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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

**Presentation to Korean delegation| 21.02.2018**

# The SmartNet Project

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# Agenda

- The project SmartNet
- Year 1 – Year 2 – Year 3
- Five TSO-DSO coordination schemes
- Proposed AS market design
- The simulation platform
- Cost-benefit analysis of the coordination schemes
- Layout of three project pilots
- Some preliminary regulatory reflections

# 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 e
secure and efficient operatio

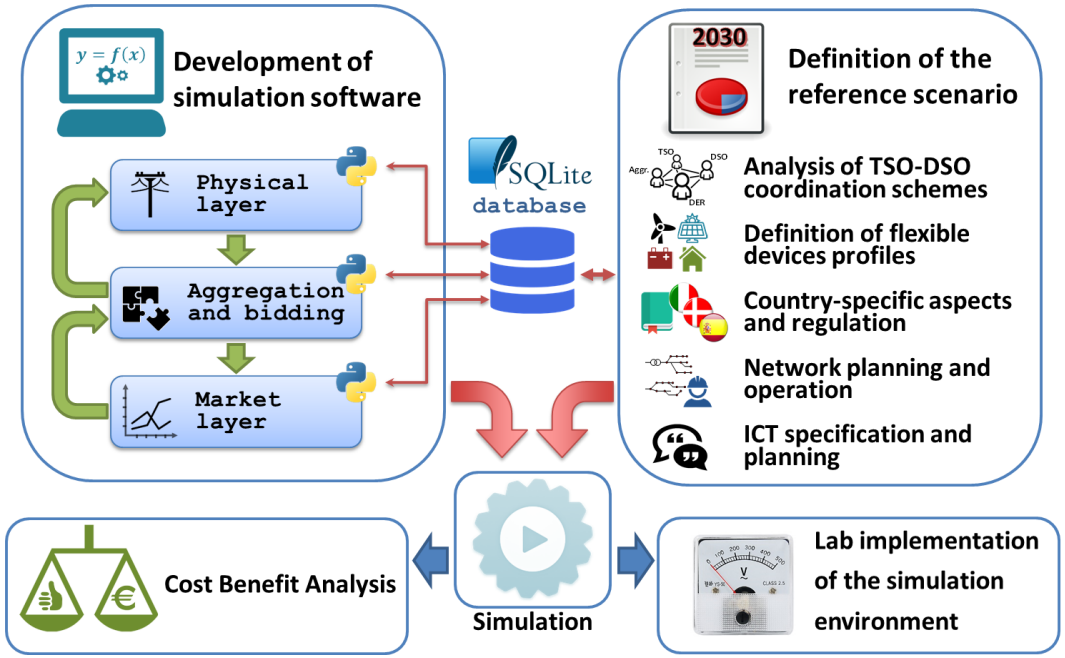
EC (2016) Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity

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).



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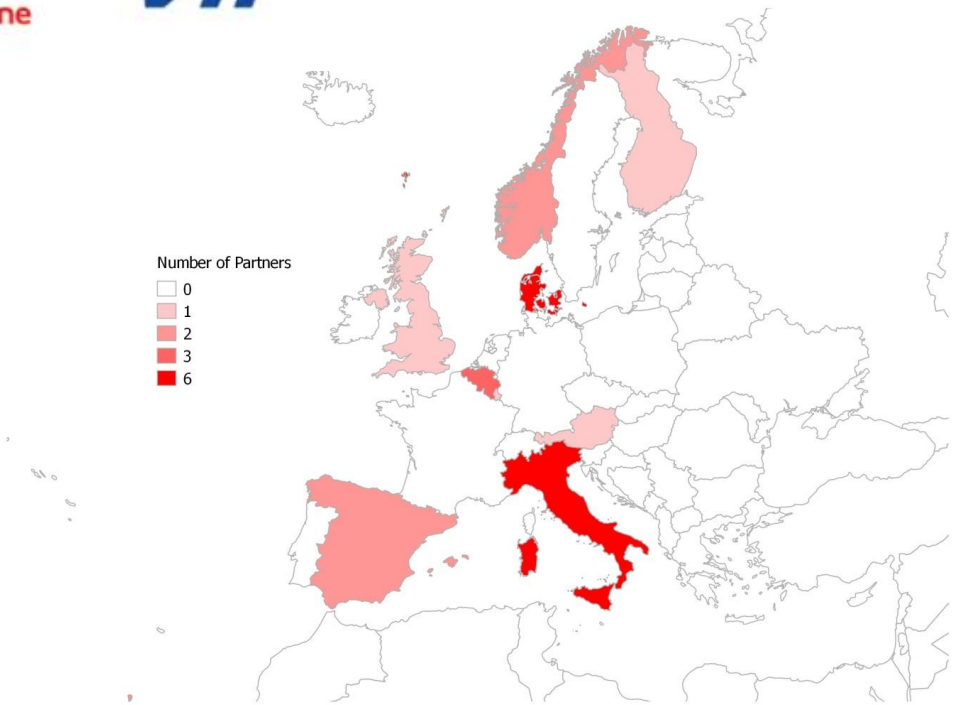
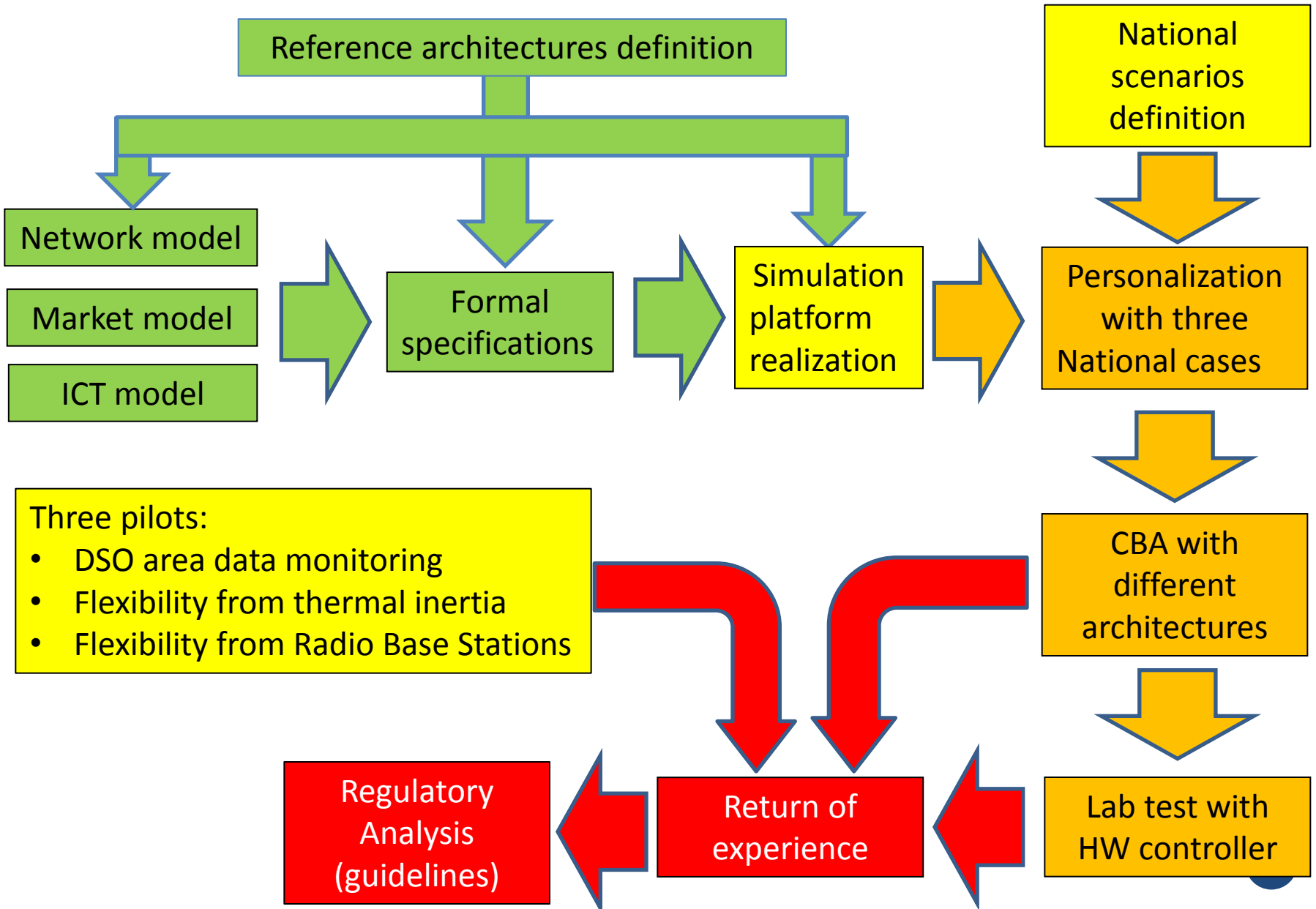


# Year 1 – Year 2 – Year 3



# TSO-DSO coordination schemes

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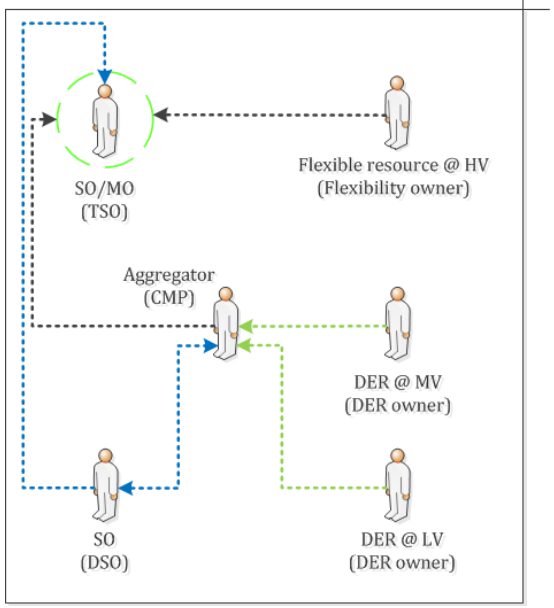
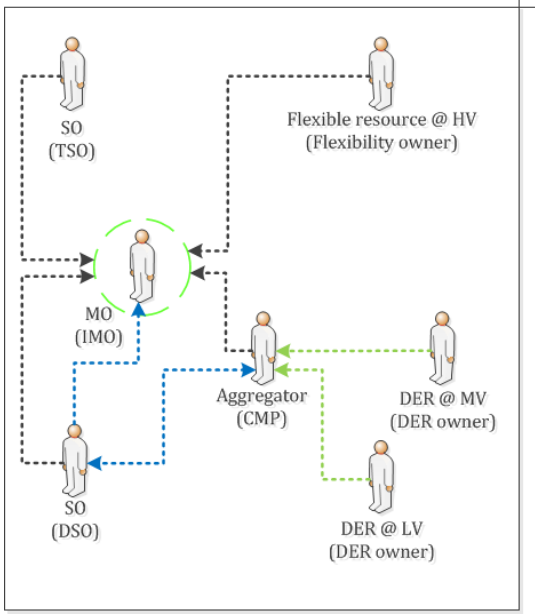
## 5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

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

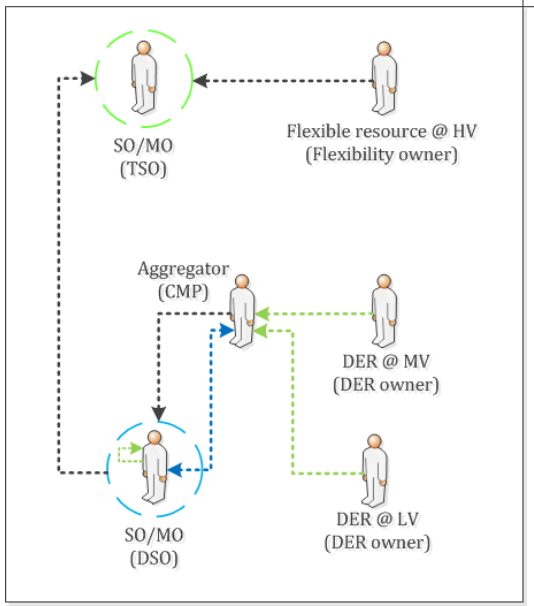
Centralized AS market model



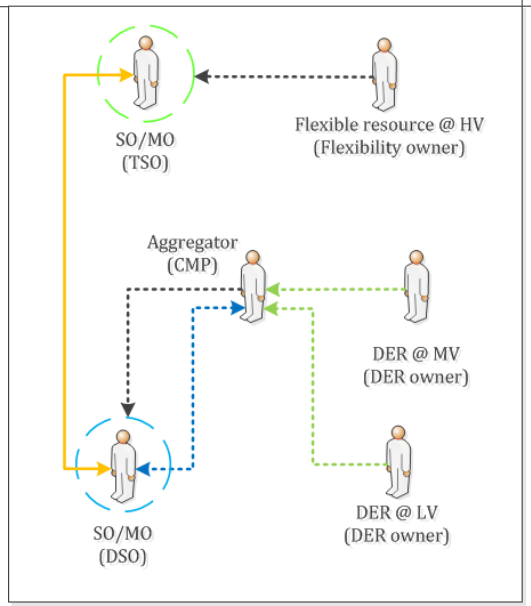

Integrated flexibility market model



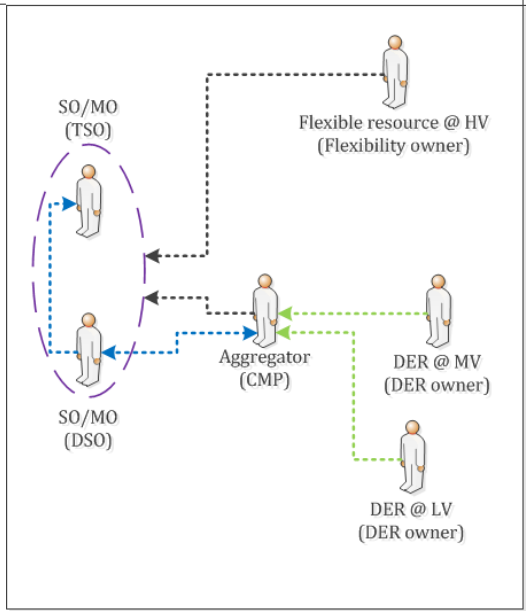

Local AS market model

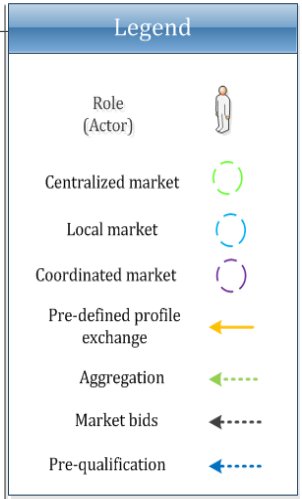



Shared balancing responsibility model



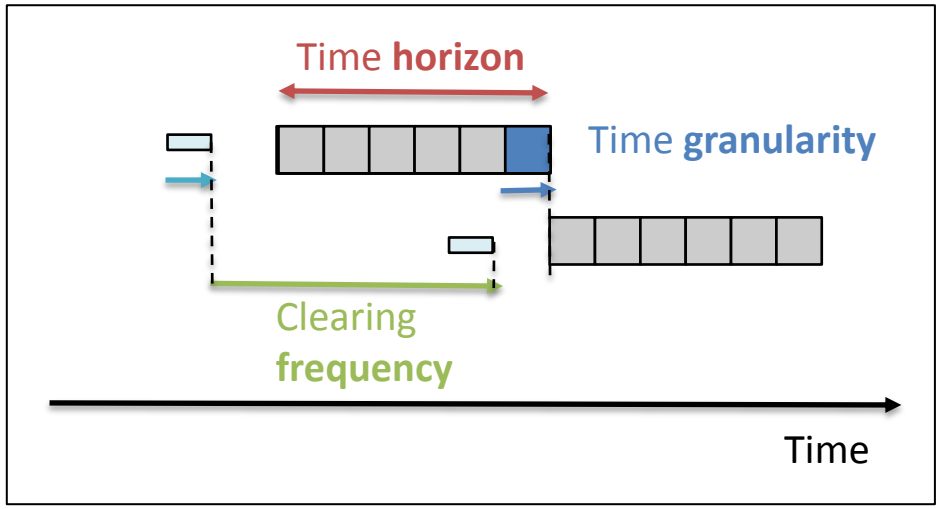

Common TSO-DSO AS market model

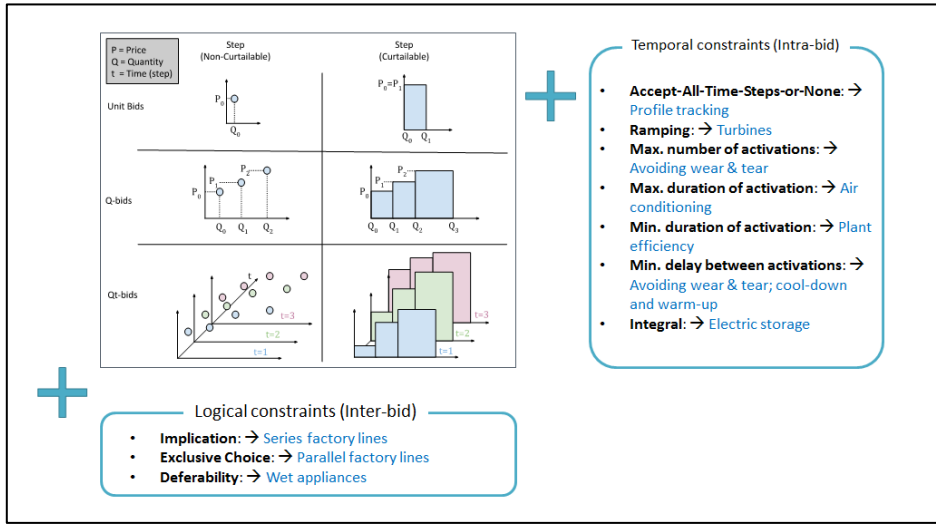


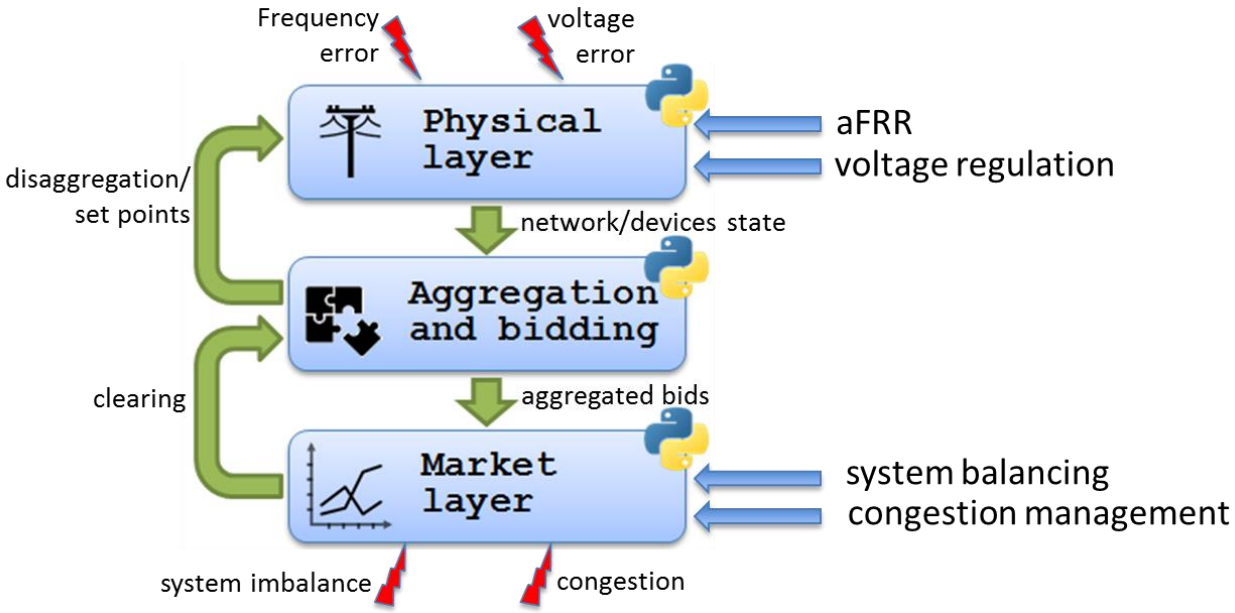
# Proposed Market Design

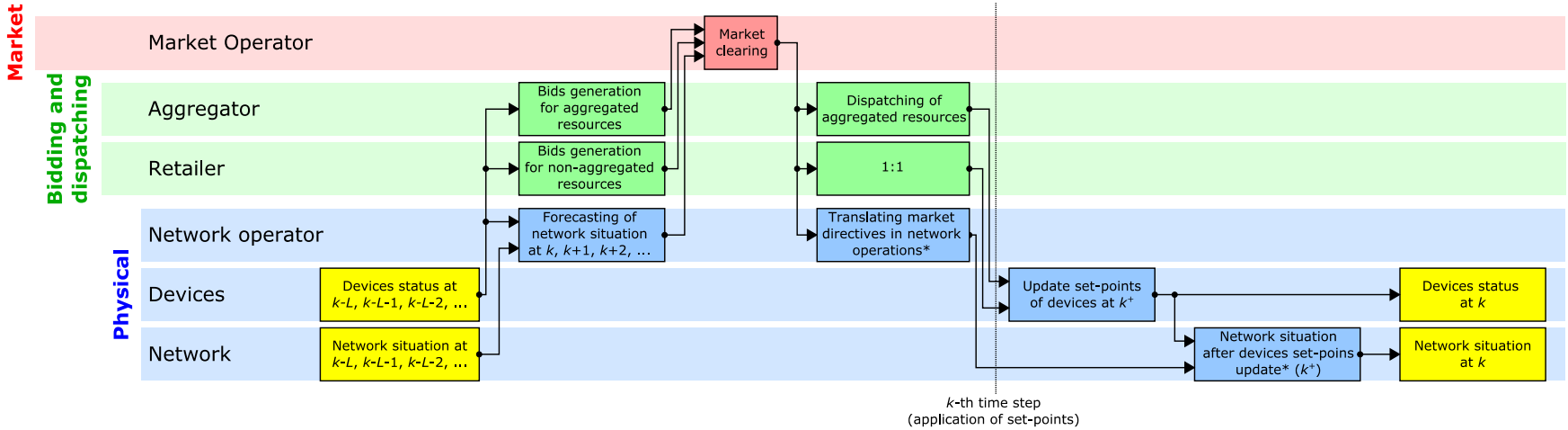
- **Considered services:** **balancing** and **congestion** management at transmission (HV) and distribution level (MV), including voltage constraint at MV
- **Rolling optimisation concept:** Results for the **first** time step are a **firm** decision. Results for the **next** time steps are **advisory**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



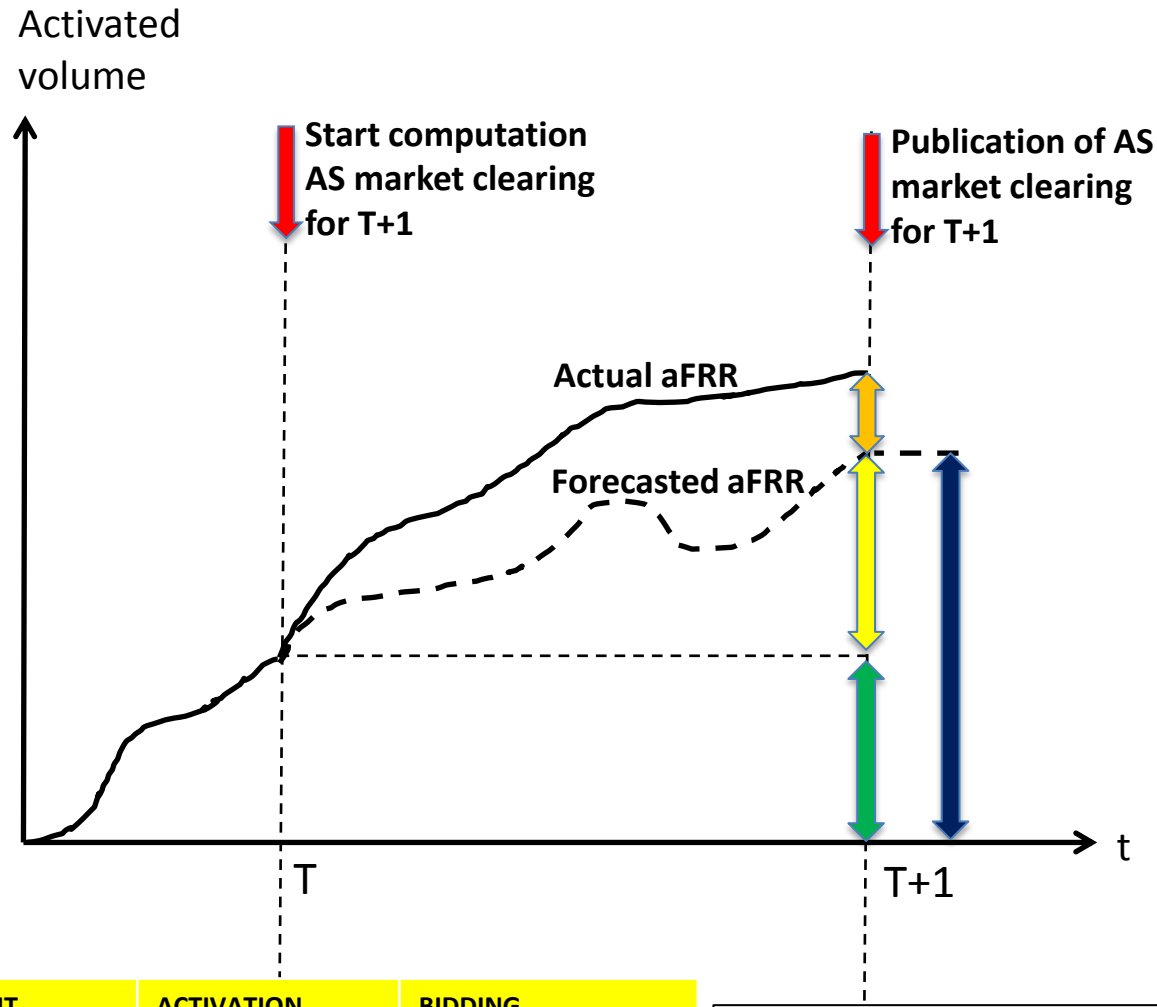
# The simulation platform



# 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




| PLATFORM LAYER | REGULATION | PAYMENT | ACTIVATION | BIDDING |
|---|---|---|---|---|
| Market layer | AS market | Pay as clear | Market clearing | Bids |
| Physical layer | aFRR regulation | Pay as bid<br>Pay as clear | Pro quota | (1+p%) * UPBids<br>(1-p%) * DWNBids<br>Highest market nodal price |

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

# CBA among TSO-DSO coordination schemes

- Literature review:
  - EPRI/JRC
  - REALISEGRID
  - e-Highway2050

- Proposed CBA indicators:
  - **Reduction of total AS market cost** (not social welfare!)
  - **Reduction of secondary regulation activations** due to:
    - **congestion not "seen" by the AS market**
    - **Forecasting errors**
    - **Losses in transmission** (not considered by AS market)

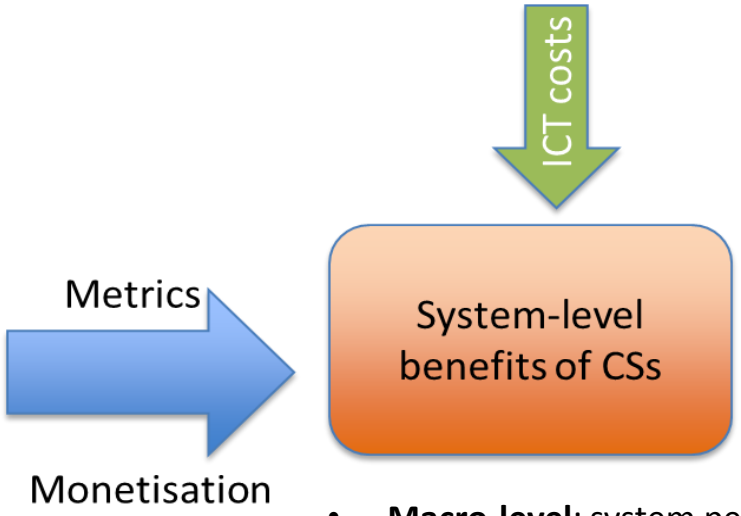
- Sensitivity factors
  - **Emissions savings**: with standard emission rates for each generation technology and CO2 prices forecasted at studied horizon.

- Side indicators (not in CBA to avoid double count
  - **Cost percentage due to network limitations:** comparing costs with Ideal situation (bus-bar network)
  - **Reduction of transmission network losses**

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

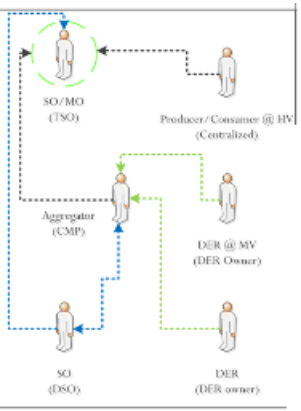
1. Comparison of the coordination schemes in terms of functionalities and ICT
2. Convert each ICT system into a cost at target year

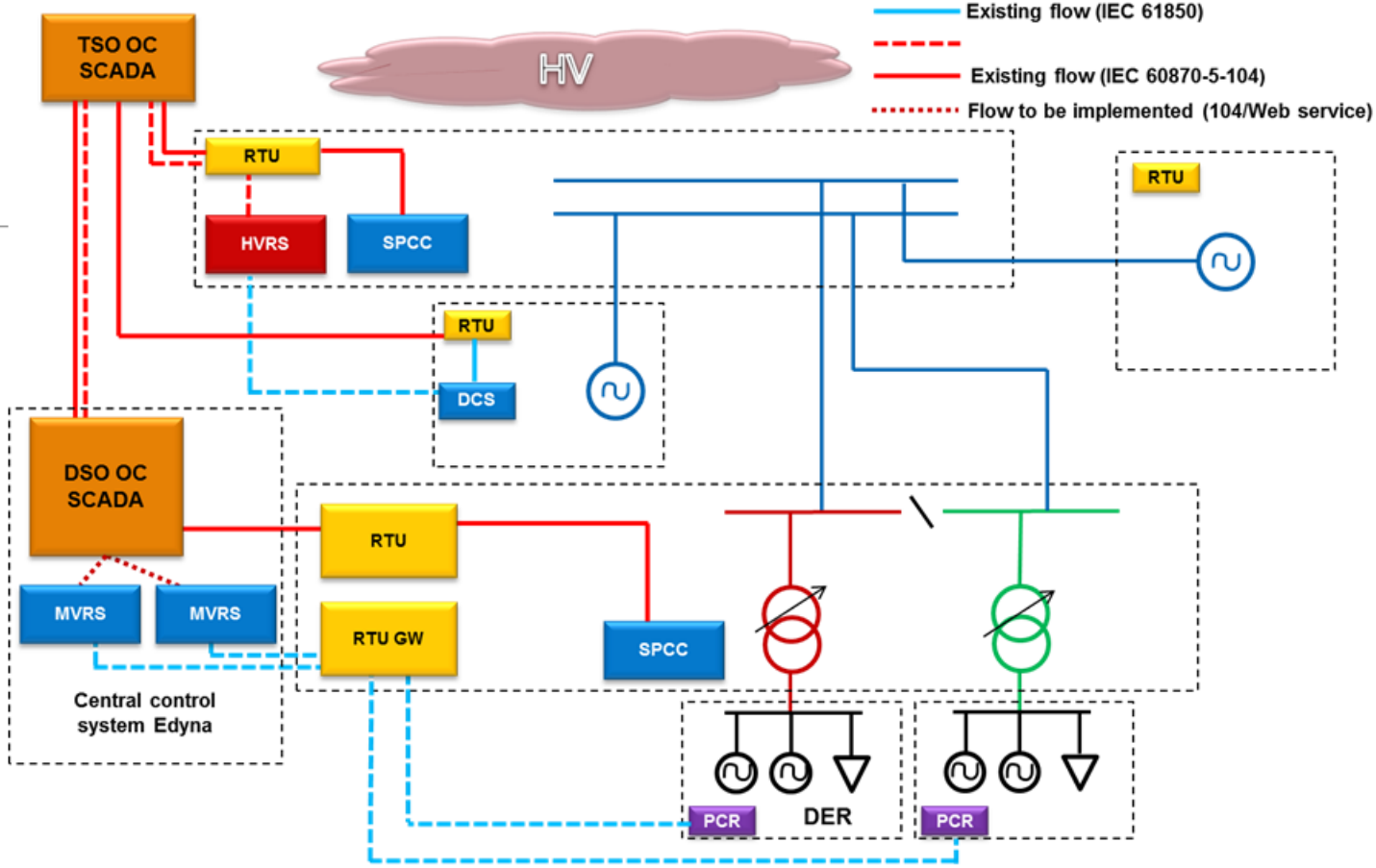
Main focus on issues that can differ between coordination schemes.




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

# Pilot A: Distribution monitoring and control



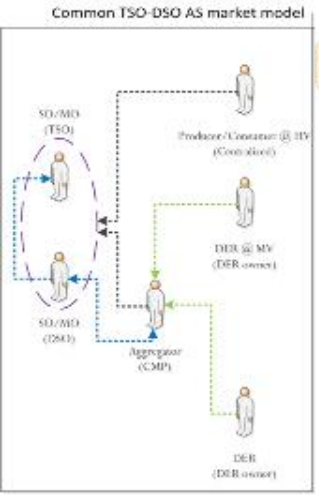




**Aggregation of information**
in RT at TSO-DSO interconnection (HV/MV transformer)

**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

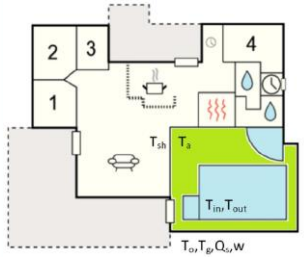
DER trading system

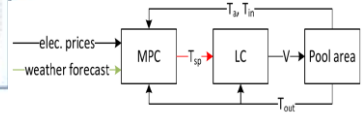
DER

Measurements

Setpoint

NOVASOL



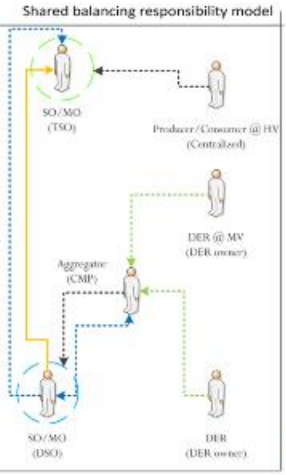




**Congestion management**
to better integrate PV, EV and HP

**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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