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The SmartNet Project on
TSO-DSO interactions, market architectures and
ICT for distributed provision of ancillary services

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The SmartNet Project

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The SmartNet consortium

- **R&D partners**
  - Research Organizations: RSE, AIT, SINTEF, Tecnalia, VITO, VTT
  - Universities: DTU, Uni-Strathclyde, KU Leuven
  - Other: EUI/FSR

- **Industrial partners**
  - TSO: Energinet.dk, TERNA
  - DSO: ENDESA, NYFORS, SELNET
  - Manufacturers: SELTA, SIEMENS Italia
  - Software developers: Eurisco, N-SIDE
  - Telecom: VODAFONE
  - Trader: Danske Commodities
  - Vacation rental: NOVASOL
The context: some key “driving forces”

Need to balance G and L in real time (bulk storage is still insufficient)

An adequate level of reserve must stay available

Need for new patterns of TSO-DSO coordination

Possibility to provide advanced services for the system if dispatchability is guaranteed

Evolution of distribution systems:
- Smart Grids
- VPP (storage + generation)
- DSM

System unbundling: creation of electricity markets:

Need to provide economic “signals” to allocate reserve in an efficient way

Drive to extend market coupling towards real time markets

Increased needs for system flexibility and reserve

Explosion of RES deployment in T&D system: network under stress
SmartNet analyses architectures for optimized interaction between TSOs and DSOs in managing the exchange of information for the acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management) from subjects located in the distribution segment. Different architectures are compared on three simulated national cases (Italy, Denmark, Spain). The simulation platform is then implemented in a full replica lab, where the performance of real controller devices will be tested.

Three physical pilots developed to show:

- modalities to exchange monitoring signals between transmission and distribution networks
- study cases on services that can be offered by entities connected to distribution
  - thermal inertia of indoor swimming pools,
  - storage of radio-base stations for telecommunication.
Work packages and activities chronogram

- **Models for TSO-DSO coordination and ancillary services provision**
  - Target simulation platform:
    - Market architectures
    - ICT environment
    - Advanced power technologies

- **National cases (lab demo)**

- **Physical pilots (technological)**

- **Lesson learnt: Regulatory guidelines**

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Legend:
- WP1: Transmission/distribution model specification
- WP2: Market layout specification
- WP3: ICT specification
- WP4: National cases in lab test
- WP5: Pilot tests
- WP6: Regulatory guidelines
Relationship between main system actors

Regulatory Framework

National ancillary services market

National transmission dispatch under TSO responsibility

Local dispatching under DSO responsibility

Aggregators

Cross-border exchange of balancing services

ICT

Bids

G

L

Offer of ancillary services from resources in distribution (distributed generation, DSM, VPP)
To be analysed and refined.

Three main reference architectures

**Extended central dispatching market**

TSO hoitaa reservimarkkinat myös hajautettujen reservien osalta. DSO kertoo siirtorajoituksensa TSO:lle. Lisäksi DSO voi ostaa paikallisesti kiinteään hintaan.

**Local DSO dispatching market**

DSO hoitaa jakeluverkkoonsa liitetyjen reservien markkinat. TSO hoitaa siirtoverkkoon kytettyjen reservien markkinat ja ostaa DSO markkinoilta. DSO voi ostaa paikallisesti kiinteään hintaan.

**Programmed exchange at primary substations**

DSO hoitaa jakeluverkkoonsa liitetyjen reservien markkinat. Kertoo TSO:lle missä rajoissa TSO voi ohjata (profiili). TSO hoitaa siirtoverkkoon kytettyjen reservien markkinat. DSO voi ostaa paikallisesti kiinteään hintaan.
Questions

- What are the pros and cons of the different models from the point of view of aggregated Demand Side Flexibility?
- Other modes? Why?
- The same aggregator for flexible loads and generation?
- DSO buying also local services directly at fixed price?
- Own market for each DSO is not feasible for small DSOs. Common market for several DSOs?
- TSO only buys from the local DSO market. What if the TSO could also sell?
- What are the regulatory implications?

Your views?
The project SmartNet aims at providing answers to important questions such as:

- Which ancillary services could be provided by distributed flexible resources to the whole system (via transmission)?
- How to optimize the TSO-DSO interface: which monitoring and control signals could be exchanged?
- How could the architectures of the real time markets be revised?
- Which regulatory implications could the above issues have?
Deliverables (plan)

- See http://smartnet-project.eu/publications/
The three national pilot projects

DSO area data monitoring

- Development of an aggregation system and implementation in field of a device in order to exchange all the data with the TSO.
- Development of an architecture and implementation in field of a system for the voltage regulation.
- Development of an architecture and implementation in field of a system for the power-frequency regulation.
The three national pilot projects

- Aggregation of a sample of 16 summer houses.
- Implementation in field of ICT technology to exchange data between TSO, DSO, aggregator and smart houses.
- Development of an architecture and implementation in field of a system for the voltage regulation.
- Development of an architecture and implementation in field of a system for the provision of balancing power.
- Development of an architecture and implementation in field of a system for the provision of congestion management.
The three national pilot projects

- Aggregation of a 10-20 radio base stations to build up about 50 kW of flexible demand.
- Virtual provision of frequency control service by the DSO to the TSO.
- Implementation of the mechanism for DSO-TSO coordination related to the technical validation of flexibility services at the distribution level.
- Development of flexible simulation tools for complementing the 50 kW available in the pilot reach the minimum 5 kW required by the TSO.
Bidding (Market Products)

Bids are sent via aggregators. Bids can be curtailable or non-curtailable.

Three bid-types are accepted:

1. **Unit bids** (single price)
2. **Q-bids** (price changes over quantity)
3. **Qt-bids** (price changes over quantity and time)

Clearing Optimization Problem

Key steps:

1. **Definition of decision variables**
2. **Definition of objective function**
   - Maximization of welfare or Minimization of activation cost
3. **Definition of constraints**
   - Temporal intra-bid constraints and Logical inter-bids constraints

Example: TSO need upwards regulation and is the buyer. Sellers provide either positive (+Δ) or negative (-Δ) flexibility.

Pricing Mechanism (Nodal Prices)

One price per network node (DLMP = Distributed Local Marginal Prices).

Marginal price means pay-as-clear (compared to pay-as-bid).

Main factors which lead to having different prices at each node:

1. **Losses**
2. **Congestions**
Aim and goals of WP3: ICT specification

- Evolved ICT opens new possibilities to develop advanced communication solutions to support TSO-DSO coordination and ancillary service provision in a reliable and secure way.

Main goals in WP3 are

- **To analyze** the need of information exchange and communication among different stakeholders in centralized and distributed coordination schemes.
- **To discover** what ICT technologies are available now and in the future, and understand possibilities and challenges associated with them.
- **To elaborate ICT architecture design** and provide communication layer specifications for the SmartNet simulation platform and pilots.
WP3 Work Flow and Interactions with other WPs

WP1 TSO-DSO
Coordination and ancillary service provision

D3.1 End-user requirements

WP3
Communication and ICT requirements

Analyze Requirements

Design ICT Architecture

Prepare ICT Specifications

D3.2 ICT Specifications

WP5
Physical pilots realisation

WP4
Simulation environment
Procedure in WP3

- Different use cases identified in WP1 are evaluated from ICT’s viewpoint in order to understand better the role of ICTs for various TSO-DSO interaction cases.
- The relationships among involved stakeholders are broken down to physical communication components and interfaces and critical requirements for e.g. networking, security, latency, and data protocols are analysed.
- New technologies e.g. 5G and IoT are studied to exploit their capabilities.
- The SmartNet ICT architecture will be presented as a SGAM (Smart Grid Architecture Model) model including business, function, information, communication, and component layers.
Translation from Business Descriptions to ICT Specifications

Business layer

Component and communication layer

Information and function layer model
WP4 – Development of the national cases in lab test environment

Development and validation of a future scenario (2030) and simulation environment in order to reproduce the TSO-DSO interactions in the three national cases

Elaboration of ad-hoc Cost Benefit Analysis methodology and selection of the TSO-DSO interactions with the highest potential

Implementation of the simulation environment in the laboratory in order to test real equipment aimed at contributing in TSO-DSO interactions
Simulator blocks

The simulation software is divided in blocks with different functions:

- **Market layer** (including the market clearing algorithms)
- **Physical layer** (including the model of the electrical network and connected devices)
- **Bidding layer** (performing the conversion from devices status to bids, including the aggregation of small devices)
The simulation will be performed by considering the selected scenario (how Italy, Denmark and Spain will evolve in 2030).

Variations to the average scenarios will be introduced in order to evaluate the sensitivity of simulation results to...
e³value methodology

**Very suitable for networked business**
- Graphical approach
- Shows the whole picture
- Who exchanges what with whom

**Focuses on the concept of economic value**
- At least one of the items exchanged is money
- Presents the sequence for money flows
- Only recurrent exchanges are represented
- All needed participants must have an economic gain

**Allows profitability assessment**
- Cash-flows calculation + Investments
- Sensitivity analysis
The SmartEST laboratory features:

• 1 MW lab for Smart Grid component tests and system integration
  • Inverter tests
  • Tests with multiple components
  • Environmental tests
  • Simulation and validation
• Research, design and validation environment for Smart Grid
  • Component development
  • Automation and communication
  • Design and validation

Tests on physical equipment for TSO-DSO interactions

• SCADA
• Power plant controllers
• ICT
Summary

- Provision of ancillary services will become distributed.
- SmatNet project aims on finding out how this can work:
  - Market models
  - TSO-DSO interface
  - ICT
  - Simulation
  - National cases in labs and pilots
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

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