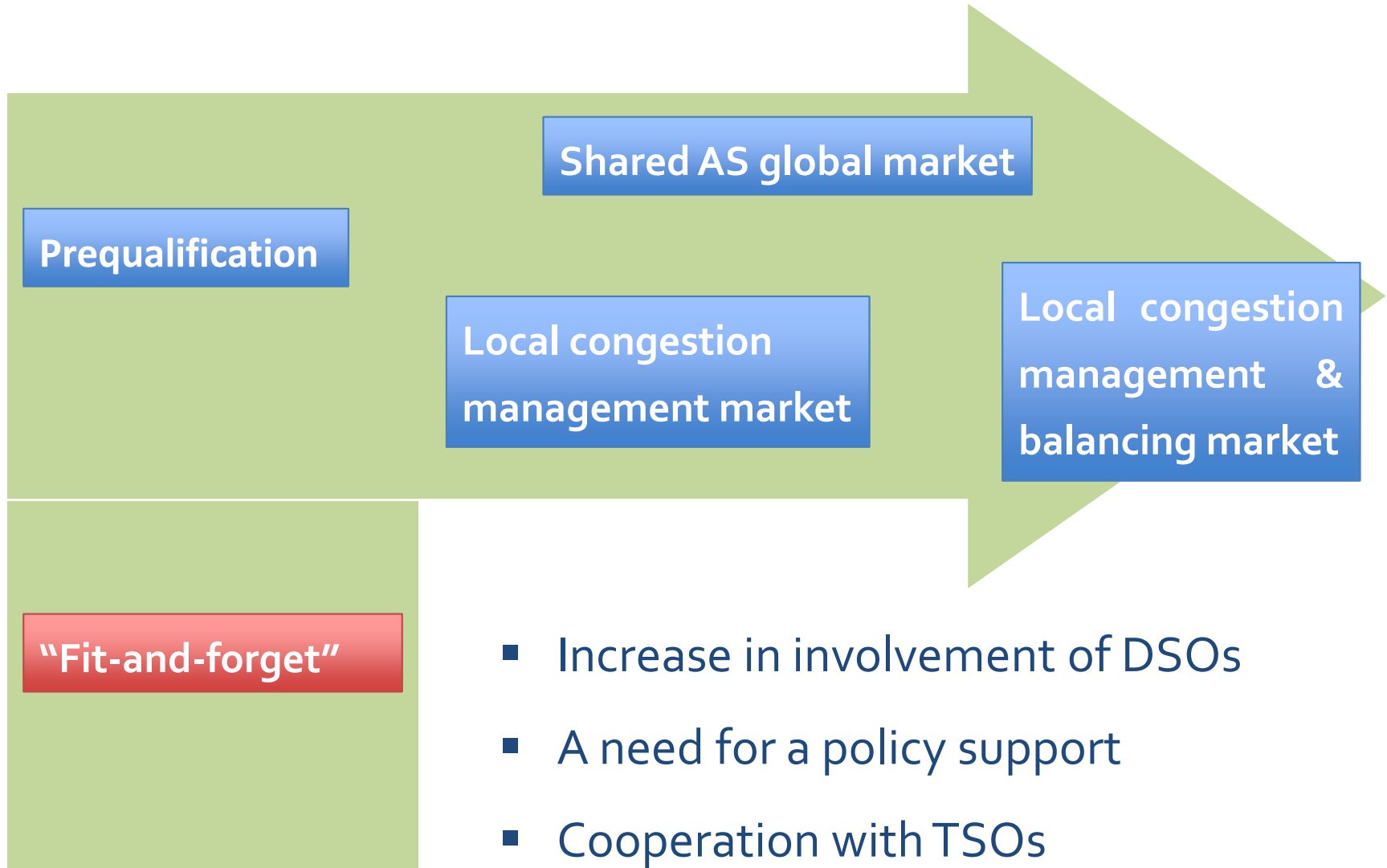
Arrangements  
for Ancillary  
Services by  
DERs



- Where does our learning fit in current EU/national regulatory plans?
- What are the lessons learned from evaluation and testing of new market and operational strategies?

- **What can we recommended to regulators & industry?**

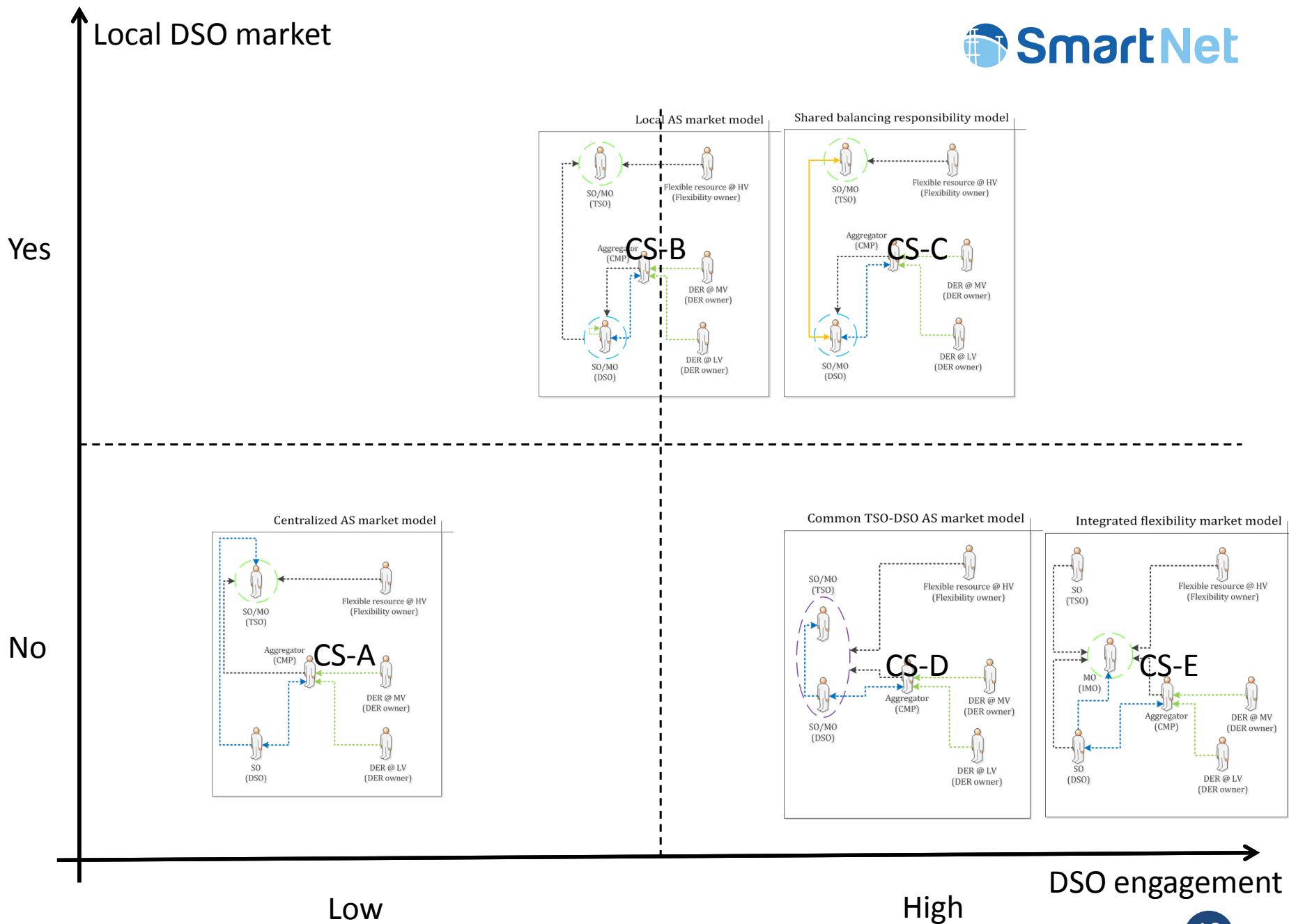
## Evolution of the DSOs



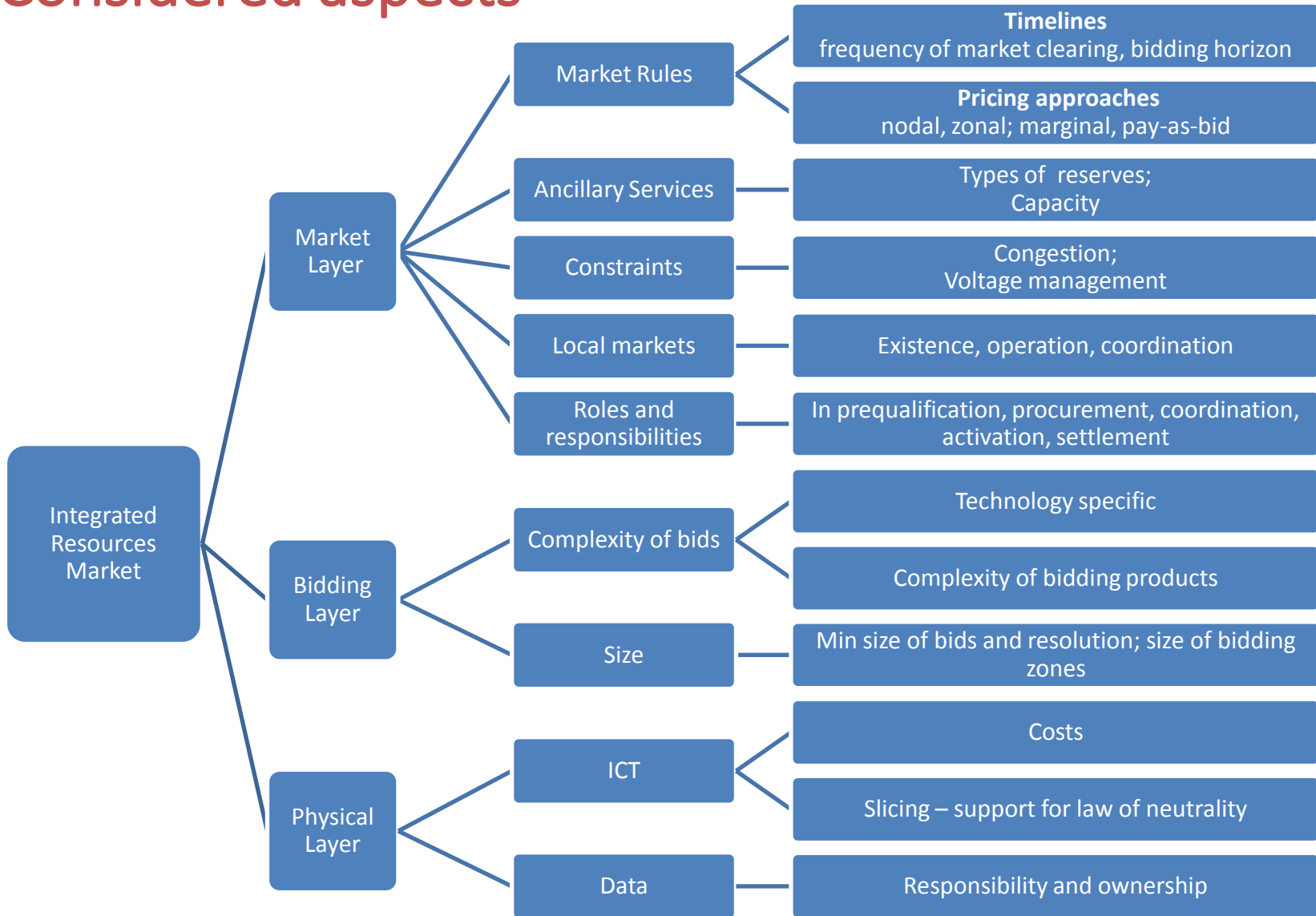


## Foreseen tasks for the new DSO

- The foreseen tasks for the new 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



# Considered aspects



## Market modelling and timelines

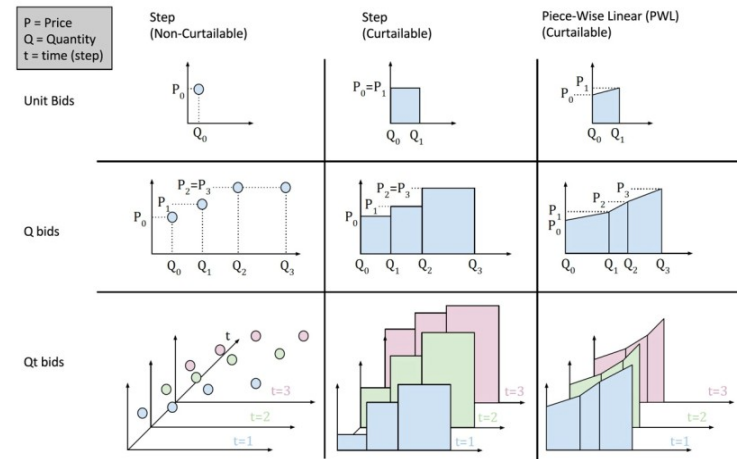
- In SmartNet simulations time step has been selected as 15min
- In line with regulation that from 1st January 2025, the imbalance settlement period should be 15 minutes in all control areas.
- Further considerations
  - Latency issues and network slicing
  - Frequency of market clearing vs. accuracy of results
  - Inclusion of a rolling horizon in the market clearing
  - Understanding behaviour of market participants

## Accounting for technical DER constraints

- No present legal requirements for inclusion of device-related constraints - proposal for inclusion of certain requirements on portfolio-level are advanced by stakeholders
- Who should account for this and how?
  - directly accounted by a market design and optimization formulation – in SmartNet
  - to expect market participants, and in particular aggregators, to develop bidding strategies that include those constraints indirectly
- The way in which this is done in the market design will directly influence the definition of bids, i.e. products

# Complexity of bids/products

- A simple bids that will not reflect technical characteristics of DERs and their operation, leaving to the more complex market clearing algorithm to model these constraints
- More complex bids that reflect DERs technical characteristics
  - This is adopted in SmartNet
  - range of bidding products is one of the strengths of the SmartNet as it allows detailed descriptions of available bid types



## Management of voltage constraints

- Voltage control is formally defined as non-frequency ancillary service and TSOs and DSOs should agree on voltage control parameters at the border of the networks
- This requires more accurate AC modelling of distribution networks
- Modelling of non-linear constraints, and in particular combined with the binary variables, is computationally challenging task
- Modelling of the distribution network in the SmartNet simulator is based on simplified Dist-flow optimisation model
- Transmission networks has been modelled using DC network approximation

# Market liquidity and forecasting errors

- liquidity of the local market is one of the crucial issues that needs to be resolved
- issues are related to liquidity:
  - scope and the size of the local market may dictate its liquidity
  - the timing of the market sessions
  - the lack of advance reservation of capacity to the real time market
  - minimum bid sizes may be too large and the bid structures too complex
- Reliability of these renewable resources is strongly dependent on accuracy of their forecast
- How to address this
  - improved forecasting errors
  - to set the gate closure of ancillary services markets as close as possible to the re-al-time operation



# Final remarks from the SmartNet

- Technical reasons advise to continue centralizing balancing responsibility to TSOs.
- Local services could be shared, instead (*Clean Energy for All Europeans*).
- **Shallow of deep DN congestion management**
  - Traditional TSO-centric schemes could stay optimal if distribution networks are not significantly congested – but...
  - More advanced centralized schemes incorporating distribution constraints show higher economic performances but are more complex
- **Local or centralized schemes**
  - Decentralized two-step schemes are usually less efficient than centralized ones
  - Local congestion markets should have a “reasonable” size to avoid scarcity and illiquidity
- **Importance of accurate forecasting**
- **Importance of adequate market products to enable DER participation**

# Thank You

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