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

Future Power Market Platform - Meeting on TSO-DSO-PX Cooperation| Milan, 10.01.2018

SmartNet project: TSO-DSO interaction architectures to enable DER participation in ancillary services markets

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Agenda

- SmartNet project motivations
- Outline of SmartNet
- Five TSO-DSO coordination schemes
- Proposed AS market design
- The simulation platform
- Cost-benefit analysis of the coordination schemes
- Layout of three project pilots

Project motivations

- 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-trans-mission 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 operatio

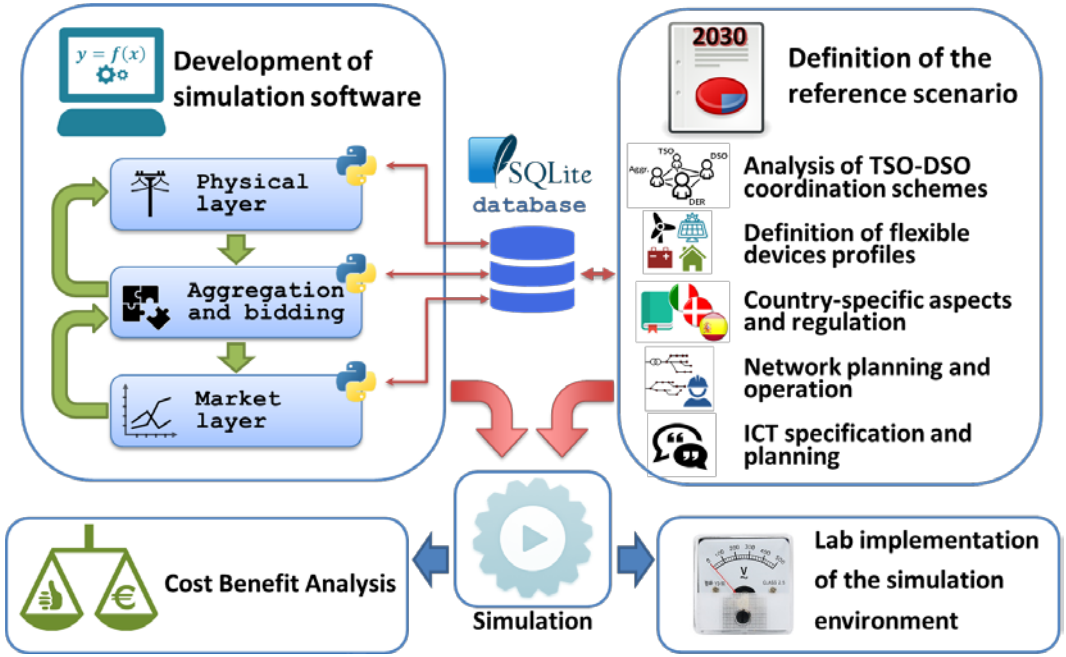
EC (2016) Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity

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

The SmartNet project http://SmartNet-Project.eu

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).



TSO-DSO coordination schemes

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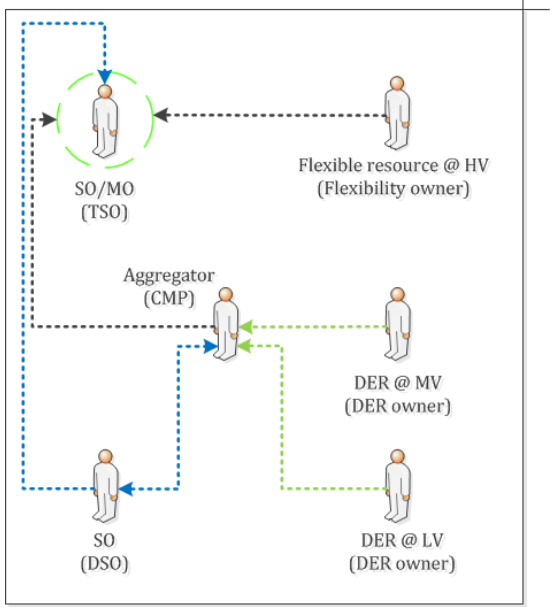
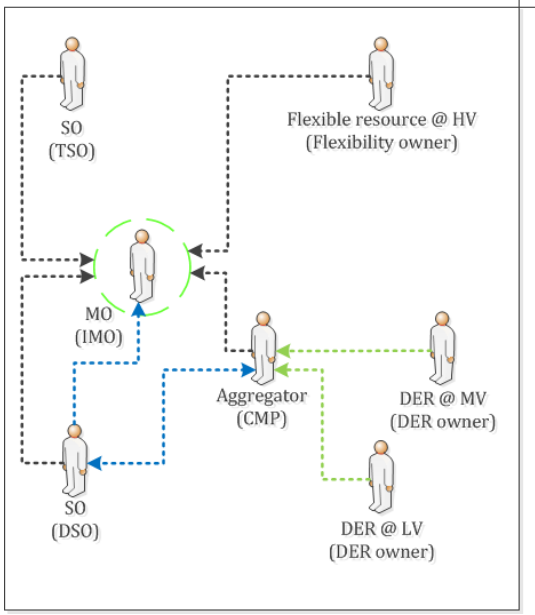
5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

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

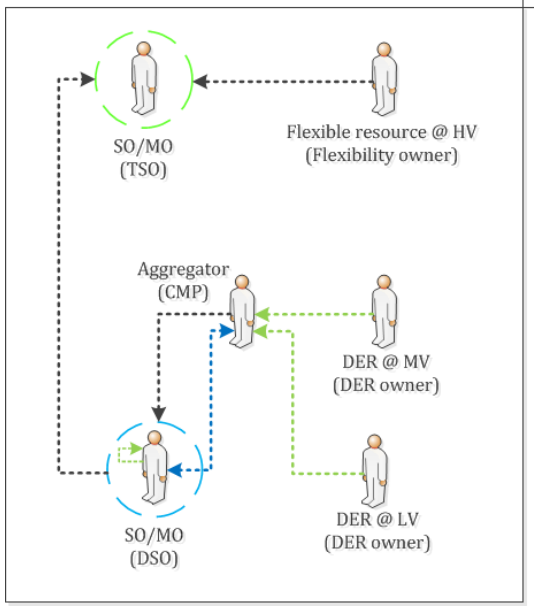
Centralized AS market model



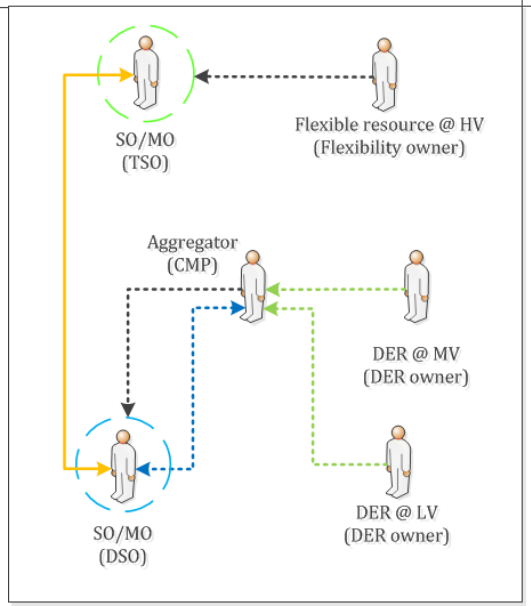
Integrated flexibility market model



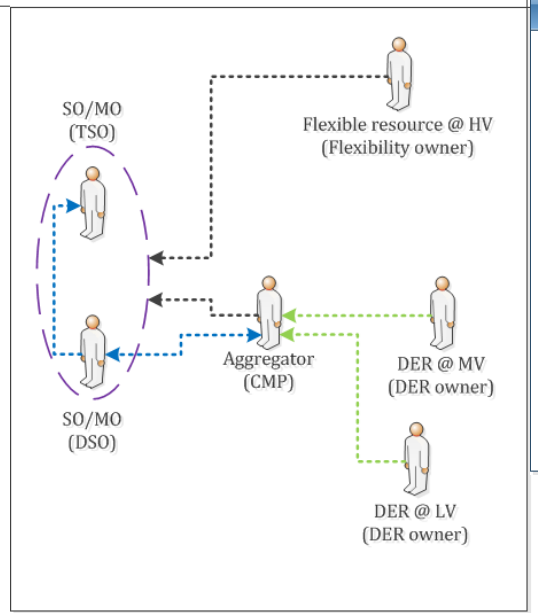
Local AS market model

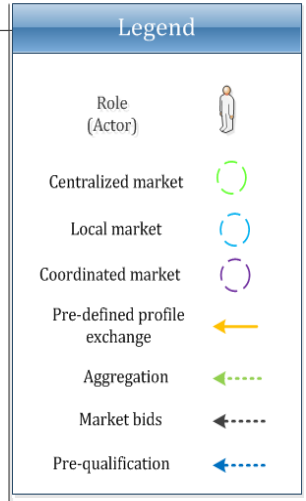


Shared balancing responsibility model



Common TSO-DSO AS market model





Coordination scheme	Benefits	Attention points
Centralized AS market model	▪ Efficient scheme in case only the TSO is a buyer for the service ▪ A single market is low in operational costs and supports standardized processes ▪ 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 to use local flexibility ▪ DSO supports actively AS procurement ▪ Local markets might create lower entry barriers for small scaled DER	▪ TSO and DSO market cleared sequentially ▪ Local markets might be rather illiquid ▪ Need for extensive communication between the TSO market and the 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 DER ▪ Clear boundaries between system operation TSO and DSO	▪ Total amount of AS to be procured by TSO and DSO will be higher in this scheme ▪ BRPs might face higher costs for balancing ▪ Small local markets might be not liquid enough to provide sufficient resources for the DSO ▪ Defining a pre-defined schedule methodology agreed by both TSO/DSO might be challenging
Common TSO-DSO AS market model	▪ Total system costs of AS for the TSO and local services for the DSO are minimized ▪ TSO and DSO collaborate closely, making optimal use of the available flexible resources	▪ 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 competitive prices due to large number of buyers and sellers	▪ Independent market operator needed to operate the market platform ▪ Negative impact on the development and liquidity of intraday markets ▪ TSO and DSO need to share data with IMO

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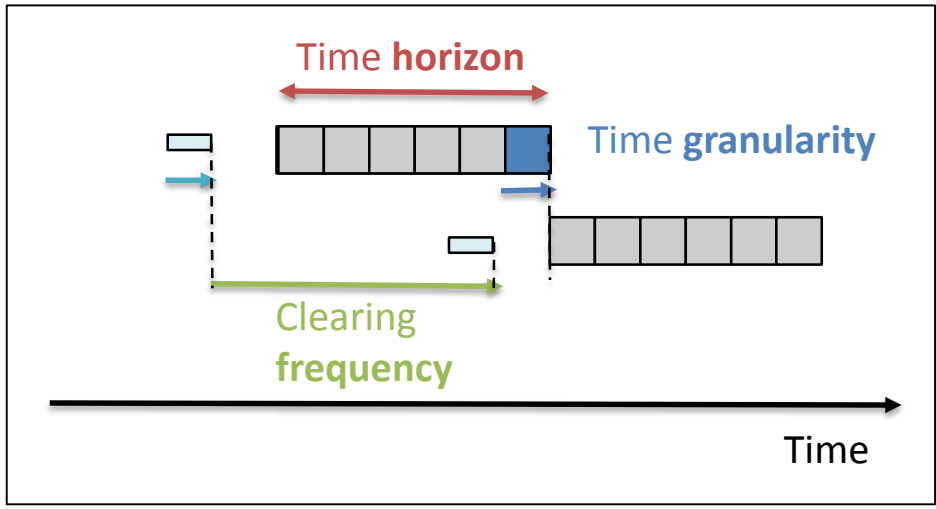
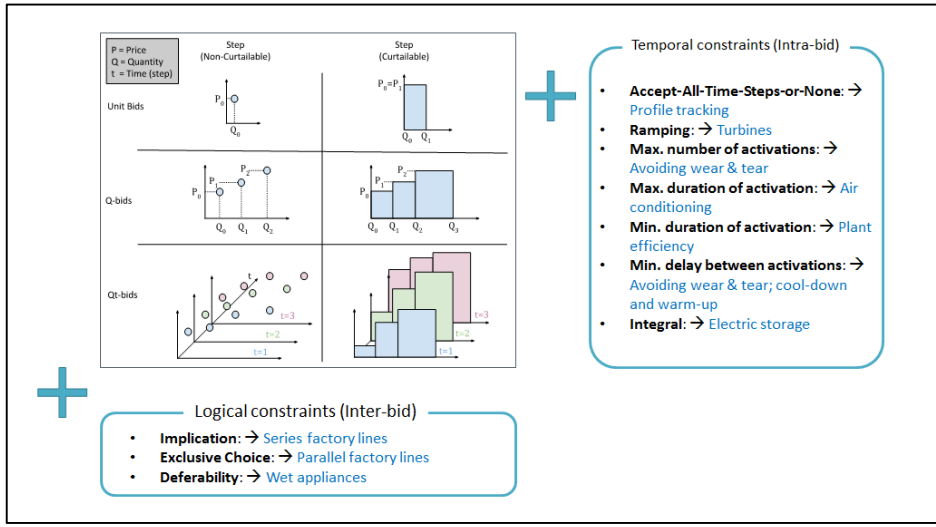
TSO-DSO coordination schemes

From SmartNet deliverable D1.3
http://smartnet-project.eu/wp-content/uploads/2016/12/D1.3_20161202_V1.0.pdf

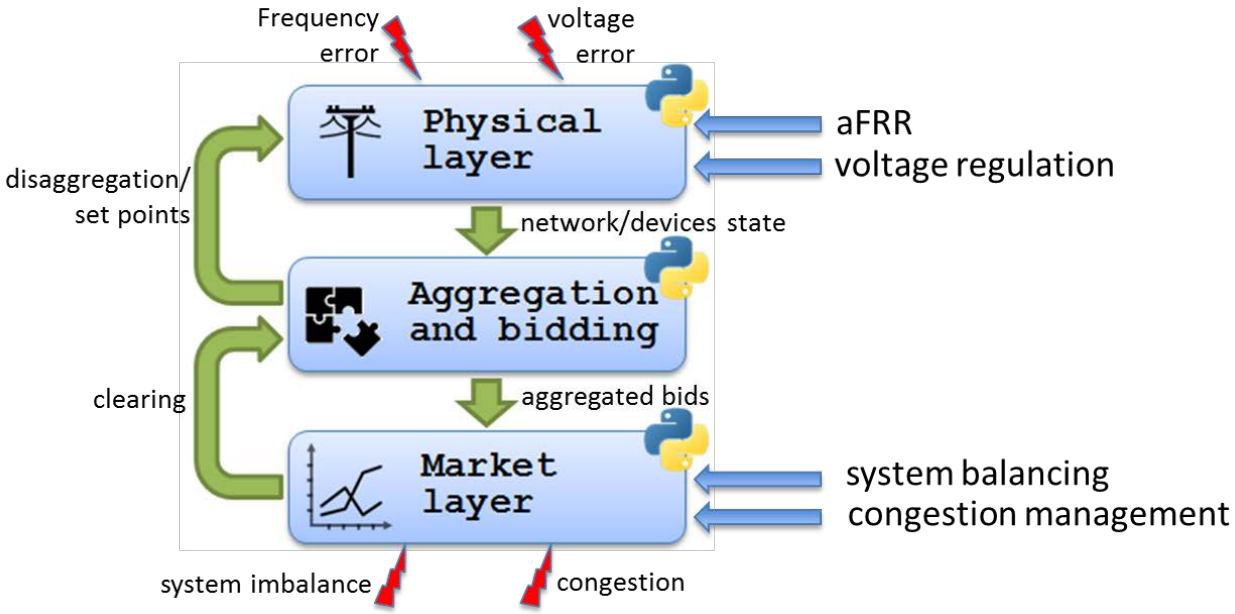
Proposed Market Design

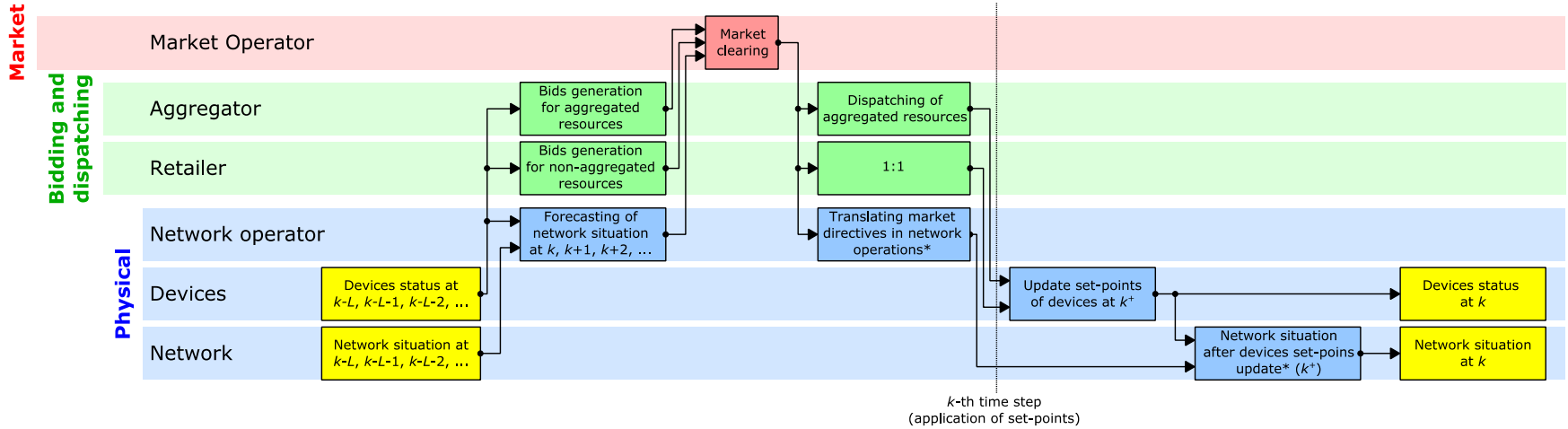
- **Considered services:** **balancing** and **congestion** management at transmission (HV) and distribution level (MV), including voltage constraint at MV
- **Rolling optimisation concept:** Results for the **first** time step are a **firm** decision. Results for the **next** time steps are **advisory** 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





The simulation platform





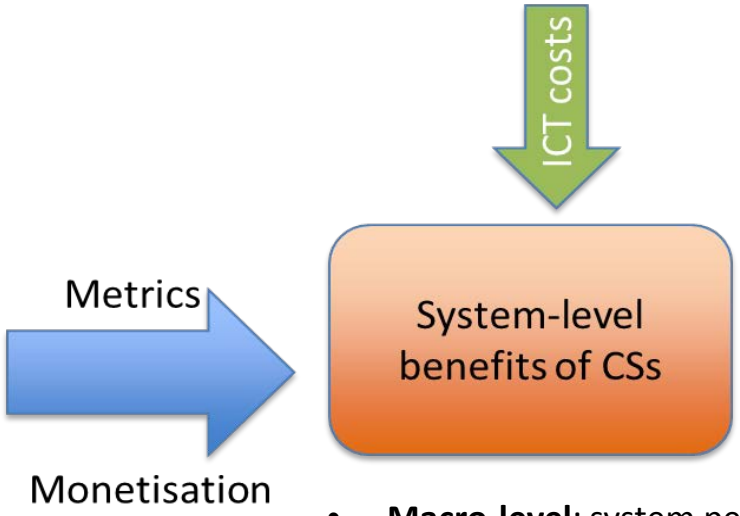
CBA among TSO-DSO coordination schemes

- Literature review:
  - EPRI/JRC
  - REALISEGRID
  - e-Highway2050
- Proposed indicators:
  - **Reduction of total balancing cost** (not social welfare!)
  - **Reduction of network losses** (calculated ex-post)
  - **Reduction of congestion not "seen" by the AS market:** trapped by the regulations of the physical layer
- Sensitivity factors
  - **Emissions savings**: with standard emission rates for each generation technology and CO2 prices forecasted at studied horizon.
  - **Cost percentage due to network limitations:** comparing costs with Ideal situation (bus-bar network)

ICT costs include communication, market clearing software)…. Steps :

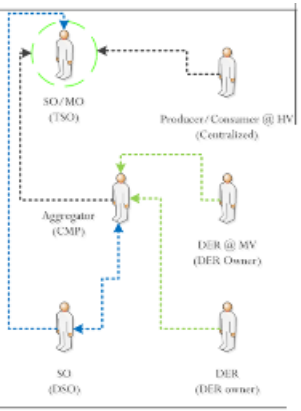
1. Comparison of the coordination schemes in terms of functionalities and ICT
2. Convert each ICT system into a cost at target year

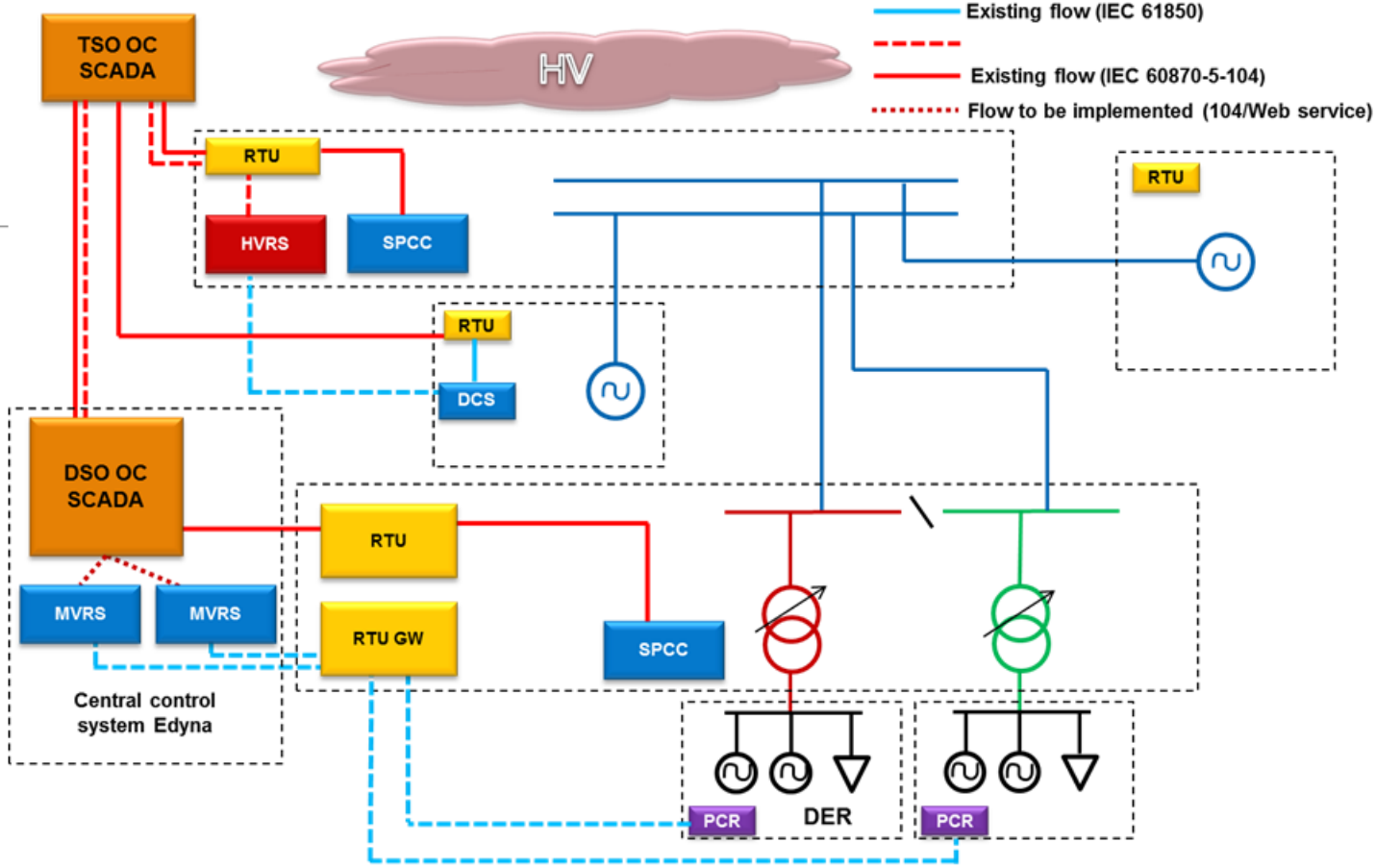
Main focus on issues that can differ between coordination schemes.



- **Macro-level**: system perspective
- **Micro-level**: actors' business case

Pilot A: Distribution monitoring and control



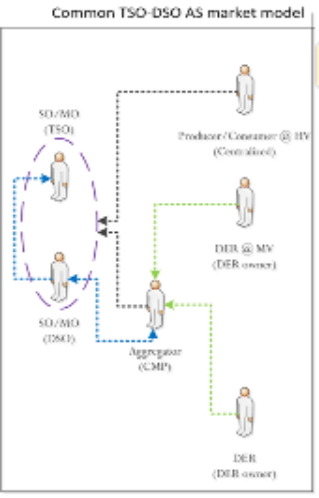


Aggregation of information
in RT at TSO-DSO interconnection (HV/MV transformer)

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



Receive Grid Load

Market Management System

Day-ahead | Intraday | Real-time

MO

Receive bids

Activate bids

Calculate residual capacity

Clear market

Energy Trading

Day-ahead market

Intraday market

Real-time market

CMP

CMP Trading System

EMS-SCADA

Send price signal incl. forecast

Technical aggregation

DER services

Value-added services

DER aggregator

EMS-SCADA

Ancillary services

TSO Trading System

Frequency control

Congestion management

Voltage control

EMS-SCADA

TSO

High Voltage Substation

Primary Substation

Secondary Substation

Ancillary services

DSO Trading System

Local Frequency control

DMS-SCADA

Local Voltage control

Congestion management

DSO

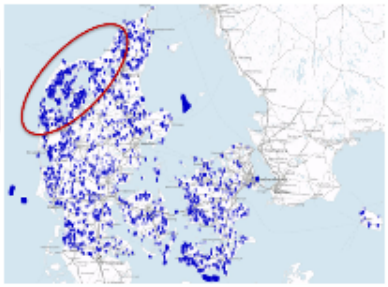
DER gateway

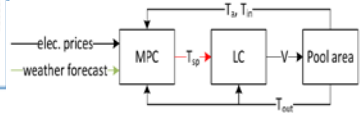
DER trading system

DER

Measurements

Setpoint



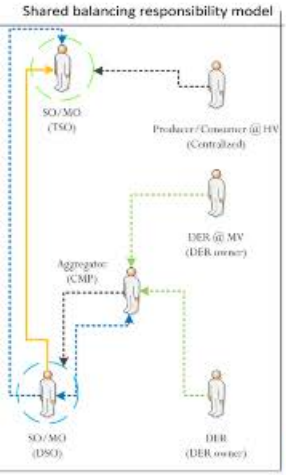


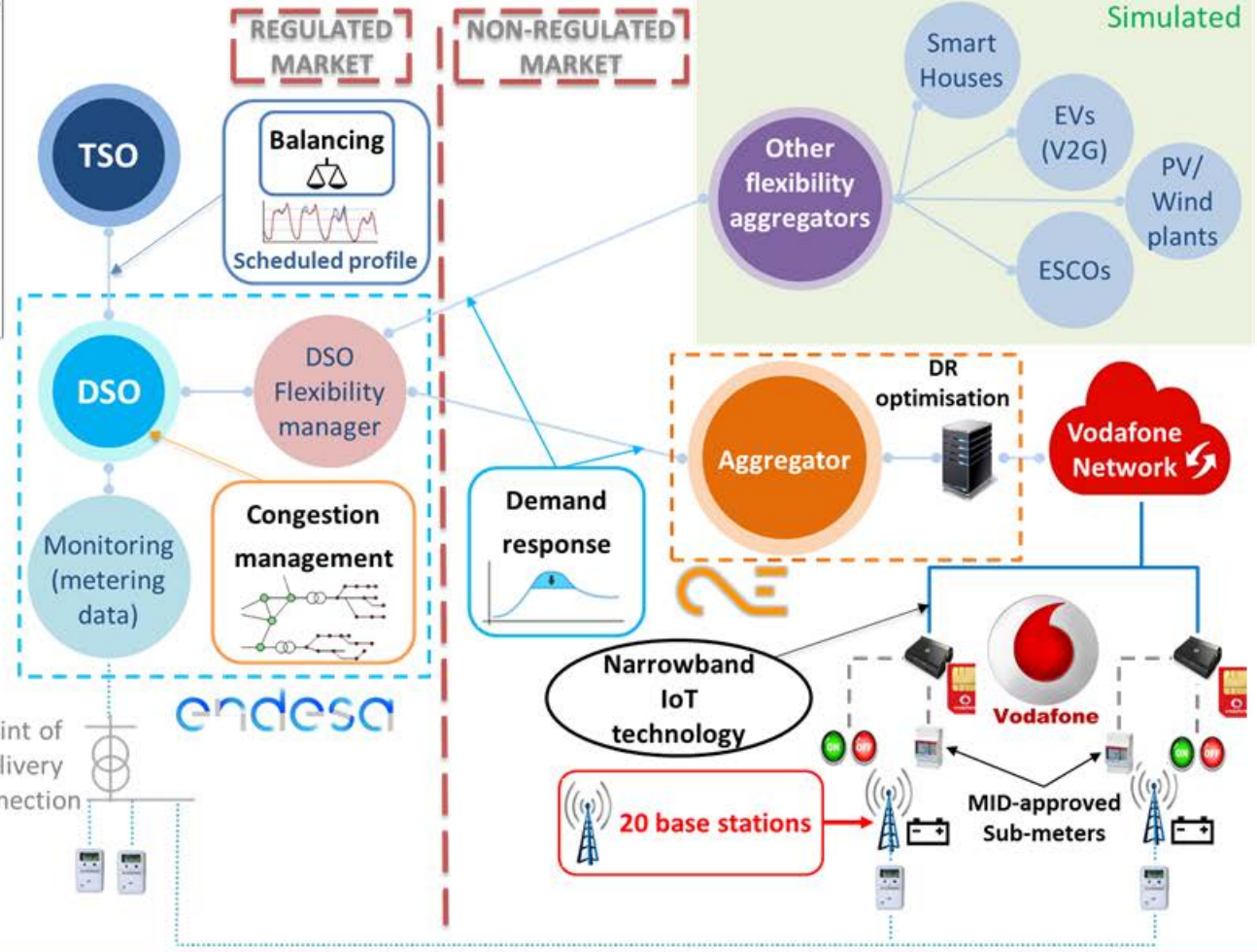
Congestion management
to better integrate PV, EV and HP

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

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Thank You

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