Results for the three project pilots

Carlos Madina (Tecnalia)
Aims and goals of WP5

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.
Status of the pilots

Centralised TSO control in high-DER area
Italian context: Energy situation

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
Pilot A: Centralised TSO control in high-DER area

Aggregation of information in real-time at TSO-DSO interconnection

Voltage regulation by generators connected at HV and MV levels

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

Centralized AS market model.
Pilot A: Centralised TSO control in high-DER area

Aggregation of information in real-time at TSO-DSO interconnection

Acquisition of measurements (active and reactive power) through PCR

Estimation of unmonitored plants data through Sentinel Measurements (weather data, neighboring plants, historical profiles...)

Aggregation of active and reactive power data differentiated by energy source
Every 20 s

Data transmission to TSO control room
Every 4 s

TSO

Virtual capability computation

Voltage regulation

MVRS calculates the reactive power limits (for both capacitive and inductive operating conditions) considering the plants capabilities and the grid constrains

MVRS receives the voltage or reactive power setpoint at the HV-MV interface and split the request among MV controllable resources
Pilot A: Centralised TSO control in high-DER area

Voltage regulation by generators connected at HV and MV levels

TSO sends to HVRS at Primary Substation

- Q setpoint
- V setpoint

HVRS splits the Q requirement among the power plants

- HVRS converts the V setpoint in Q setpoint

Q command to power plants

Reactive setpoint

- Setpoint Q
- Setpoint V

Reactive power setpoint per generator

- Setpoint G1
- Setpoint G2
- Setpoint G3
- Sum

Generators’ terminals

- Voltage G1
- Voltage G2
- Voltage G3

Overall response at the voltage regulation

- Setpoint sum
- Measurements sum

HV busbar voltage

- Voltage setpoint
- Voltage measurement

ΔV [p.u.]
Pilot A: Centralised TSO control in high-DER area

Power-frequency regulation / balancing by generators connected at HV and MV levels
Pilot A: Centralised TSO control in high-DER area

- Observability function: OK

- Voltage regulation:
  - HVRS: OK (lower impact than big power plants and small delays)
  - MVRS:
    - OK for distribution
    - Very low impact at transmission
    - Good to avoid reactive power loops which waste resources

- Frequency regulation:
  - RES were able to provide downward balancing
  - But they could not follow aFRR control signal (they may for mFRR)
Status of the pilots

Common TSO-DSO market with pool flexibility
Smart Energy Operating System (SE-OS)
Pilot B: Common TSO-DSO market with pool flexibility

- 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

Diagram:
- **Common TSO-DSO AS market model**
- **MO**
- **CLEAR MARKET**
- **SEND RESULTS (ACTIVATIONS)**
- **RECEIVE RESULTS**
- **CALCULATE PRICE**
- **SIGNAL**
- **ACQUIRE SIGNAL**
- **INTERPRET SIGNAL**
- **ACTIVATION**
- **DER (DER owner)**
- **Aggregator**
- **DER**
- **DER**
- **SURVEY WEATHER, MARKET PRICES AND NRV**
- **RUN BIDDING PRICE STRATEGY**
- **PREPARE VOLUME @ PRICE BID**
- **ESTIMATE AVAILABLE REACTION = f(PRICE, VOLUME)**
- **PHASE 1 TRAINING**
- **BASELINE**
- **CALCULATE PRICE SIGNAL**
- **ACQUIRE SIGNAL**
- **INTERPRET SIGNAL**
- **ACTIVATION**
- **INTERFACE**
- **MEASURE AND SEND TSO GRID LOAD**
- **DSO**
- **MEASURE AND SEND DSO GRID LOAD**
- **Legend**

1. **SO/MO (TSO)**
2. **SO/MO (DSO)**
3. **SURVEY WEATHER, MARKET PRICES AND NRV**
4. **RUN BIDDING PRICE STRATEGY**
5. **PREPARE VOLUME @ PRICE BID**
6. **ESTIMATE AVAILABLE REACTION = f(PRICE, VOLUME)**
7. **CLEAR MARKET**
8. **SEND RESULTS (ACTIVATIONS)**
9. **RECEIVE RESULTS**
10. **CALCULATE PRICE**
11. **SIGNAL**
12. **ACQUIRE SIGNAL**
13. **INTERPRET SIGNAL**
14. **ACTIVATION**
15. **INTERFACE**
16. **MEASURE AND SEND TSO GRID LOAD**
17. **DSO**
18. **MEASURE AND SEND DSO GRID LOAD**
19. **Legend**
Pilot B: Common TSO-DSO market with pool flexibility

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

Diagram showing the process from DSO/TSO to MO and AGGREGATOR, with steps for calculating grid load, sending grid load, clearing market, and sending control signals. Diagram also includes calculations for control signal and flexibility function, with references to peak shaving, voltage control, balancing, and congestion management.

Graphs showing temperature trends and normalized electricity demand over time.
Pilot B: Common TSO-DSO market with pool flexibility

- Indirect control is useful for controlling DER
- Indirect control can be based on prices or other penalties, such as CO2-content
- Challenges in estimating flexibility function, but lightweight approach
- Need to have a strong communication network ➔ Focus on urban areas
Status of the pilots

Shared responsibility with base station flexibility
Spanish context

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

- Poor interconnections
- Big contribution by highly-variable RES production
Pilot C: Shared responsibility with BS flexibility

Congestion management at DSO level

Demand Response Aggregation by using storage flexibility (BS)

Power-frequency regulation / balancing by maintaining the exchange program at the TSO-DSO interconnection
Pilot C: Shared responsibility with BS flexibility

Demand Response Aggregation
By using storage flexibility (BS)
Pilot C: Shared responsibility with BS flexibility
Pilot C: Shared responsibility with BS flexibility

Power-frequency regulation / balancing
by maintaining the exchange program at the TSO-DSO interconnection
DSO can operate local markets to avoid congestions and maintain scheduled profile:

- Perfect matching between real exchange and scheduled profile, except:
  - When downward balancing was needed
  - There was not enough flexibility available

CBA shows CS C as the least efficient one. However, from a practical point of view, it worked.

- No impact on Vodafone’s service
- High replicability: More than 250 MW available on Vodafone’s sites across Europe
This presentation reflects only the author’s view and the Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains.
Thank You

Carlos Madina

Contact Information

Affiliation: Tecnalia
Phone: +34 667 165 473
Email: carlos.madina@tecnalia.com