The SmartNet Project

Gianluigi Migliavacca (RSE)
Agenda

- The project SmartNet
- Year 1 – Year 2 – Year 3
- Five TSO-DSO coordination schemes
- Proposed AS market design
- The simulation platform
- Cost-benefit analysis of the coordination schemes
- Layout of three project pilots
- Some preliminary regulatory reflections
Motivations

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

<table>
<thead>
<tr>
<th>Which ancillary services could be provided from entities located in distribution networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>How the architectures of dispatching services markets should be consequently revised</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Which optimized modalities for managing the network at the TSO-DSO interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>What ICT on distribution-transmission border to guarantee observability and control</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Which implications on the on-going market coupling process</th>
</tr>
</thead>
</table>

“Some actions can have a negative cross-network effect. For instance, TSO use of distributed resources for balancing purposes has the potential to exacerbate DSO constraints. Equally, whilst DSO use of innovative solutions, such as active network management, can deliver benefits to customers, if not managed properly they may in some cases counteract actions taken by the TSO” (CEER Position Paper on the Future DSO and TSO Relationship – Ref. C16-DS-26-04 – 21.09.2016)

The SmartNet project [http://SmartNet-Project.eu](http://SmartNet-Project.eu)

Project video: [https://vimeo.com/220969294/73d98edde6](https://vimeo.com/220969294/73d98edde6)

- **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).
The SmartNet project  [http://SmartNet-Project.eu](http://SmartNet-Project.eu)
Year 1 – Year 2 – Year 3

Network model
Market model
ICT model

Reference architectures definition
Formal specifications
Simulation platform realization

National scenarios definition
Personalization with three National cases

CBA with different architectures
Lab test with HW controller

Three pilots:
• DSO area data monitoring
• Flexibility from thermal inertia
• Flexibility from Radio Base Stations

Regulatory Analysis (guidelines)
Return of experience
5 possible coordination schemes
TSOs & DSOs for AS by distributed flexibility resources

A. Centralized AS market model
B. Local AS market model
C. Shared balancing responsibility model
D. Common TSO-DSO AS market model
E. Integrated flexibility market model
Proposed Market Design

- **Considered services:** balancing and congestion management at transmission (HV) and distribution level (MV), including voltage constraint at MV.

- **Rolling optimisation concept:** Results for the first time step are a firm decision. Results for the next time steps are advisory decisions.

- **Network representation:** DC approximation for HV, SOCP for MV.

- **Market products:** implementation of typical constraints of flexibility providers (extension to multi-period bids with temporal and logical constraints).

- **Representation of arbitrage opportunity between cascading markets:** day-ahead, intraday, AS market.
The simulation platform

Physical layer

- Frequency error
- Voltage error
- Disaggregation/set points
- Network/devices state
- Aggregation and bidding
- Aggregated bids
- System imbalance
- Congestion

AFRR voltage regulation

System balancing congestion management

Market layer

Market Operator

Bidding and dispatching

- Aggregator
- Retailer

Network operator

Physical

- Devices
- Network

$k$-th time step (application of set-points)
Balancing market and aFRR

- aFRR volume already activated before T and not yet released
- Forecasted further aFRR volume activated to compensated imbalance between T and T+1
- Actual aFRR volume activated between T and T+1 (different from forecast due to forecast errors and CS imperfections in representing the system)
- Volume of tertiary reserve activated by the AS market at T+1

<table>
<thead>
<tr>
<th>PLATFORM LAYER</th>
<th>REGULATION</th>
<th>PAYMENT</th>
<th>ACTIVATION</th>
<th>BIDDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market layer</td>
<td>AS market</td>
<td>Pay as clear</td>
<td>Market clearing</td>
<td>Bids</td>
</tr>
<tr>
<td>Physical layer</td>
<td>aFRR regulation</td>
<td>Pay as bid</td>
<td>Pro quota</td>
<td>[((1+p%) \times \text{UPBids})] [-(1-p%) \times \text{DWNBids}] Highest market nodal price</td>
</tr>
</tbody>
</table>

System imbalance not «seen» by the AS market (e.g. CS-A disregards congestion in distribution), is trapped by aFRR and economically penalized.
CBA among TSO-DSO coordination schemes

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

- Proposed CBA indicators:
  - **Reduction of total AS market cost** (not social welfare!)
  - **Reduction of secondary regulation activations** due to:
    - Congestion not “seen” by the AS market
    - Forecasting errors
    - Losses in transmission (not considered by AS market)

- Sensitivity factors
  - **Emissions savings**: with standard emission rates for each generation technology and CO2 prices forecasted at studied horizon.

- Side indicators (not in CBA to avoid double count
  - **Cost percentage due to network limitations**: comparing costs with ideal situation (bus-bar network)
  - **Reduction of transmission network losses**

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.

- **System-level benefits of CSs**
  - **Macro-level**: system perspective
  - **Micro-level**: actors’ business case
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

- **TSO Trading System**
  - Frequency control
  - Congestion management
  - Voltage control

- **DSO Trading System**
  - Local Frequency control
  - Local Voltage control
  - Congestion management

- **DER Gateway**
  - DER trading system
  - Measurements

- **DER Aggregator**
  - Technical aggregation
  - DER services
  - Value-added services

- **CMP**
  - Send price signal incl. forecast

- **Energy Trading**
  - Day-ahead market
  - Intraday market
  - Real-time market

- **SmartNet**
  - Receive bids
  - Activate bids

- **Receive Grid Load**
  - Day-ahead
  - Intraday
  - Real-time
  - MO

- **Calculate residual capacity**

- **Clear market**

- **Market Management System**
  - Day-ahead
  - Intraday
  - Real-time

**Key Features**

- **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
Some preliminary regulatory reflections

• If the contribution from entities in distribution will grow, DSOs should implement real time network monitoring and TSOs could need to share with DSOs part of responsibility for the provision of AS.
• Whatever coordination scheme is implemented, it is important that that actions taken by the TSO and DSO don’t cause counteracting effects (e.g. between local congestion management and balancing) – see CEER Position Paper on Future DSO-TSO Relationship
• between the different AS markets, “common marketplace” (see ENTSO-E working paper on Distributed Flexibility and the value of TSO/DSO cooperation) is preferable in order to avoid duplicating bids and avoiding double activations.
• before implementing a separate market for a given AS, it should be attentively considered if it can be sufficiently liquid (e.g. local congestion management in distribution).
• restructuring national AS markets should take into account possibility of a seamless integration with preceding energy markets (DAM, ID) so as to avoid providing gaming opportunities (e.g. between non-nodal energy markets and nodal AS market)
• new AS architectures should integrate with on-going transnational integration process (ENTSO-E platforms): sharing reserve between Countries is a key for allowing further RES integration.
• a balance has to be sought for between local optimality (e.g. for a given Country) 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 architectures must take into account the characteristics/constraints 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.
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

Gianluigi Migliavacca

Contact Information

Affiliation: RSE S.p.A.
Phone: +39 02 3992 5489
Email: gianluigi.migliavacca@rse-web.it