European Utility Week 3 - 5 October 2017 Amsterdam, The Netherlands

SmartNet

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

SmartNet: A European research project to study TSO-DSO coordination for ancillary services provision from distribution networks

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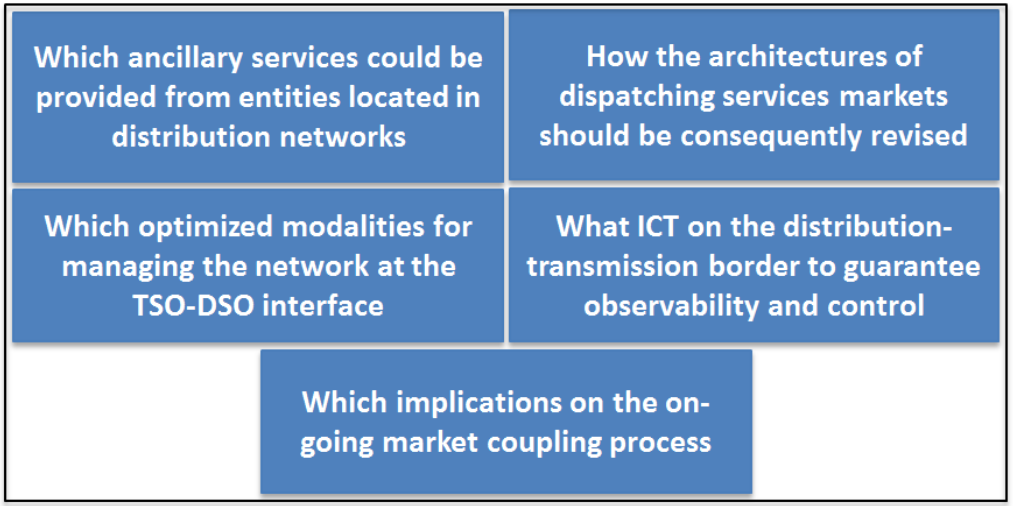
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691405

Agenda

- SmartNet project motivations
- Outline of SmartNet
- The simulation platform
- Five coordination schemes and their CBA
- Market architecture design
- Aggregation process
- The three technological pilots
- Some (preliminary) regulatory remarks

Motivations

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



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, demand response, and aggregators. Distribution system operators shall exchange all necessary information and coordinate with transmission system operators in order to ensure the optimal utilisation of resources, ensure the secure and efficient operation of the system and facilitate market development.

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

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

The SmartNet project

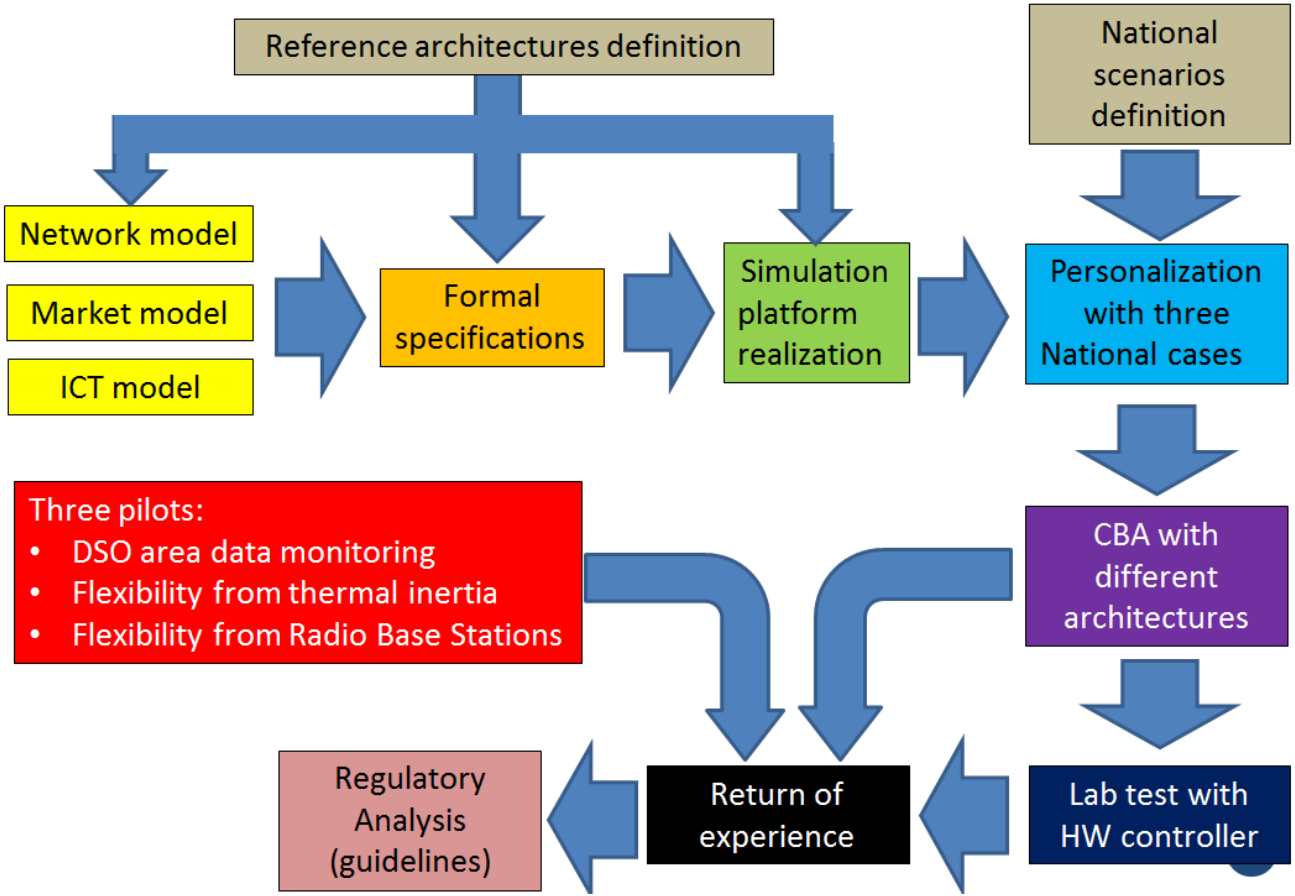
http://SmartNet-Project.eu

- **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 monitoring and control distribution by the TSO and flexibility services that can be offered by distribution (thermal inertia of indoor swimming pools, distributed storage of radio-base stations).

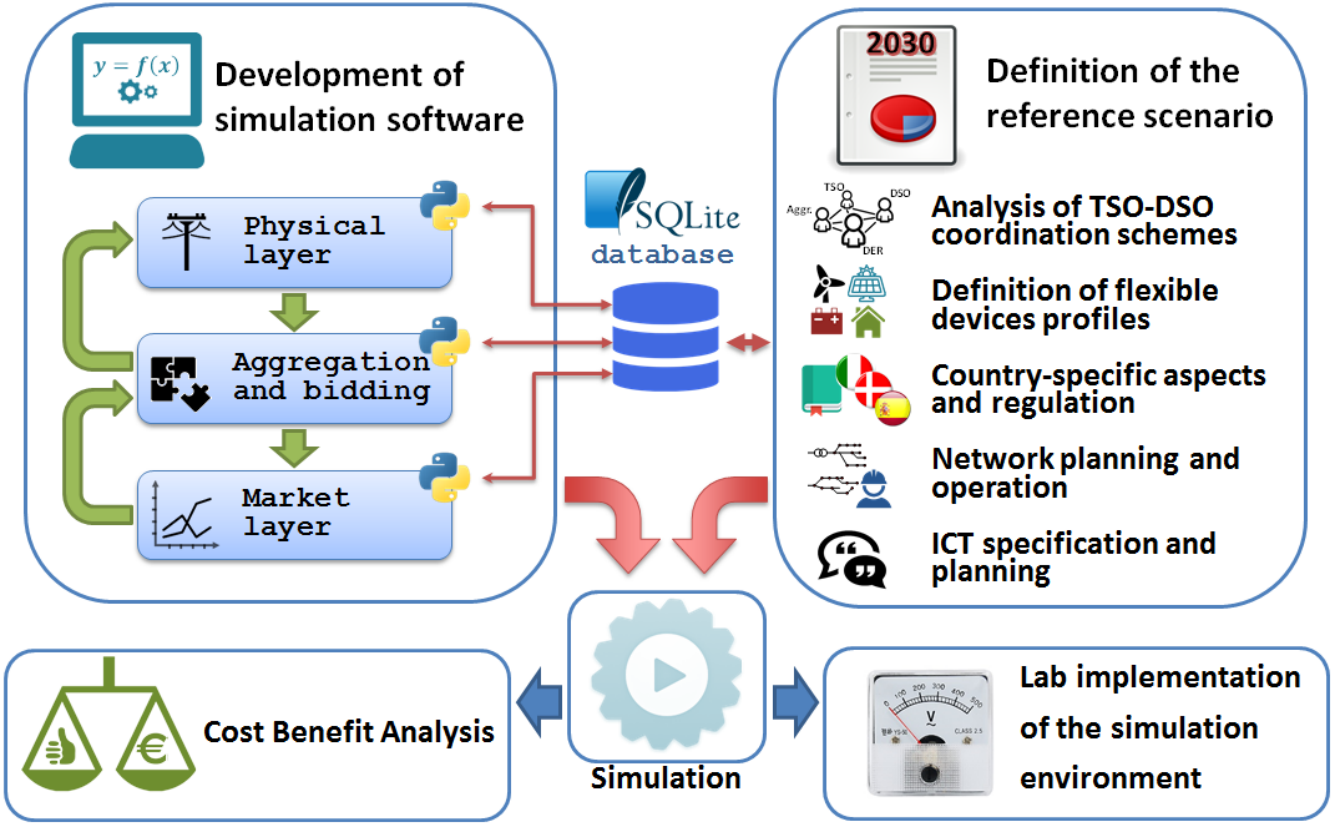
Project video:

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

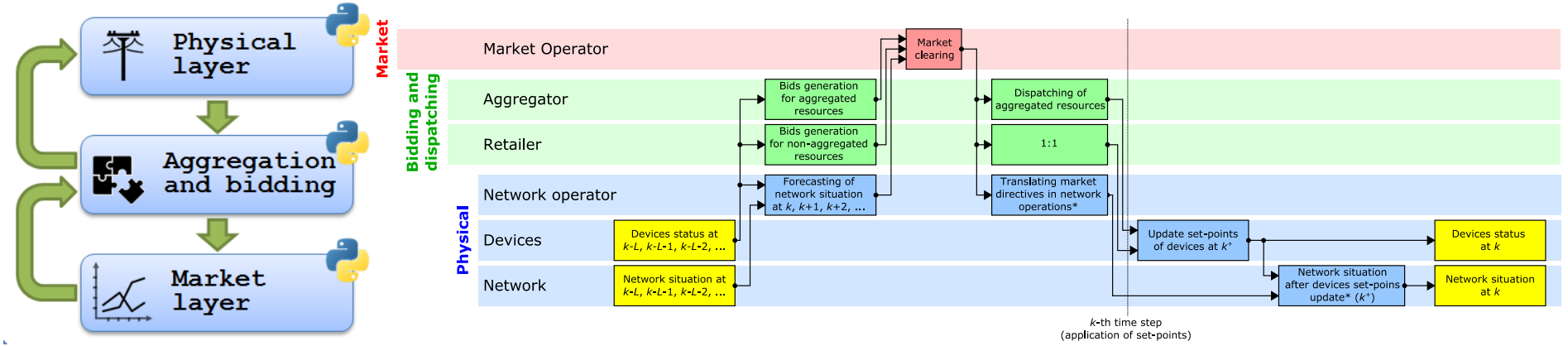
Overall project layout

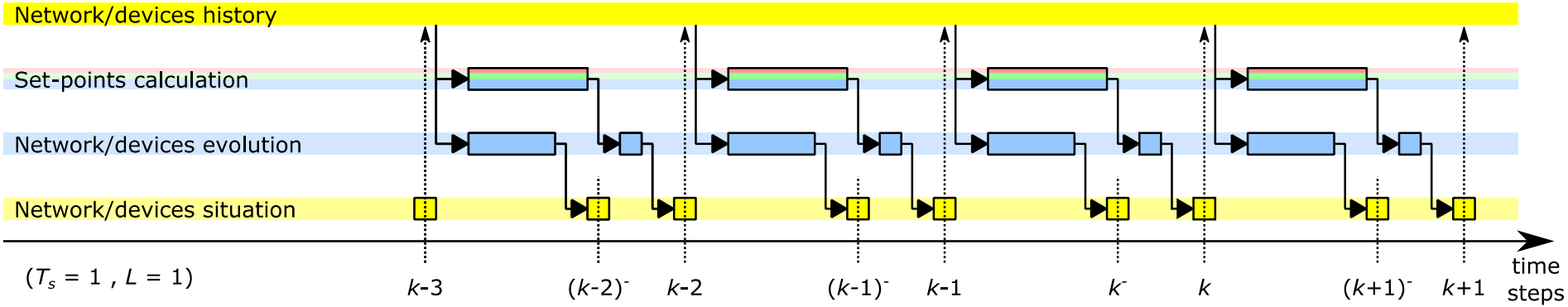


Comparison of the national cases in a simulation environment and laboratory testing

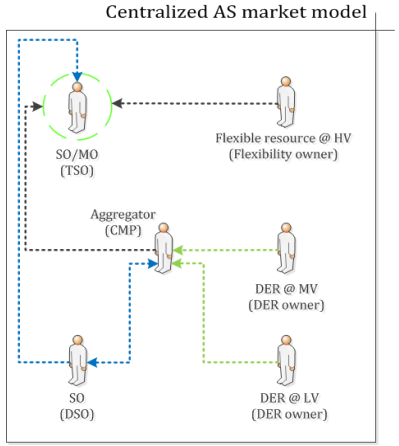


Interaction between the three layers



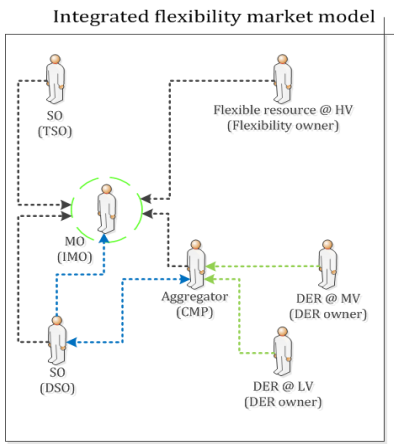


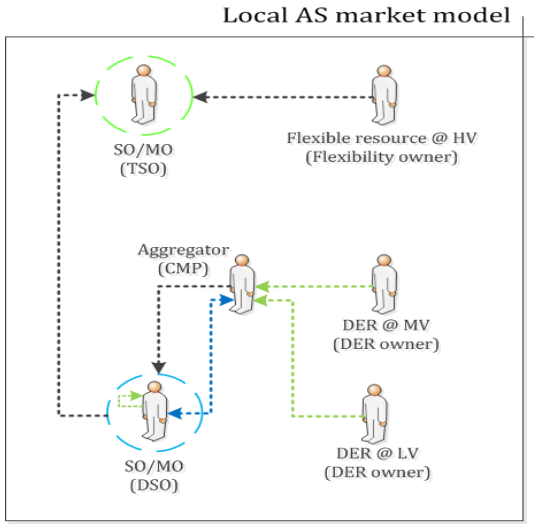
Five TSO-DSO coordination schemes

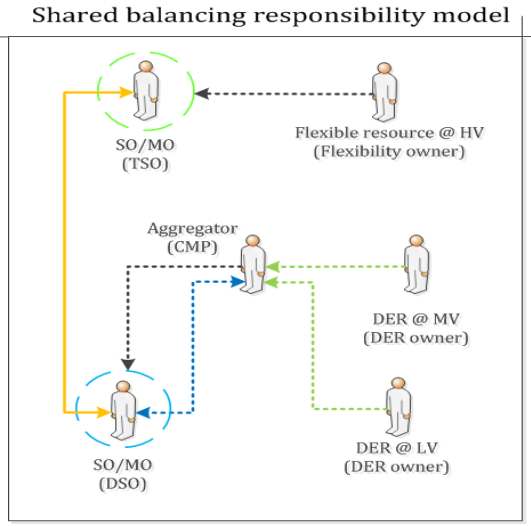


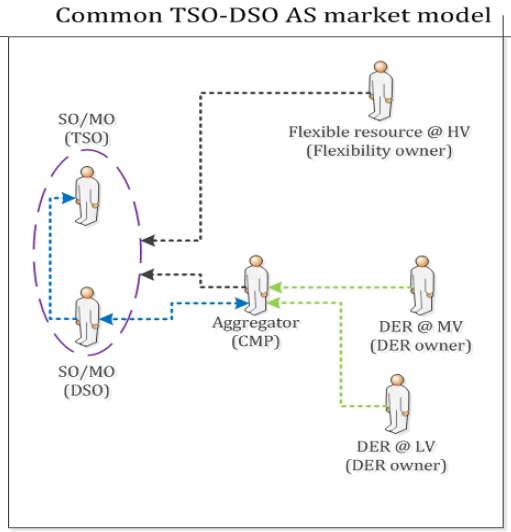
5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

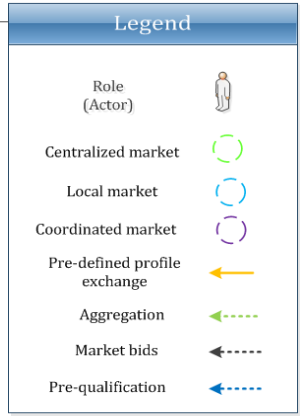
- Centralized AS market model
- Local AS market model
- Shared balancing responsibility model
- Common TSO-DSO AS market model
- Integrated flexibility market model











CBA among TSO-DSO coordination schemes

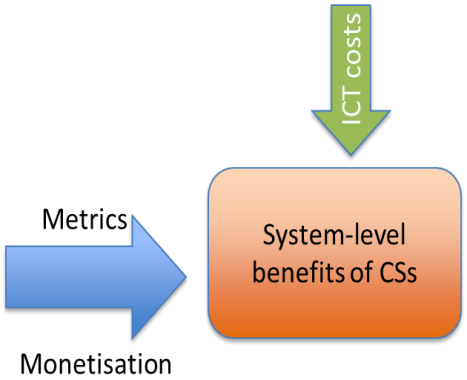
- Literature review:
  - EPRI/JRC
  - REALISEGRID
  - e-Highway2050

- Proposed indicators:
  - **Enhanced provision of ancillary services**: total balancing cost (vs social welfare)
  - **Cost due to network limitations:** comparing costs taking network into account with Ideal situation (busbar)
  - **Reduction of unwanted measures :** unexpected congestions solved with curtailment of load/generation, etc. Monetized at imbalance price or associated resource costs
  - **Reduced network losses**
  - **Emissions savings**: with standard emission rates for each generation technology and CO2 prices forecasted at studied horizon.

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

Objectives of proposed Market Design

Defining a new ancillary service (AS) market for TSO-DSO coordination schemes

What is required?

- Ensure a safe AS **activation** at the **lowest cost** for system operators
- Extract flexibility of **distributed energy resources** (DERs) in an efficient way
- Allow a **level playing field** for competition between different sources of flexibility
- Valorize flexibility at its **real value** for the power system

What has to be avoided?

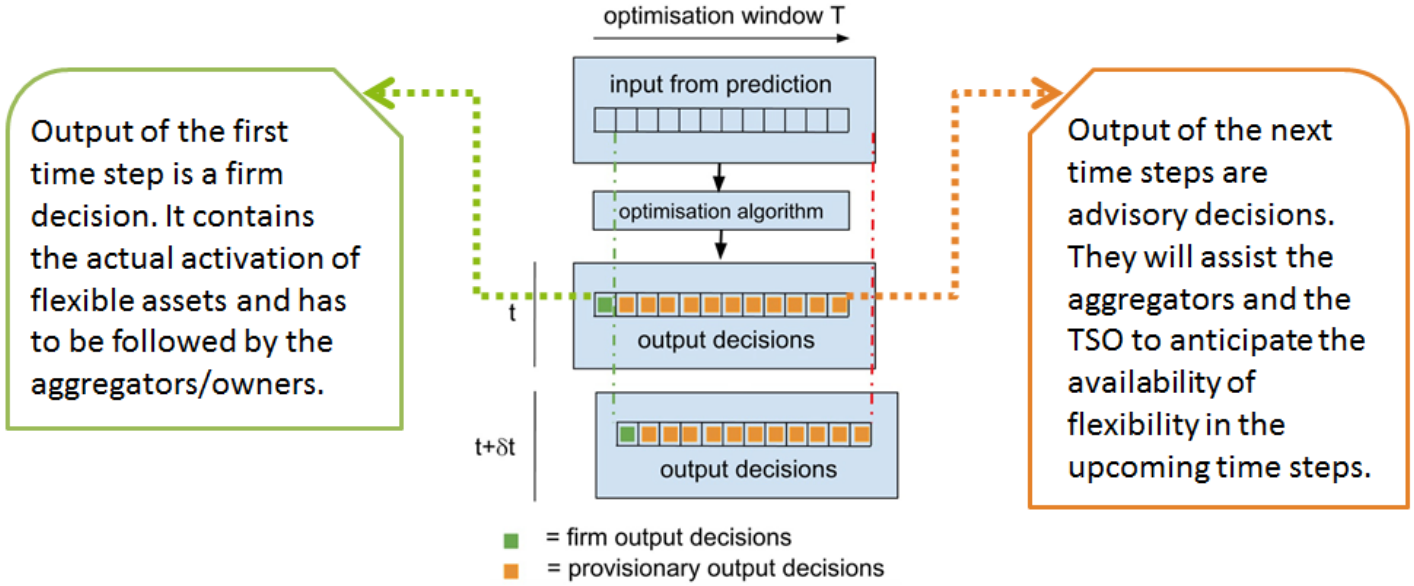
- Discouraging participation of DERs by not taking into account their **constraints**
- Creating **congestion** and/or **voltage problem** by activation at a wrong location
- Making **myopic** real-time decisions that compromise an efficient balancing management for future time steps
- Doing **unnecessary activations** that increase cost and/or risk for system operators

Timing Dimension

Market clearing frequency, time step and horizon

The market is a **closed-gate auction**. The clearing frequency is chosen close to real-time (e.g. **5 minutes**).

The market uses a **rolling optimization**. The optimization window (or horizon) contains several time steps (e.g. **1 hour**)

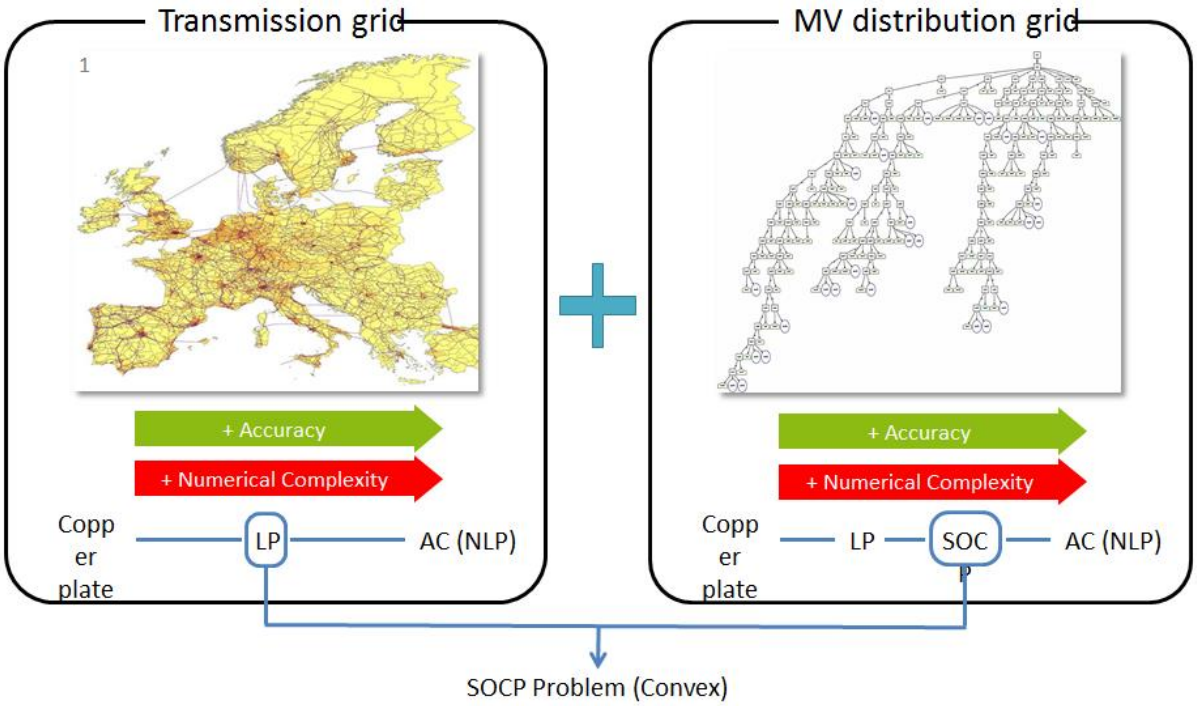


Output of the first time step is a firm decision. It contains the actual activation of flexible assets and has to be followed by the aggregators/owners.

Output of the next time steps are advisory decisions. They will assist the aggregators and the TSO to anticipate the availability of flexibility in the upcoming time steps.

Network Dimension

Network layout and constraints

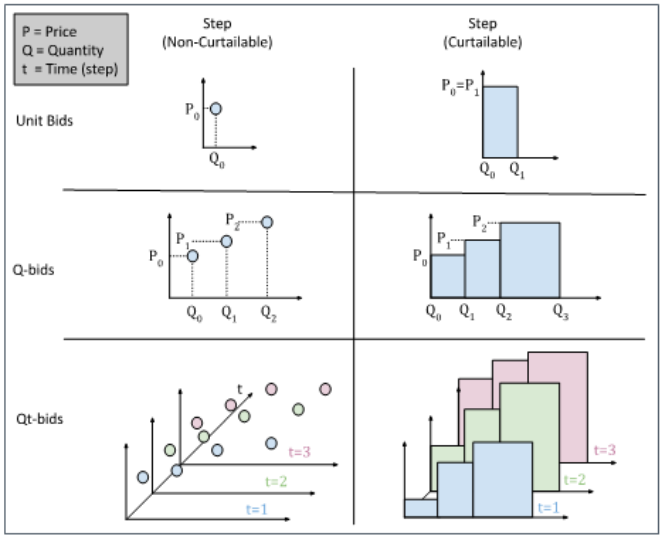


[1] Photo source: Technical University of Munich (*http://ens.ei.tum.de*)

Bidding Dimension

Market products

Market allows various bid format, accompanied by temporal and logical constraints:



Temporal constraints (Intra-bid)

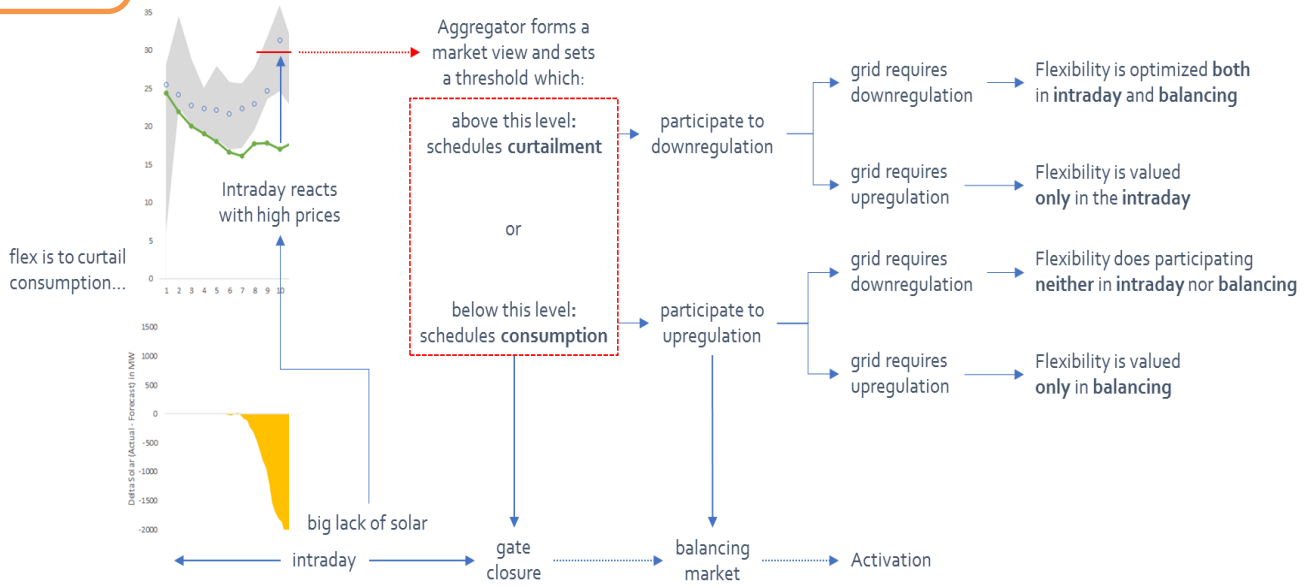
- **Accept-All-Time-Steps-or-None**: → Profile tracking
- **Ramping**: → Turbines
- **Max. number of activations**: → Avoiding wear & tear
- **Max. duration of activation**: → Air conditioning
- **Min. duration of activation**: → Plant efficiency
- **Min. delay between activations**: → Avoiding wear & tear; cool-down and warm-up
- **Integral**: → Electric storage

Logical constraints (Inter-bid)

- **Implication**: → Series factory lines
- **Exclusive Choice**: → Parallel factory lines
- **Deferability**: → Wet appliances

Bidding Dimension

Arbitrage between markets



Additionally…

- Aggregators are not always expected to immediately activate flexibility as soon as it is “in the money”: strategies consider multiple market layers and multiple periods.
- A risk-premium is a “market discomfort” bid-up price delaying flexibility activation in real-time balancing markets when more profitable opportunities exist in the next markets
- The rationale behind this strategy is based on the fact that forecast errors are often correlated.

$$RiskPremium = f(next\ market, current\ market\ price, etc)$$

The aggregation algorithms

The aggregator acts on behalf of the service providers on the electricity market:

- determining the price and the quantity of individual bids (per node),
- performing aggregation (before bidding on the market)
- Performing disaggregation (after getting market clearing results)

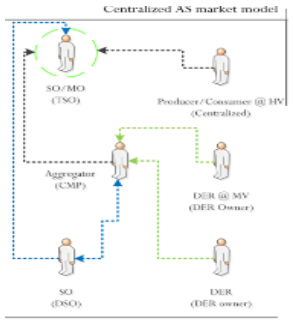
Models	Aggregation approach
Atomic Loads	• Traces
CHP	• Physical
TCL	• Physical • Hybrid
Storage	• Physical
Curtailable generation and sheddable loads	• Physical

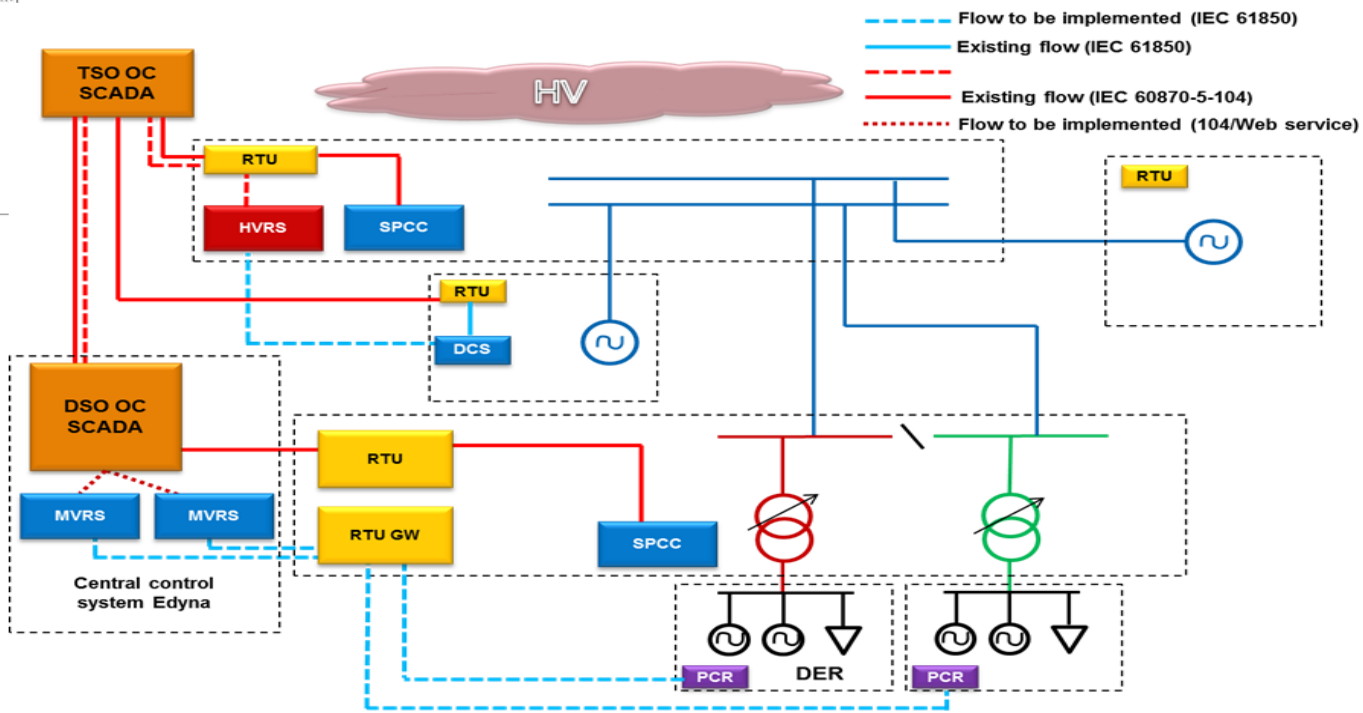
TRACES: the aggregation is represented by all the possible combinations of feasible profiles of all the devices.

PHYSICAL (bottom-up): horizontal summation of power for the individual devices: the aggregator knows all of the parameters of each individual device and also its real time status. It becomes difficult to implement when many heterogeneous energy resources are included

HYBRID: uses a single, or a limited number of virtual devices in order to represent the entire population of aggregated devices. Such practice reduces the number of individual devices and avoids exhaustive bid parametrization. Should the number of clusters equal the number of individual devices, the hybrid approach becomes the physical, bottom-up, approach.

Pilot A: Distribution monitoring and control



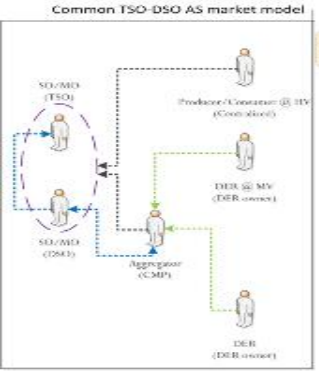


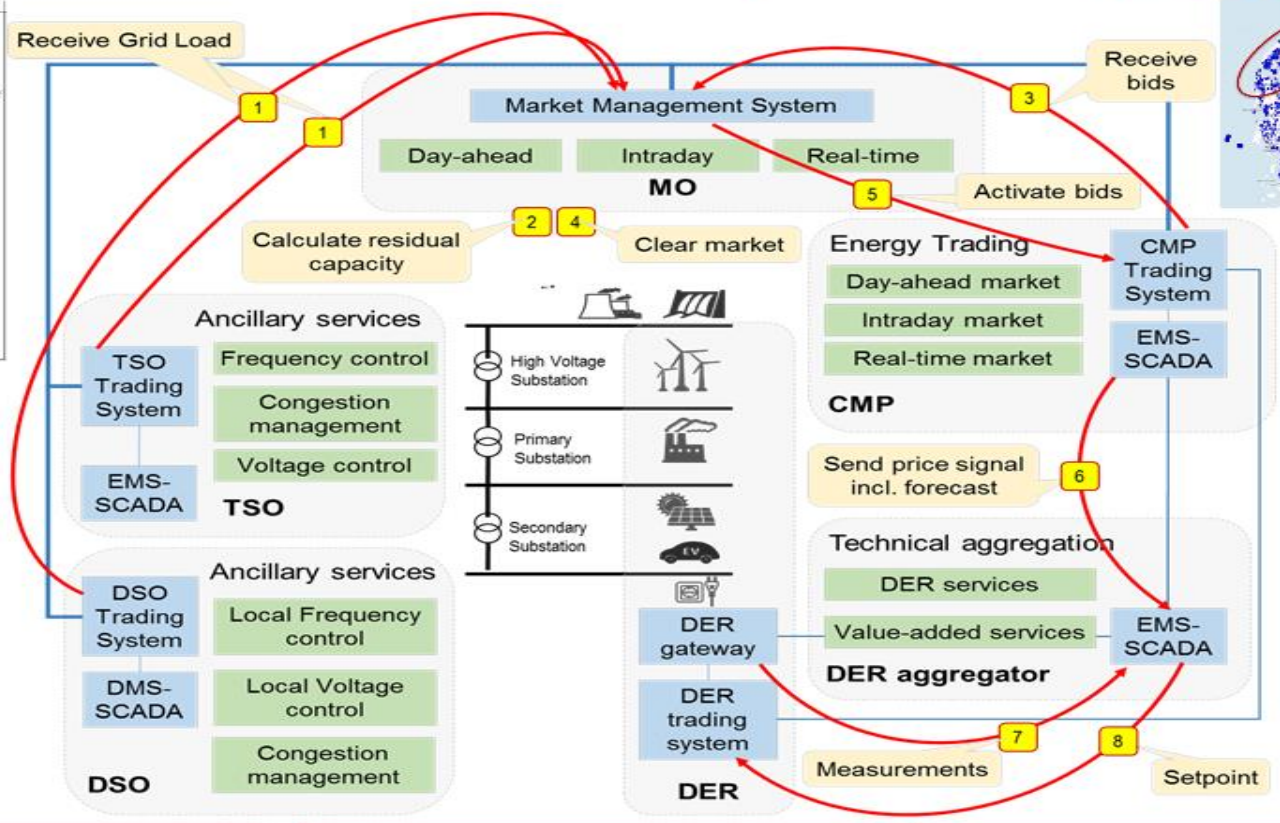
Aggregation of information
in RT at TSO-DSO interconnection (HV/MV transformer)

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



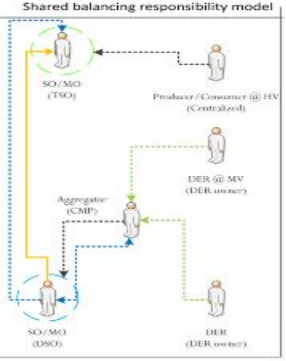


Congestion management
to better integrate PV, EV and HP

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



REGULATED MARKET

NON-REGULATED MARKET

Simulated

TSO

Balancing

Scheduled profile

Other flexibility aggregators

Smart Houses

EVs (V2G)

PV/ Wind plants

ESCOs

DSO

DSO Flexibility manager

Monitoring (metering data)

Congestion management

Demand response

Aggregator

DR optimisation

Vodafone Network

endesa

Point of delivery connection

Narrowband IoT technology

Vodafone

20 base stations

MID-approved Sub-meters

Congestion management at DSO level

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

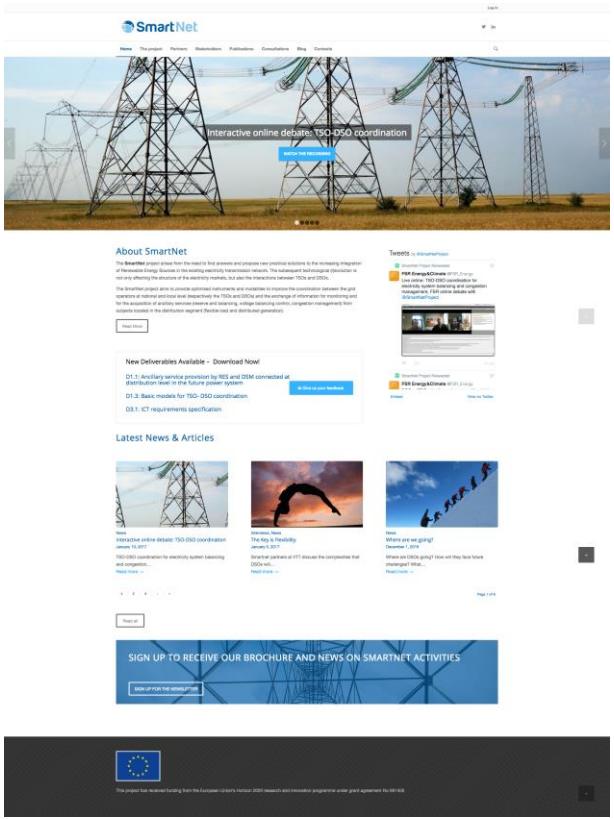
Power-frequency regulation / balancing by respecting the exchange program at the TSO-DSO interconnection

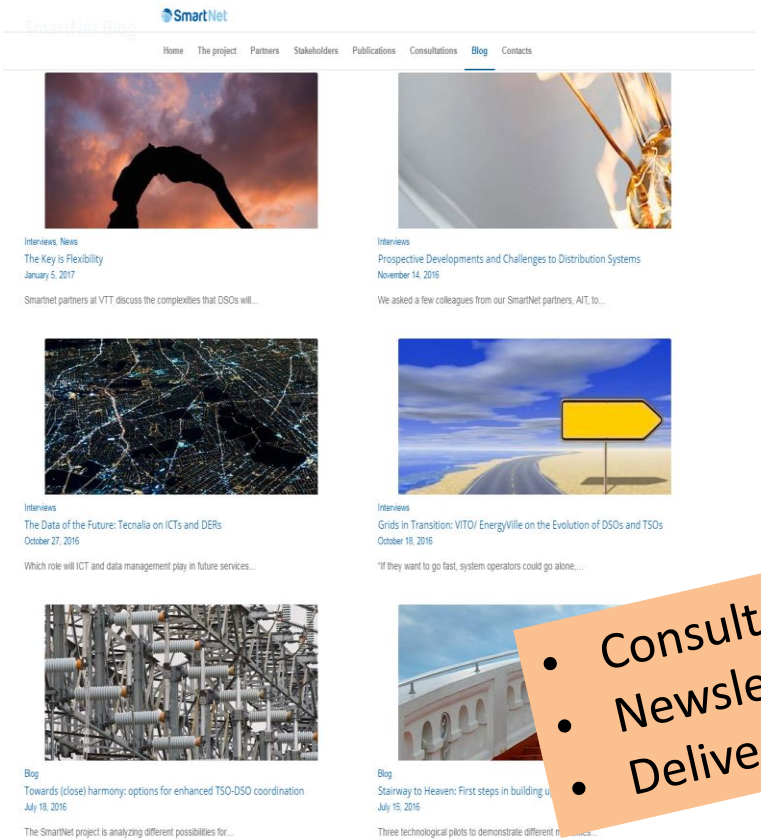
Some regulatory (preliminary) remarks

- TSOs could have to **share with DSOs part of responsibility** for the provision of balancing services if the contribution from entities in distribution will grow.
- a **balance** has to be sought for between local optimality 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 architecture** must to take into account the characteristics 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.

SmartNet-project webpage

http://SmartNet-Project.eu





- Consultations
- Newsletters
- Deliverable preview

SmartNet-Project.eu

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Thank You

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