SmartNet

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

Finnish Demand Flexibility Forum Meeting
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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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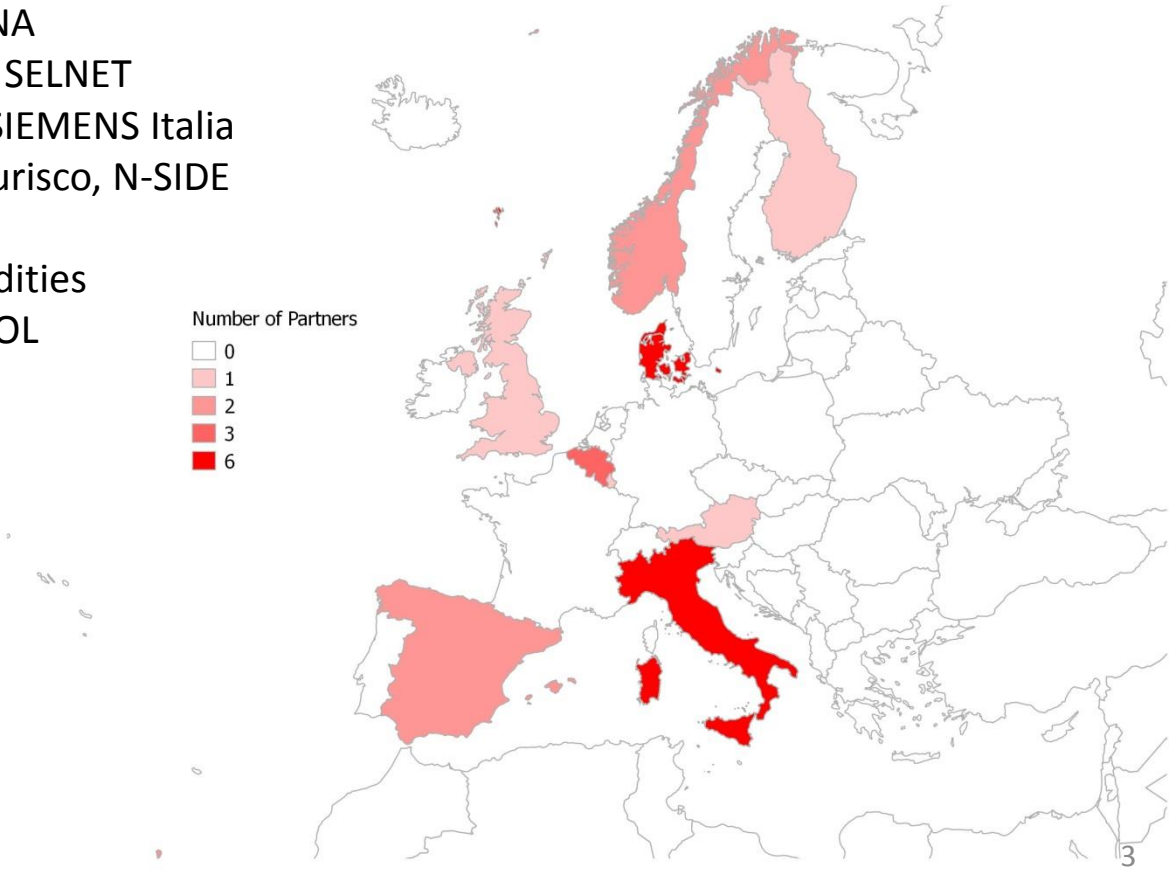
The SmartNet consortium

- **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**

Increased needs for system flexibility and reserve

Explosion of RES deployment in T&D system: network under stress

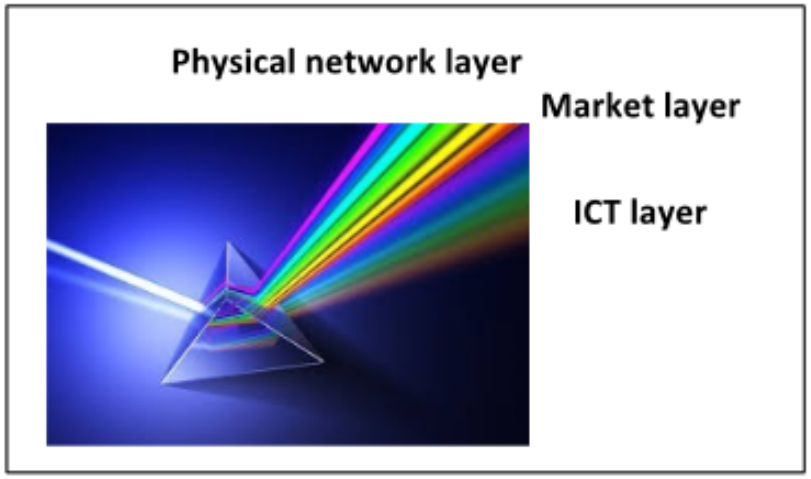
Drive to extend market coupling towards real time markets

Need to provide economic "signals" to allocate reserve in an efficient way

System unbundling: creation of electricity markets:

SmartNet: goals

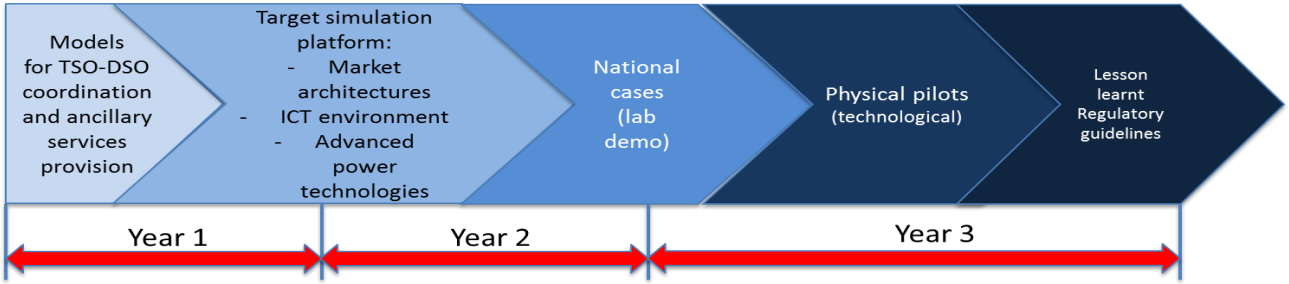
SmartNet analyses **architectures for optimized interaction between TSOs and DSOs** in managing the exchange of information for the acquisition of ancillary services (reserve and balancing, voltage regulation, congestion management) from subjects located in the distribution segment.
Different architectures 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.

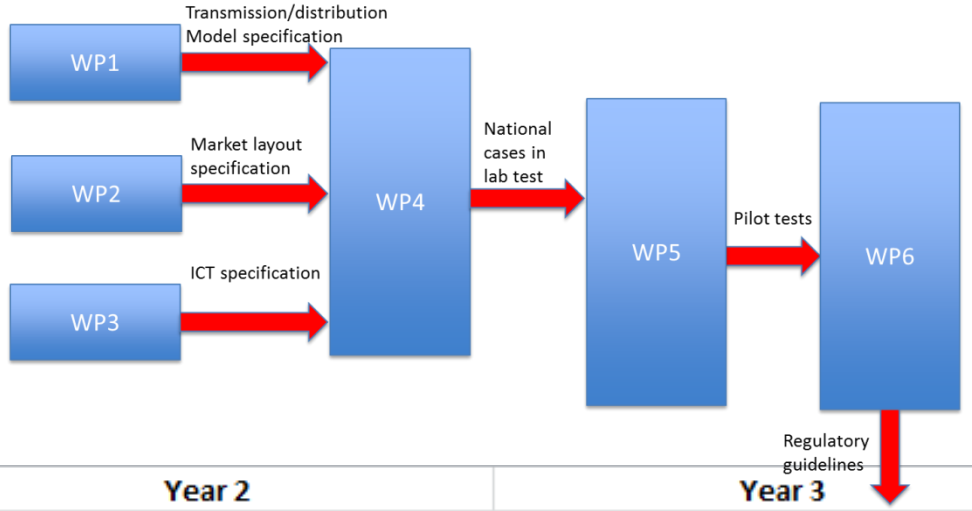


Three physical pilots developed to show:

- 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).

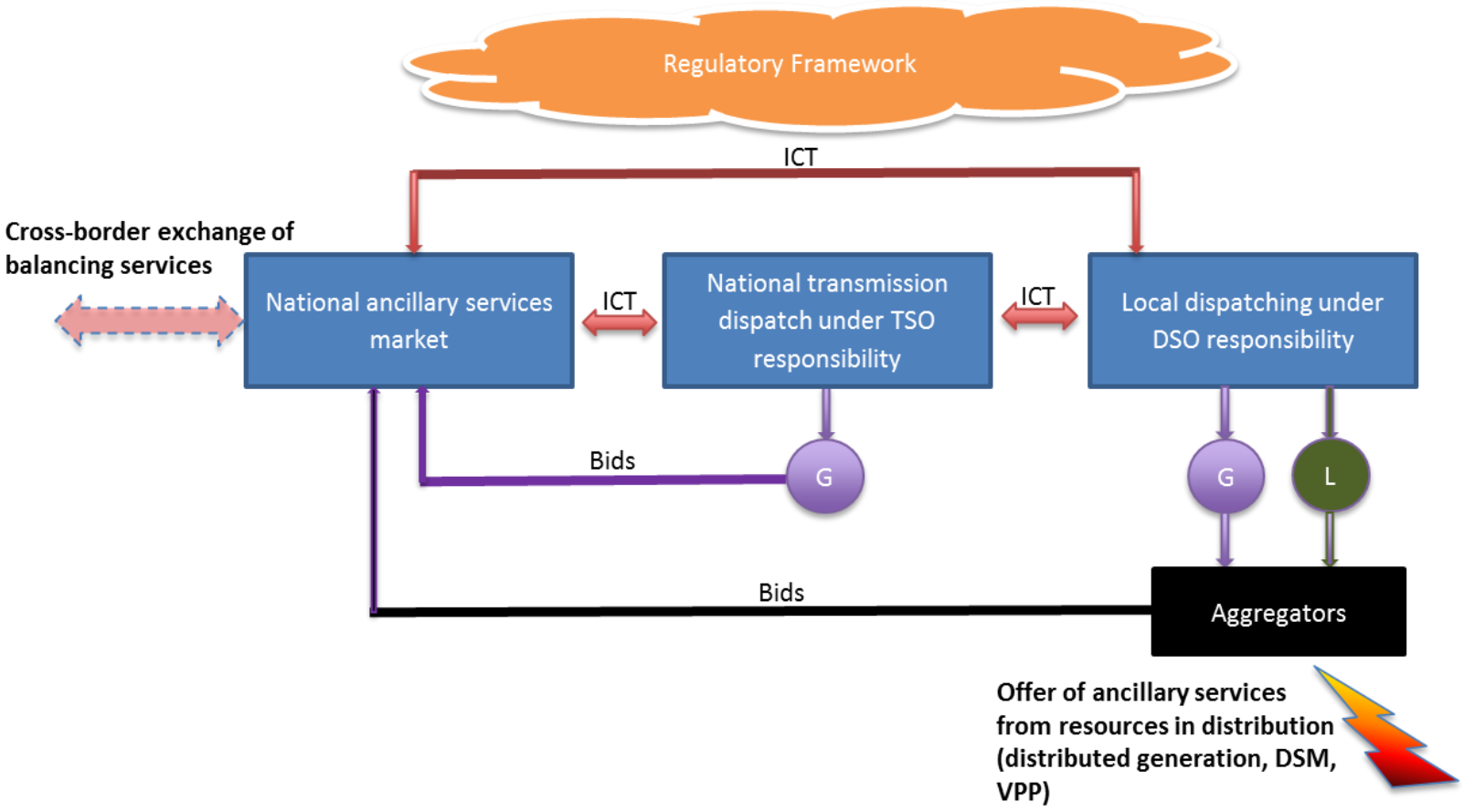
Work packages and activities chronogram





	Year 1				Year 2				Year 3			
	1	4	7	10	1	4	7	10	1	4	7	10
WP1												
WP2												
WP3												
WP4												
WP5												
WP6												
WP7												
WP8												

Relationship between main system actors

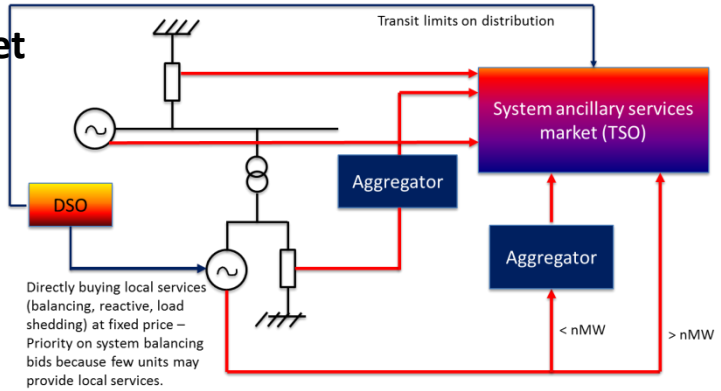


To be analysed and refined.

Three main reference architectures

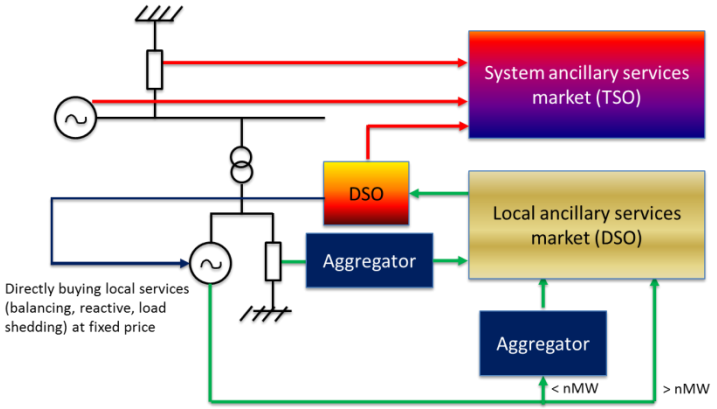
Extended central ~~dispatching~~ market

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



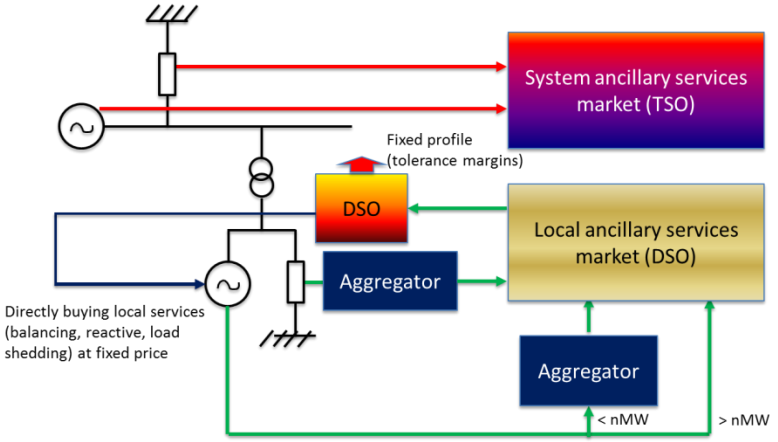
Local DSO ~~dispatching~~ market

DSO hoitaa jakeluverkkoonsa liitettyjen reservien markkinat.
TSO hoitaa siirtoverkkoon kytkettyjen reservien markkinat ja ostaa DSO markkinoilta.
DSO voi ostaa paikallisesti kiinteään hintaan.



Programmed exchange at primary substations

DSO hoitaa jakeluverkkoonsa liitettyjen reservien markkinat. Kertoo TSO:lle missä rajoissa TSO voi ohjata (profiili).
TSO hoitaa siirtoverkkoon kytkettyjen 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?

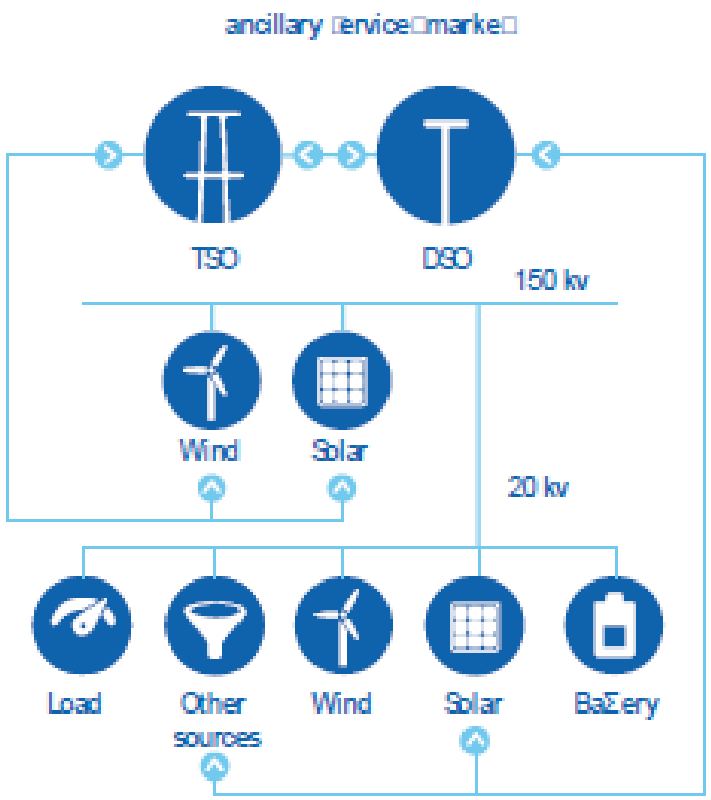
The project SmartNet aims at providing answers to important questions such as:

- 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 1



DSO area data monitoring

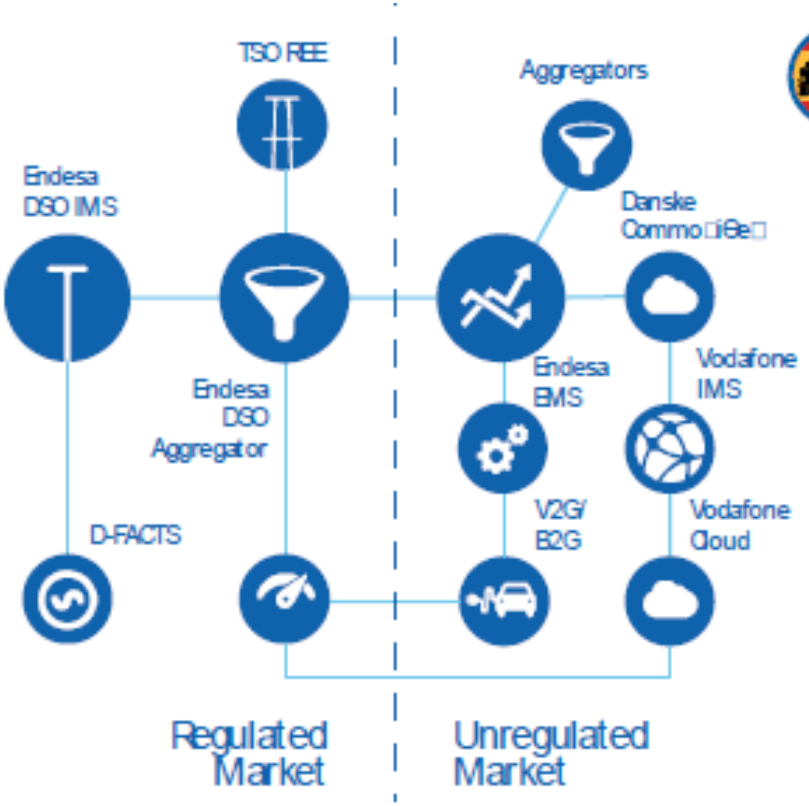
- Development of an aggregation system and implementation in field of a device in order to exchange all the data with the TSO.
- Development of an architecture and implementation in field of a system for the voltage regulation.
- Development of an architecture and implementation in field of a system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

The three national pilot projects 2

Flexibility from thermal inertia

- 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



Flexibility from Radio Base Station

- 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.

WP2: Market Design in SmartNet

General Market Design

Bidding (Market Products)

Clearing Optimization Problem

Pricing Mechanism (Nodal Prices)

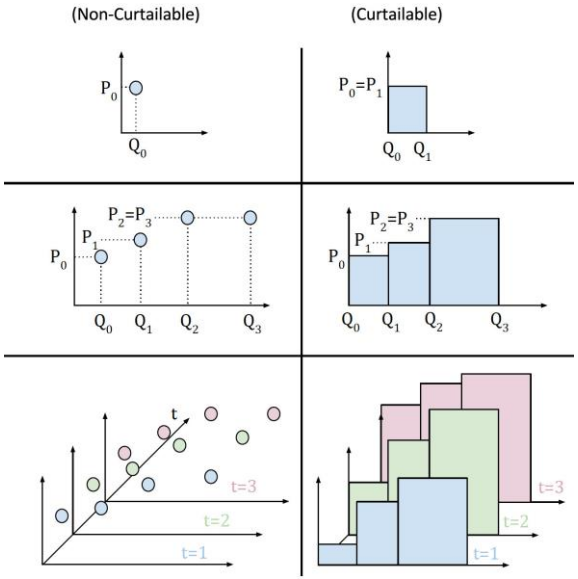
Bids are sent via aggregators. Bids can be curtailable or non-curtailable.

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)



Key steps:

① **Definition of decision variables**

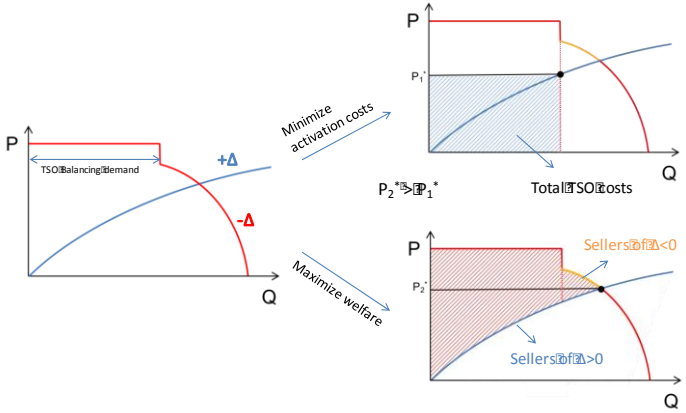
② **Definition of objective function**

- 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.



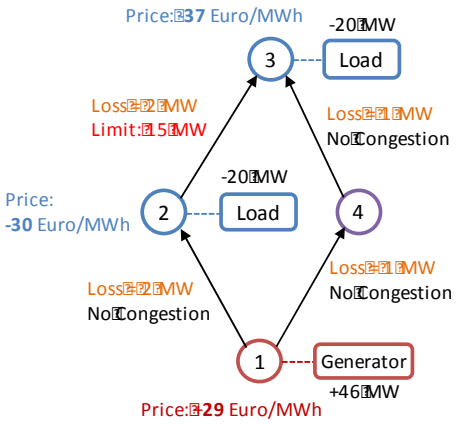
One price per network node (DLMP = Distributed Local Marginal Prices).

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**



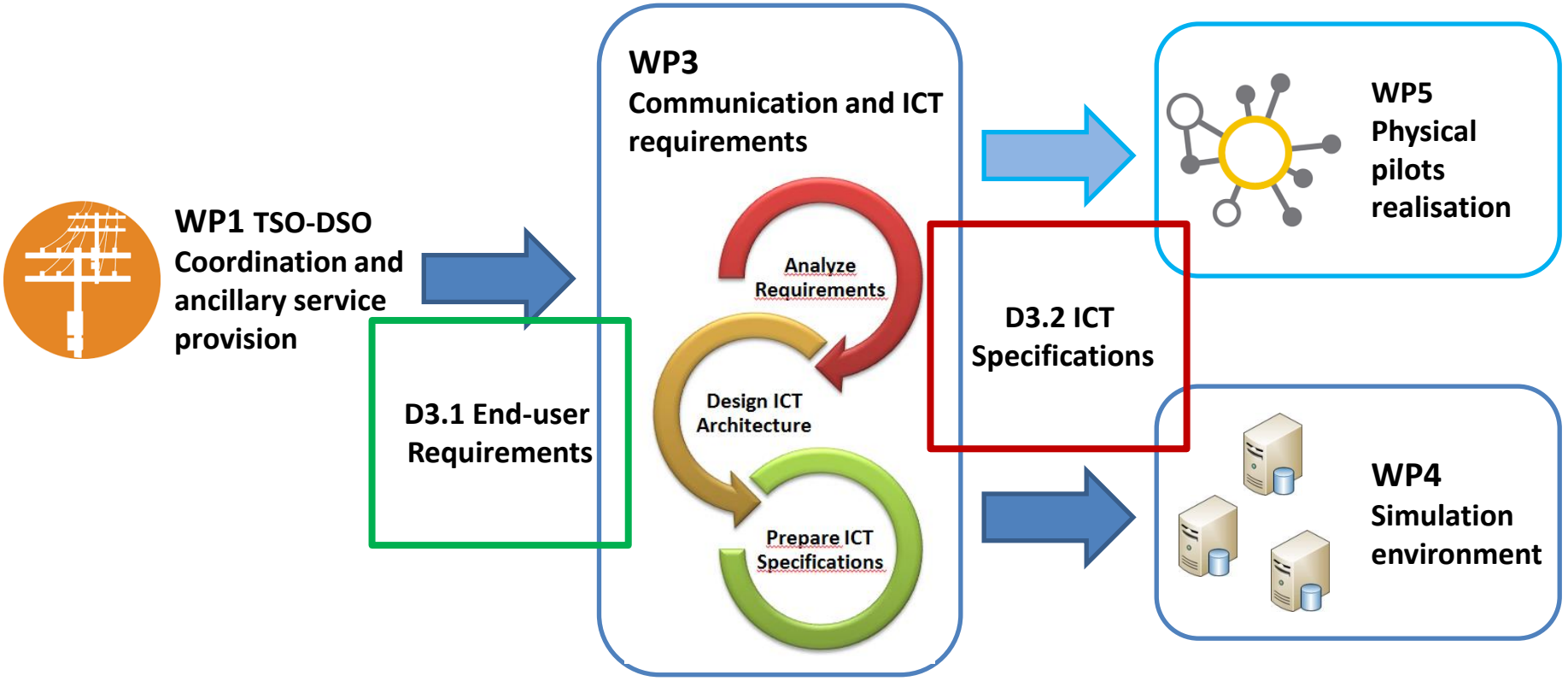
Aim and goals of WP3: ICT specification

- 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.

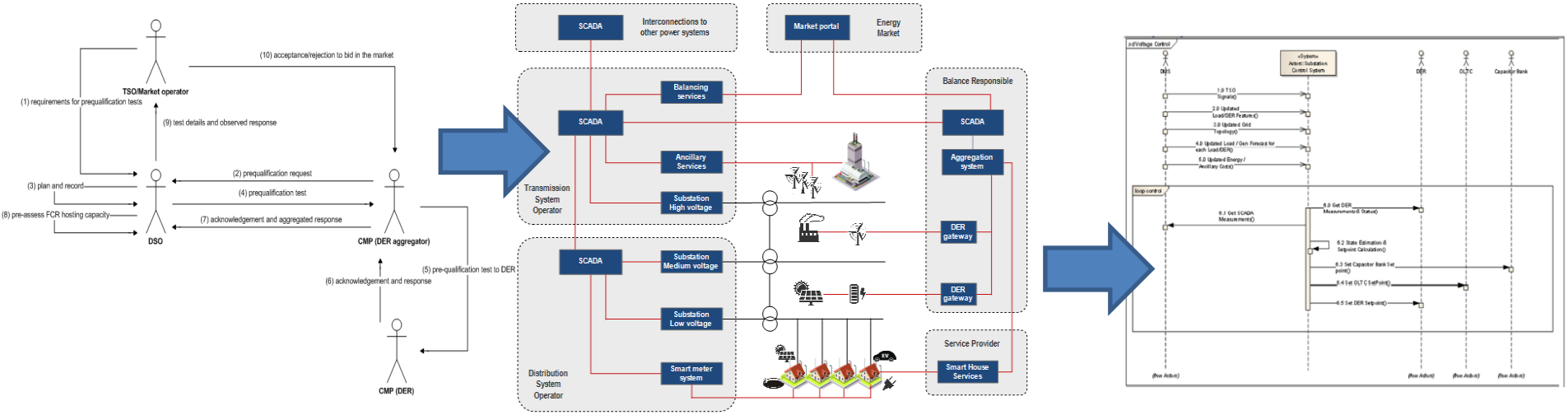
WP3 Work Flow and Interactions with other WPs



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

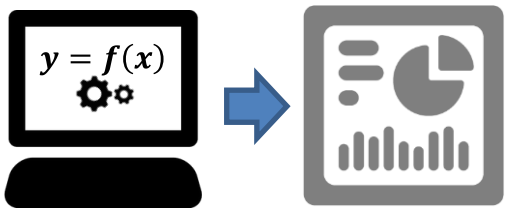


Business layer

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

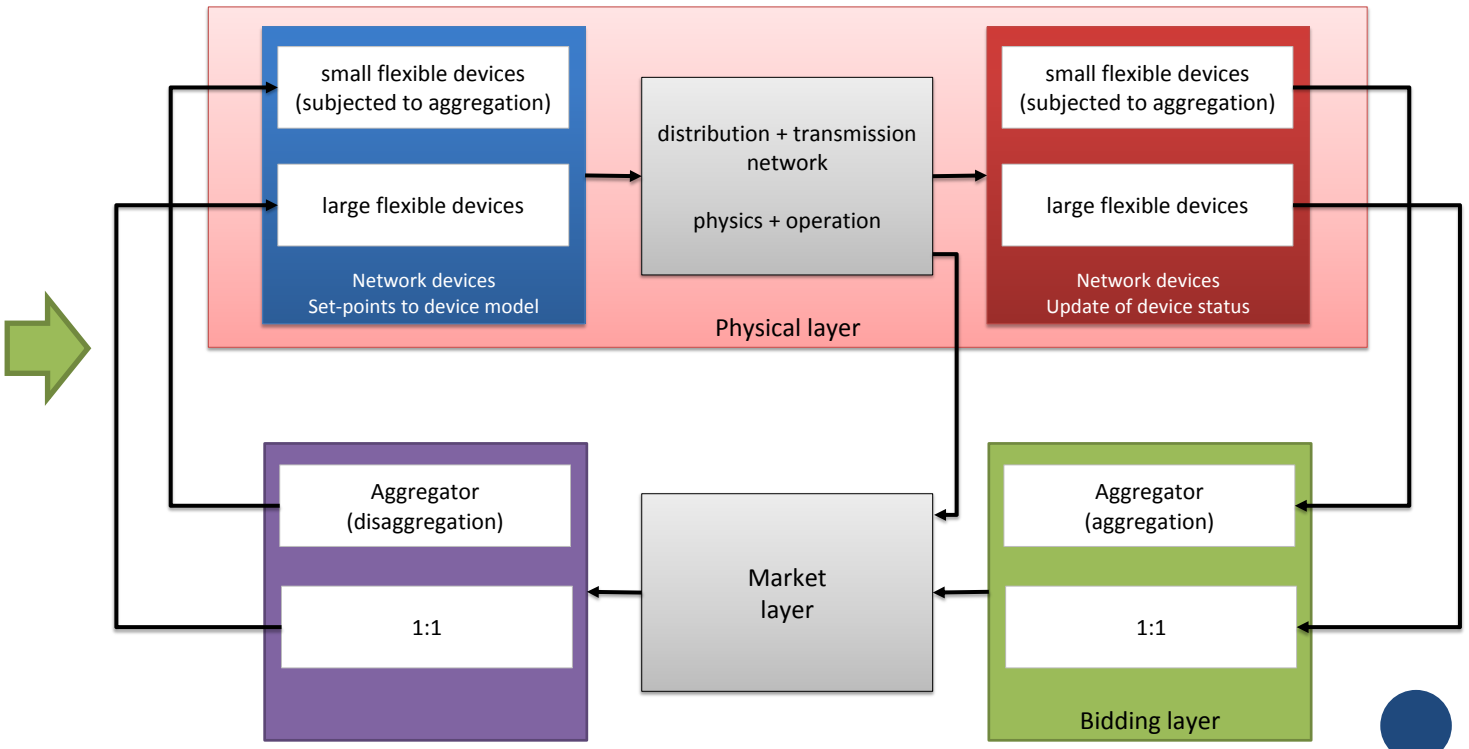
Implementation of the simulation environment in the laboratory in order to test real equipment aimed at contributing in TSO-DSO interactions

Simulator blocks

The simulation software is divided in blocks with different functions:

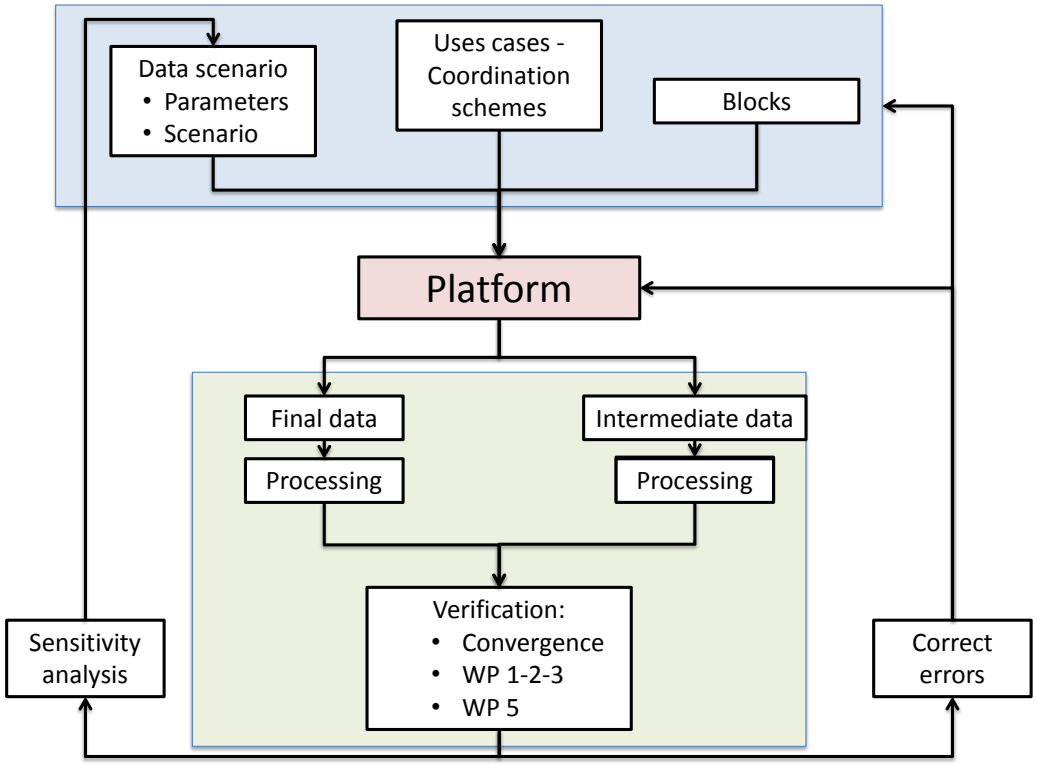
- **Market layer** (including the market clearing algorithms)
- **Physical layer** (including the model of the electrical network and connected devices)
- **Bidding layer** (performing the conversion from devices status to bids, including the aggregation of small devices)

2030 scenarios data



Simulation approach

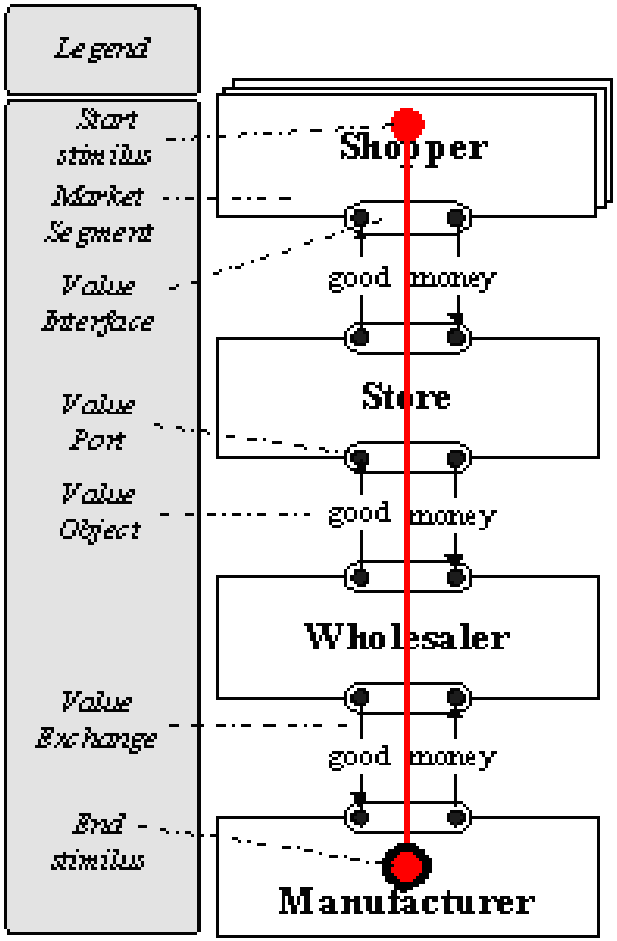
The simulation will be performed by considering the selected scenario (how Italy, Denmark and Spain will evolve in 2030).



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

Cost Benefit Analysis

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

Laboratory tests

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Tests on physical equipment for TSO-DSO interactions

- *SCADA*
- *Power plant controllers*
- *ICT*

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

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

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Thank You

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