



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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The SmartNet Project

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Agenda

- The SmartNet project (motivations, set-up, consortium)
- Five TSO-DSO coordination schemes
- Proposed AS market design
- The simulation platform
- Layout of three project pilots
- Regulatory Analysis: work structure

- 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.

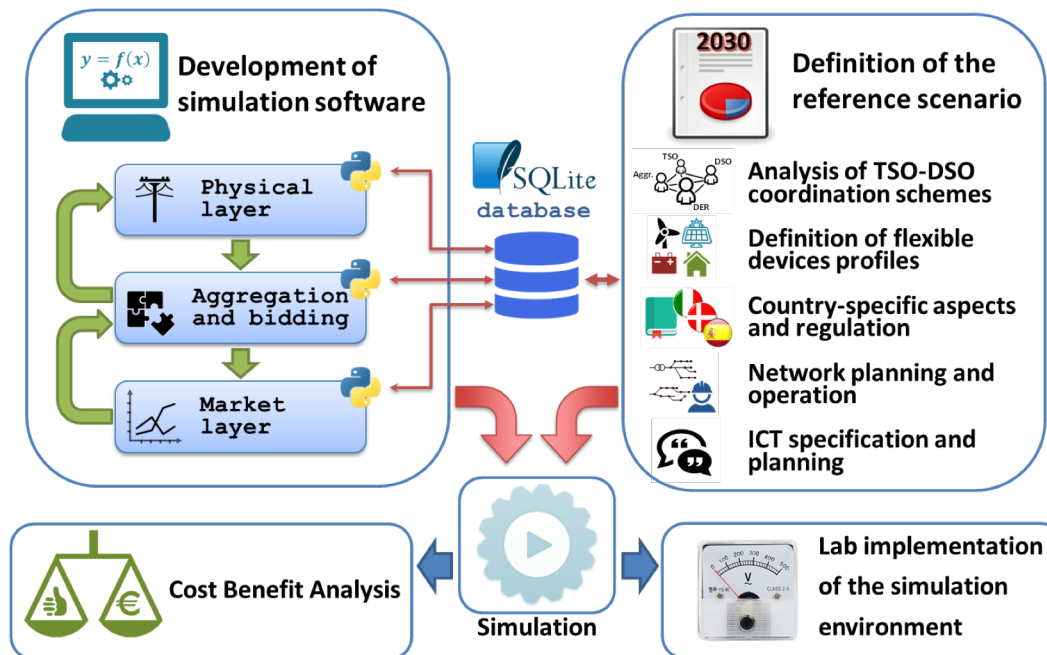
Distribution system operators shall define standardised market products for the services procured ensuring effective participation of all market participants including renewable energy sources, de
operators shall exchange all n
system operators in order to
secure and efficient operation

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>

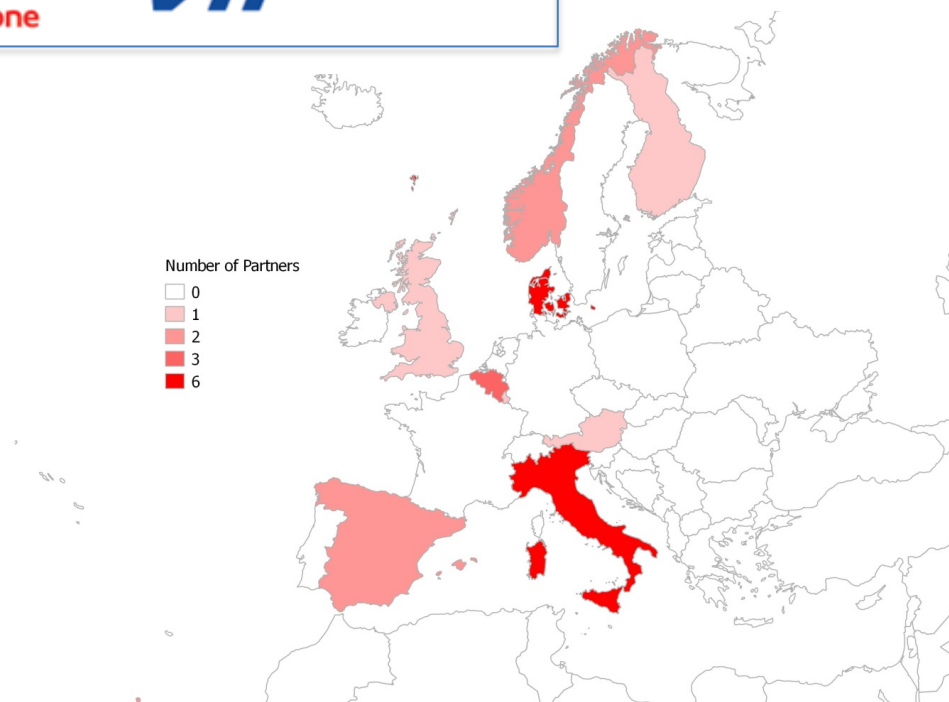
- **architectures for optimized interaction between TSOs and DSOs** in managing the purchase of ancillary services from subjects located in distribution.
- **three national cases** (Italy, Denmark, Spain);
- **ad hoc simulation platform** (physical network, market and ICT)
- **CBA** to assess which TSO-DSO 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

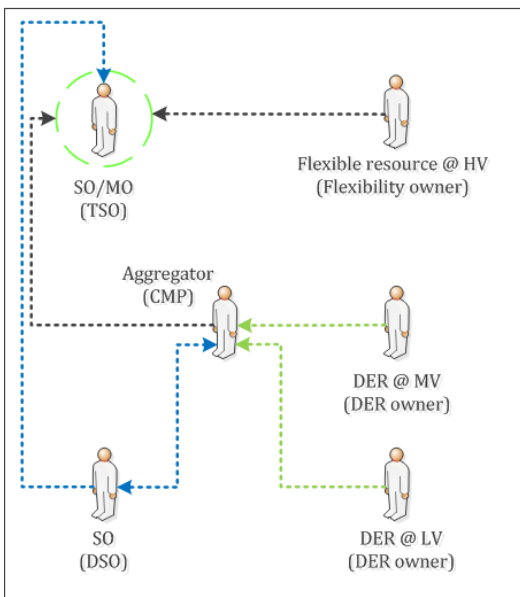


<http://SmartNet-Project.eu>



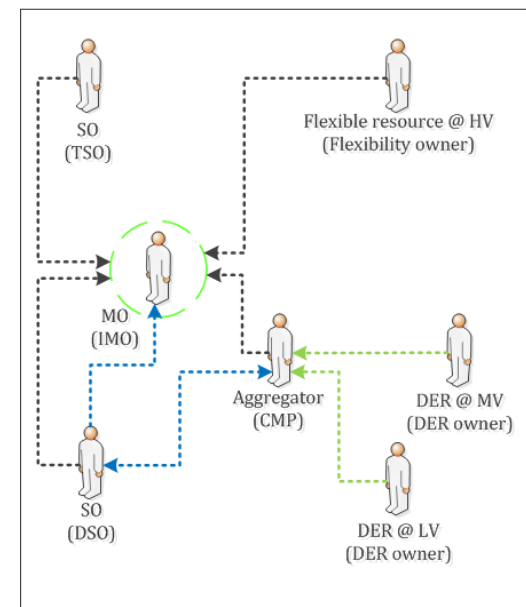
TSO-DSO coordination schemes

Centralized AS market model

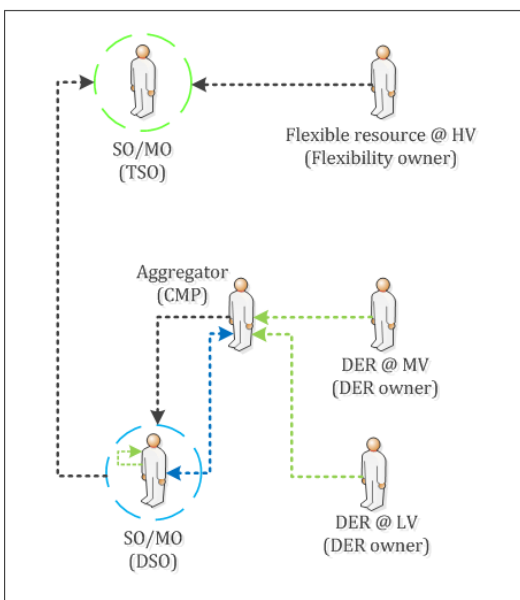


5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

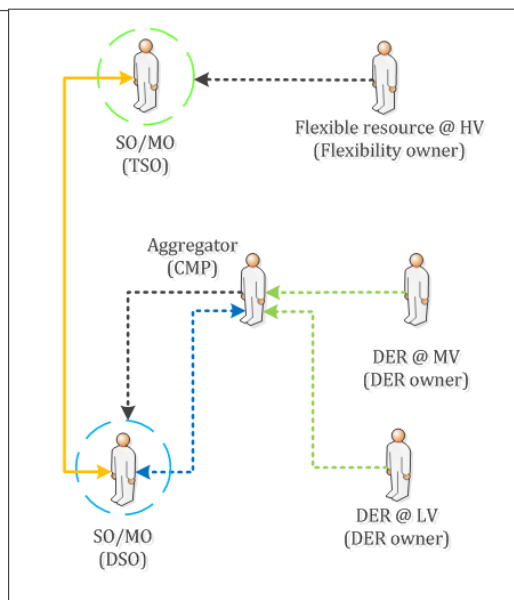
- Centralized AS market model
- Local AS market model
- Shared balancing responsibility model
- Common TSO-DSO AS market model
- Integrated flexibility market model



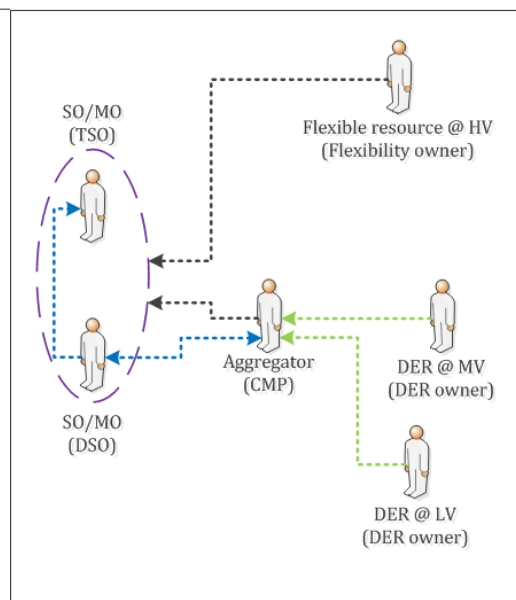
Local AS market model



Shared balancing responsibility model



Common TSO-DSO AS market model

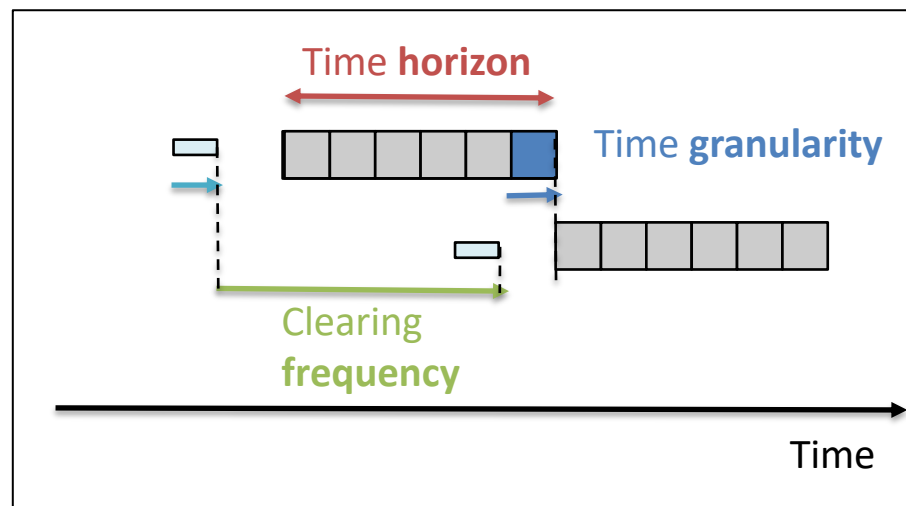
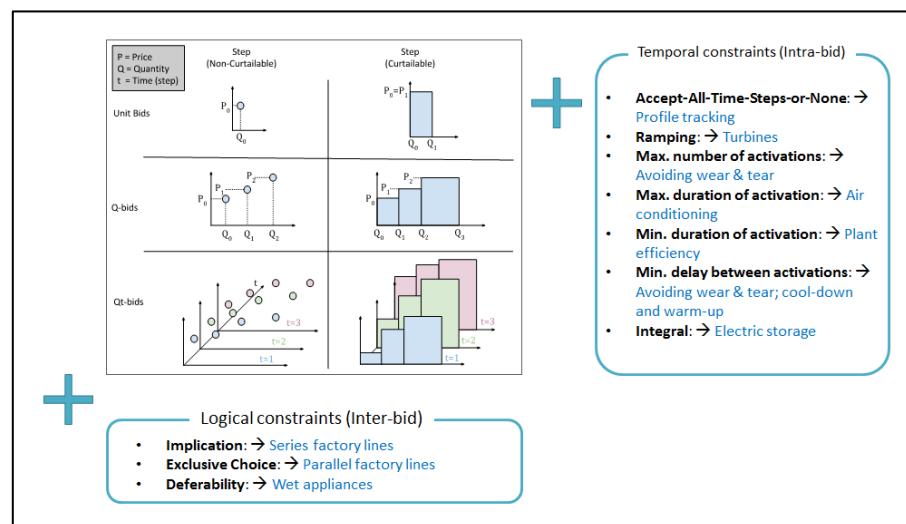


Legend

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

Proposed Market Design

- **Considered services:** **balancing** and **congestion** management at transmission (HV) and distribution level (MV), including voltage constraint at MV
- **Rolling optimisation concept:** Results for the **first** time step are a **firm** decision. Results for the **next** time steps are **advisory** decisions.
- **Network representation:** DC approximation for HV, SOCP for MV
- **Market products:** implementation of typical constraints of flexibility providers (extension to **multi-period bids** with **temporal** and **logical** constraints
- **Representation of arbitrage opportunity between cascading markets:** day-ahead, intraday, AS market





Tertiary market mFRR
(balancing + congestion management)

Cost mFRR

Energy awarded but not delivered (forecasting errors) is paid only for actual delivery (= imbalance settlement at tertiary market price) **New**

Residual congestion and imbalance
congestion not detected by tertiary market and
imbalance/congestion due to forecasting errors

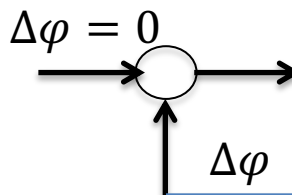
Unwanted measures
(re-dispatching to remove residual congestion)
creating further imbalance

Cost Unwanted Measures

Paid at tertiary market bid price **New**

Residual imbalance

aFRR in physical layer
(system balancing: by
controlling flows with
neighbouring countries)



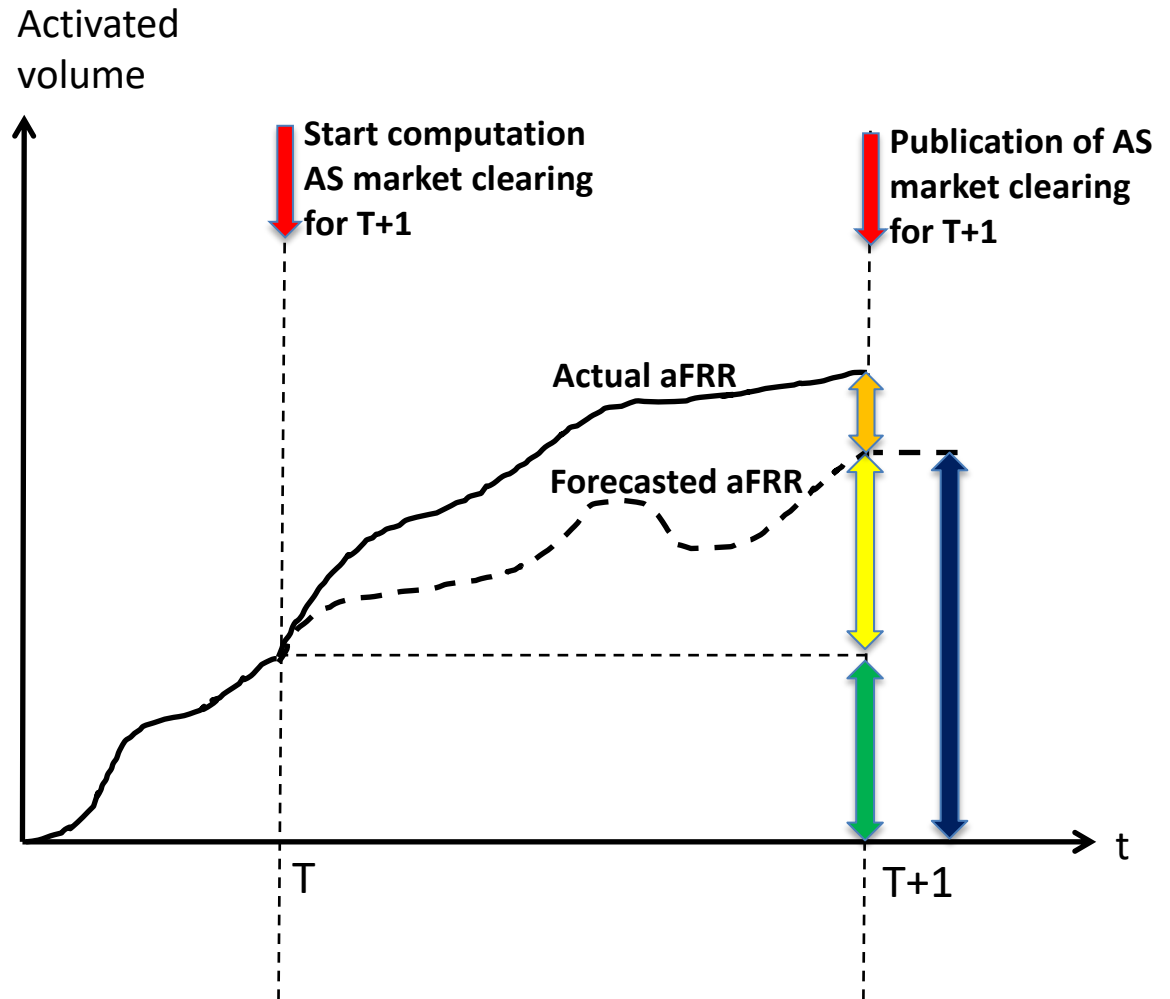
Cost aFRR, higher than mFRR:

$$P_{\text{mFRR\_BID}} * k$$

$$k < 1 \text{ if } P_{\text{mFRR\_BID}} < 0$$

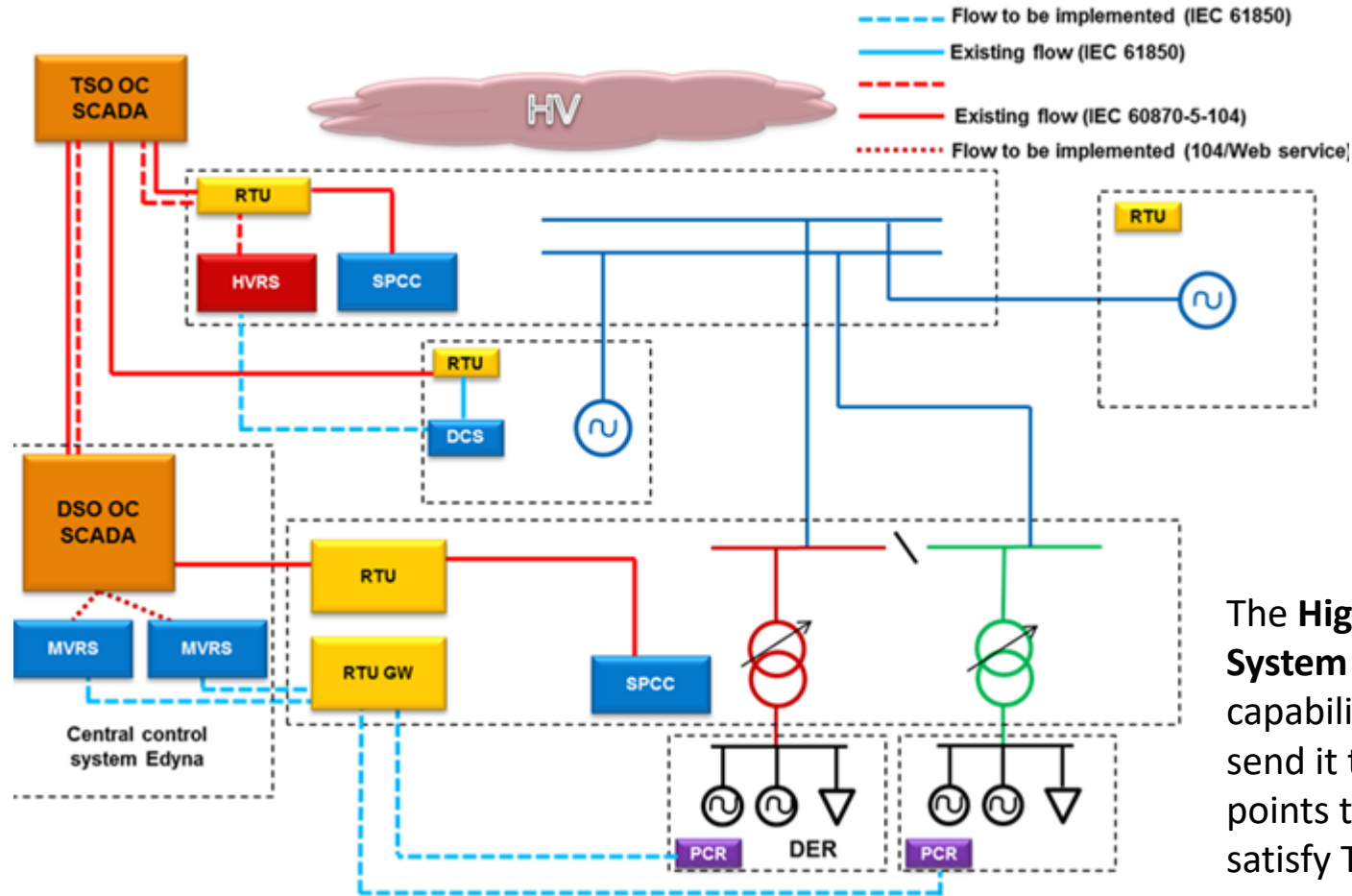
$$k > 1 \text{ if } P_{\text{mFRR\_BID}} > 0$$

-  aFRR volume already activated before T and not yet released
-  Forecasted further aFRR volume activated to compensated imbalance between T and T+1
-  Actual aFRR volume activated between T and T+1 (different from forecast due to forecast errors and CS imperfections in representing the system)
-  Volume of tertiary reserve activated by the AS market at T+1



Pilot A: monitoring and control

It implements an «intelligent» version of CS_A by additionally estimating the virtual capability at the TSO/DSO interconnection point



The **Plant Central Regulators (PCR)** represents the most peripheral device in the communication chain between the TSO and the plant. It makes available the functions of reactive power modulation and active power modulation.

The **High Voltage Regulation System (HVRS)** calculates reactive capability of the generators and send it to the TSO; then sends set points to generators in order to satisfy TSO command (reactive power or voltage set point)

The **Medium Voltage Regulation System (MVRS)** aggregates active and reactive power, differentiated according to the type of energy source, calculates the virtual capability at the TSO/DSO interconnection point in order to define the active and reactive availability of the MV resources and sends set point variations in order to actuate TSO command

Common TSO-DSO AS market model



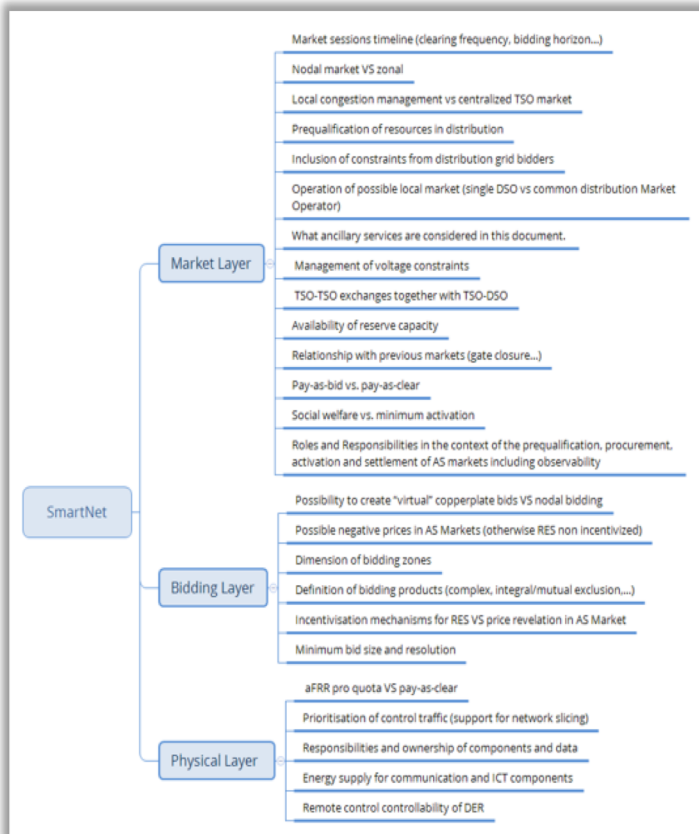


Demand Response Aggregation

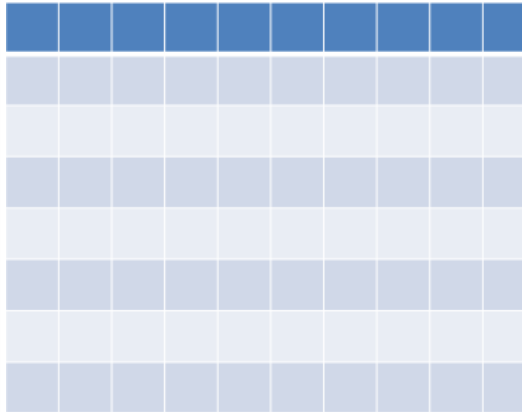
by using storage flexibility (BS and EV)

Power-frequency regulation / balancing
by respecting the exchange program at the
TSO-DSO interconnection 13

Regulatory Analysis: work structure

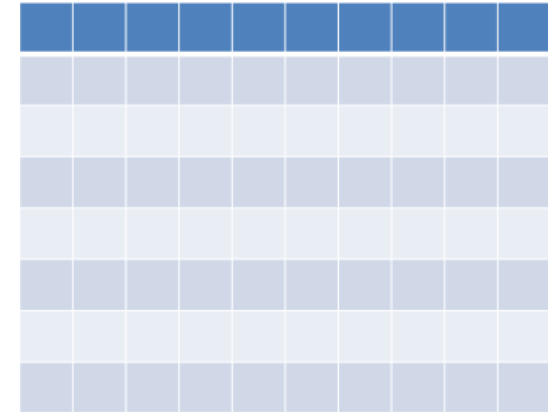


**40+ regulatory documents
and position papers (EU, I, DK, ES)**



Deliverable D6.2

**lessons learned from
project activities**



Deliverable D6.1



Regulatory guidelines (deliverable D6.3)

Some preliminary regulatory reflections

- If the contribution from entities in distribution will grow, DSOs should **implement real time network monitoring** and TSOs could need to **share with DSOs part of responsibility** for the provision of AS.
- Whatever coordination scheme is implemented, it is important that that actions taken by the **TSO and DSO don't cause counteracting effects** (e.g. between local congestion management and balancing) – see CEER Position Paper on Future DSO-TSO Relationship
- between the different AS markets, “**common marketplace**” (see ENTSO-E working paper on Distributed Flexibility and the value of TSO/DSO cooperation) is preferable in order to avoid duplicating bids and avoiding double activations.
- before implementing a separate market for a given AS, it should be attentively considered if it can be **sufficiently liquid** (e.g. local congestion management in distribution).
- restructuring national AS markets should take into account possibility of a **seamless integration with preceding energy markets** (DAM, ID) so as to avoid providing gaming opportunities (e.g. between non-nodal energy markets and nodal AS market)
- new AS architectures should **integrate with on-going transnational integration process** (ENTSO-E platforms): sharing reserve between Countries is a key for allowing further RES integration.
- a **balance** has to be sought for between local optimality (e.g. for a given Country) and the implementation of a harmonized pan-European design.
- **smaller DSOs have to integrate their efforts** in order to be fit for the new responsibilities.
- **real-time market architectures** must take into account the characteristics/constraints of the potential flexibility providers connected to distribution grids
- **aggregators** must be able to provide a simplified interface towards the market, hiding details of flexibility providers, and deliver efficient price signals to incentivize participation from distribution.
- **viable business models** must be available for all market participants, including DERs, aggregators and other customers.
- **network planning** will also have to facilitate better utilization of RES exploiting flexibility.

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Thank You

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