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Deliverable D3.1: DRES2Market Simulation Environments

Work Package 2: "DRES2Market solutions for the effective integration of variable renewable energy according to market terms"

DRES2Market: Technical, business, and regulatory approaches to enhance the renewable energy capabilities to take part actively in the electricity and ancillary services markets

Horizon 2020-LC – SC3 – 2020 -RES-IA-CSA

Project Number 952851

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1. Objective of the document

The present document is aimed at presenting a review of the work prepared for the Deliverable 3.1, since it is not originally meant to be a report but a task of preparation of the simulation environments and tools that will be used in the subsequent tasks of the WP3 of DRES2Market project. Hence, the document shall serve as a proof of the work performed by the consortium to fulfil the corresponding task, and an info.

2. Introduction to the Simulation Environments

Along the WP3, the partners of the project will simulate and evaluate the impact of the proposed solutions and case studies in two main simulation environments: electricity markets and system operation.

- **The power exchange or market simulation environment**, provided by OMIE, will be used evaluate the impact of the installation of different amounts of RES and VREs and the application of different market rules on the electricity market price, the revenues of the RES and distributed variable renewable energy producers, the prices of the interconnection and the exchange of electricity among the different systems. Also, the environment will allow the simulation of local markets of flexibility, oriented to the participation of prosumer through the intervention of aggregators.
- The **electricity systems and grid simulator**, provided by IMDEA, will allow simulating in real-time a complete electricity system including the electricity flows in the transmission and distribution systems, the requirements of ancillary services, different grid codes and market rules. The environment will focus on the supply of system reserve by aggregation of prosumers and the simulation of the ancillary services markets considering the active participation of the demand. In order to perform this process, the IMDEA's Smart Energy Integration Lab (SEIL) and a leading power system analysis software application will be at disposal of the partners.

Both environments will perform separate analysis, but also work in conjunction in some test cases. In this manner, a complete energy system and the potential markets are enabled to be simulated for a more thorough assessment of the solutions. In ANNEX A and ANNEX B, a presentation and scheme of the main environments is displayed.

The consortium will contribute with the information and data required to carry out the established test cases:

- Market rules, prices, and signals from real historical data of Spanish, Greek and Polish markets.
- Complete grid structure (lines, substations, loads) from Spanish grid, simulated and real low and medium voltage grids.
- Demand profiles of anonymous clients from the retail players of the consortium, and at least 3 real consumptions to simulate their demand response.

3. Additional support simulation tools

The analysis of the solutions will require as well of a set of simulation and calculation tools that will support the assessment carried out by the Simulation Environments. These tools are aimed at generating input and perform interactions for the grid and market simulators, treating the outputs from the resulting simulations, and establishing general conclusions from the real and processed information extracted from grid operation and market participation in the simulations.

The additional support simulation tools that the consortium will use in the studies are:

- An **Active Demand Application** that will engage into the market simulation environment to perform the process of a retailer or aggregator of enabling demand response to their clients, in such way that both retailer/aggregator and clients benefit from the solution.
- A **Prosumer simulator** that allows the characterization of a PV installation for self-consuming, including the possibility of attached batteries and grid feed-in. The tool assesses the operative of the installation and generates the derived energy and economic flows.
- A **Dispatch calculation datasheet** that estimates the demand coverage according to different scenarios, generation dispatch, costs, and the introduction of different alternatives like demand response, consumption switching and energy storage.
- The **General Algebraic Modelling System** (GAMS) is an evolved and mature system that gives the consortium access to cutting-edge modelling and optimization technology.

4. Test cases first approach

The DRES2Market consortium have prepared an initial set of test cases that has supported the definition of requirements for the subsequent collection and characterization of the simulation environments and tools. The test cases state the concepts, solutions, or scenarios to be performed in the simulations, what kind of data will be required, and the outputs purchased in the analysis. While the current set of test cases is not definitive, it allows to begin the analysis, and it is expected to evolve during the duration of the WP3, according to derived or new ideas or solutions, to the requirements of information and the appearance of unexpected results.

In the following lines, a short description of the test cases is presented:

- Evaluate the technical challenges of distributed generators providing fast frequency response and voltage support.
- Evaluate the technical challenges of distributed generators providing black-start functionalities.
- Analyse impact of massive penetration of PV self-consumption.

- Analyse the entry barriers of a distributed resource to engage in a local flexibility market.
- Large renewable penetration impact in the grid.
- Local Flexibility Resources participation in the Wholesale Market through RES aggregators, with the objective of profit maximisation of the local resources.
- The Local Energy Communities manages local flexibility for their needs and if possible, to sell the flexibility in the wholesale market. The objective function is the cost minimisation for the Local Energy Community.
- Integrate flexible demand in local markets through an aggregation company.
- Integrate a large volume of electric vehicles in the energy system.
- Integration of energy storage in the grid.
- Repowering of renewable generation installations.
- Hybridisation of renewable generation installations.
- Integration of "Dynamic Line Rating" in the system.

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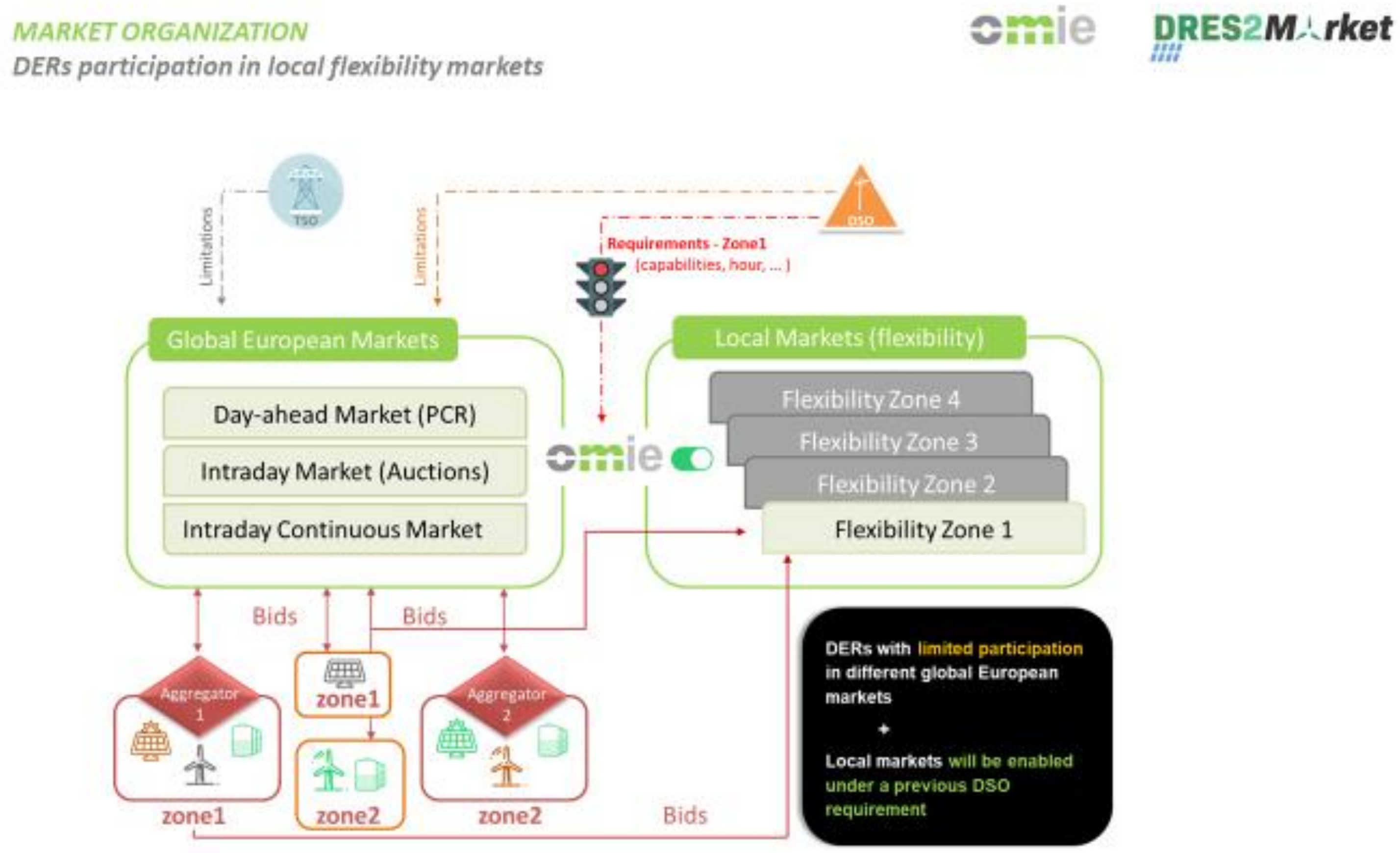
ANNEX A: Market environment scheme



ANNEX B: IMDEA's SEIL presentation

instituto imdea energía

Electrical Systems Unit

Smart Energy Integration Lab (SEIL)

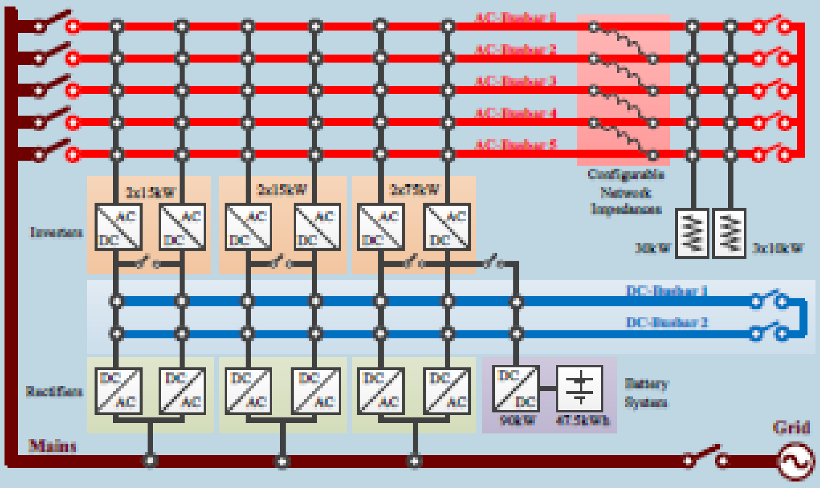
EUROPEAN UNION STRUCTURAL FUNDS — La Suma de Todos, Comunidad de Madrid, www.madrid.org

Objectives

Electricity networks will have a key role in the future energy sector and as they will facilitate a massive integration of renewable energy sources and guarantee high quality energy supply to industrial, residential and transportation sectors. Moreover, a new relationship between energy producers, network operators and final user will be forged.

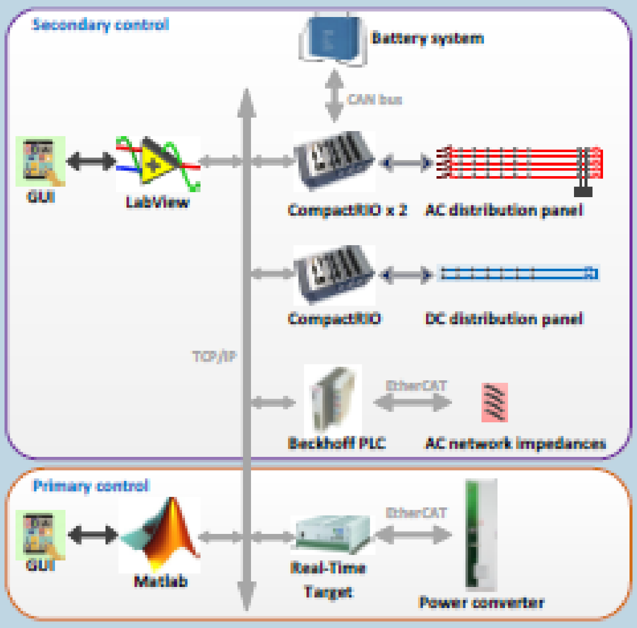
Based on the PHIL concept, the SEIL offers the necessary flexibility for:

- Implementation of advanced energy scenarios
- DC and AC (or hybrid) network studies
- Network stability analysis and development of new algorithms for primary, secondary and tertiary controls of power networks
- Renewable and storage integration



Lab Facilities

- 4 x 15 kVA AC/DC converters
- 4 x 15 kW AC/DC rectifiers
- 2 x 75 kVA AC/DC converters
- 2 x 75 kW AC/DC rectifiers
- 1 x 90 kW battery charger (DC/DC converter)
- 1 x 47.5 kWh Li-Ion battery
- 1 x 30 kW balanced, programmable resistive load
- 1 x 30 kW unbalanced, programmable resistive load
- 5 x configurable three-phase AC busbars
- 2 x configurable DC busbars
- 4 x configurable AC network impedances



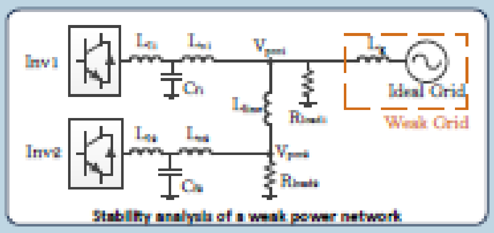
Control and data acquisition

- 4 x Nexcom® NISE 6140 RTTs with Linux-kernel OS
- 3 x NI CompactRIO™
- 1 x modular Beckhoff CX244680 system
- 2 x industrial PCs
- Measurement of voltages, currents and other relevant system variables
- Manual or automatic configuration of power networks
- Supports the development of primary, secondary and tertiary control in AC, DC or hybrid networks
- Rapid application development in LabView
- Lab monitoring from any external location

Applications

Power network study

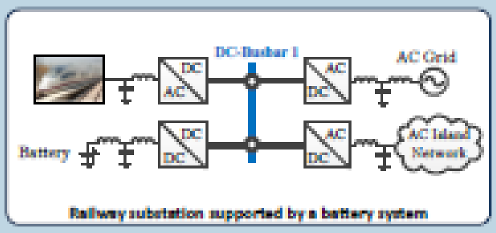
- Stability analysis
- Weak power networks
- Power flow management
- Reactive power compensaction
- Microgrids



Stability analysis of a weak power network

Direct Current Links

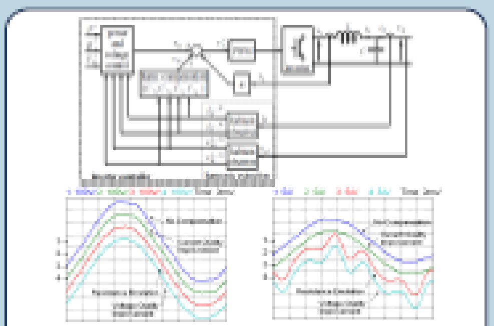
- HVDC and MVDC links
- Distribution power networks (SNOP)
- Substations for transportation sector
- Stabilization of AC power networks
- Multi-terminal DC networks



Railway substation supported by a battery system

Primary control strategies

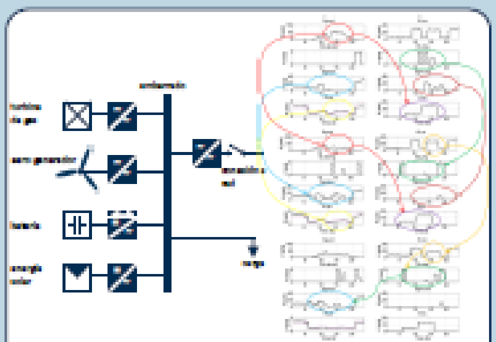
- Control of power interfaces
- Active power filters
- Voltage and frequency control
- Power quality



Comparison of voltage and current waveforms for different harmonic compensation techniques

Secondary and tertiary control

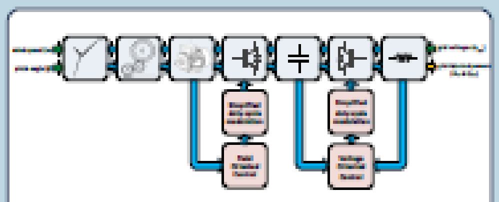
- Energy Management Systems (EMS)
- Optimal energy dispatch, demand management, self-consumption etc.
- Management of energy storage systems



Energy Management System (EMS) for a Microgrid

Renewable integration

- Integration of variable generation
- Emulation of dynamic and techno-economic properties
- Ramp control, grid codes



Real-time emulation of a wind turbine

Energy storage integration

- Fast frequency response
- Battery charging strategies
- Hybrid storage systems
- Distributed storage

A battery emulating inertia in an islanded network

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