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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

The Global Forum Electricity Ancillary Services and Balancing | Berlin, 23.11.2017

SmartNet Pilots: The demonstration of the different TSO-DSO coordination schemes and market structures

Carlos Madina (Tecnalia)

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

Agenda

- Aims and goals of the pilots
- Timeline
- Presentation of Italian pilot
- Presentation of Danish pilot
- Presentation of Spanish pilot
- Key results

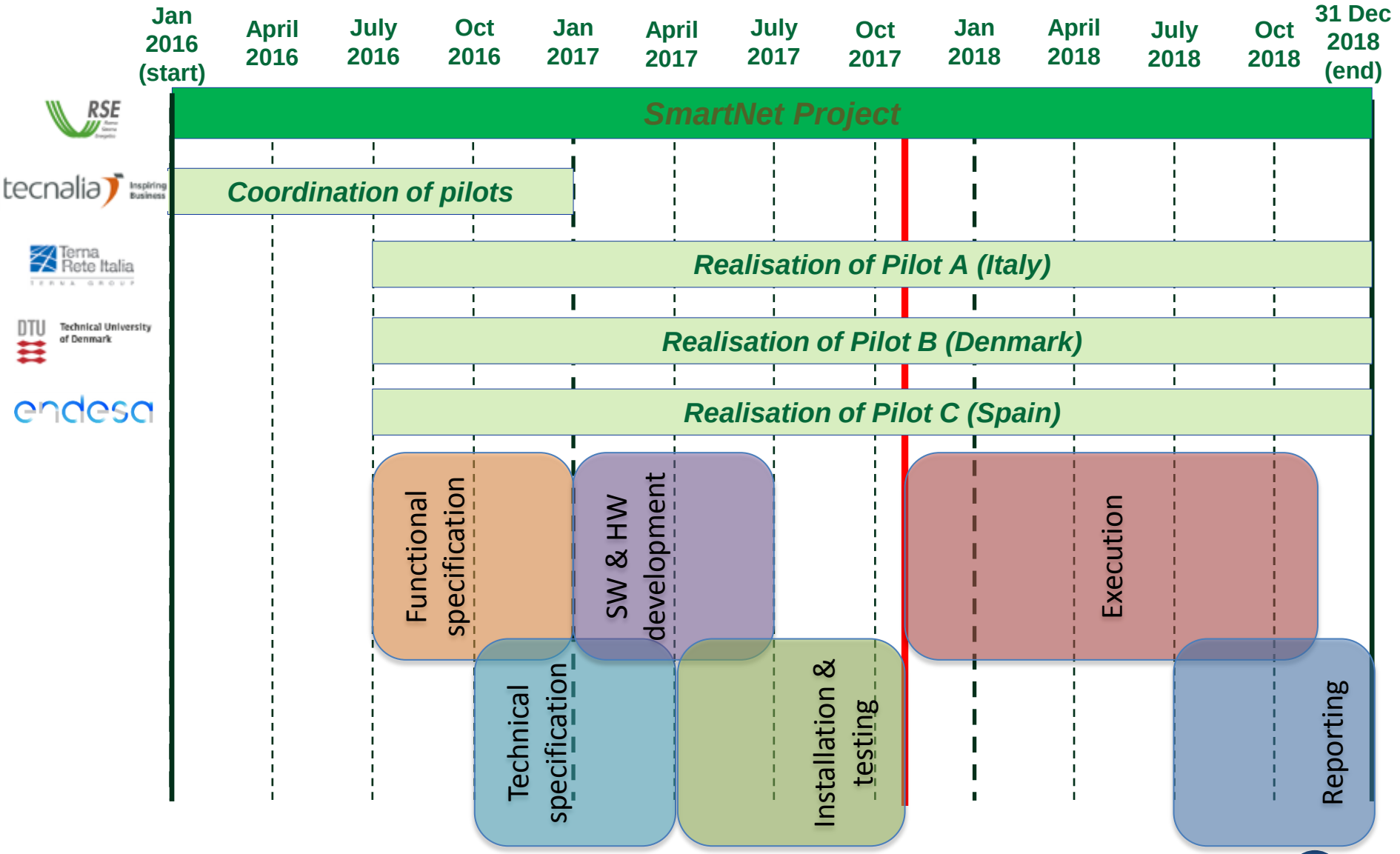
Aims and goals of the pilots

Realisation of three complementary pilots to evaluate the performance of different TSO-DSO interactions under different market structures.

Coordination with laboratory simulations to bridge the gap between present real-world implementation and the opportunities envisaged for the future.

Identify & remove barriers to facilitate the way to the pan-European market for ancillary services.

Timeline


Jan 2016 (start)
April 2016
July 2016
Oct 2016
Jan 2017
April 2017
July 2017
Oct 2017
Jan 2018
April 2018
July 2018
Oct 2018
31 Dec 2018 (end)
SmartNet Project
Coordination of pilots
Realisation of Pilot A (Italy)
Realisation of Pilot B (Denmark)
Realisation of Pilot C (Spain)
Functional specification
SW & HW development
Execution
Technical specification
Installation & testing
Reporting

Centralised TSO control in high-DER area

Energy context

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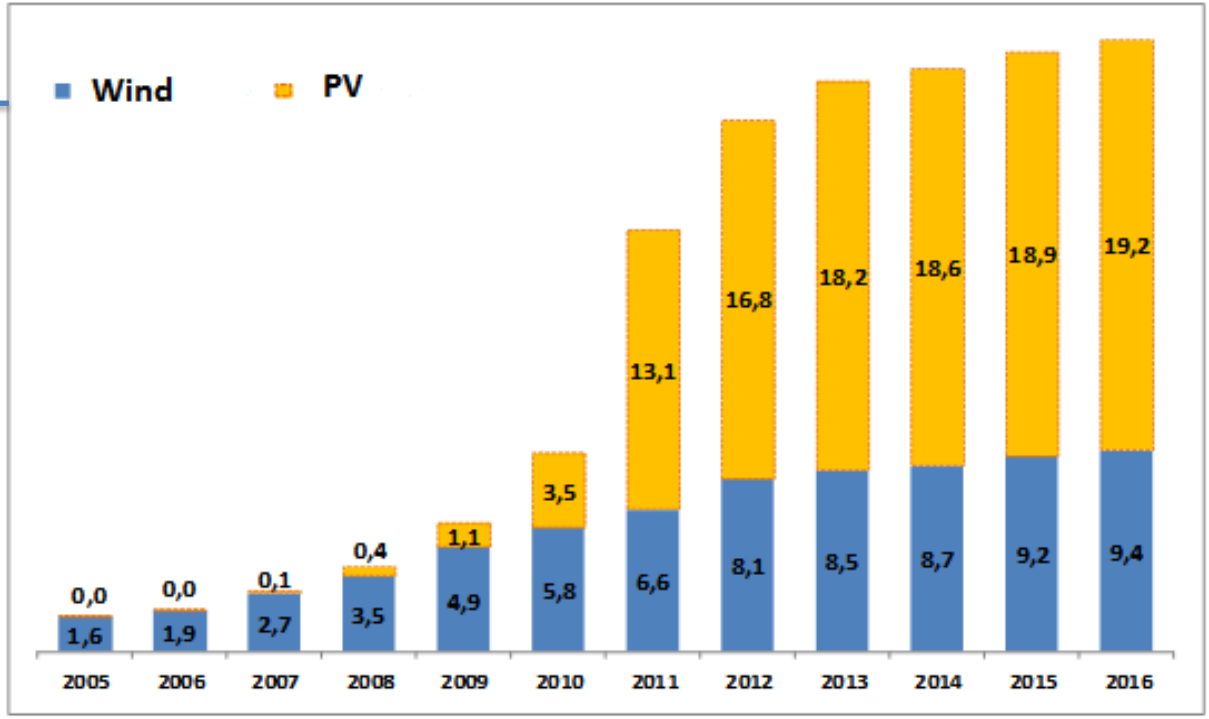
Large increasing of RES in the last 10 years



New issues in terms of power management of the electrical grid

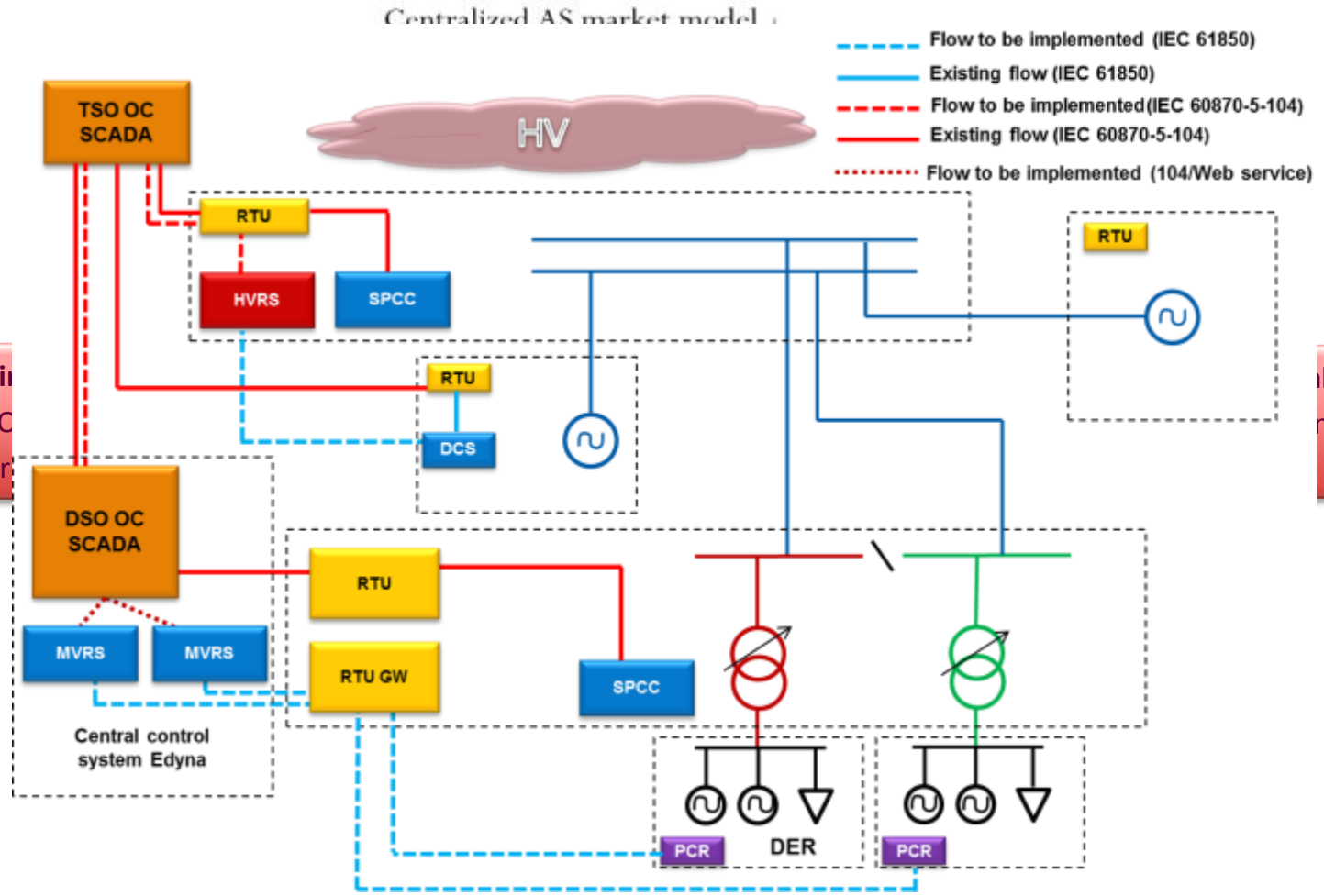
Active power rise from MV up to HV grid

Difficulty to predict RES production

Italian NRA is opening the market to DG and DR through *aggregators* and requiring the DSO to improve *observability* for the TSO

Needs to improve the infrastructure for monitoring and control of MV and LV levels

Centralised TSO control in high-DER area



Aggregation of i ... **lancing**
in RT at TSO-DSC ... nd MV
(HV/MV transfor

Implementation in field

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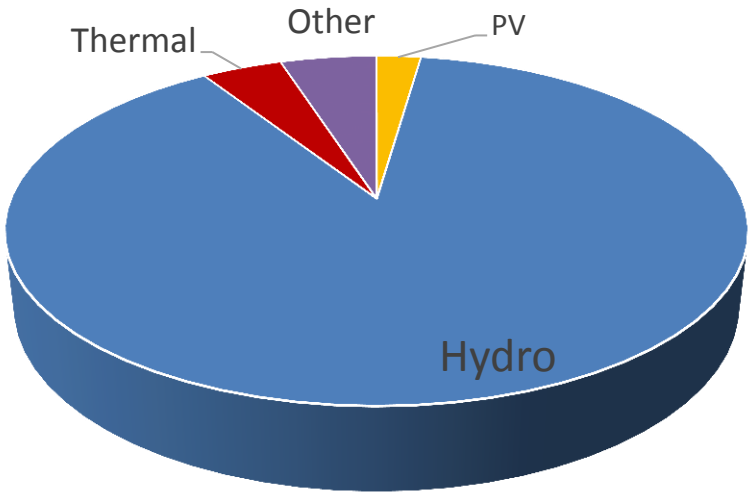
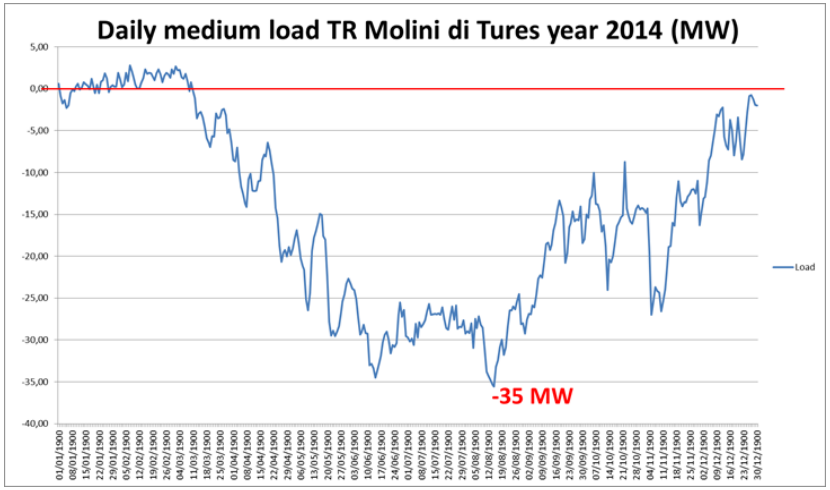




- **HV** Generation:
  2 Hydraulic plants of **20MW** each.
- **MV** and **LV** Generation:
  More then 30 plants with more than **40MW** of total nominal power (Hydro, thermal and other)

Functionalities

1) **Aggregation of information in real-time** at the interconnection point TSO-DSO (HV/MV transformer). Exchange of distribution data with the TSO:
   - Load (total load, gross amount of load compensated by distributed generation);
   - Total distributed generation at the interconnection point, differentiated by source (PV, rotating, etc.).

2) **Voltage regulation** - development of an architecture and implementation of a system for the HV voltage regulation:
   - One generation unit connected to HV grid;
   - One or more generation units connected to MV grid;
   - A device for each power plant in order to receive command from the TSO through the DSO.

3) **Power-frequency regulation** - development of an architecture and implementation of a system for the power-frequency regulation:
   - One generation unit connected to HV grid;
   - One or more generation units connected to MV grid;
   - A device for each power plant in order to receive command from the TSO through the DSO (FRR).

Expected results

TSO will receive aggregated data for control and to manage the allocation of services

Data must aggregated by DSO, but other parties could also provide the aggregation service

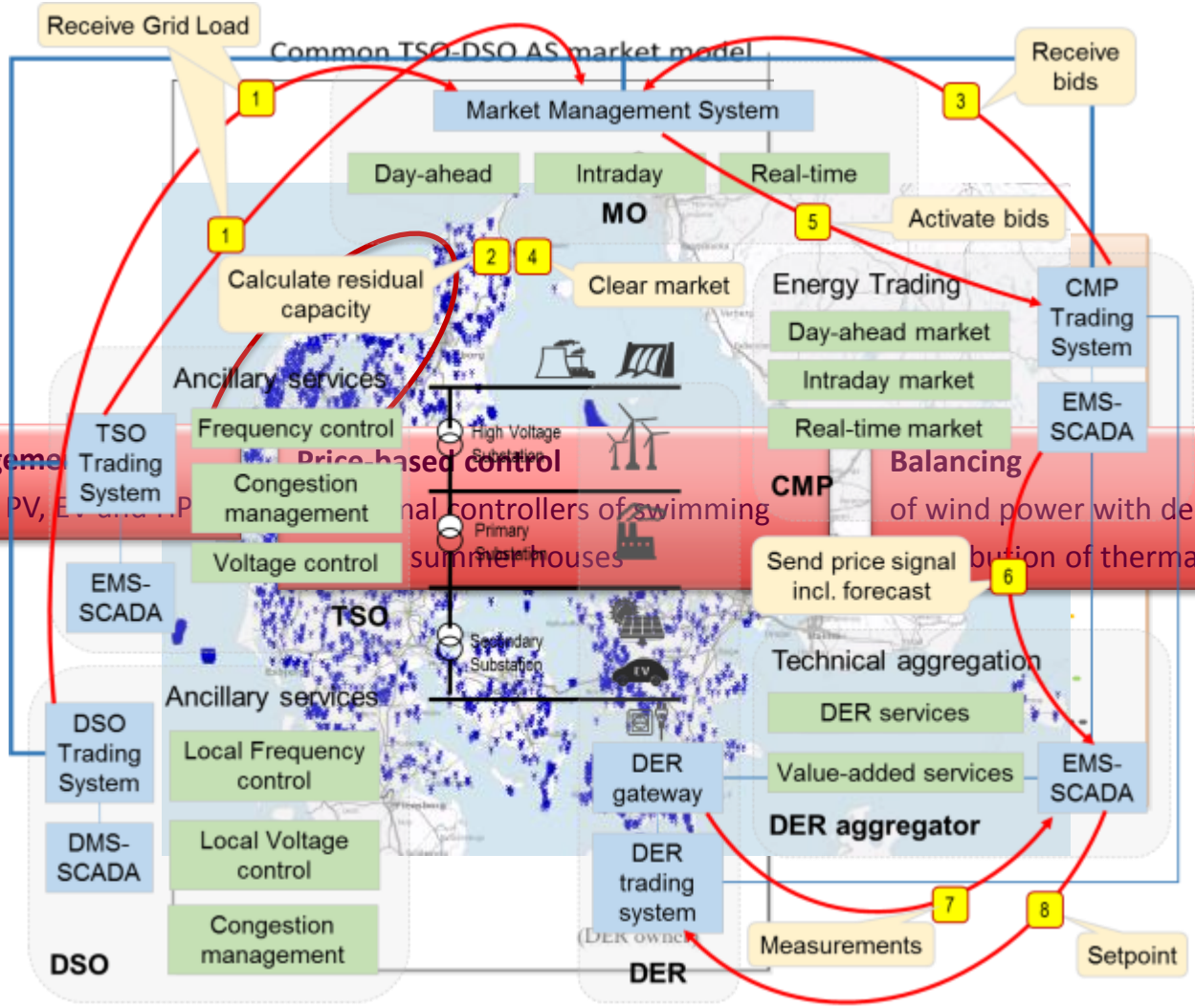
The VPP is defined by P, Q and forecast ➔ Needed for AS allocation

New device installed at TSO-DSO interconnection to collect data and make it available to the TSO (VPP)

TSO will know, for each VPP, the limits for P and Q (virtual capability) that may be used when activating AS

Common TSO-DSO market with pool flexibility

Common TSO-DSO market with pool flexibility



Congestion management **Price-based control** **Balancing**

to better integrate PV, E… …nal controllers of swimming … of wind power with decreasing

… summer houses … bution of thermal units

Implementation in field

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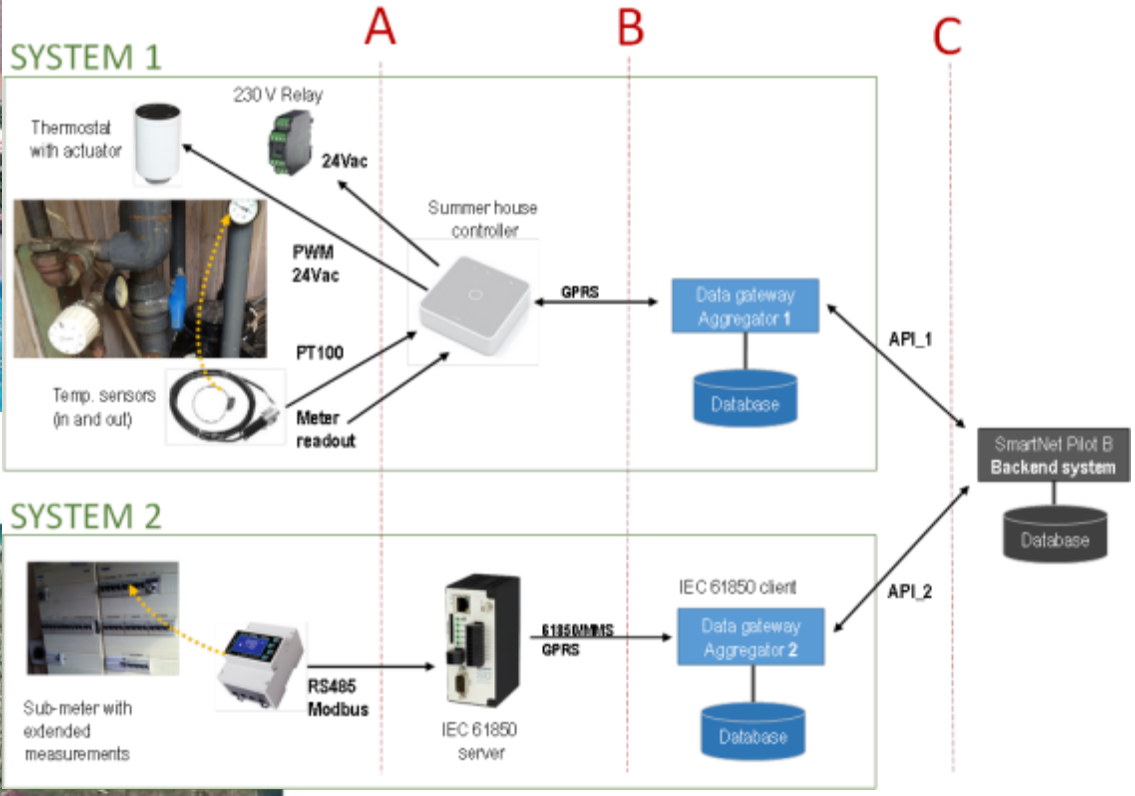

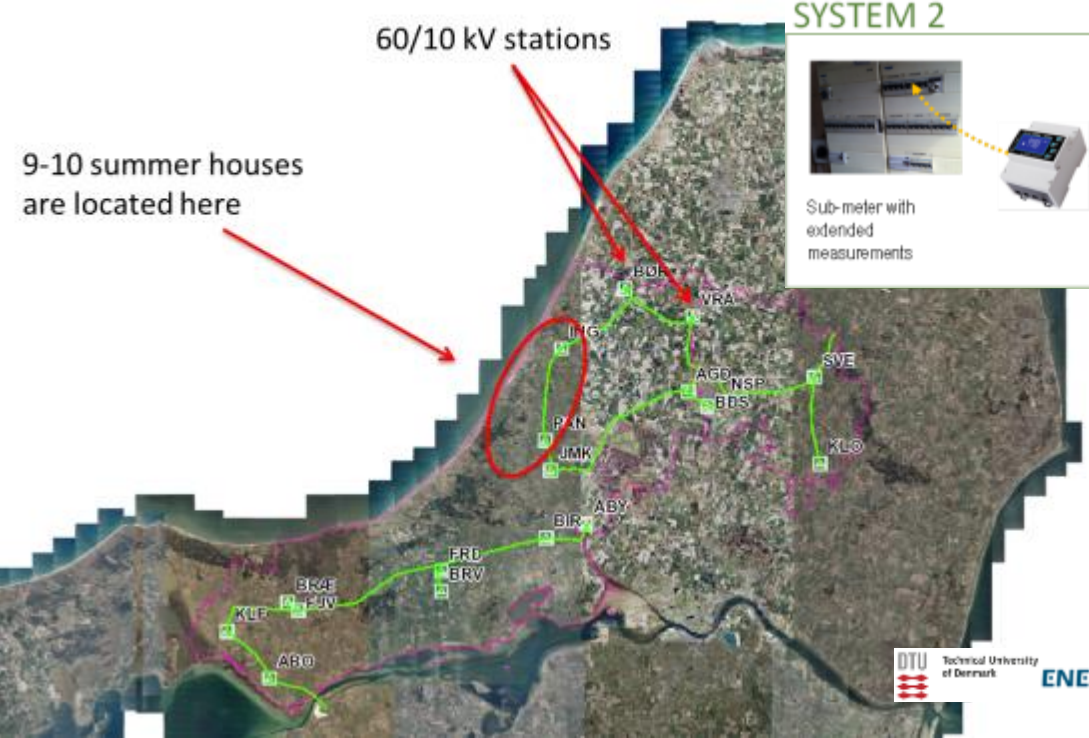

Price-based control

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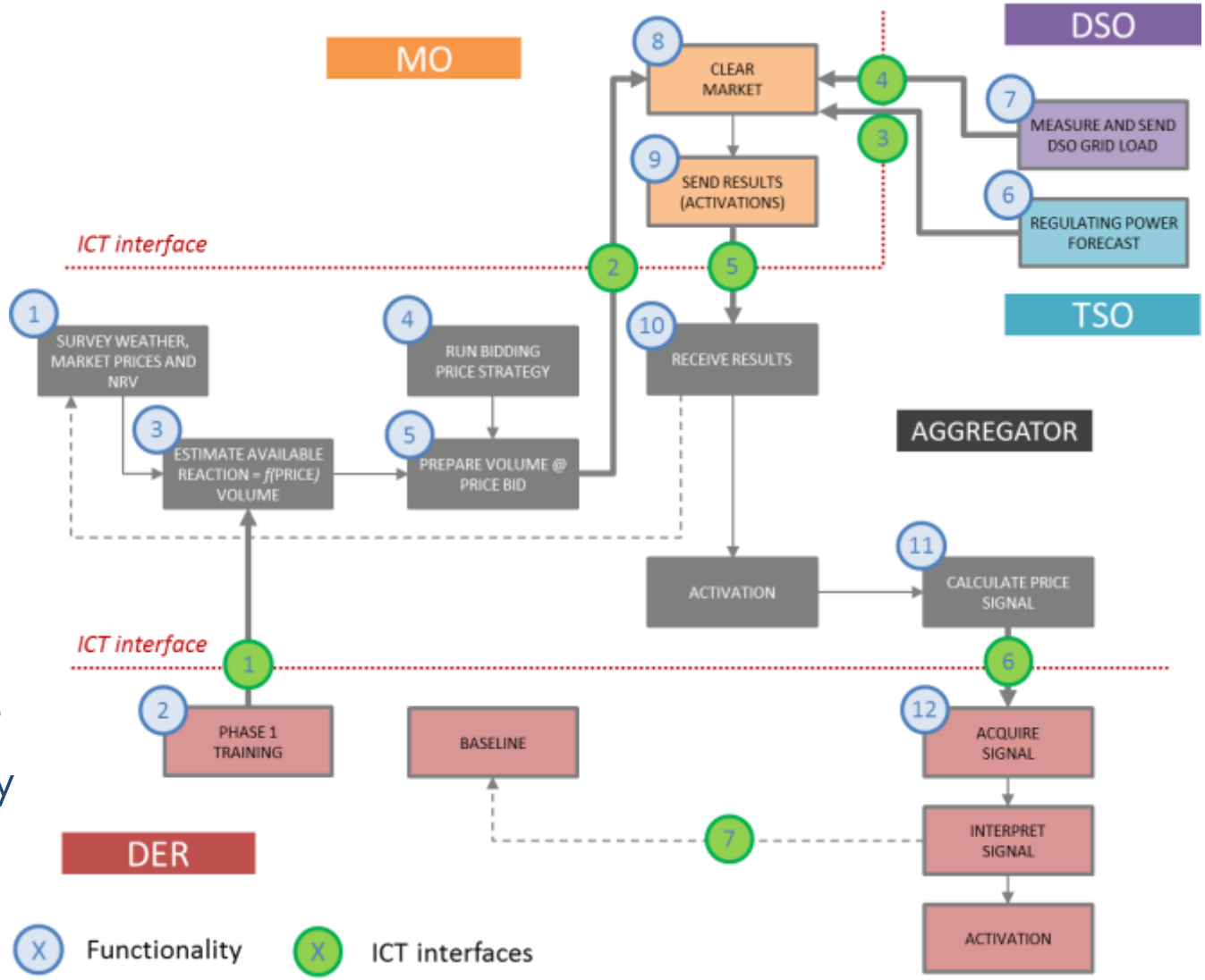
Advantages

- Highly scalable
- No data safety issues
- Very low transaction costs

Disadvantage

- Application to all demand vs. to the provided flexibility
- Estimation of reaction curve



Expected results

Demonstration of aggregation service in 30 rental houses (10 + 10 +10)

Implementation in field of ICT to exchange data: TSO-DSO-Aggregator-DER

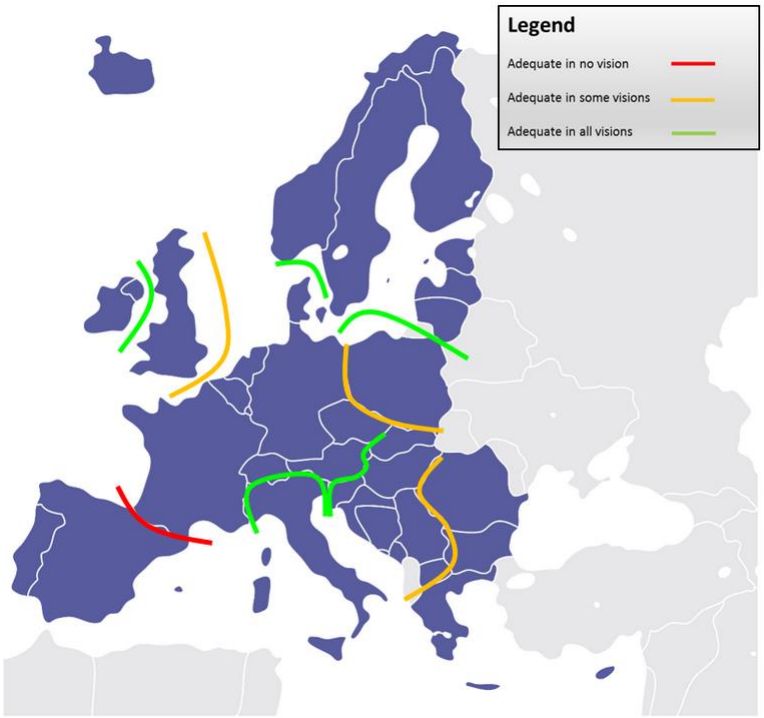
On-line services for price & load forecasting + model predictive control

Development of an architecture for AS provision by DER through aggregation

Estimation of DER reaction curves + unidirectional signals to gather flexibility

Shared responsibility with base station flexibility

Energy context

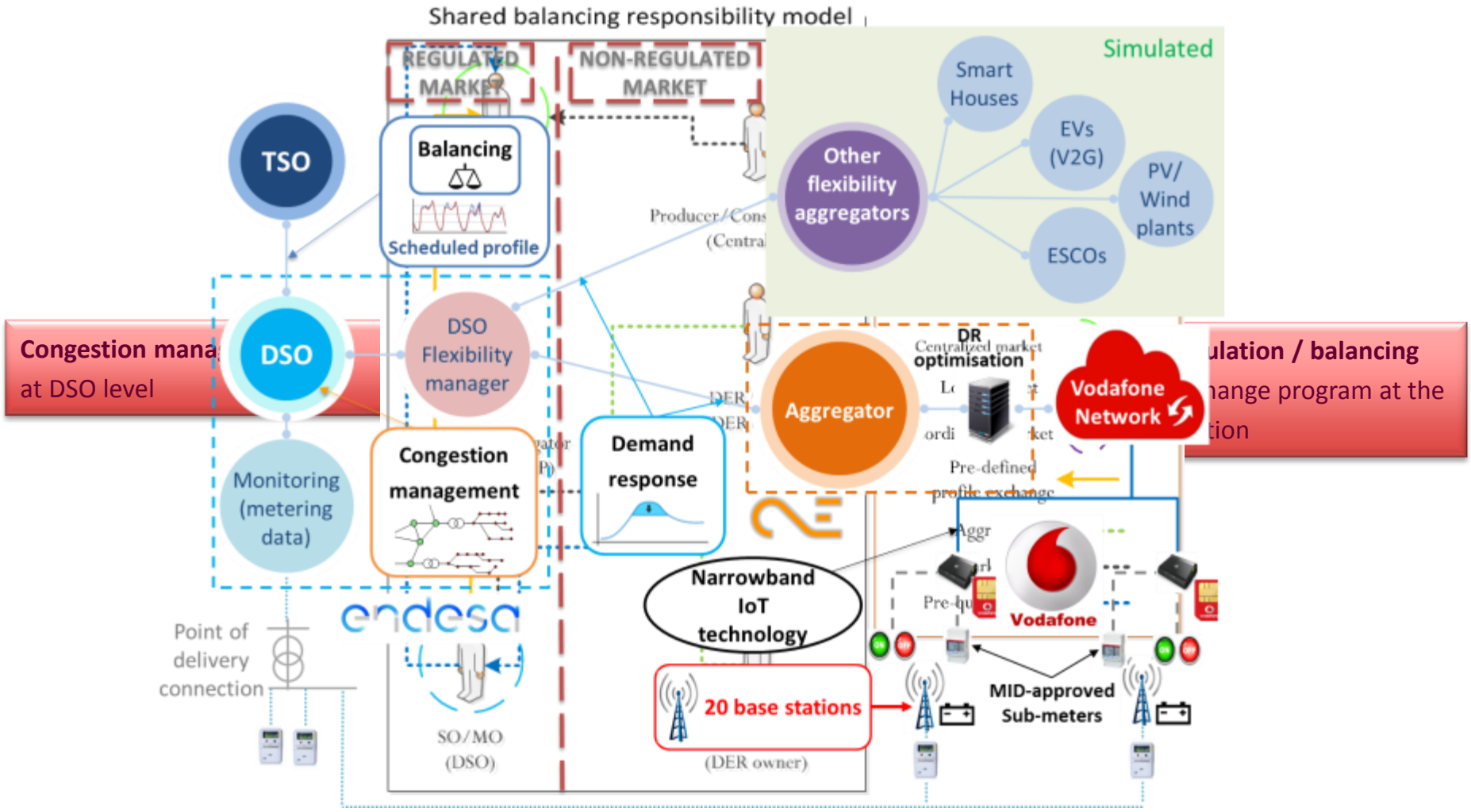


2030 Transmission adequacy (TYNDP'16)
http://tyndp.entsoe.eu/exec-report/

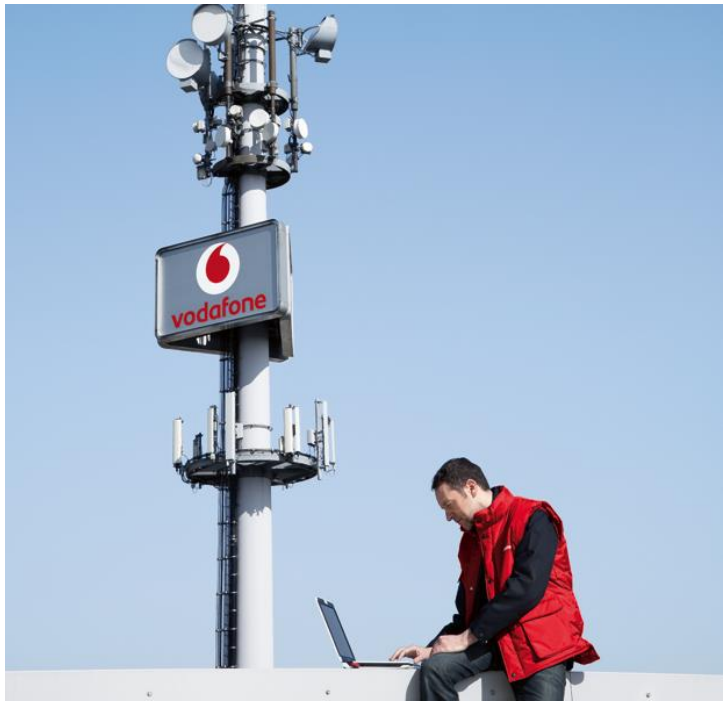
Poor interconnections

Big contribution by highly-variable RES production

Shared responsibility with BS & EV flexibility

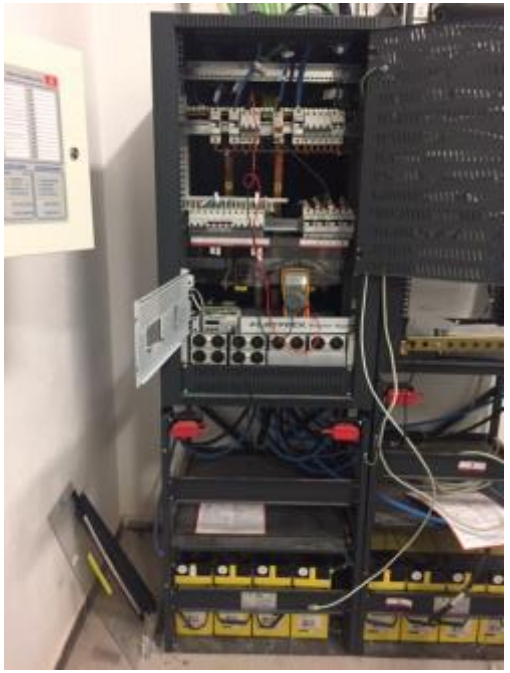


Implementation in field

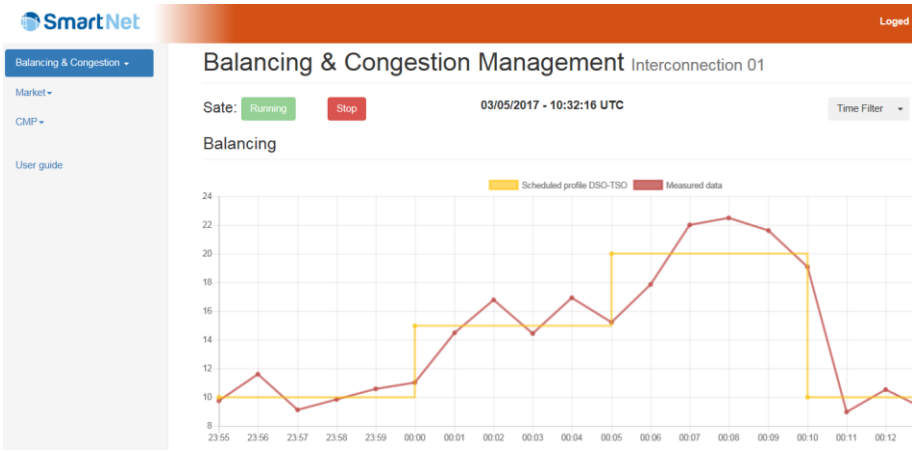


More than 400 Base Stations just in Barcelona

Contracted power of each one from 5 kW to 15 kW



Software Flexible Tool for the DSO



Balancing. Time plot of active power exchanged at TSO-DSO interconnection points

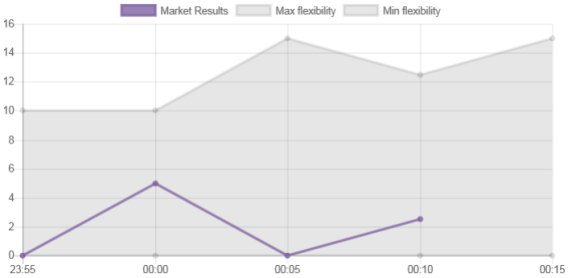
Flexibility. Time plot of total flexibility volumes per market session at each TSO-DSO interconnection point (kW)

CMPs. Time plot of aggregated load of customers' portfolio of each CMP.

Market prices. Time plot of the clearing price per market session at each TSO-DSO interconnection point

Market results. Table of dispatched flexibility volumes per CMP per market session and node at each TSO-DSO interconnection point (kW)

Flexibility



Market results

Market time	Node	CMP	ΔP (kW)
2017-02-14T00:10:00Z	6	ONE	2.5
2017-02-14T00:00:00Z	6	ONE	2.5
2017-02-14T00:00:00Z	10	TWO	2.5

Network Status. Diagram of the distribution network downstream each TSO-DSO interconnection point:

Expected results

Demonstration of DER aggregation service in 20 mobile phone base stations

Creation of AS local market to solve DSO's congestion issues and to share balancing responsibility

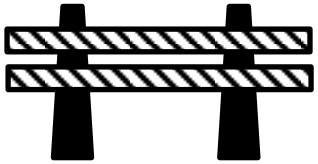
Development of tools for DER aggregation and for bidding to DSO-managed local AS markets

Development of tools for determining DSO's balancing and congestion management needs

Key results

Validated TSO-DSO interactions (technical + operational)

Demonstrated interoperability and scalability to the whole European system.



Identified barriers for real implementation and regulatory proposals

Guidelines on best practices to implement the considered TSO-DSO schemes

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SmartNet-Project.eu

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Thank You

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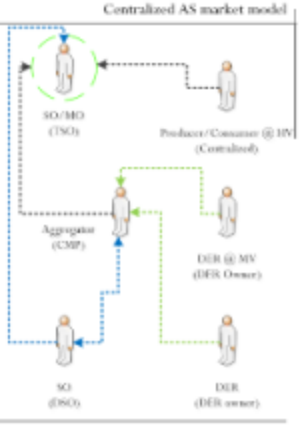
Pilot A: Back-up slide



Flow to be implemented (IEC 61850)
Existing flow (IEC 61850)
Flow to be implemented(IEC 60870-5-104)
Existing flow (IEC 60870-5-104)
Flow to be implemented (104/Web service)

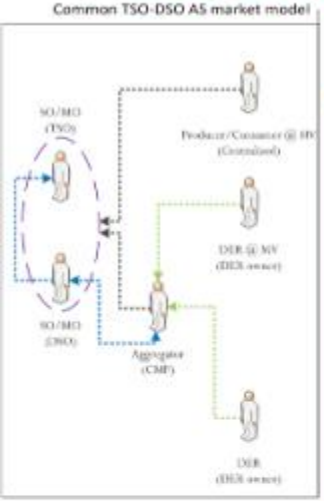
TSO OC SCADA
HV
RTU
HVRS
SPCC
RTU
RTU
DCS
DSO OC SCADA
RTU
MVRS
MVRS
RTU GW
SPCC
Central control system Edyna
PCR
DER
PCR

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: Back-up slide



Receive Grid Load

1

Market Management System

Day-ahead | Intraday | Real-time

MO

Receive bids

3

5

Activate bids

1

Calculate residual capacity

2 4

Clear market

Energy Trading

Day-ahead market

Intraday market

Real-time market

CMP

CMP Trading System

EMS-SCADA

Send price signal incl. forecast

6

Ancillary services

TSO Trading System

EMS-SCADA

Frequency control

Congestion management

Voltage control

TSO

High Voltage Substation

Primary Substation

Secondary Substation

Technical aggregation

DER services

Value-added services

DER aggregator

DER gateway

DER trading system

DER

Ancillary services

DSO Trading System

DMS-SCADA

Local Frequency control

Local Voltage control

Congestion management

DSO

7

Measurements

8

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: Back-up slide

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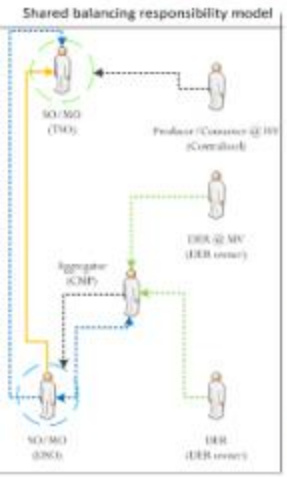

REGULATED MARKET

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