SmartNet

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

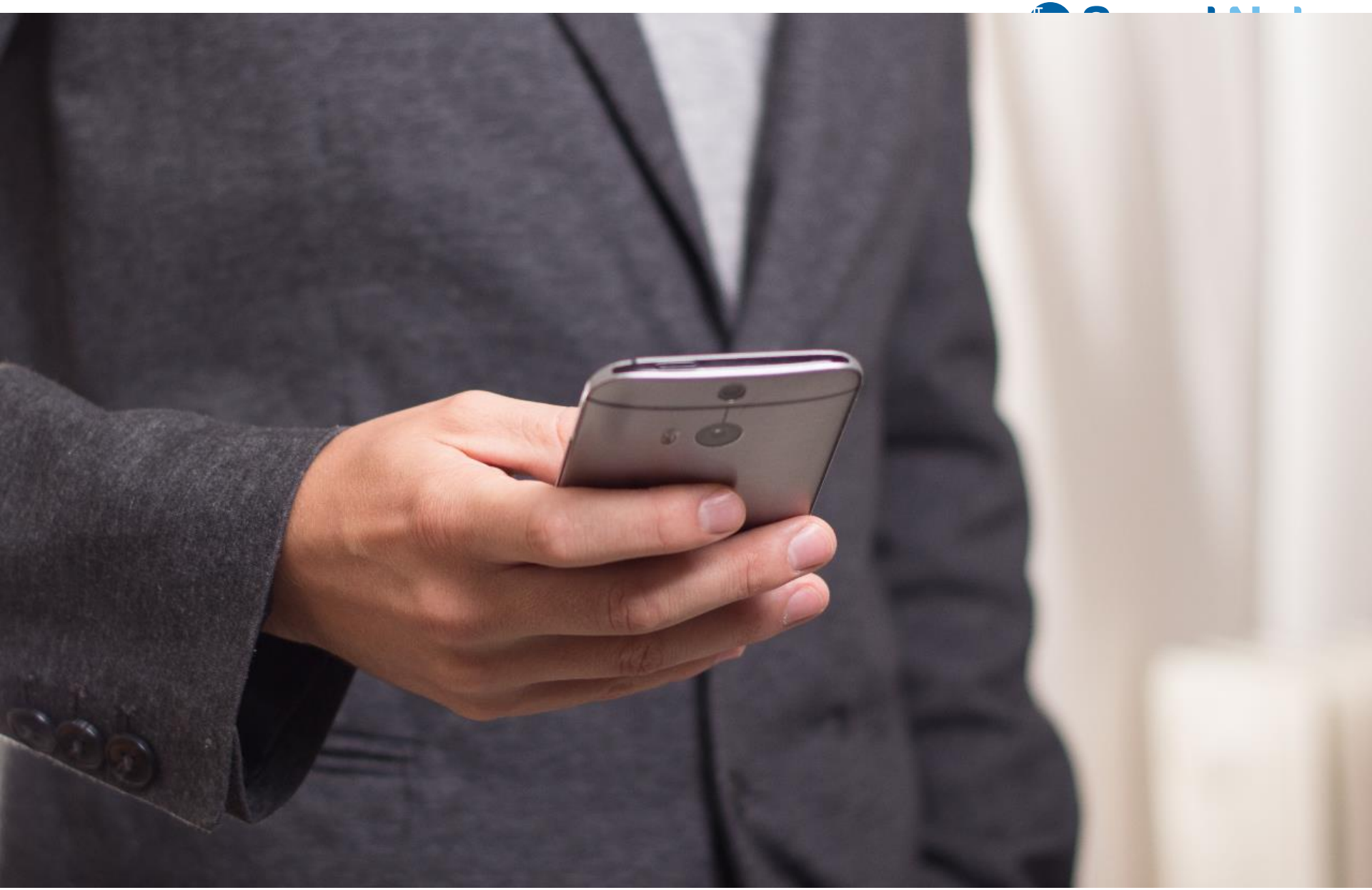
SmartNet Project Meeting, Florence| 24.10.2018

Pilot C
Miguel Pardo – Endesa Distribución

Endesa - Vodafone – ONE - Tecnalia

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

SmartNet



Vodafone
Base Stations

More than 400 units just in Barcelona

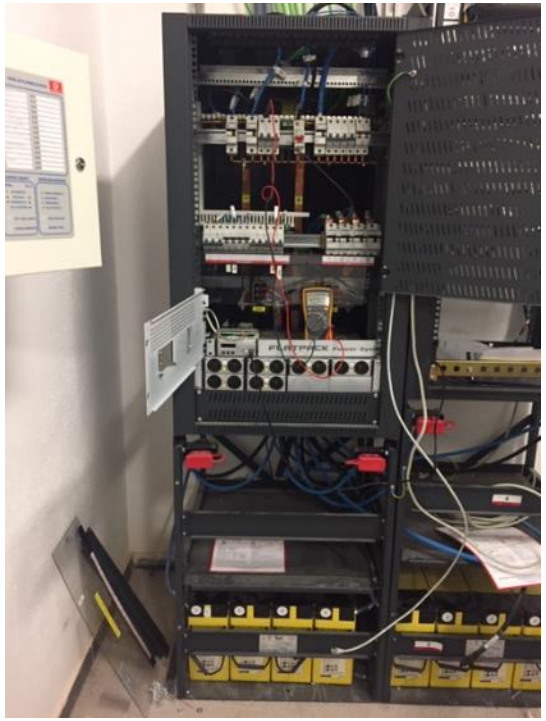
Contracted Power of each one from
5kw to 15kw

SmartNet

Vodafone Base Stations

Flexibility by Storage Capacity

- Back Up Batteries - Base Station of Vodafone



Spanish pilot

DER Owner side. Demand Response Technology over VF Base Stations

Pilot flexible aggregation capacity: around 100 kW

Spanish pilot

Pilot realisation

Italian Pilot (A)

Danish Pilot (B)

Spanish Pilot (C)

Motivation

To proof in real field the feasibility of the *Shared balancing responsibility model* of SmartNet project

Market layer

Physical network layer

ICT layer

Goal achievements

- Validation of TSO-DSO interactions
- Balancing (TSO level)
- Congestion management DSO level)

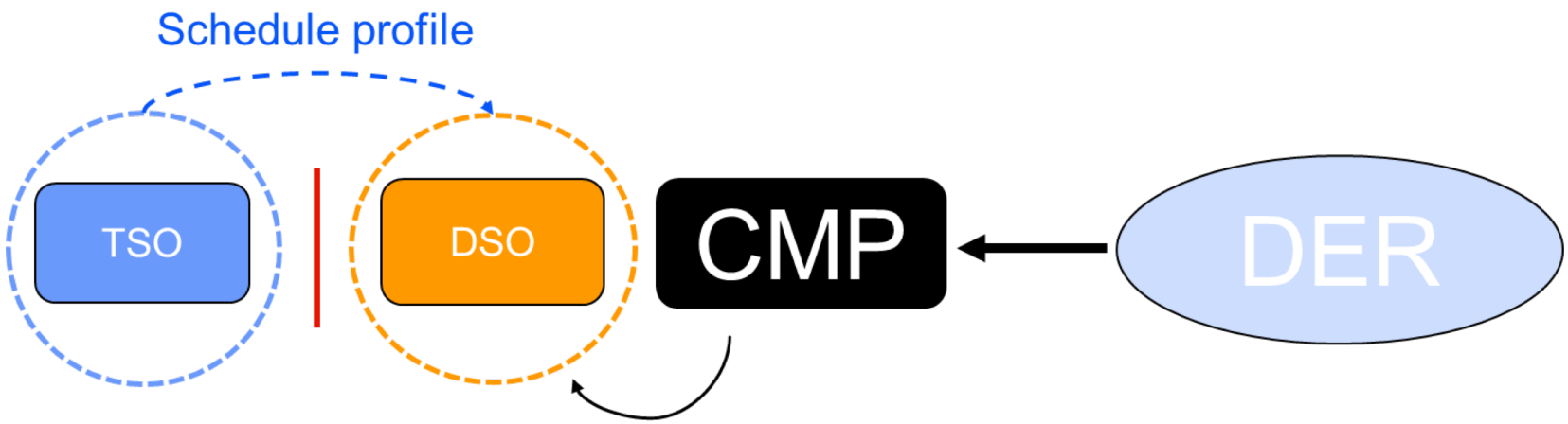
✓ Flexibility Aggregation

✓ Demand Response (Base stations)

✓ ICT communications

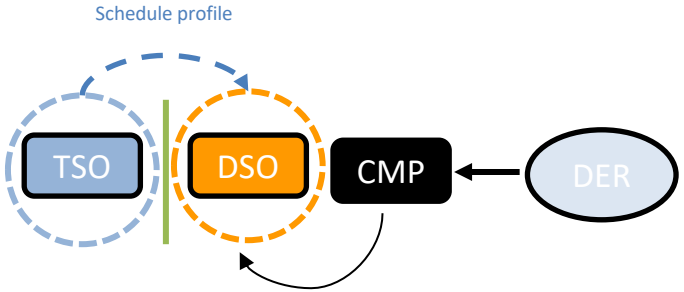
Coordination scheme

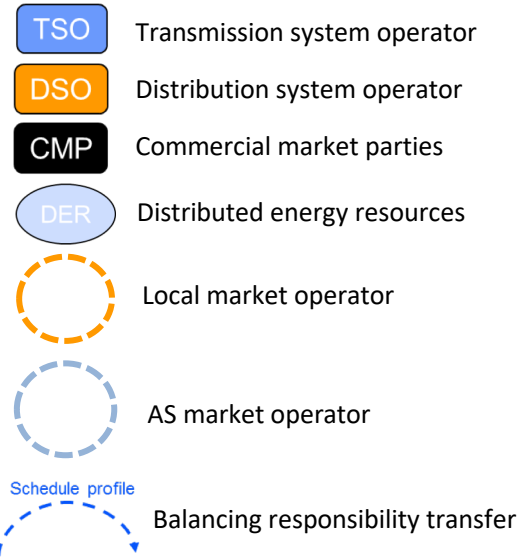
Shared balancing responsibility model



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

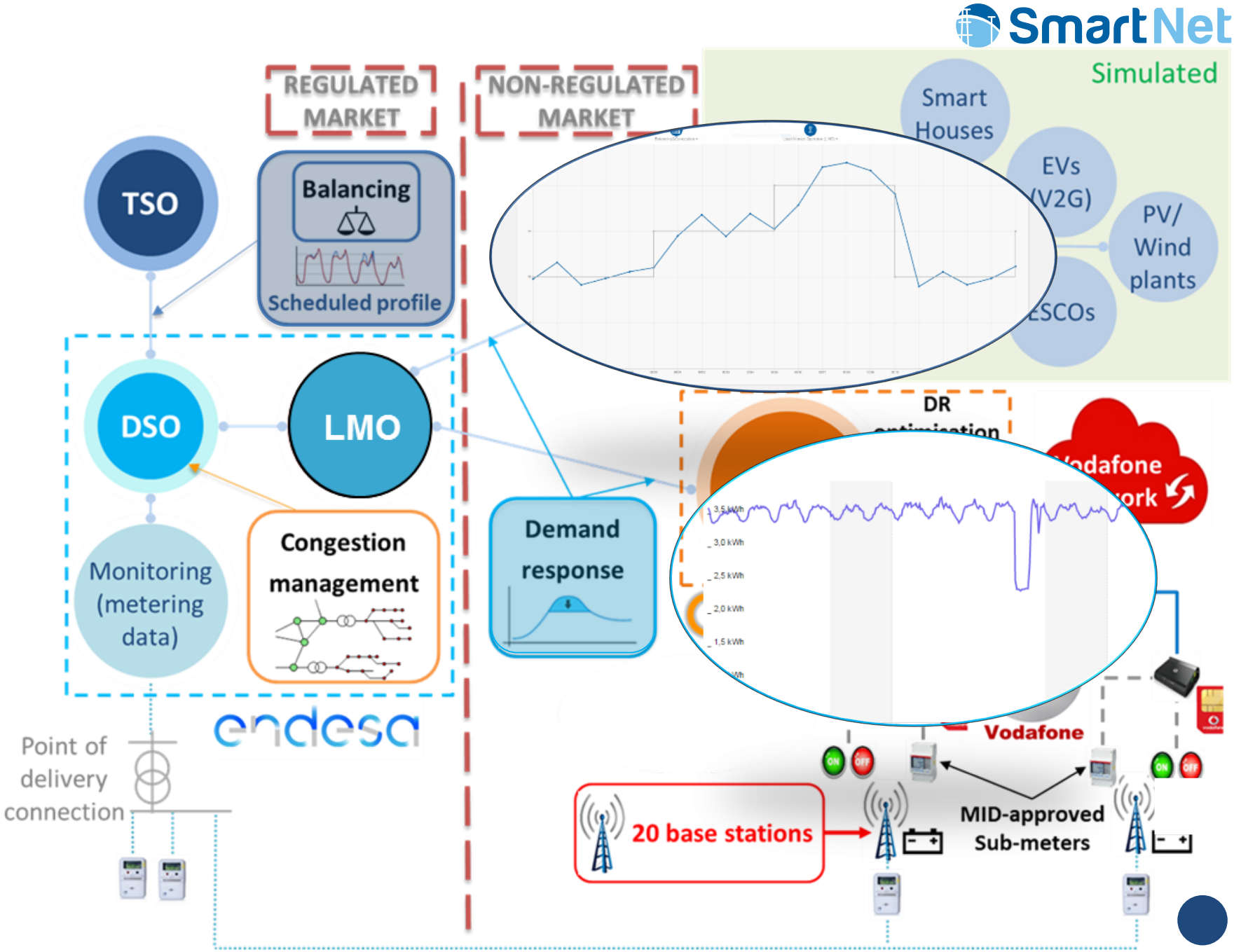
- **Balancing** in the interconnection point by respecting schedule profile (on behalf of TSO)
- **Congestion management** in the distribution grid

How? →

By using flexibility from DER owners through Commercial market parties

Roles in the project

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
DER owner	Owner of the base stations (flexible resource) Provider of connectivity services to CMP's DR providers
Consulant	


SmartNet
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

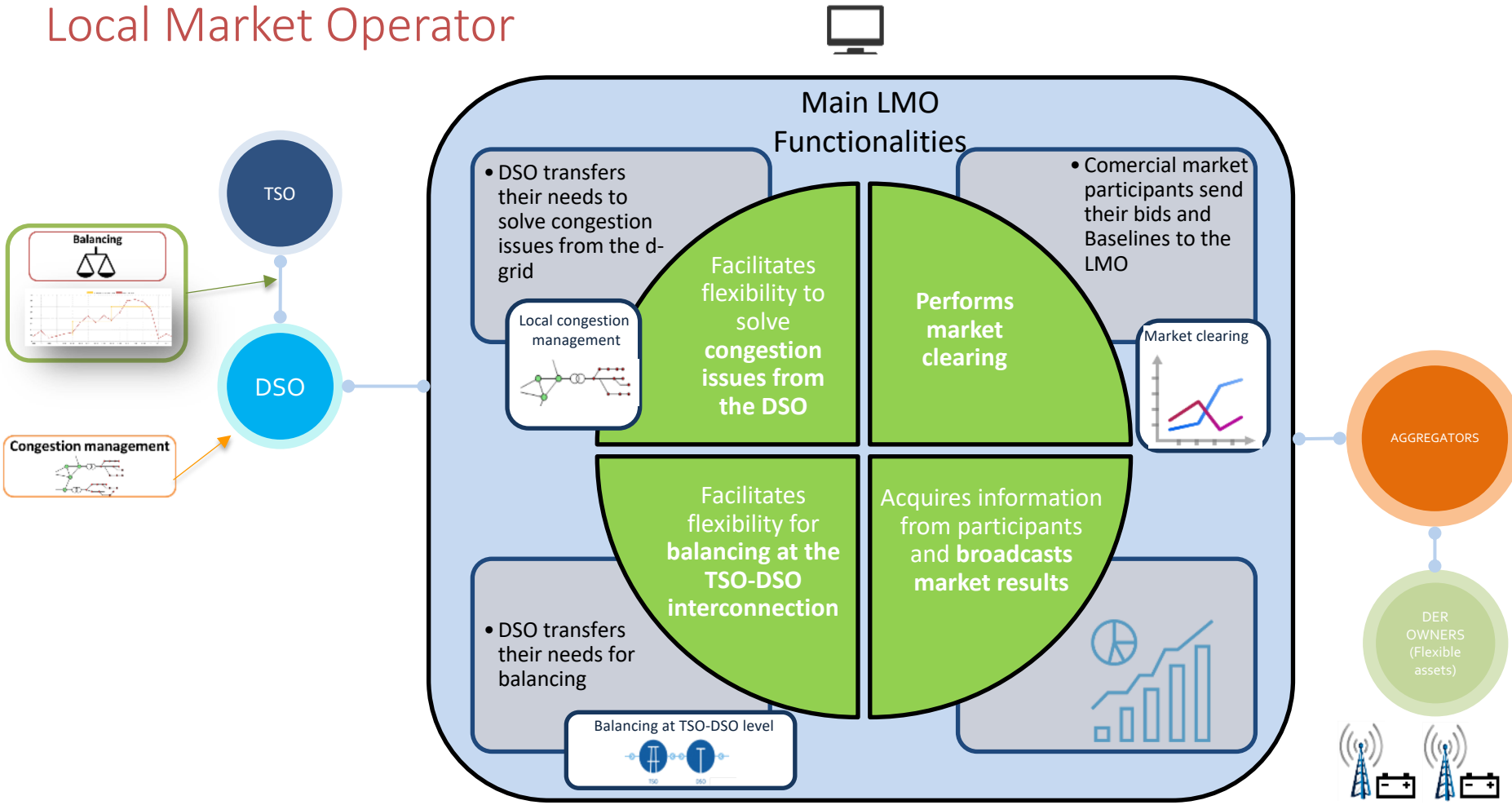
Pilot C: Local Market Operator

Endesa Distribución will play the **market operator** role at the local (distribution) level by means of the **market clearing algorithm**, which at the end is an OPF (Optimal Power Flow).

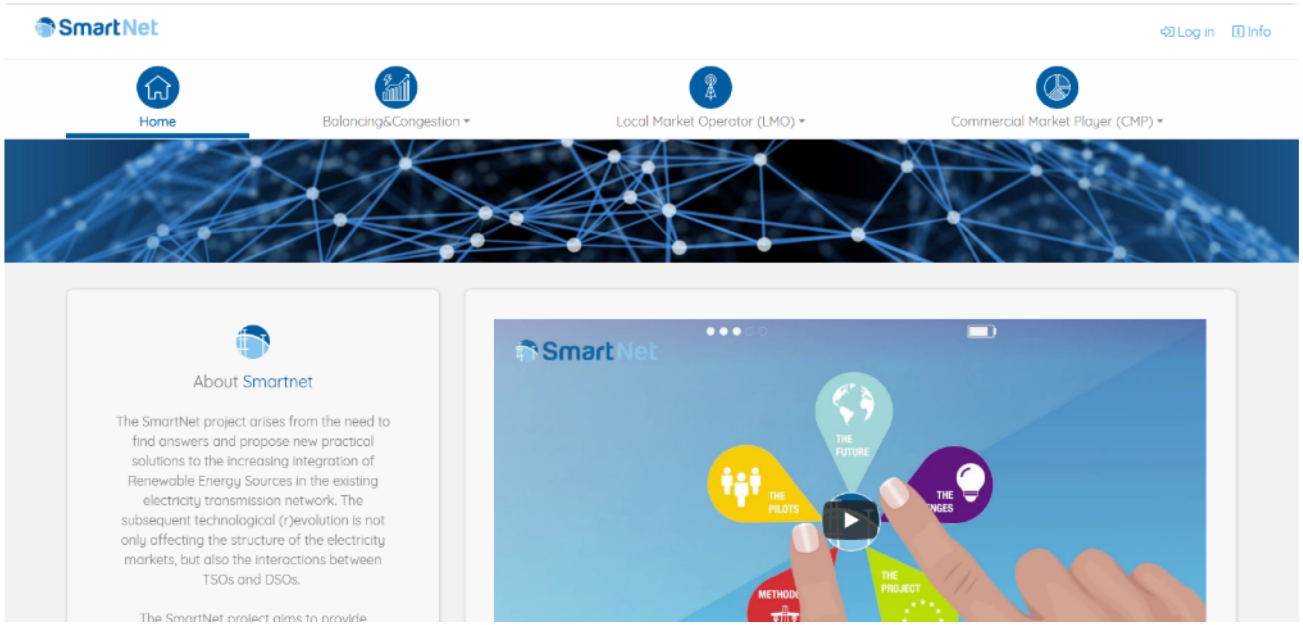
The OPF solves in the same optimization model both technical and market-related aspects of the balancing and congestion management services.

In other words, **technical constraints and bid prices are combined in the same optimisation problem**, which provides an optimal economical outcome.

Local Market Operator

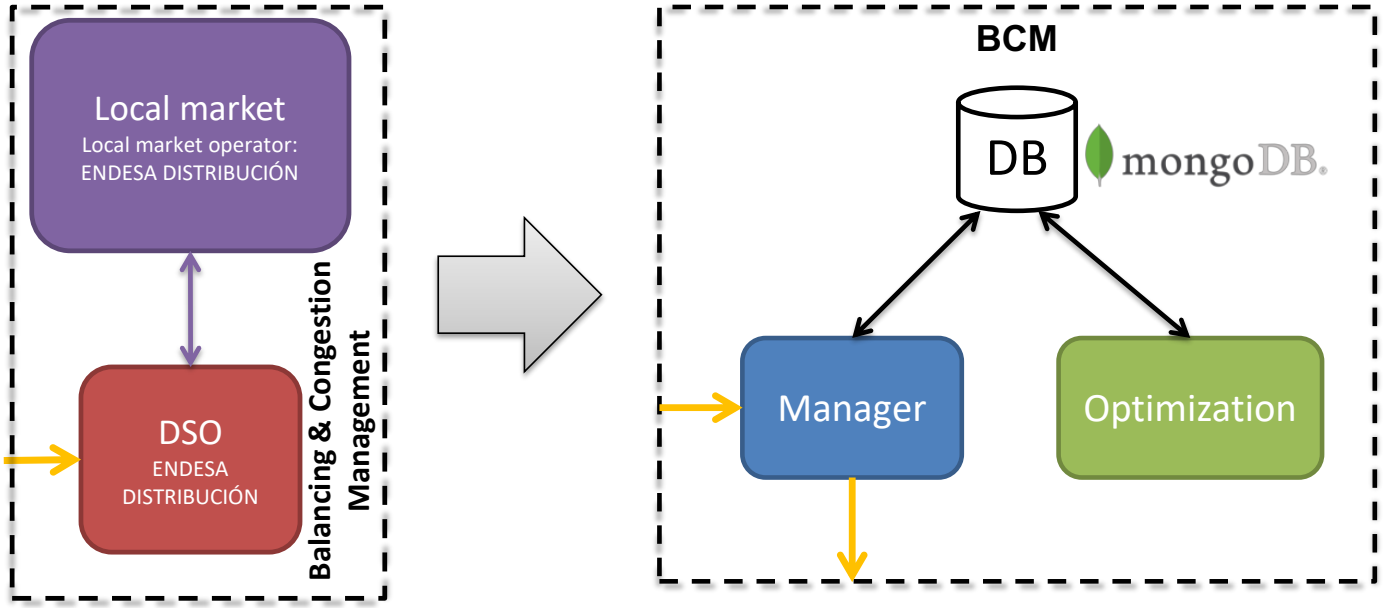


Web interface architecture



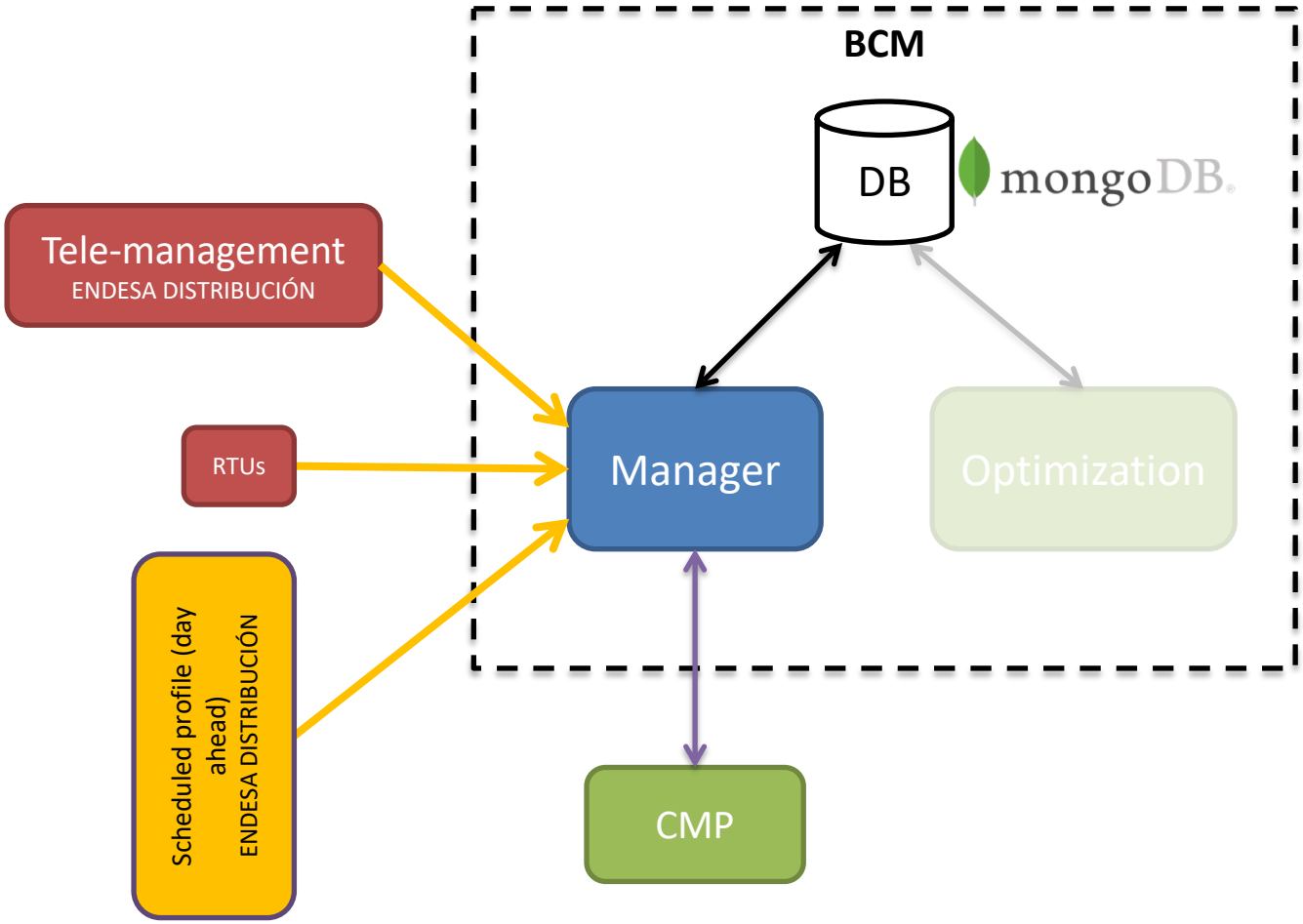
- Balancing and Congestion Management
  - Balancing
  - Network status
- Market
  - Market price
  - Flexibility
  - Market results
  - CMP bids
- CMP ONE (real)
- CMP TWO (virtual)
- CMP V2G (virtual)
  - Aggregated load (per CMP)

Pilot C: Balancing & Congestion Management

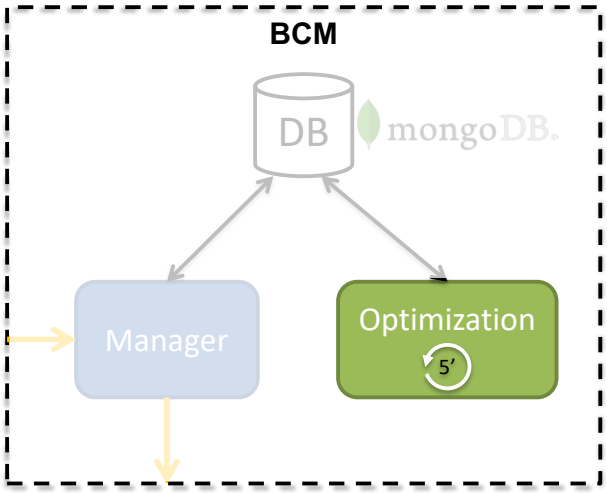


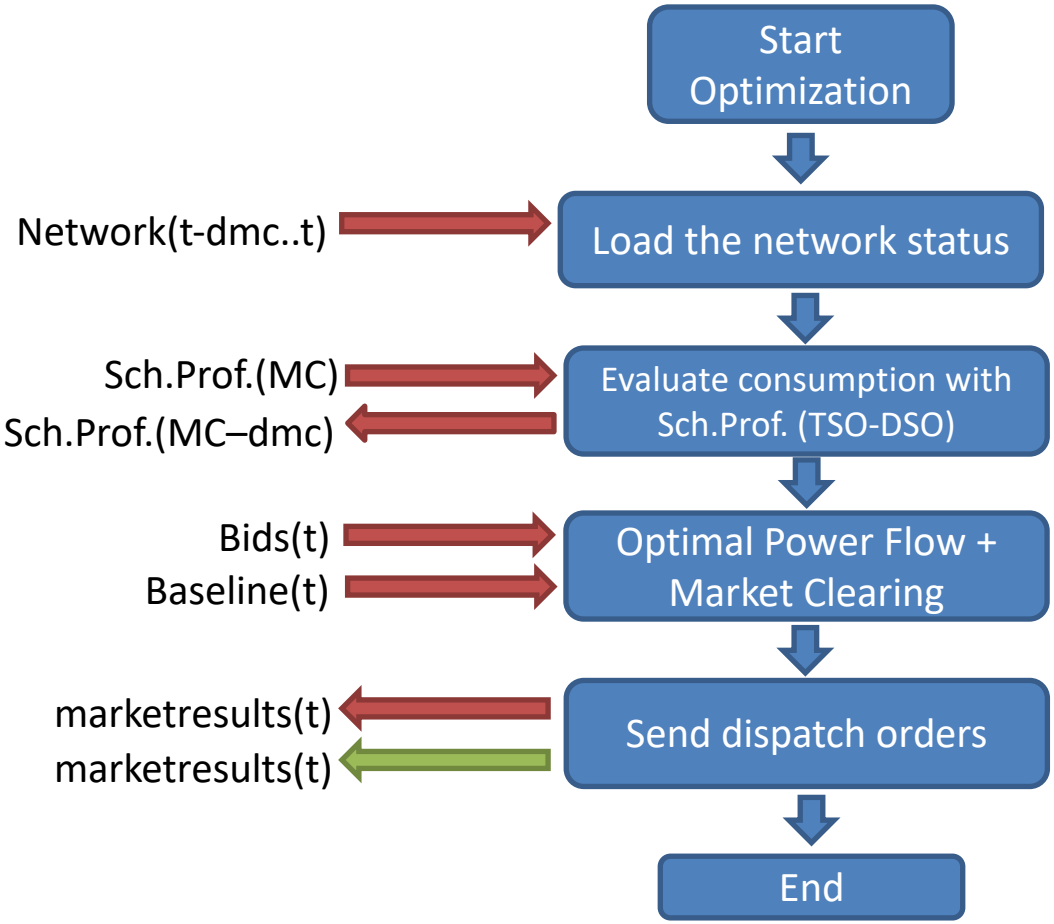

```
Information Process
================================================
Active CMP:
ONE last bids: 2018-03-21T15:30:00Z
VCMP01 last bids: 2018-03-21T15:10:00Z
------------------------------------------------
Next calculations at: 2018-03-21T15:14:00Z
Next market at: 2018-03-21T15:15:00Z
================================================
```

Pilot C: BCM - Manager



Pilot C: BCM - Optimization





MC = Market Clearing Time
dmc = 5 min

Messages

Connections to DB

Pilot C: BCM - Opt. – OPF + MarketClearing

$$\min \sum_{g \in G} \sum_{k \in K_g} lb^{+}_{gk} P^{+}_{gk} + \sum_{k \in K_{G_0}} lb^{-}_{0k} P^{-}_{0k} + \sum_{(i,j) \in \mathcal{L}} C_{ij}$$

$s.t.$

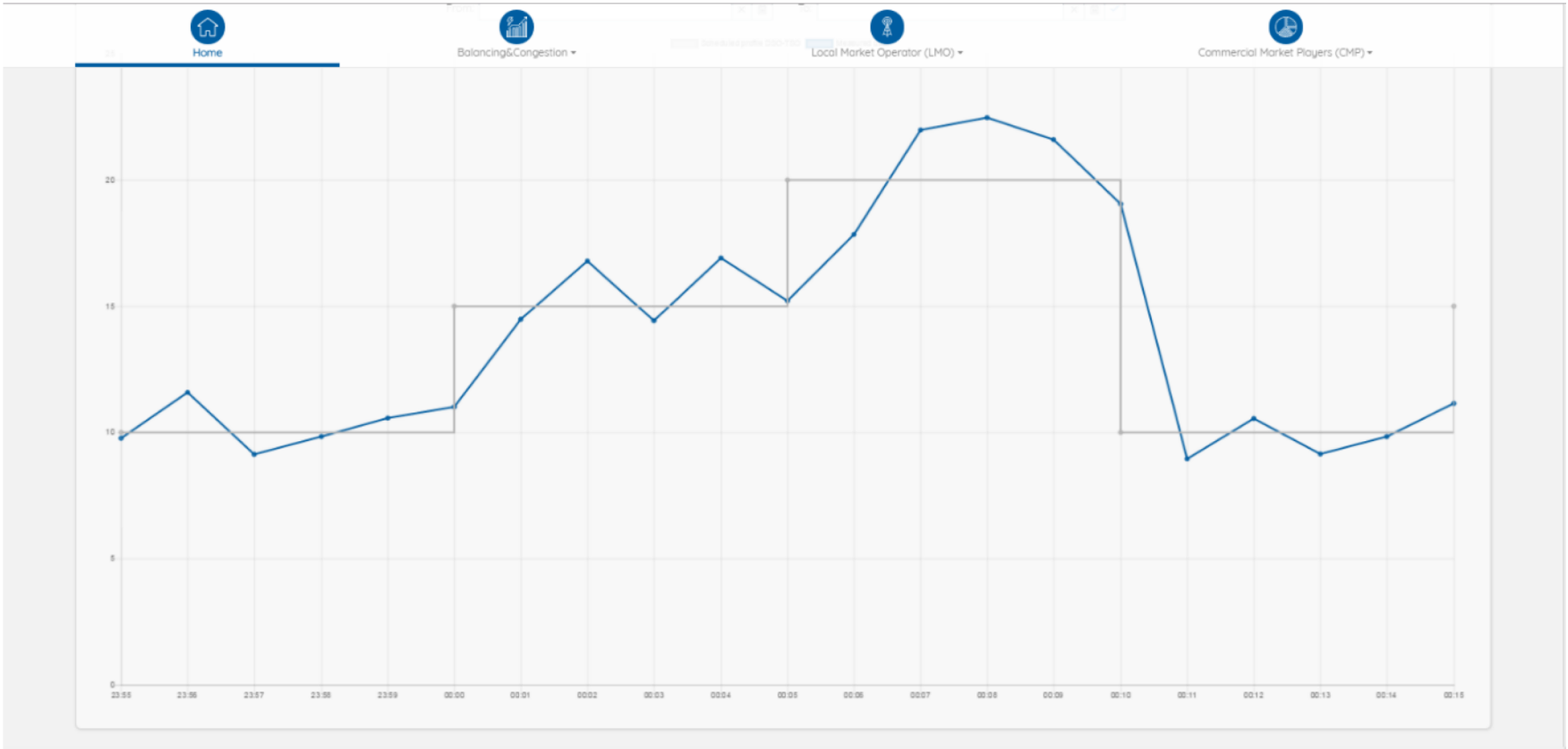
- Power Flow technical constraints
- Balancing constraints
- Congestion constraints
- Market Clearing constraints

Pilot C: BCM - Opt. – OPF + MarketClearing

Balancing	$P_{0k}^{-} > 0 \quad \exists\, k \in K_{G_0}$	Demand surplus
	$P_{0k}^{+} > 0 \quad \exists\, k \in K_{G_0}$	Insufficient generation
Congestion	$C_{ij} > 0 \quad \exists\, (i,j)$	Congestion in line (i,j)
Market Clearing	$k : \begin{cases} lb_{gk}^{+} = 1 \\ lb_{gk+1}^{+} = 0 \end{cases}$	Price bid block $k \in K_g$ for generator g

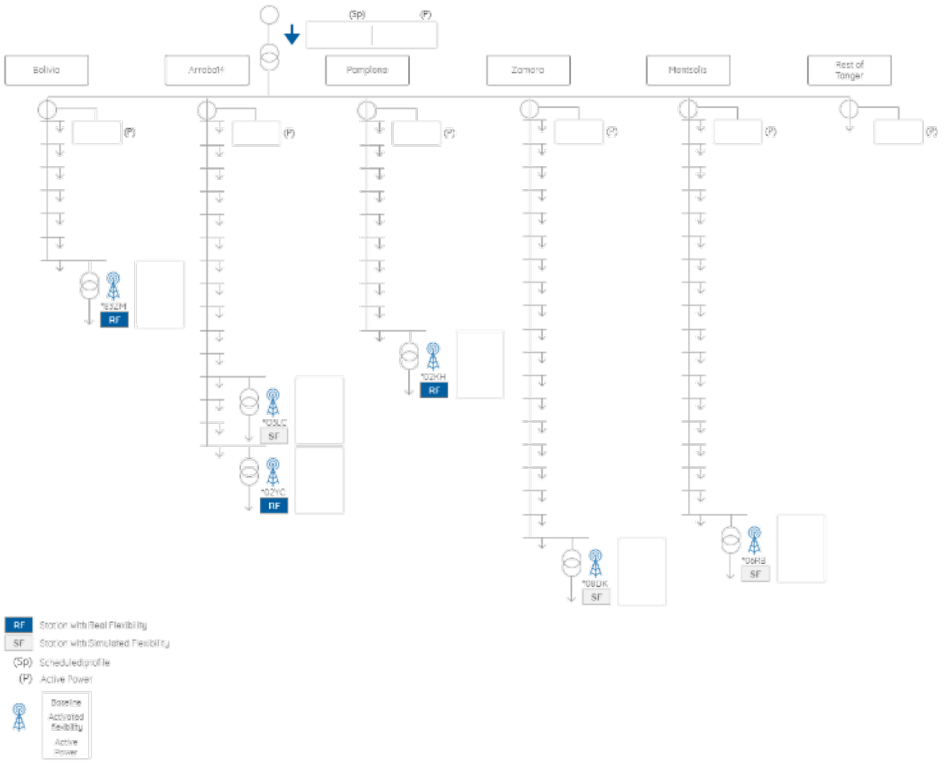
Balancing

- 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)



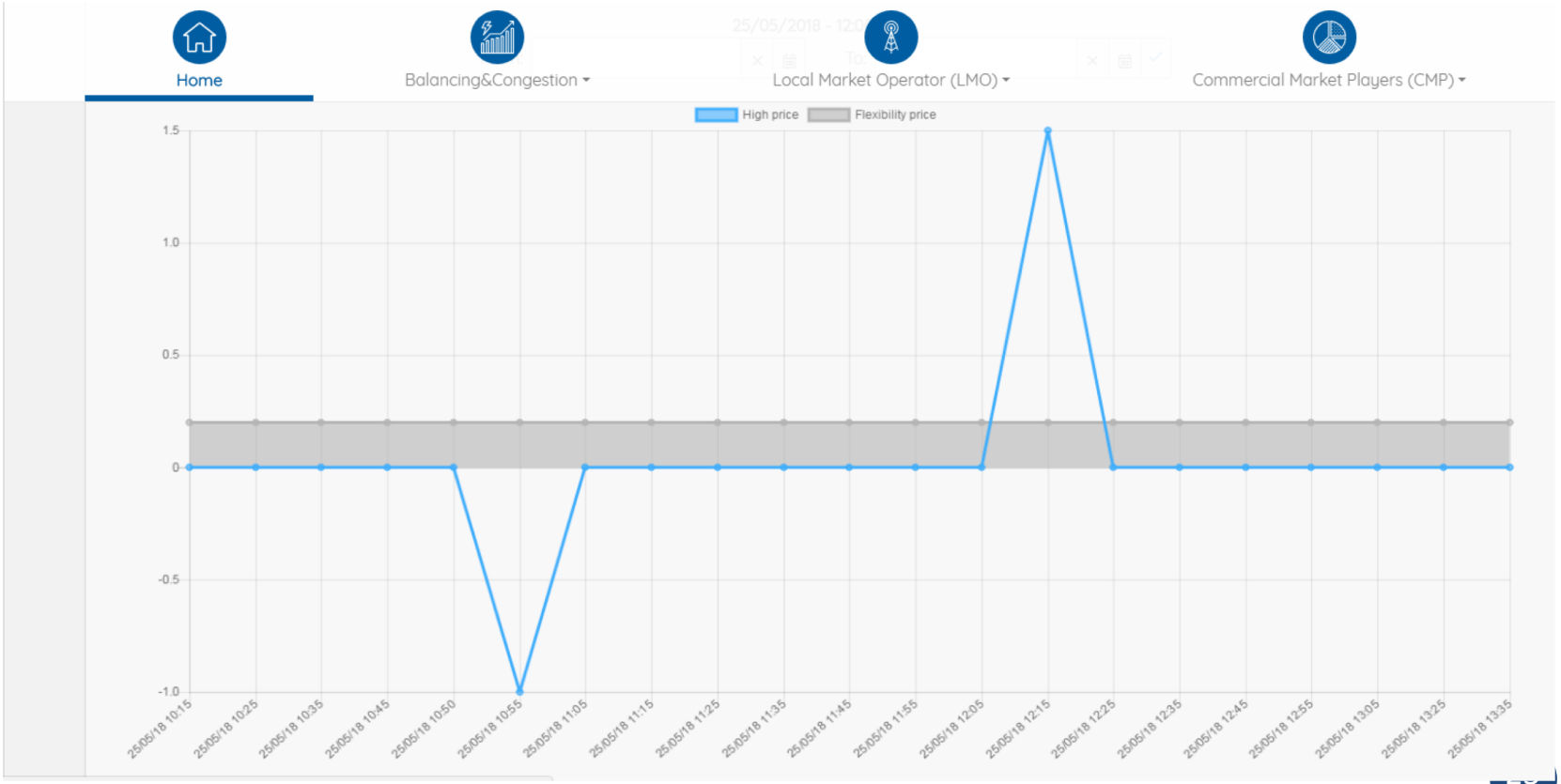
Network status

- 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



Market price

- Time plot of the clearing price per market session at each TSO-DSO interconnection point (cent/kWh)
  - 1 plot per each TSO-DSO interconnection point in Pilot C
  - Adjustable time filter (window)



Flexibility & Market results (dispatching)

- Flexibility:
  - Time plot of **total flexibility volumes** per market session at each TSO-DSO interconnection point (kW)
    - Dispatched flexibility
    - Available flexibility volumes
    - Time window with few recent market sessions
- Market results (dispatching):
  - Table of **dispatched flexibility volumes per CMP** per market session and node at each TSO-DSO interconnection point (kW)

CMP bids

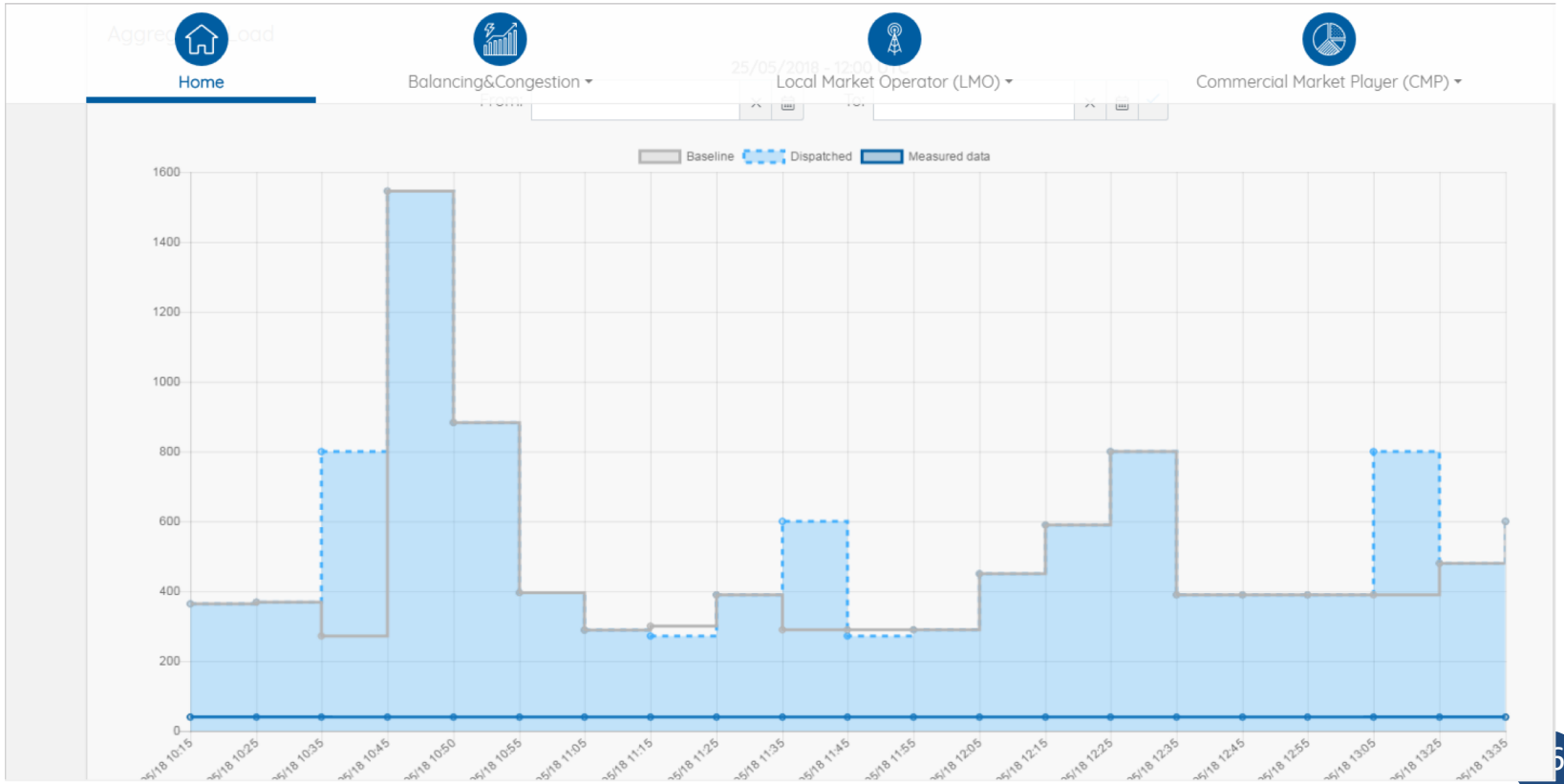
- Table of submitted flexibility bids per CMP per market session and node at each TSO-DSO interconnection point
  - Curtailable/non-curtailable bid blocks
  - Real/virtual CMP

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

CMPs (aggregated load)

- Time plot of aggregated load of customers' portfolio of each CMP
  - Baseline (yellow)
  - Dispatched power, i.e. (baseline + dispatched flexibility) (green)
  - Delivered (measured) power (brown)



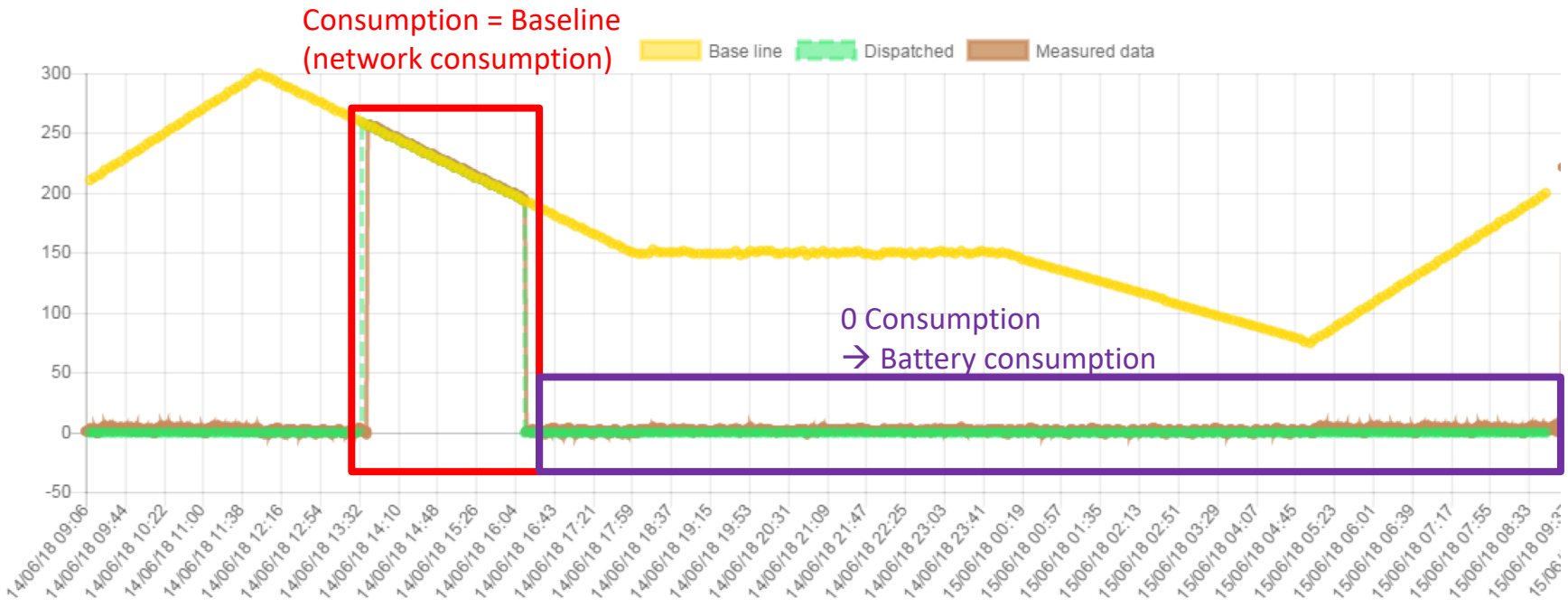
VCMP01

Sate: Running

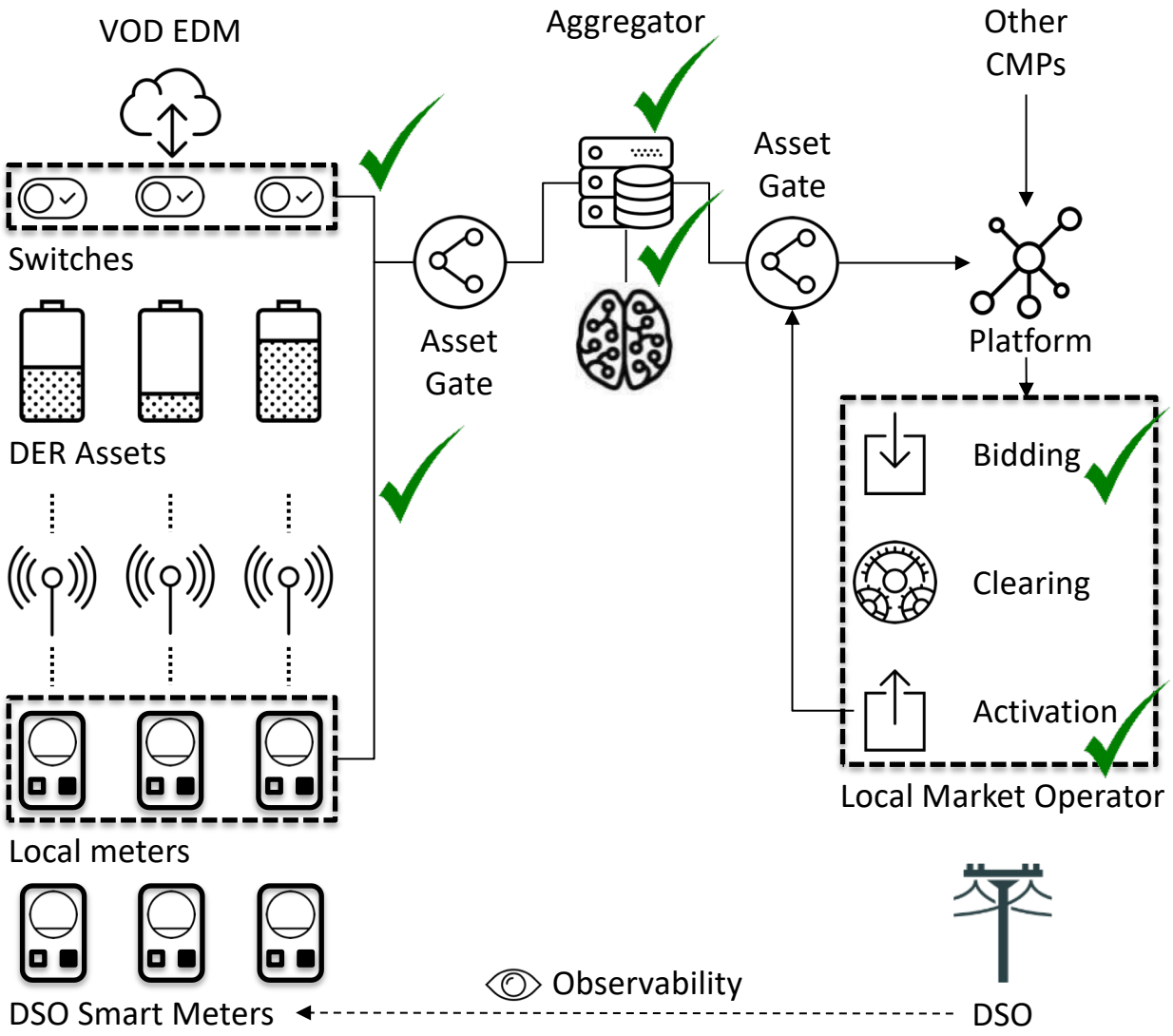
18/06/2018 06:52:21 UTC

Time Filter

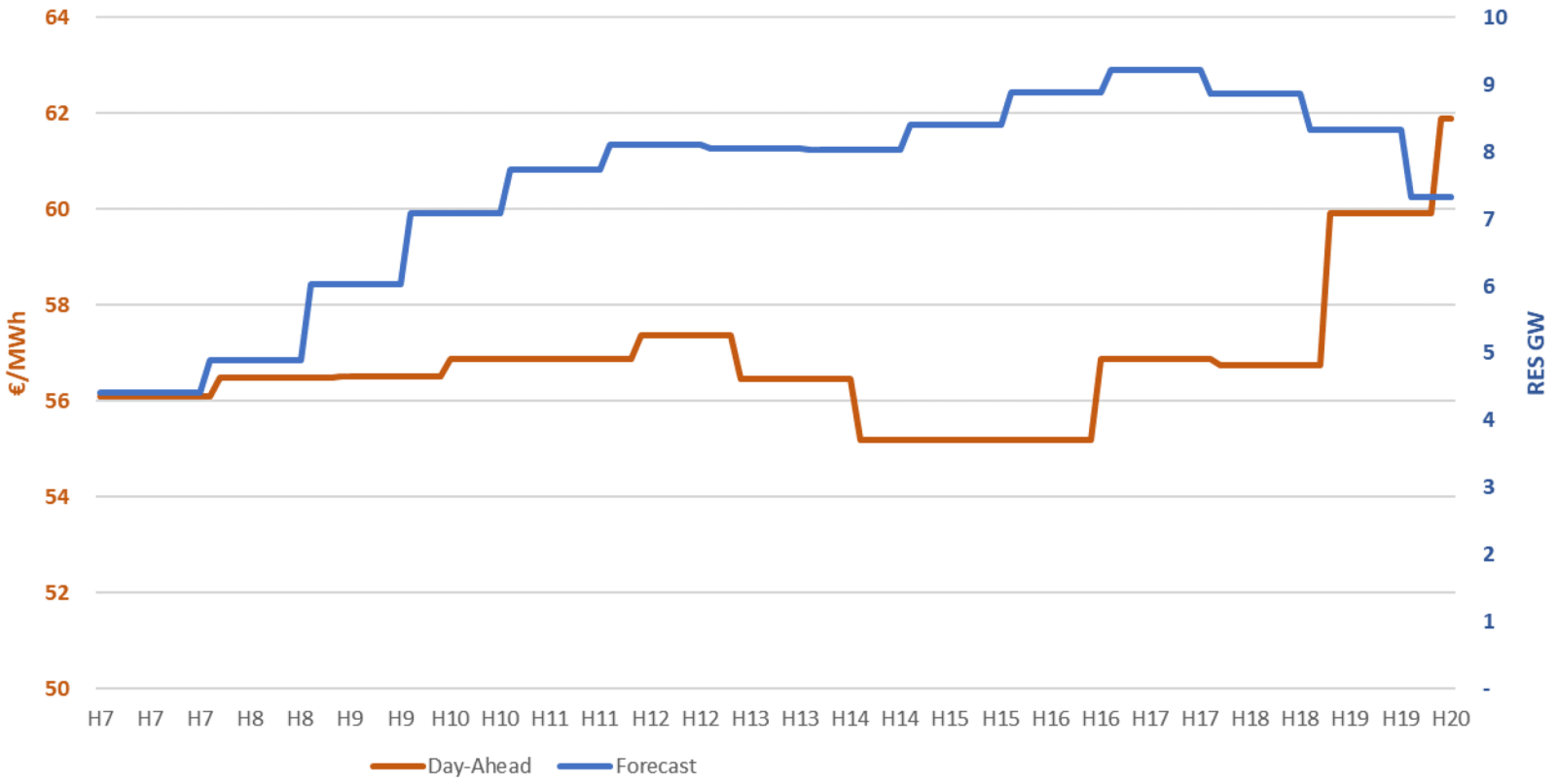
Aggregated Load



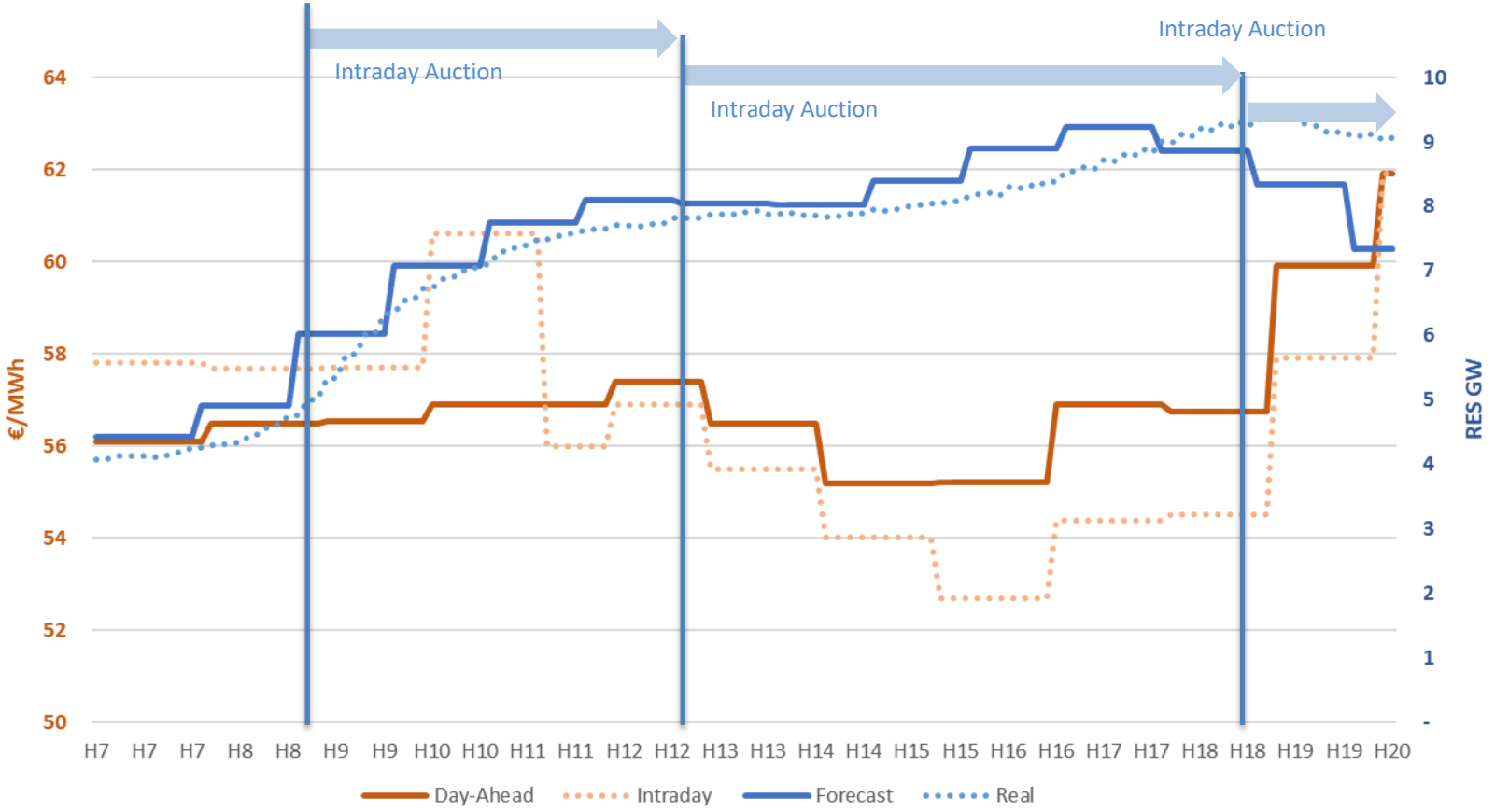
What has been done from the aggregation part



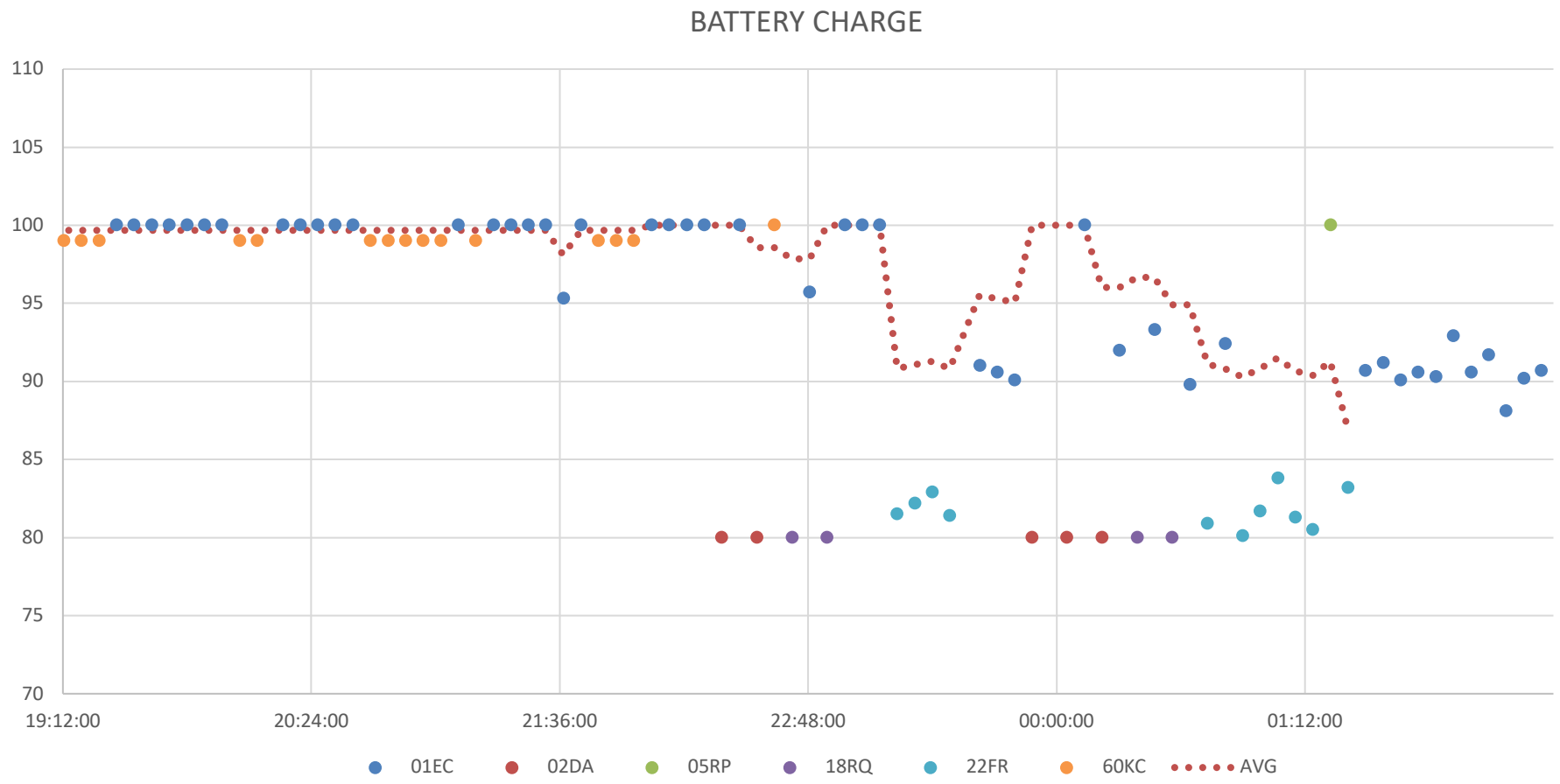
Status – Day Ahead



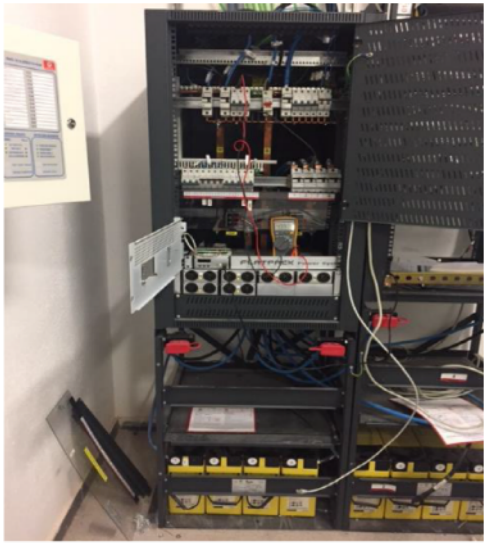
Status – Intraday

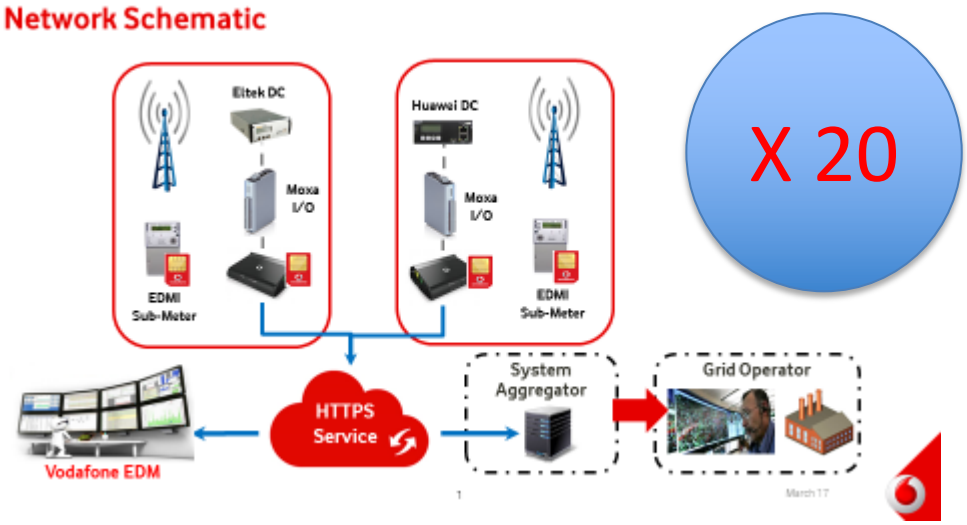


Status – Real Time



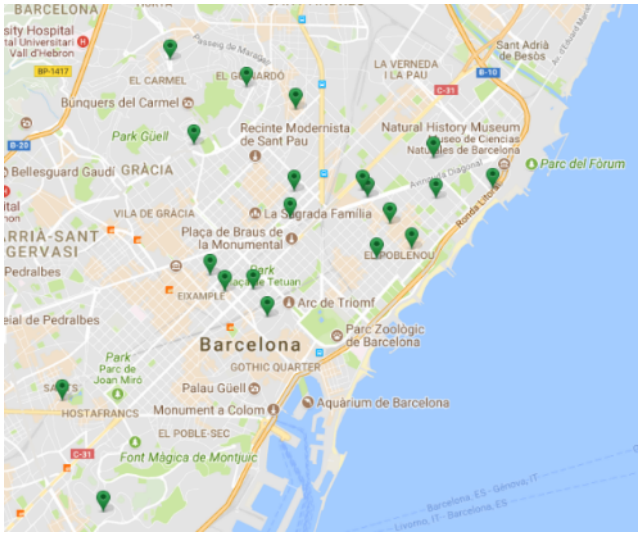
Pilot C - Physical Layer
Vodafone BTS transformation into DER plants.





- **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



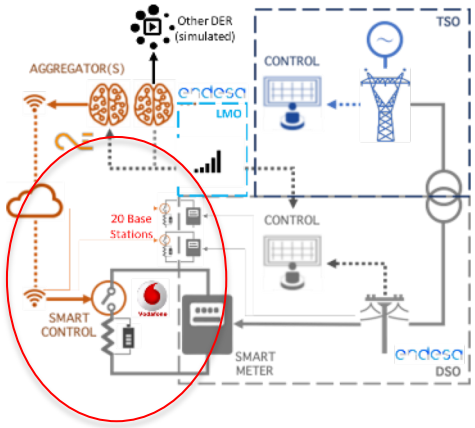
Field test: 90% operational

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_ARAGÃ_472	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

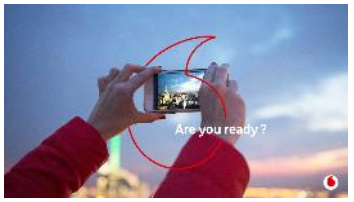
Jun 2018: 90 to 100 Kw curtailable

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_ARAGÃ_472	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



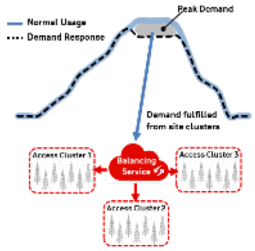
Benefits of flexibility usage for the DER

As many telecoms operators, Vodafone manages a vast technical and multi site estate, with installed energy backup to allow customer enjoying voice call and data speed in any circumstances.



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. Vodafone by itself in EU could represent 250MW + of dispatchable load.**

SmartNet benefits demonstration allowing **a regulation change in the next years will help unlock the value of Vodafone small infrastructure power assets while contributing to the social welfare of European citizens.**



Thank You

Miguel Pardo

New Technologies & Innovation

Network Technology Iberia

Global Infrastructure & Networks

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