SmartNet

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

Public workshop: Showcase and debate on the results six months away from project end
Brussels, 20.06.2018

Introduction to the SmartNet project

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Agenda

- Motivation, set up and consortium of the project SmartNet
- Year 1 – Year 2 – Year 3
- Five TSO-DSO coordination schemes
- Proposed AS market design
- Balancing market and aFRR
- Structure of the simulation platform
- Layout of three project pilots
- Some preliminary regulatory reflections

Motivations

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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 operatic…

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

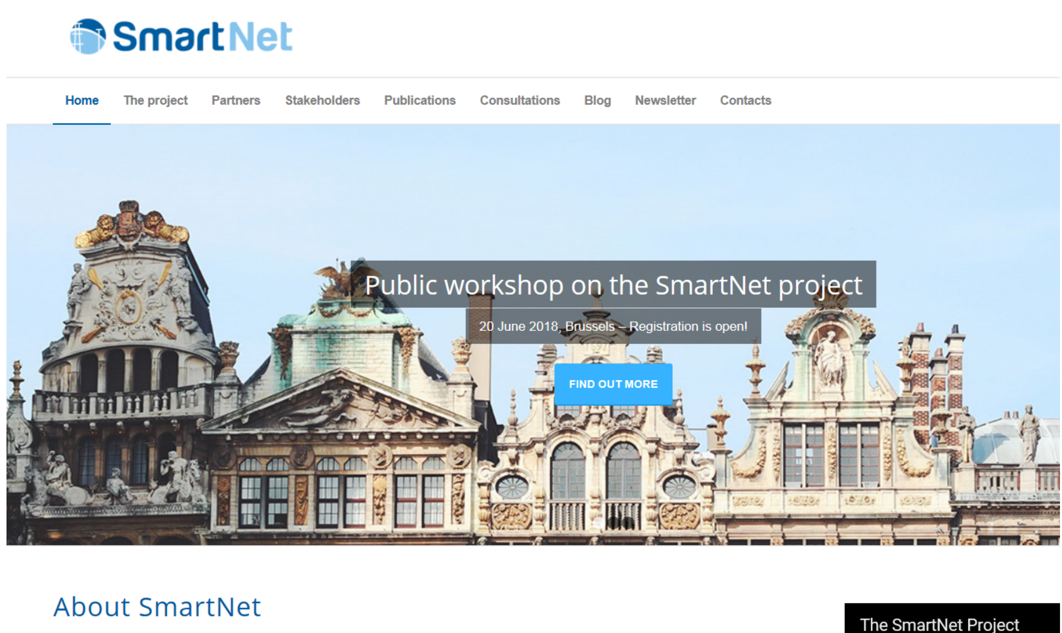
Winter package assigns a role to DSOs for local congestion management, but not for balancing

The SmartNet project

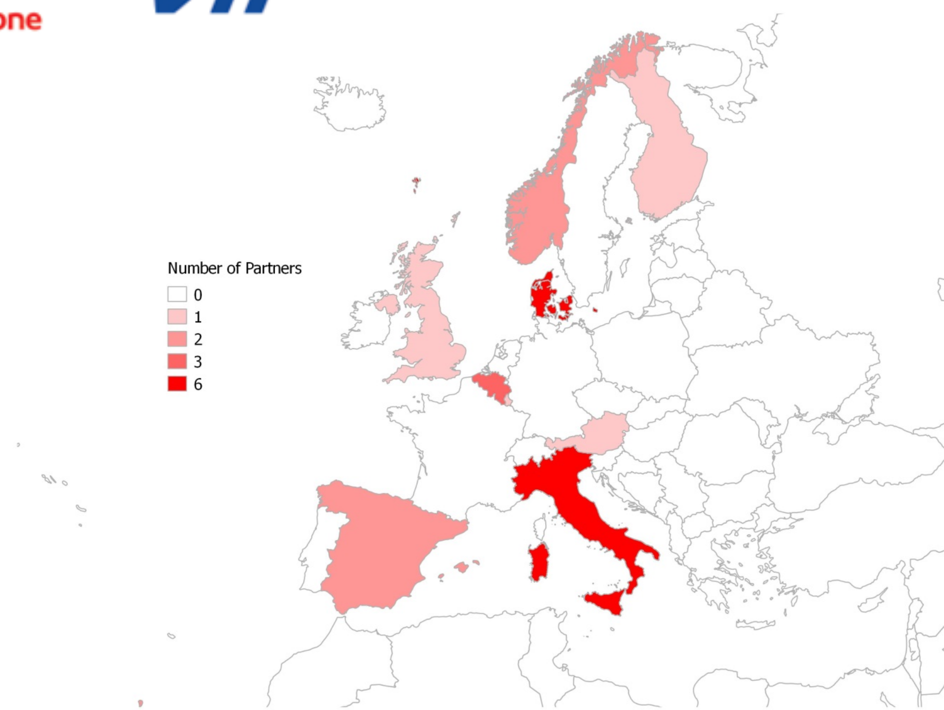
- **architectures for optimized interaction between TSOs and DSOs** in managing the purchase of ancillary services from subjects located in distribution.
- **three national cases** (Italy, Denmark, Spain);
- *ad hoc* **simulation platform** (physical network, market and ICT)
- **CBA** to assess which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

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

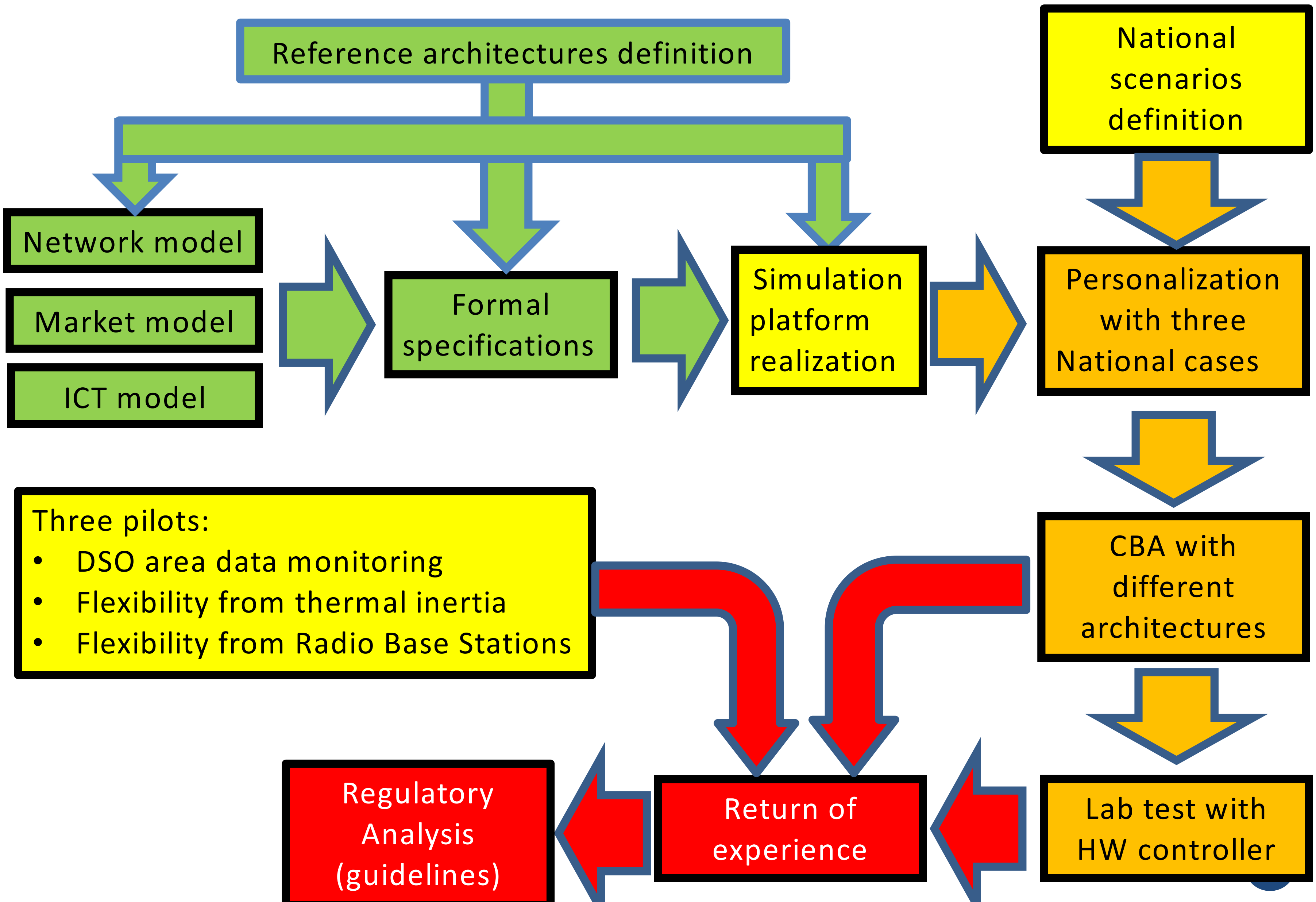
Web site http://SmartNet-Project.eu



The SmartNet project

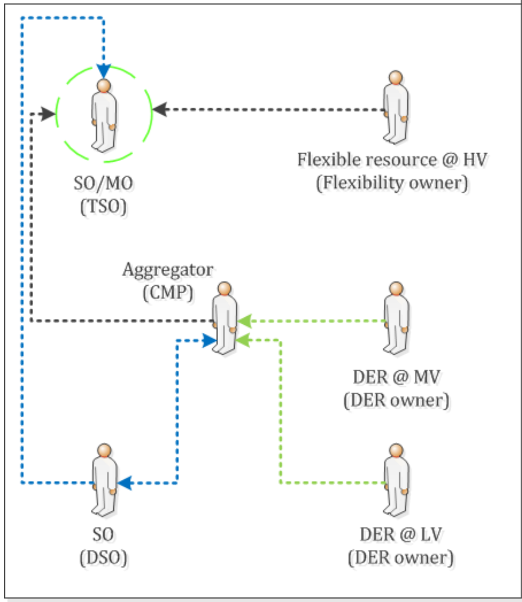


Year 1 – Year 2 – Year 3



TSO-DSO coordination schemes

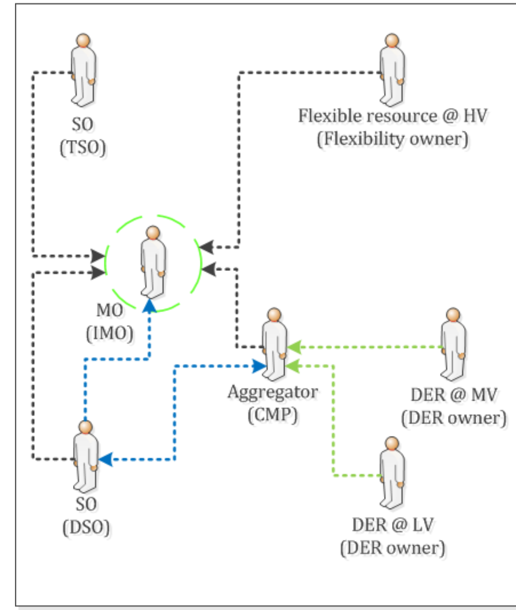
Centralized AS market model



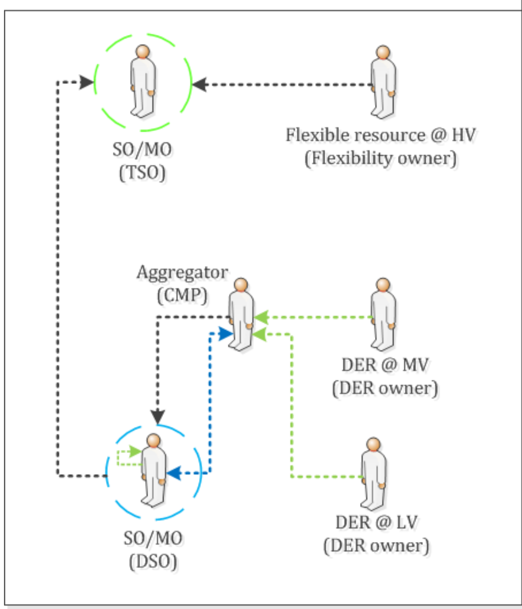
5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

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

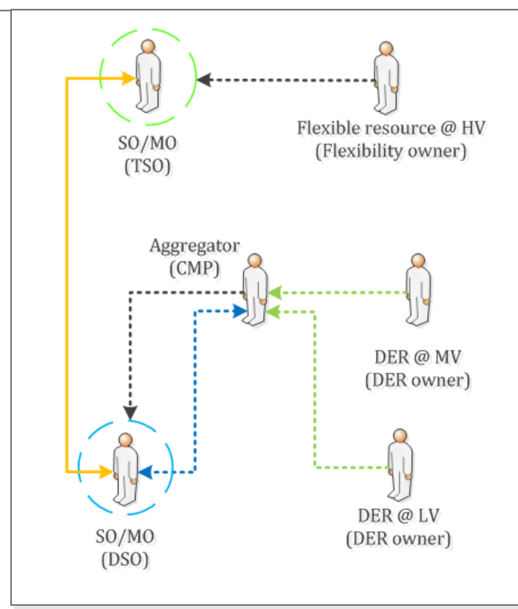
Integrated flexibility market model



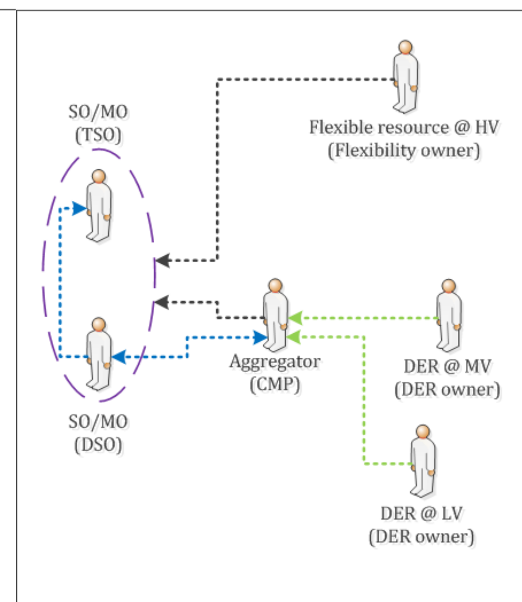
Local AS market model

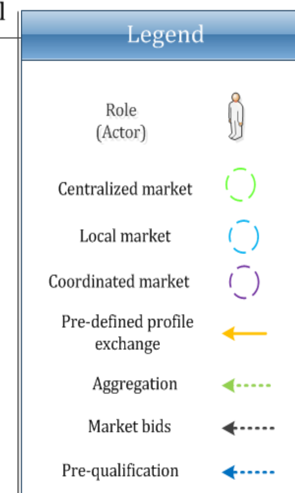


Shared balancing responsibility model



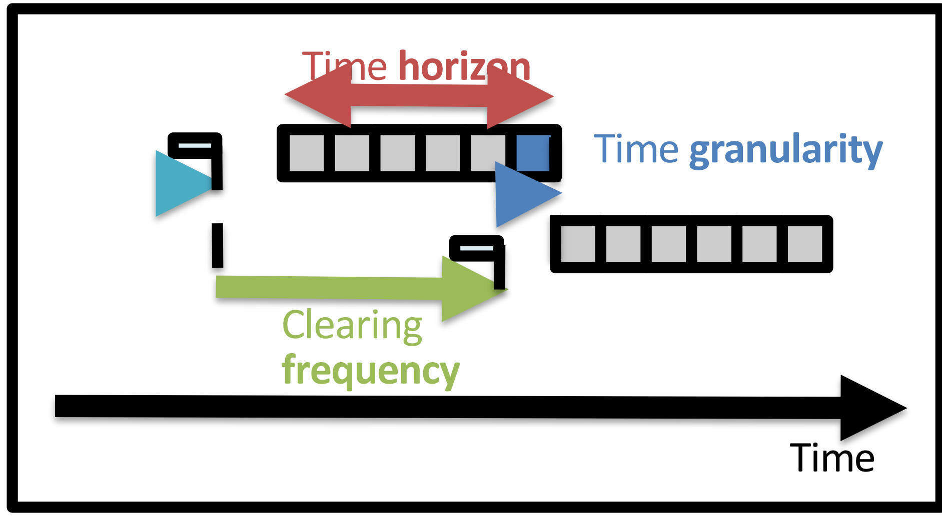
Common TSO-DSO AS market model

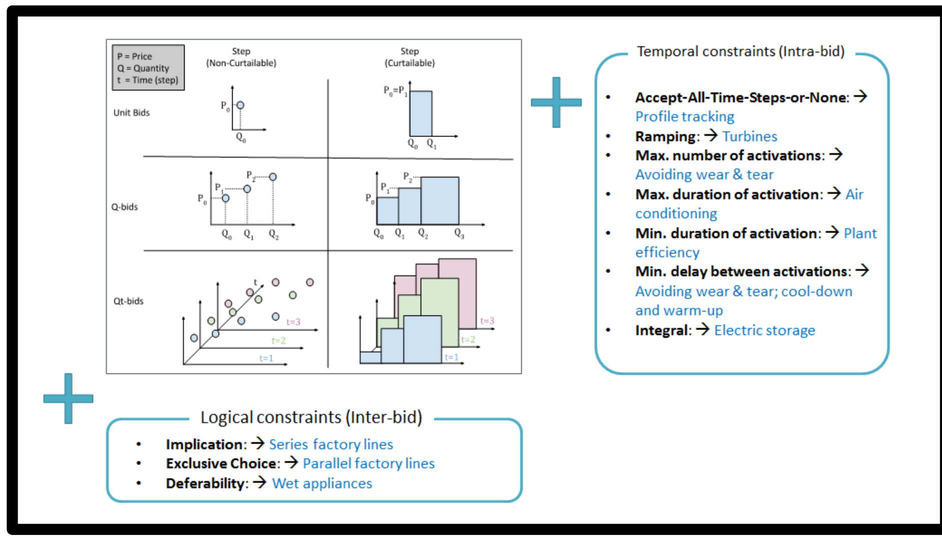




Proposed Market Design

- **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





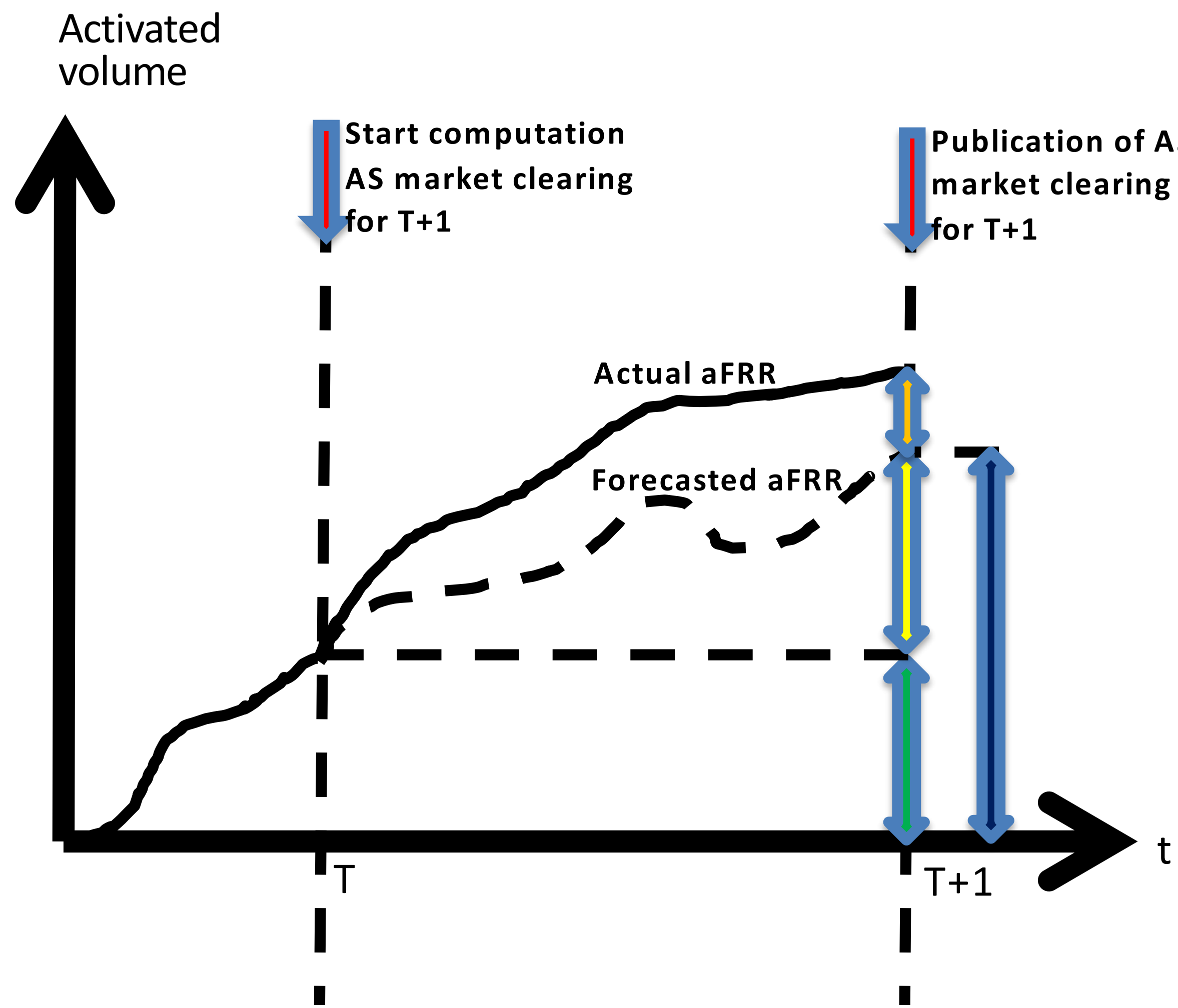
Balancing market and aFRR

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



System imbalance not «seen» by the AS market (e.g. CS-A disregards congestion in distribution), is trapped by aFRR and economically penalized

Structure of the simulation platform

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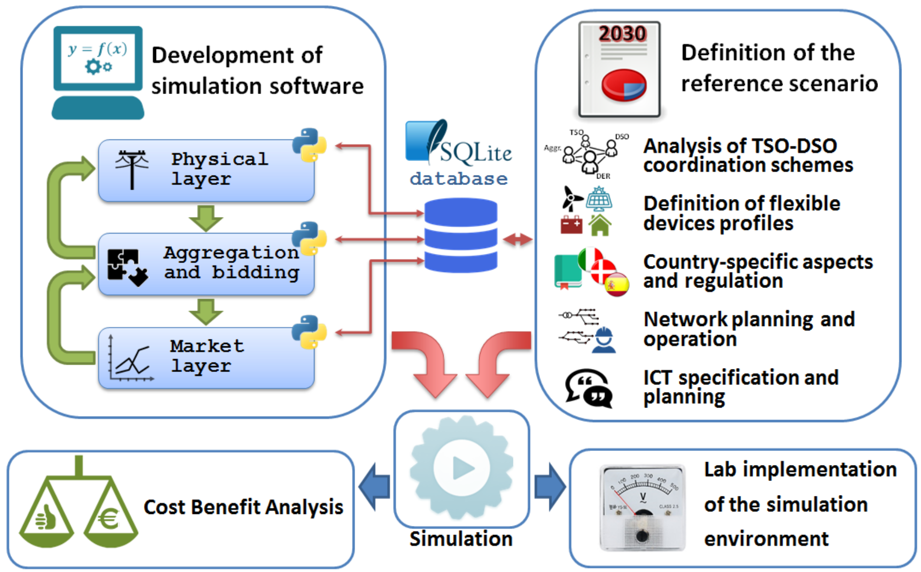
The physical layer simulates T&D and devices operation, including voltage regulation, reactive compensation, aFRR and network protections.

The bidding layer aggregates flexibility offers of a huge number of resources (electric storage, electric vehicles, distributed generation, demand response) into balancing market bids and transforms market clearing into activations.

The market layer carries out system balancing and congestion management while including voltage constraints.

Some innovative features are:

- **rolling optimisation** concept
- **network representation:** DC approximation for HV networks, SOCP for MV networks
- **market products:** typical **multi-period** and **logical** constraints of flexibility providers
- **arbitrage opportunities between cascading markets** (day-ahead, intraday, AS market).



Simulation scenarios at 2030 for Italy, Denmark and Spain. Very large datasets (Italian scenario: 655,323 photovoltaic panels, 31 wind farms, 20 large CHP plants, 1,833 run-of-river hydropower plants, 308 conventional fuel-based generators, 13 pumped hydro stations, 212,704 electrical cars, 1,489,193 residential wet appliances, 68,481 residential heat pumps, 33,783 dimmable street-lights, as well as non-controllable loads in all distribution grids and some transmission nodes.

Cost benefit analysis compares the 5 coordination schemes over 3 national scenarios on the basis of:

- **total AS market cost**
- **aFRR cost** due to congestion not “seen” by AS market, forecasting errors, transmission losses (neglected by AS market).
- **ICT deployment costs**

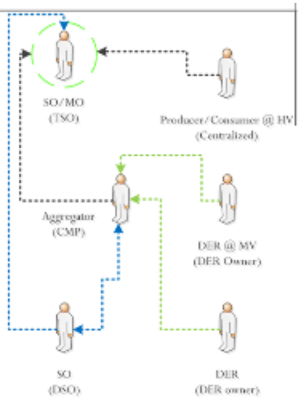
Sensitivity factors:

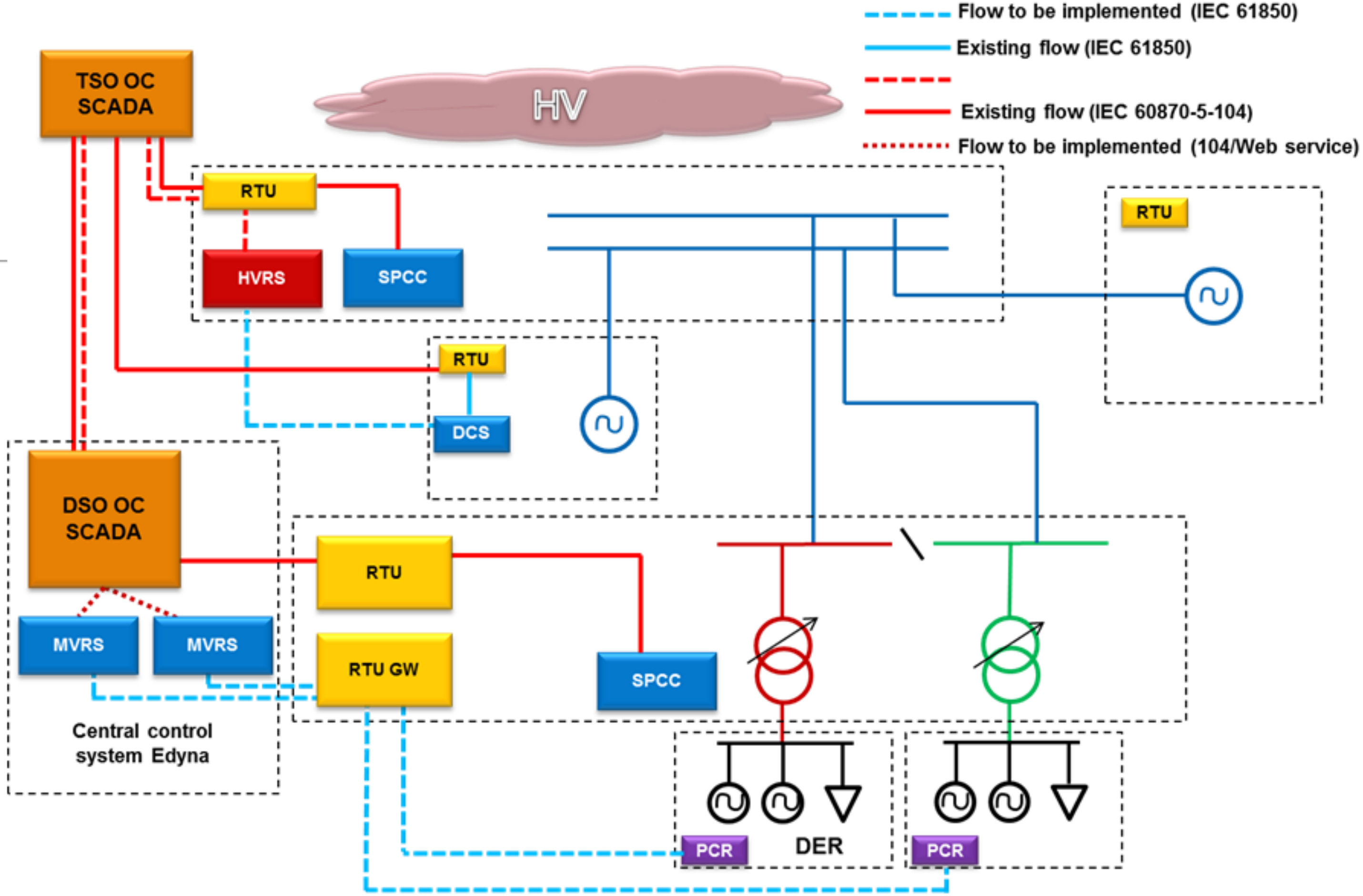
- **emission savings**
- **unwanted measures**

Further “micro” **cash flows analysis**.

Hardware-in-the-loop simulations to test in real-time-simulated scenarios the performances of real equipment (controllers for flexible devices, SCADAs, etc.) and the effects of non-ideal information transmission channels.

Pilot A: Distribution monitoring and control



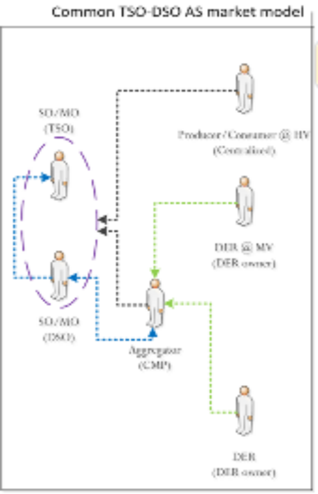


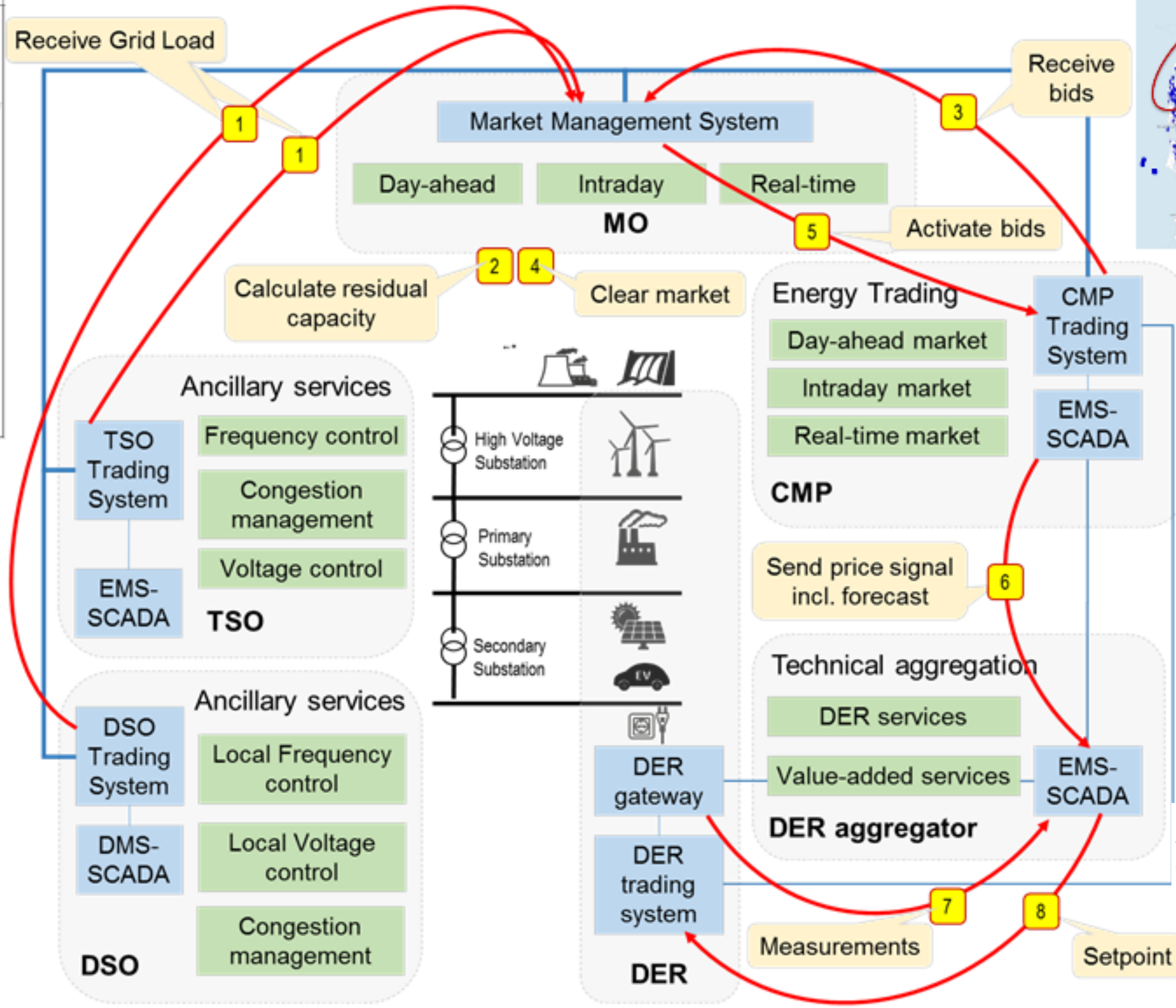
Aggregation of information
in RT at TSO-DSO interconnection (HV/MV transformer)

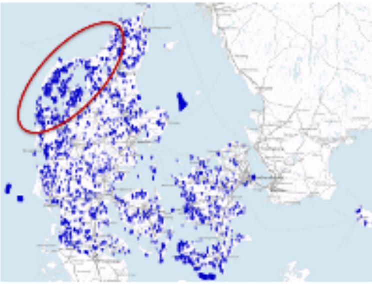
Voltage regulation
by generators connected at HV and MV levels

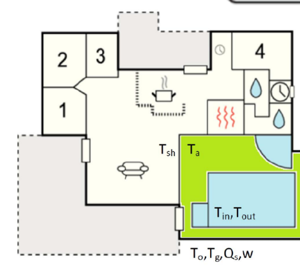
Power-frequency regulation / balancing
by generators connected at HV and MV levels

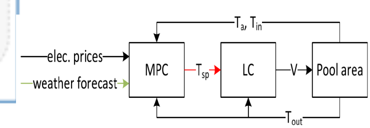
Pilot B: Ancillary services from indoor swimming pools









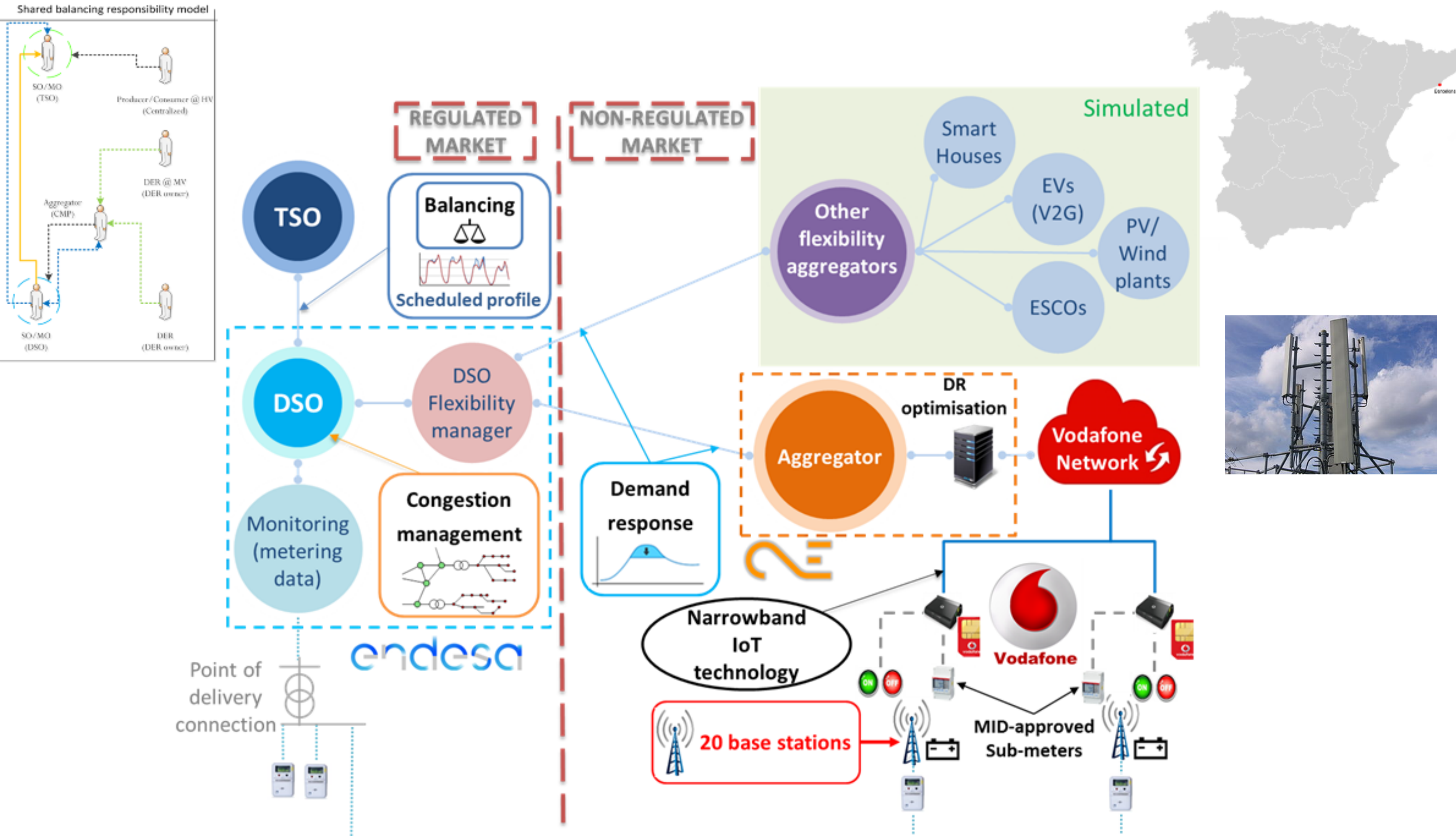


Congestion management
to better integrate PV, EV and HP

Price-based control
of thermal controllers of swimming pools in summer houses

Balancing
of wind power with decreasing contribution of thermal units

Pilot C: Ancillary services from radio-base stations



Congestion management
at DSO level

Demand Response Aggregation
by using storage flexibility (BS and EV)

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

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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