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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

What does the future look like? A Smart Networks Debate | 31.10.2018

Overview of SmartNet project

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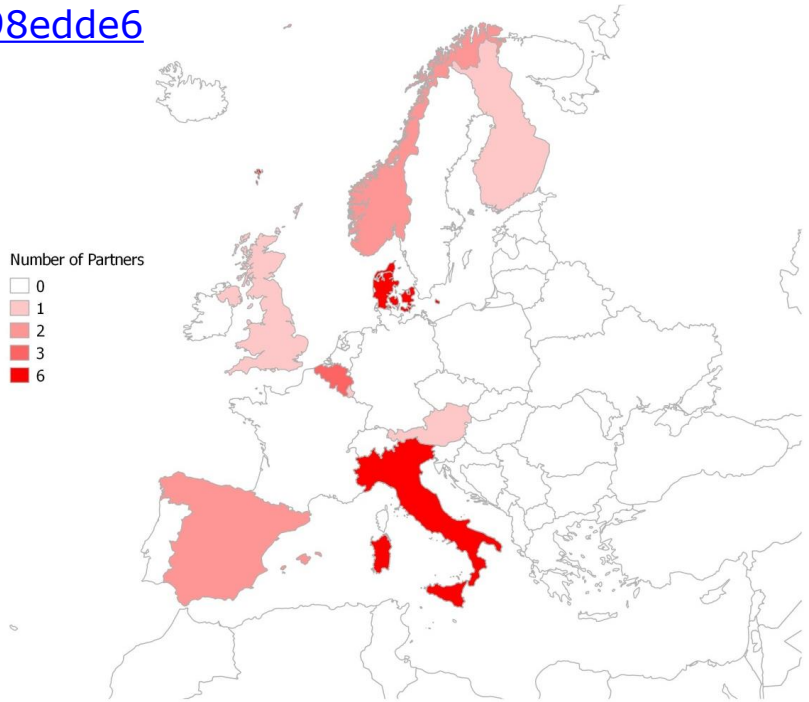
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691405

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



TSO-DSO coordination schemes

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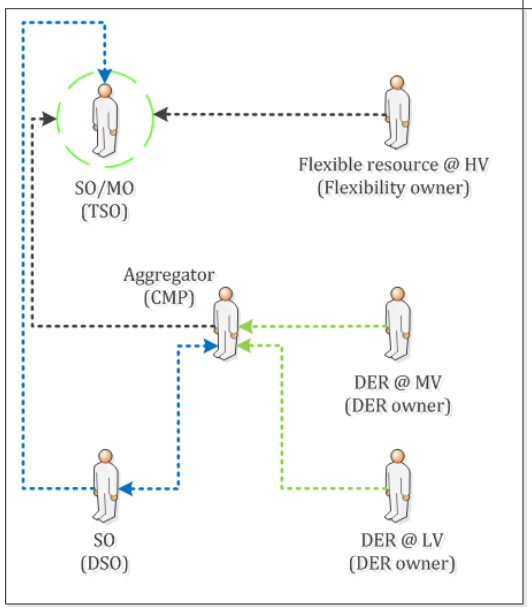
5 possible coordination schemes TSOs & DSOs for AS by distributed flexibility resources

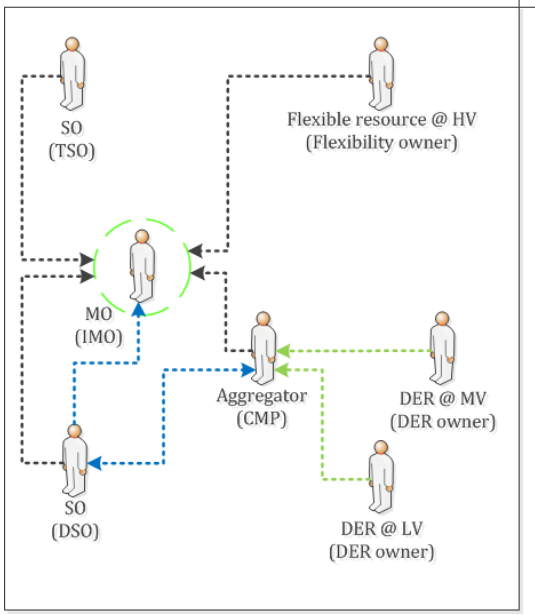
- Centralized AS market model
- Local AS market model
- Shared balancing responsibility model
- Common TSO-DSO AS market model
- Integrated flexibility market model

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

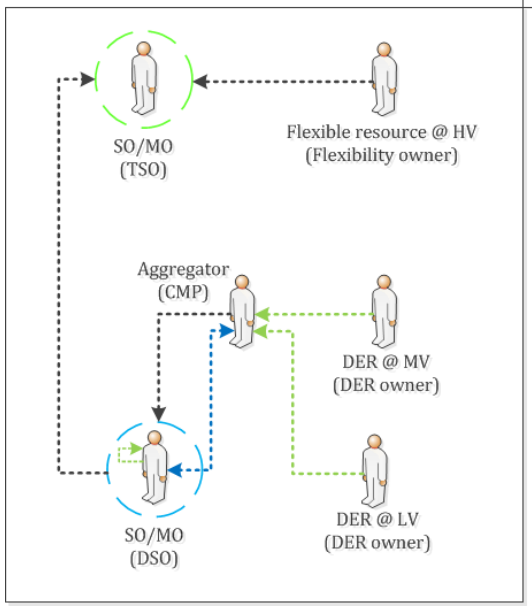
Centralized AS market model



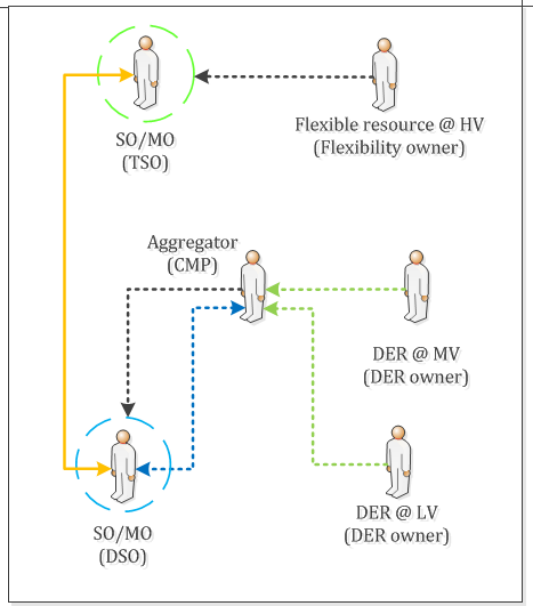
Integrated flexibility market model



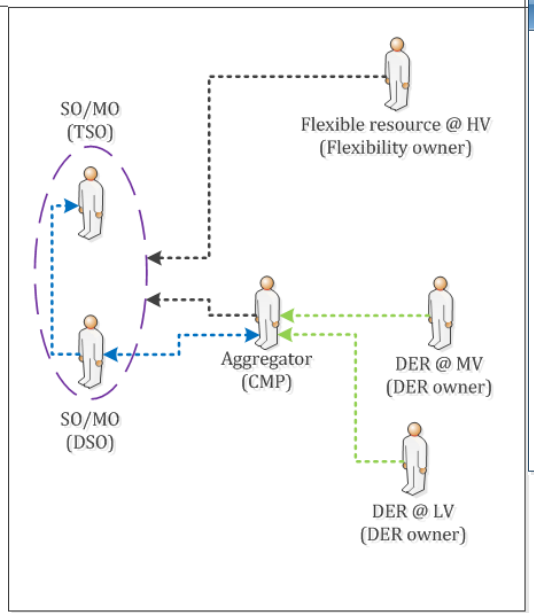
Local AS market model

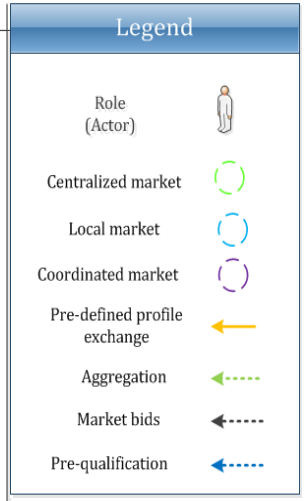


Shared balancing responsibility model



Common TSO-DSO AS market model





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

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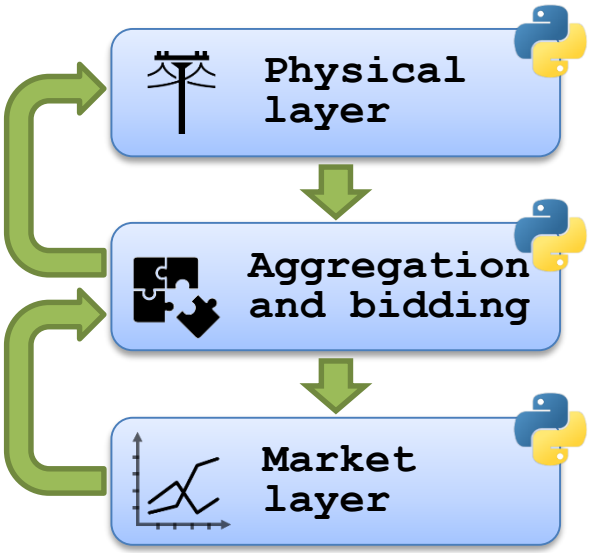
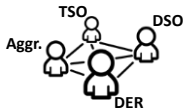
Development of simulation software



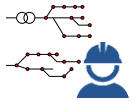
Definition of the reference scenario



Analysis of TSO-DSO coordination schemes

Definition of flexible devices profiles

Country-specific aspects and regulation



Network planning and operation

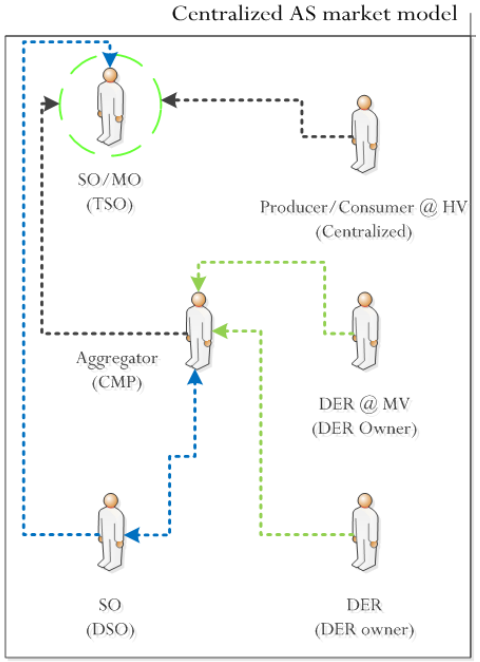
ICT specification and planning

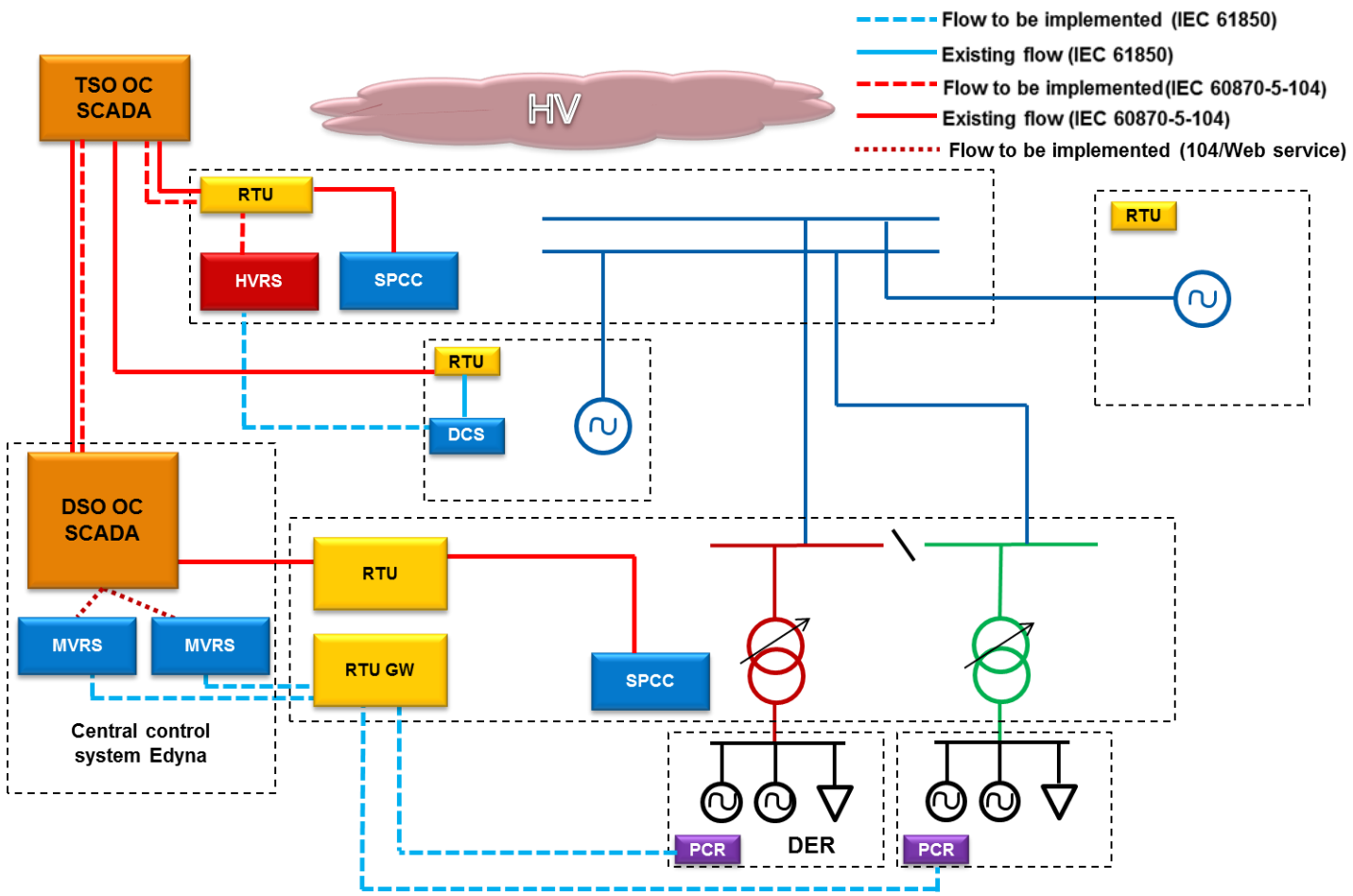
Simulation

Cost Benefit Analysis

Lab implementation of the simulation environment

Centralised TSO control in a high-DER area



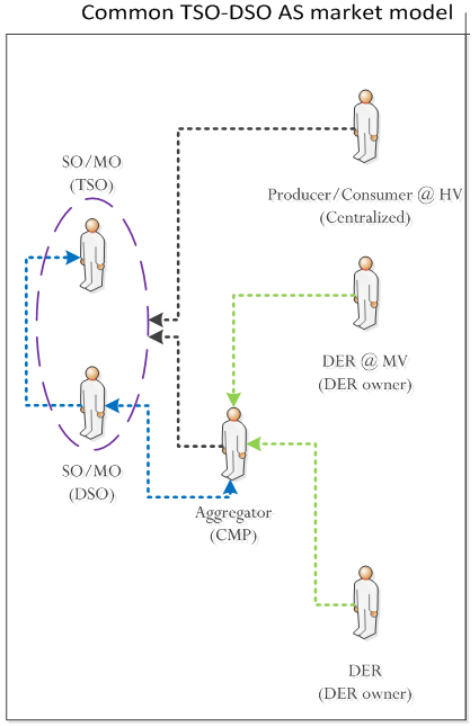


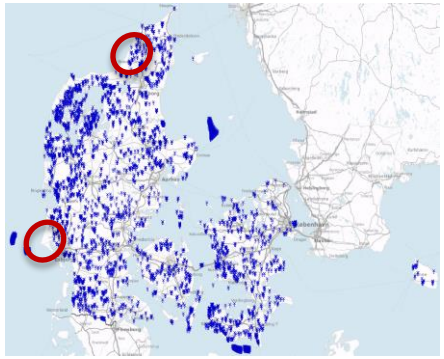
Aggregation of information
in RT at TSO-DSO interconnection (HV/MV transformer)

Voltage regulation
by generators connected at HV and MV levels

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

Common TSO-DSO market with pool flexibility





NOVASOL

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DTU Technical University of Denmark

ENFOR

DTU Technical University of Denmark

ENFOR

MO

TSO

DSO

AGGREGATOR

DER

1 SURVEY WEATHER, MARKET PRICES AND NRV

2 PHASE 1 TRAINING

3 ESTIMATE AVAILABLE REACTION = *f*(PRICE) VOLUME

4 RUN BIDDING PRICE STRATEGY

5 PREPARE VOLUME @ PRICE BID

6 MEASURE AND SEND DSO GRID LOAD

7 MEASURE AND SEND TSO GRID LOAD

8 CLEAR MARKET

9 SEND RESULTS (ACTIVATIONS)

10 RECEIVE RESULTS

11 CALCULATE PRICE SIGNAL

12 ACQUIRE SIGNAL

interface

interface

BASELINE

INTERPRET SIGNAL

ACTIVATION

ACTIVATION

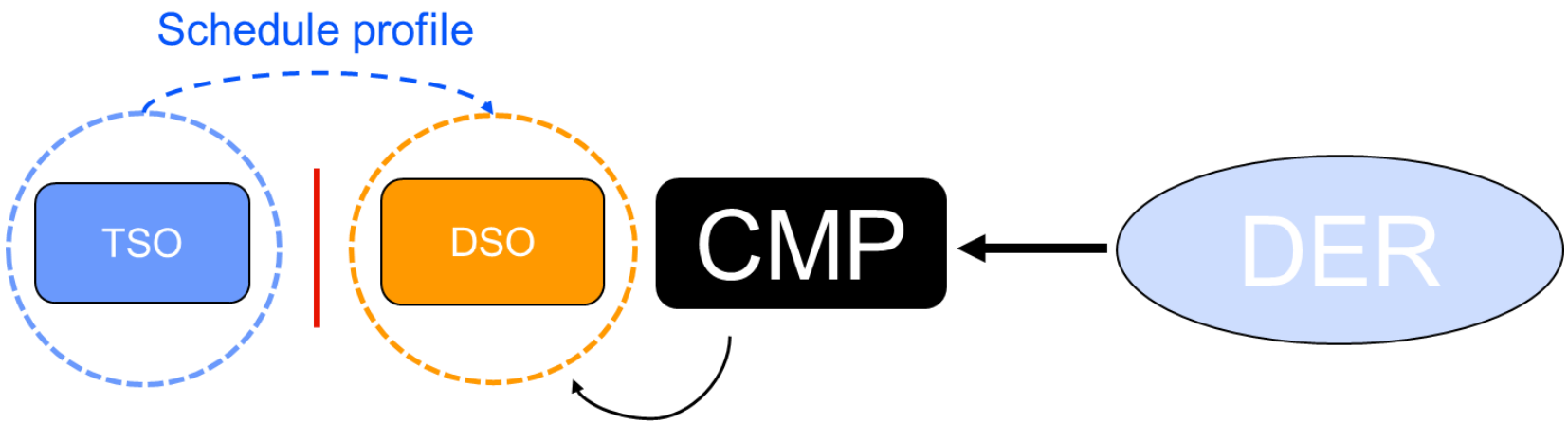
Congestion management
to better integrate PV, EV and HP

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

Balancing
of wind power with decreasing contribution of thermal units

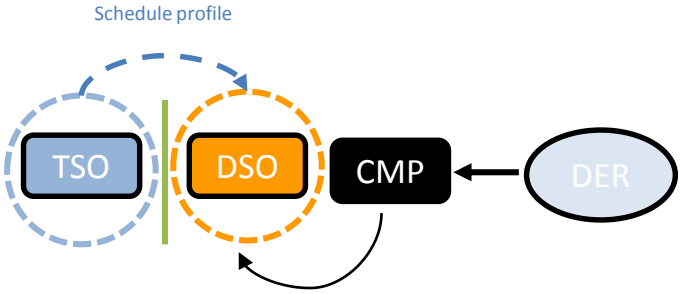
Coordination scheme

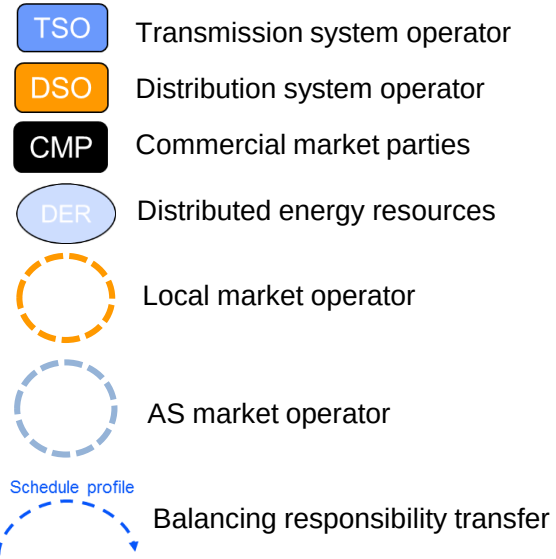
Shared balancing responsibility model



Coordination scheme

Shared balancing responsibility model





Two different markets
- Ancillary Service market for resources connected at TSO-grid
- Local Market for resources connected at DSO-grid

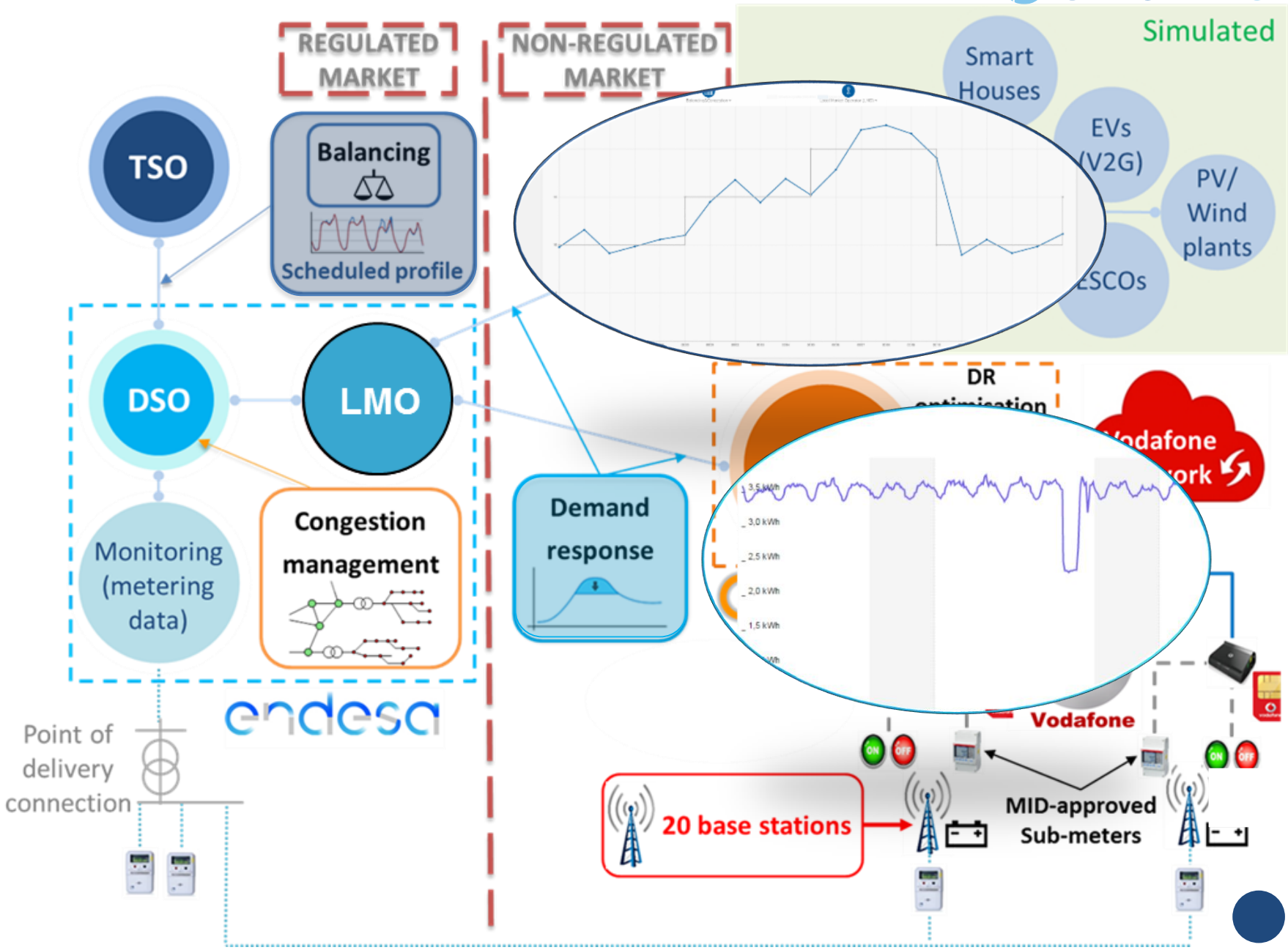
Ancillary services
- **Balancing** in the interconnection point by respecting schedule profile (on behalf of TSO)
- **Congestion management** in the distribution grid

How? →

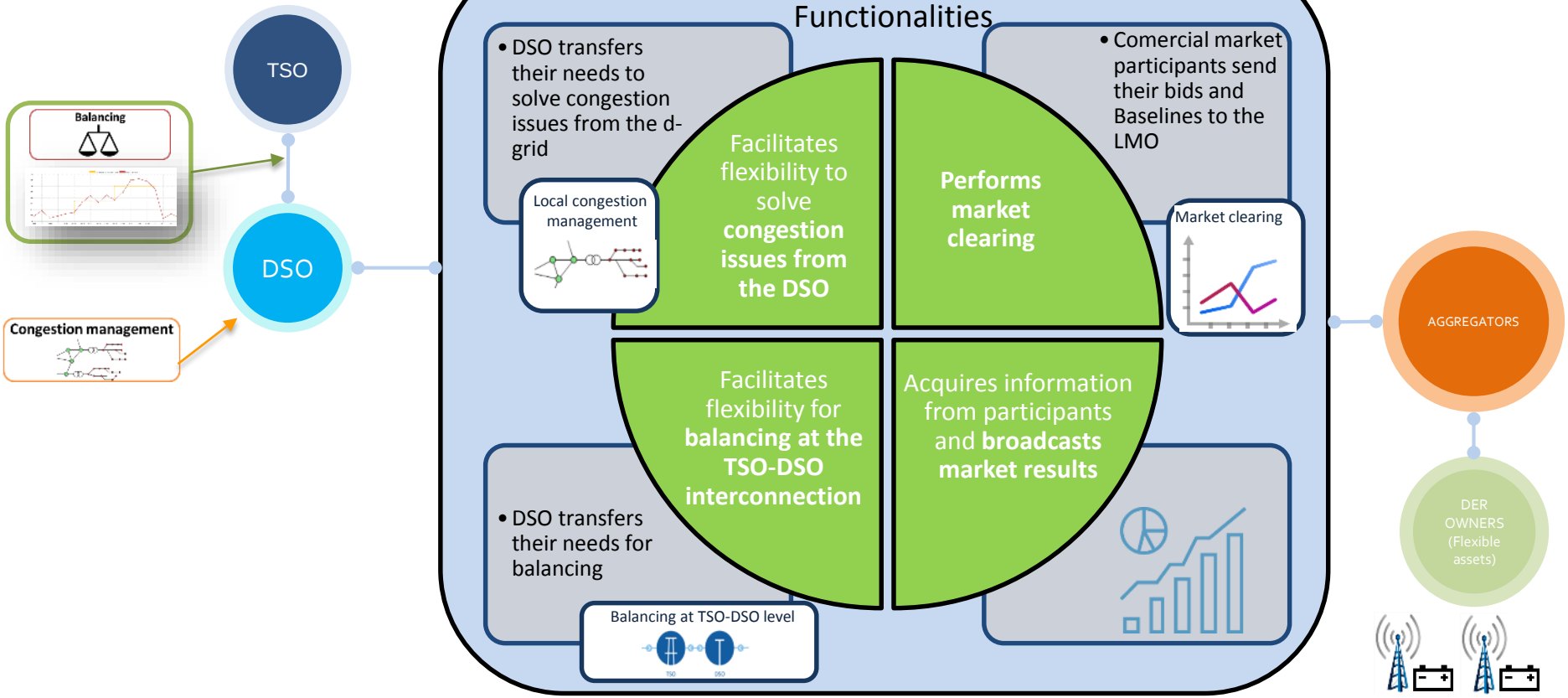
By using flexibility from DER owners through Commercial market parties

Roles in the project

endesa	Transmission System Operator	Balancing at interconnection level Developing the TSO-DSO interaction
	Distribution System Operator	By doing congestion management services for itself at local network
	Commercial Market Party	Virtual nodes emulating other CMP's (Smarthouses, PV's, BSs)
	Market operator	Local market operation
	Commercial Market Party	Managing the portfolio of Vodafone radio base stations
Vodafone	DER owner	Owner of the base stations (flexible resource) Provider of connectivity services to CMP's DR providers
tecnalia Inspiring Business	Consulant	

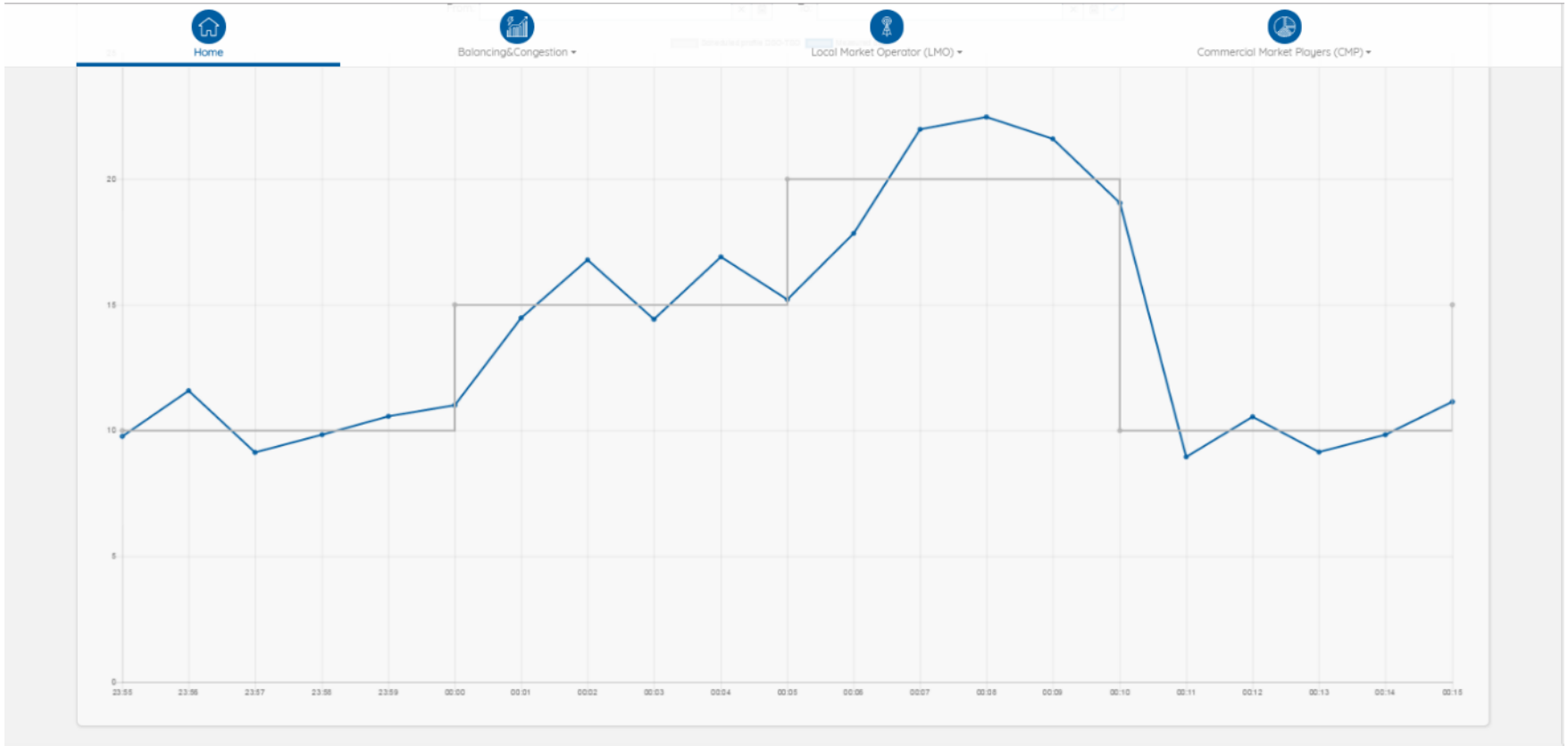

REGULATED MARKET
NON-REGULATED MARKET
Simulated
Smart Houses
EVs (V2G)
PV/ Wind plants
ESCOs
TSO
Balancing
Scheduled profile
DSO
LMO
Monitoring (metering data)
Congestion management
Demand response
DR
Vodafone
endesa
Point of delivery connection
20 base stations
MID-approved Sub-meters

Local Market Operator



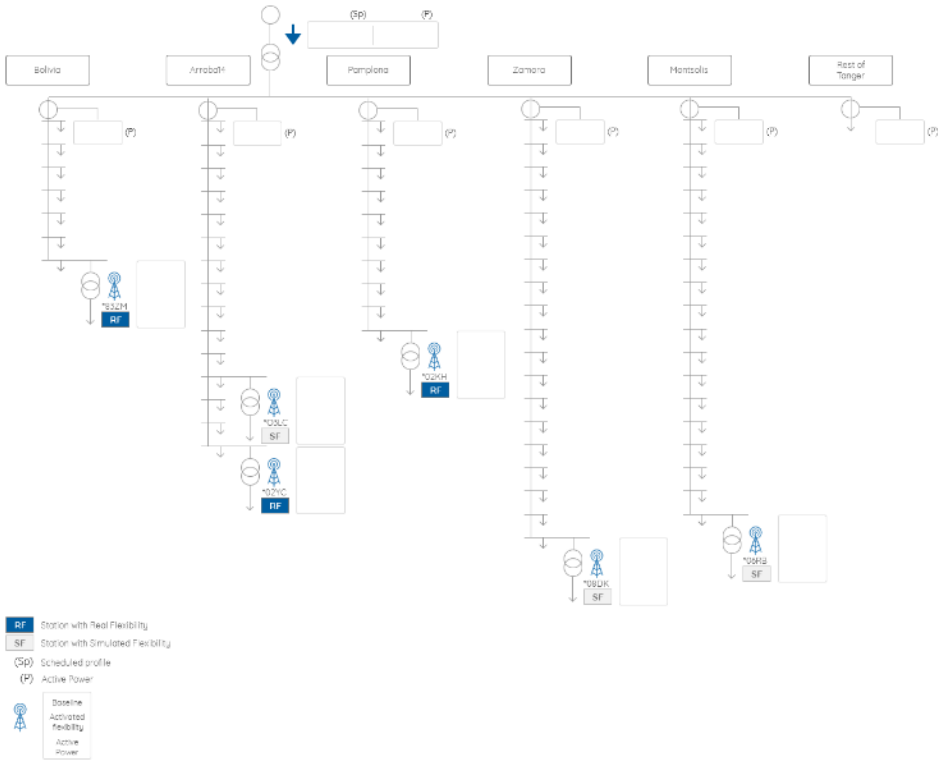
Balancing

- Time plot of active power exchanged at TSO-DSO interconnection points
  - Scheduled profile (MW)
  - Actual active power measured data (MW)
  - 1 plot per each TSO-DSO interconnection point in Pilot C
  - Adjustable time filter (window)



Network status

- Diagram of the distribution network downstream each TSO-DSO interconnection point
  - Voltage levels per node
  - Branch loadings (lines/cables, transformers)
  - Actual delivery of flexibility resources of the Pilot C (VODAFONE and virtual)
  - Updated every 1 minute



CMP bids

- Table of submitted flexibility bids per CMP per market session and node at each TSO-DSO interconnection point
  - Curtailable/non-curtailable bid blocks
  - Real/virtual CMP

CMP bids

CMP	Market time	Curtailable	Node	Price (€/kWh)	P (kW)	Virtual
ONE	2017-02-13T23:55:00Z	no	6	0.32	2.5	No
TWO	2017-02-13T23:55:00Z	no	10	0.26	7.5	Yes
V2G	2017-02-13T23:55:00Z	yes	7	0.28	50	Yes
ONE	2017-02-14T00:00:00Z	no	6	0.32	2.5	No
TWO	2017-02-14T00:00:00Z	no	10	0.26	7.5	Yes
V2G	2017-02-14T00:00:00Z	yes	7	0.28	57	Yes
V2G	2017-02-14T00:00:00Z	yes	7	0.28	-10	Yes

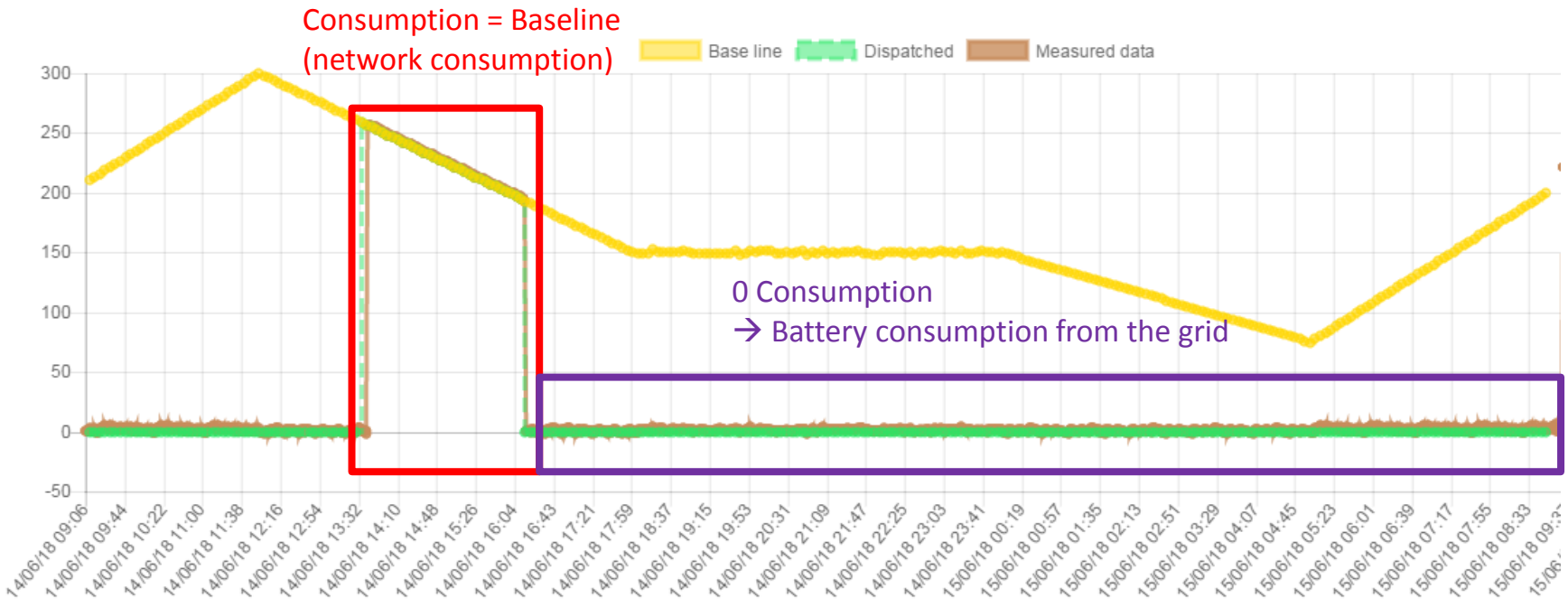
VCMP01

Sate: Running

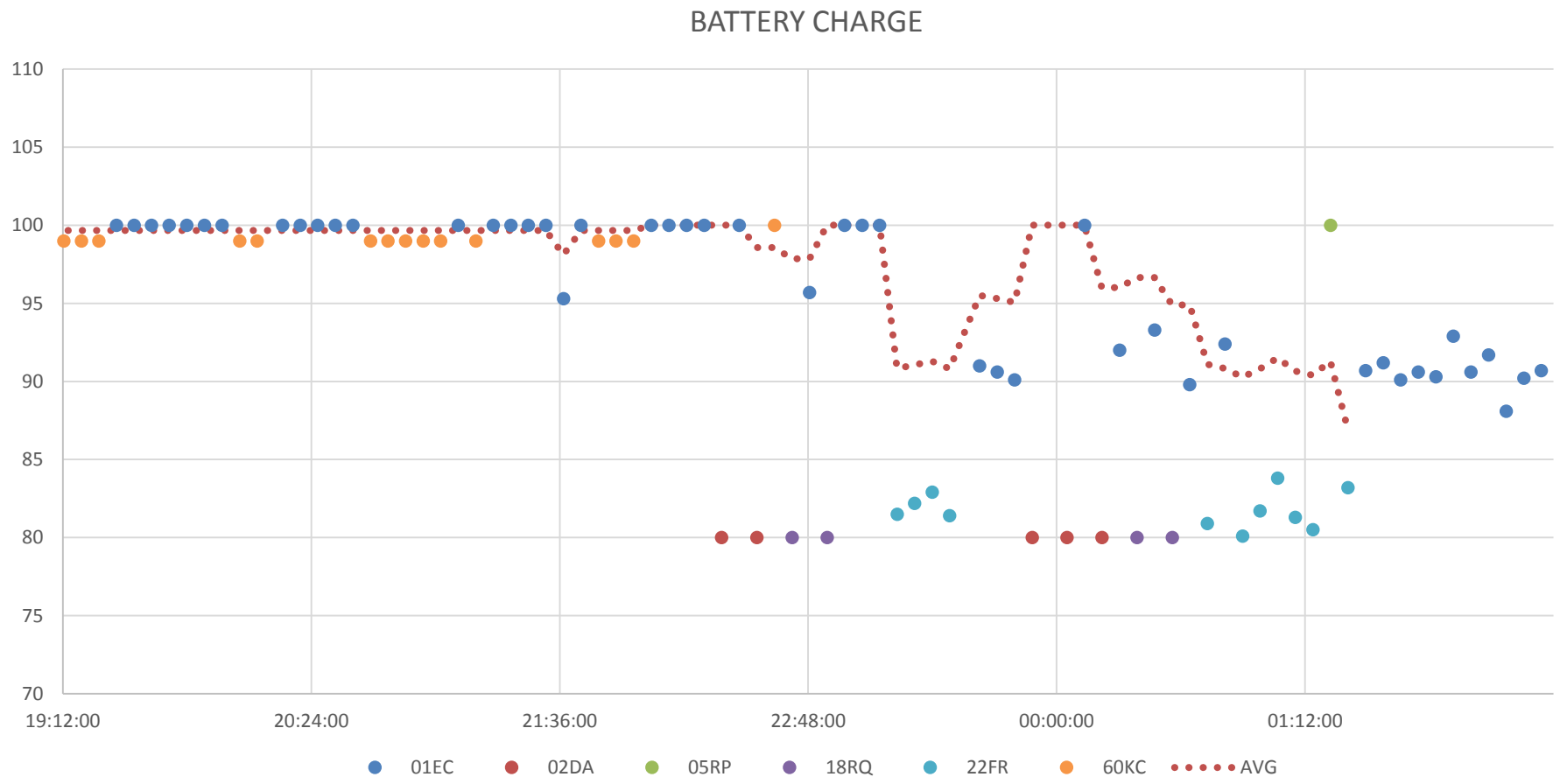
18/06/2018 06:52:21 UTC

Time Filter

Aggregated Load

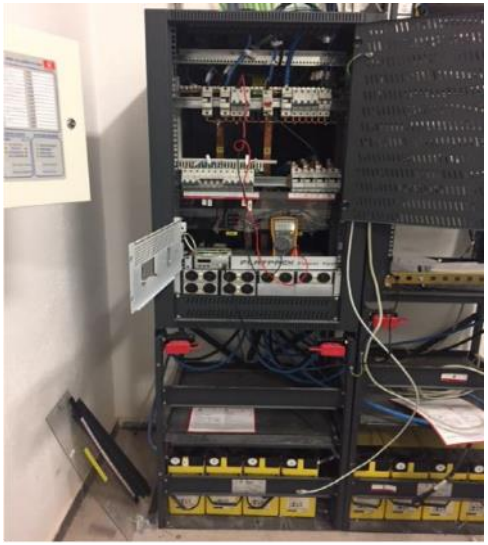


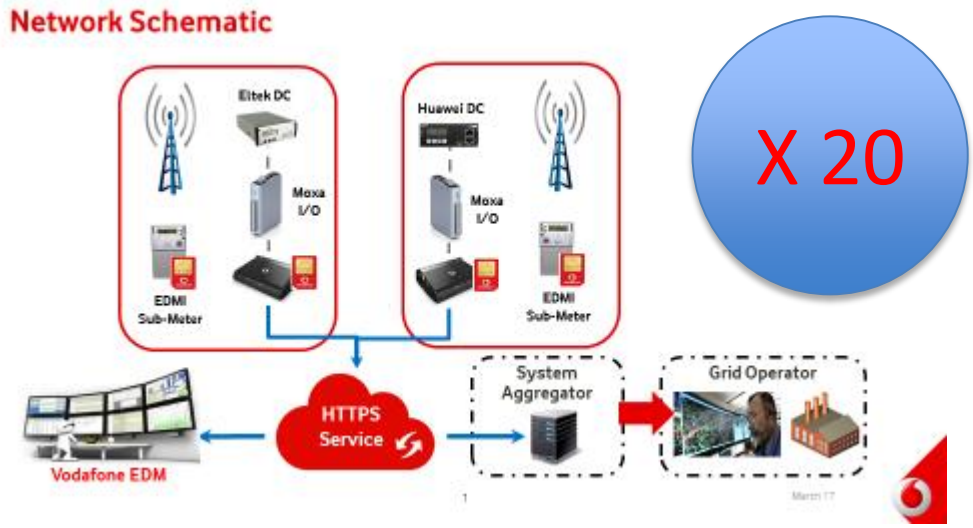
Status – Real Time



Pilot C - Physical Layer

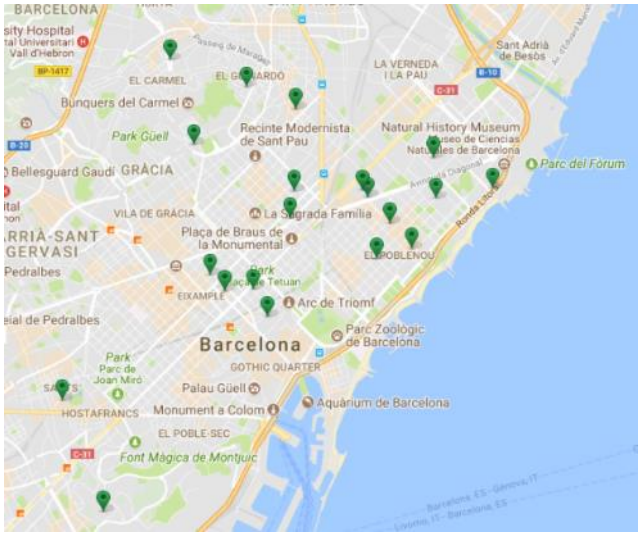
Vodafone BTS transformation into DER plants.





- **Curtailment principle :** integrate the remote battery test functionality to pilot the radio equipment switch to back up batteries on demand

- **Scenario:** 20 Radio Base stations equipped with
  - 48V controller SW: 2 brands – Eltek and Huawei
  - SNMP connection
  - Mobile Link 4G modem+ Moxa gateway
  - 4x12 V 100amph VRLA Batteries
  - 1 smart meter with 1mn slot readings



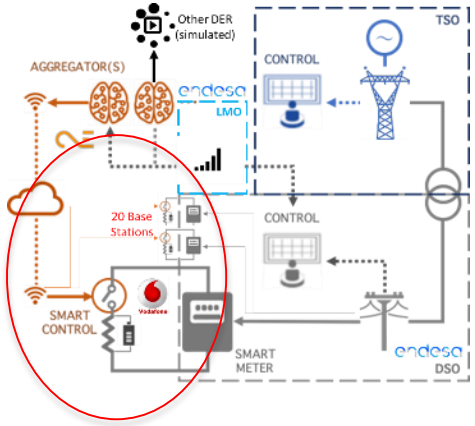
Field test: 90% operational

Feb 2018

Substation	VF Site ID	Vodaofne Name	PSU Type	Battery Status	Monitoring	Batt Test	Comment/Actions
HOSTAFRANC	618	B_SANTS	Huawei	TBC	TBC	TBC	Cabinet swap 18th of Feb
TANGER	621	B_PERU	Huawei	Good	Good	Working	Smart Meter Comms Issue
MARAGALL	801	B_ERCILLA46	Eltek	Good	Good	Working	ok
VILANOVA	3208	B_PAUCLARIS	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
VILANOVA	5297	B_CARTAGENA	Eltek	TBC	TBC	TBC	Eltek Controller upgrade 2nd Feb
SANLLEHY	10048	B_TOLRA51	Huawei	TBC	TBC	TBC	Cabinet swap 28th Jan
SANLLEHY	11847	B_MONTSERRAT20	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
VILANOVA	26435	B_GRANVIA653	Huawei	Good	Good	Working	Smart Meter Polarity issue
VILANOVA	28354	B_TRAFALGAR21	Huawei	Faulty	Good	Working	ok
BESOS	29424	B_LLULL111	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
VILANOVA	52652	B_MALLORCA272	Huawei	Good	Good	TBC	to test
BESOS	52655	B_DIAGONALMAR_U	Huawei	Good	Good	Working	ok
BESOS	62806	B_SANOFI SYNTHELABO_AVENTIS_VP	Huawei	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
HOSTAFRANC	64936	B_CN_MONTJUICH	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
VILANOVA	70903	B_BAC_DE_RODA_LLULL	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
TANGER	76469	B_BCNACTIVA	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms
MARAGALL	77879	B_ARAGÃ472	Huawei	Good	Good	Good	ok
MARAGALL	80263	B_PS_MARAGALL74	Huawei	Good	Good	Good	ok
TANGER	85405	B_LLACUNA_10	Eltek	TBC	TBC	TBC	Site Visit Required to Enbale Remote Comms
VILANOVA	85407	B_PALLARS_193	Eltek	TBC	Good	TBC	Site Visit Required to Enbale Remote Comms

Jun 2018: 90 to 100 Kw curtailable

VF Site ID	Vodaofne Name	PSU Type	Battery Status	Monitoring	Batt Test	Comment/Actions
618	B_SANTS	Huawei	Good	TBC	Good	Remote meter connectivity in test
621	B_PERU	Huawei	Good	TBC	Good	Remote meter connectivity in test
801	B_ERCILLA46	Eltek	Good	Good	Working	ok
3208	B_PAUCLARIS	Eltek	Good	Good	Working	ok
5297	B_CARTAGENA	Eltek	Good	Good	Working	ok
10048	B_TOLRA51	Huawei	TBC	TBC	TBC	Coms issue on controller
11847	B_MONTSERRAT20	Eltek	Good	Good	Working	ok
26435	B_GRANVIA653	Huawei	Good	Good	Working	ok
28354	B_TRAFALGAR21	Huawei	Good	Good	Working	ok
29424	B_LLULL111	Eltek	Good	Good	Working	ok
52652	B_MALLORCA272	Huawei	Good	Good	Working	ok
52655	B_DIAGONALMAR_U	Huawei	Good	Good	Working	ok
62806	B_SANOFI SYNTHELABO_AVENTIS_VP	Eltek	TBC	Good	TBC	SNMP issue .
64936	B_CN_MONTJUICH	Eltek	TBC	L4G to repla	TBC	Replace ML4G
70903	B_BAC_DE_RODA_LLULL	Eltek	Good	Good	Working	ok
76469	B_BCNACTIVA	Eltek	Good	Good	Working	ok
77879	B_ARAGÃ472	Huawei	Good	Good	Good	ok
80263	B_PS_MARAGALL74	Huawei	Good	Good	Good	ok
85405	B_LLACUNA_10	Eltek	Equipment swap required			
85407	B_PALLARS_193	Eltek	Good	Good	Good	ok

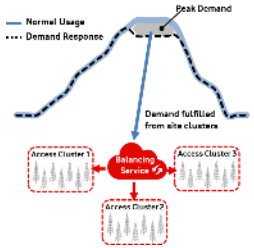


Conclusions.
Potential & Benefits of flexibility

In good grid conditions, the unused available capacity backup aggregated from Bases stations can be reused by the DSO for congestion management, and eventually avoiding costly ignition of thermic power plants. Only Vodafone by itself **in the EU could represent 250MW** of dispatchable load.

From the DSO perspective:

- Innovative ways of integrating battery systems into the power grid. Fairly compensation for DER and prosumers.
- Avoiding possible reinforcements of the grid. Network upgrades only when needed.
- Helping Balancing services means decreasing tariffs.
- Envisioning different coordination's schemes with different results on the CBA.
- Pushing new technologies and the grid digitalization.
- Contributing to the social welfare of European citizens and activating the circular economy.



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Thank You

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Thank You

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