Developing advanced EV grid interfaces (Smart charging and V2G)

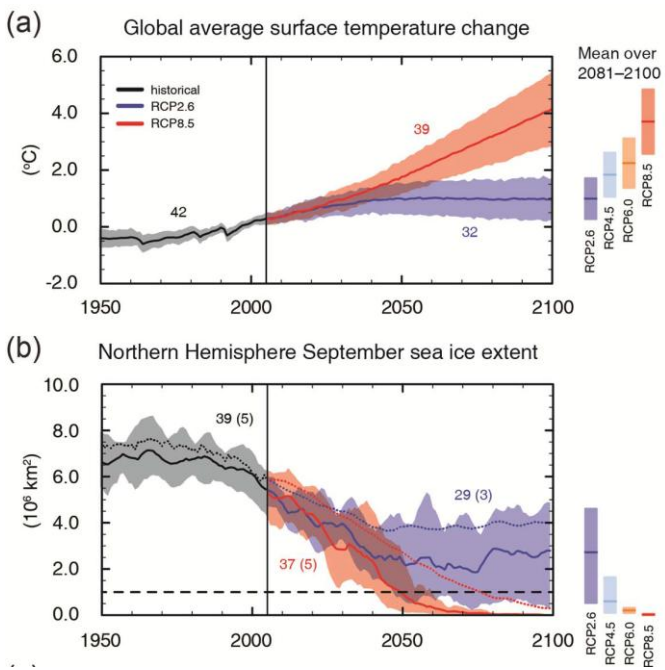
João A. Peças Lopes

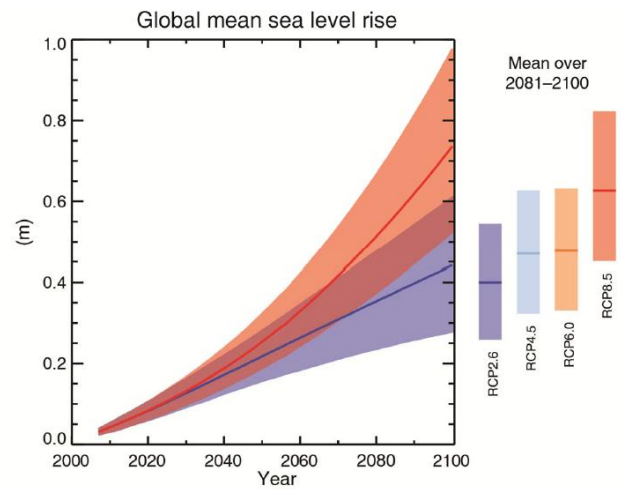
INESCTEC
TECHNOLOGY & SCIENCE
ASSOCIATE LABORATORY
COORDINATED BY
INESCPORTO
PORTUGAL

Universidade do Porto
Faculdade de Engenharia
FEUP

INTRODUCTION

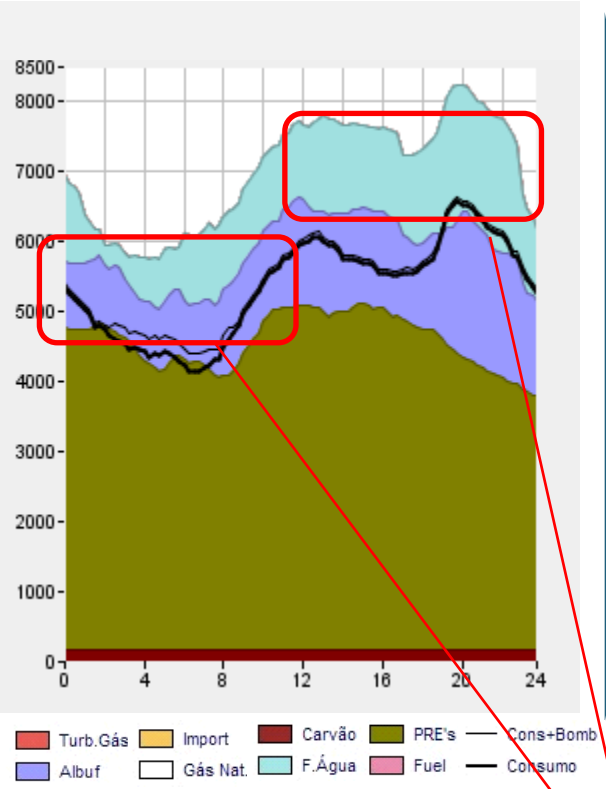
– **Threats from climatic changes**





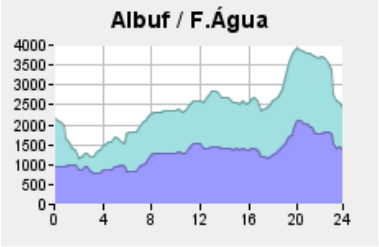
Operating the system with Very high renewable generation

29 March 2013 - Friday (holiday)



Consumption **128.3 GWh**

Hydro **66 GWh** **(4160 MW)**



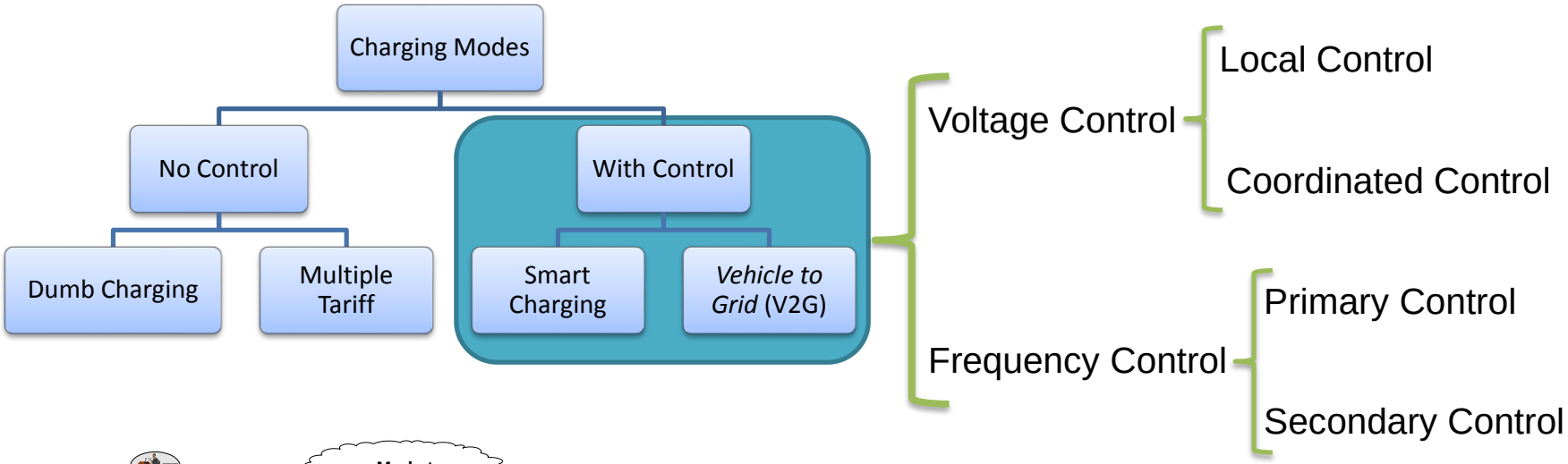
Wind **78 GWh** **(3780 MW)**

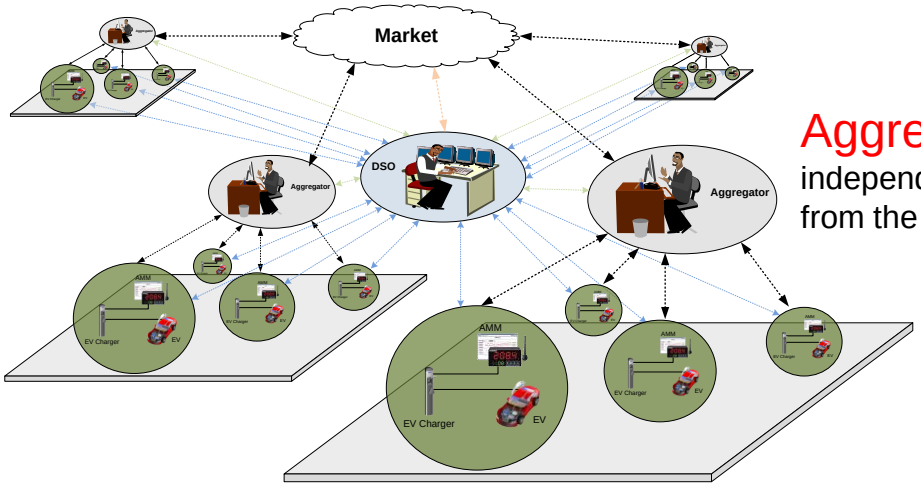
Export **37 GWh** **(2000 MW)**

EVs to use surplus of renewable generation

Definition of the Functional Architecture

- **EV Integration – Charging modes**





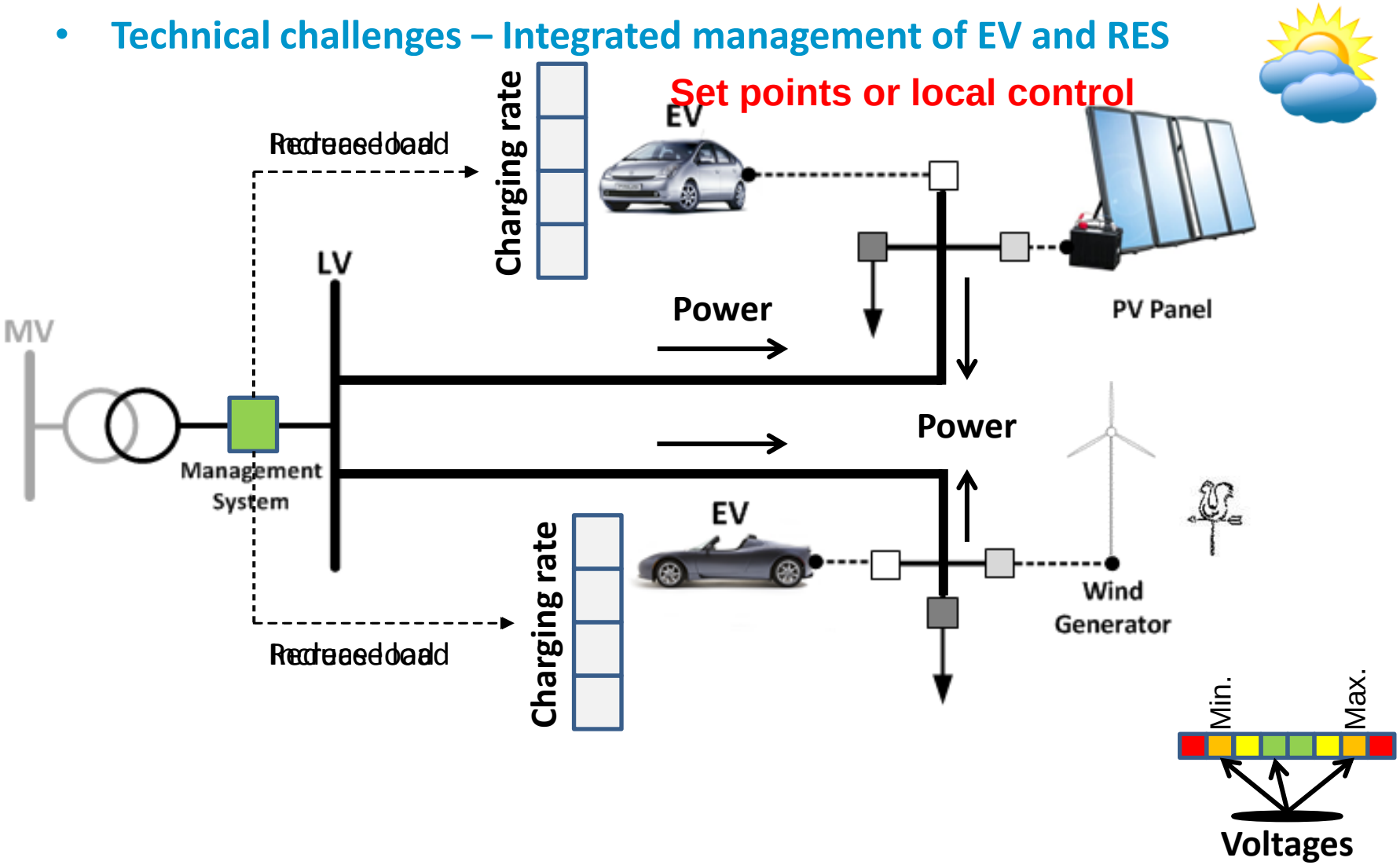
Aggregator
independent
from the DSO

Implementation of smart charging schemes

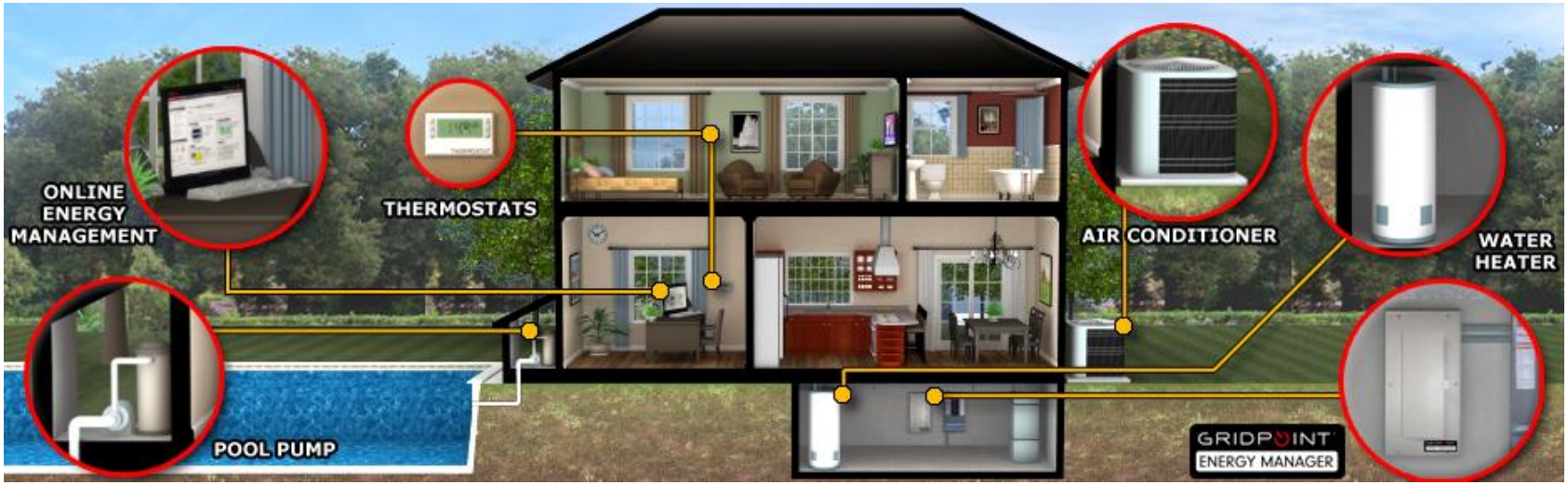
1. The Electric Mobility Paradigm

Foreseen problems for distribution networks

- Technical challenges – Integrated management of EV and RES



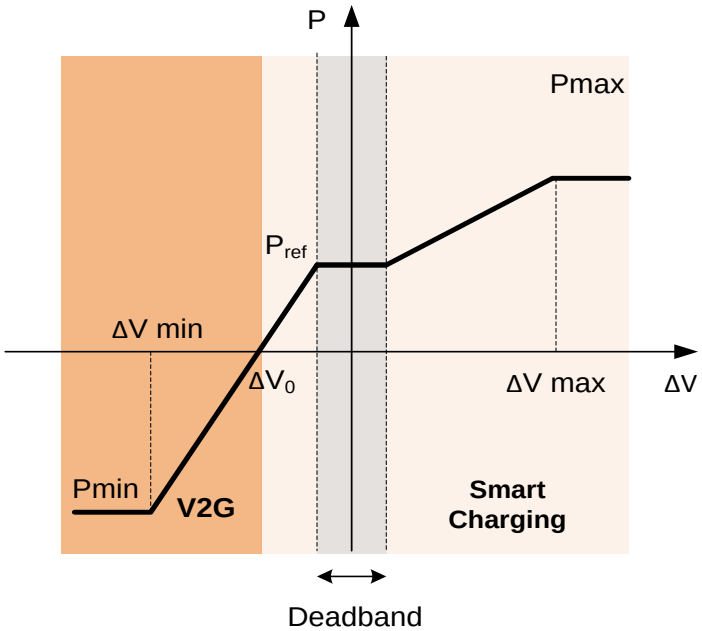
The Electric Power System of the Future - Prosumer



EVs SUPPORTING GRID OPERATION

EV grid supporting functionalities

- The EV bidirectional charger prototype is locally controlled in terms of active power:
  - Provide **voltage support** to the LV network due to low X/R ratio.
  - Participate in the **frequency regulation** in emergency conditions.

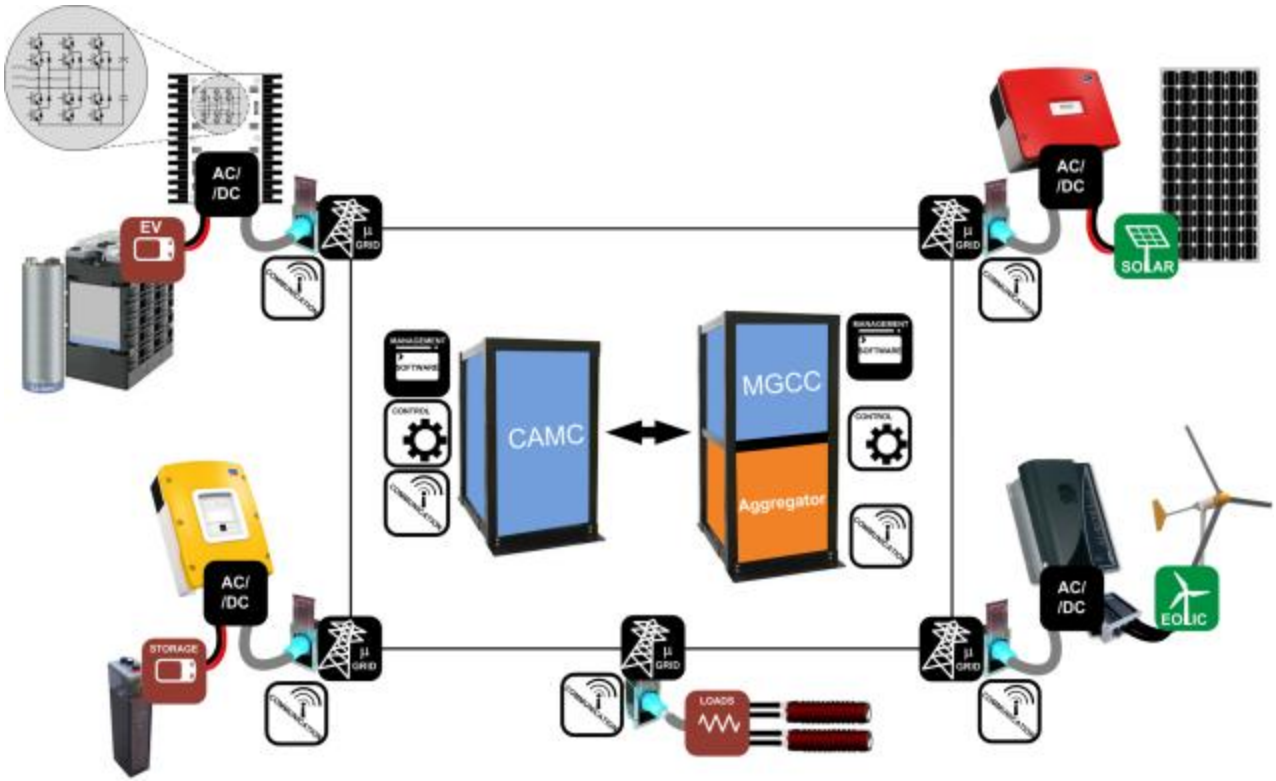


Control Rule:

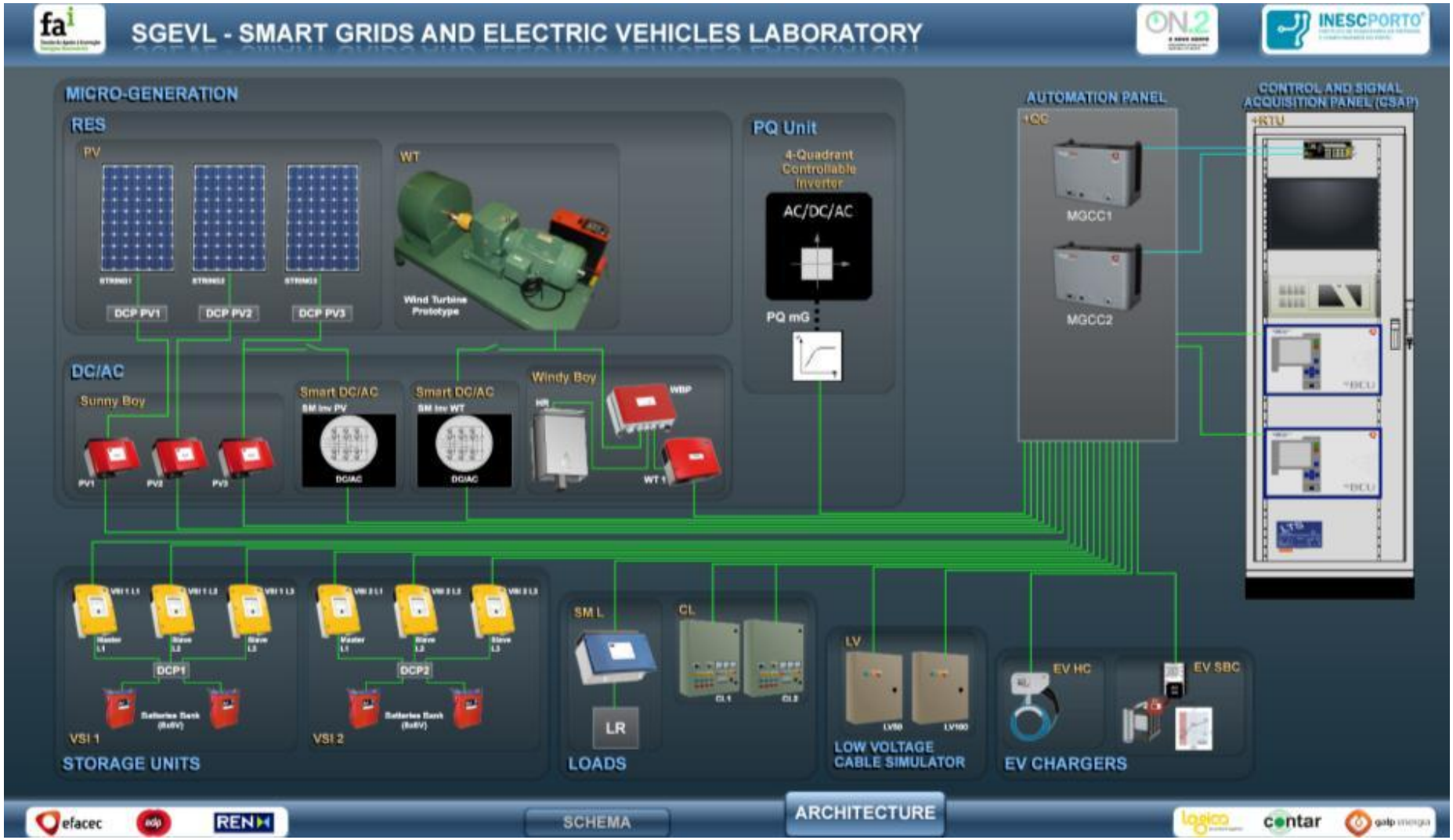
- Voltage/ Frequency **within** dead-band → The EV maintains its reference charging power.
- Voltage / Frequency **rises** above the dead-band → Automatic increase of the EV charging power.
- Voltage / Frequency **drops** below the dead-band → Autonomous decrease of the EV charging power or even power injection to the grid – V2G.

LABORATORY OF MICRO-GRIDS AND EVS

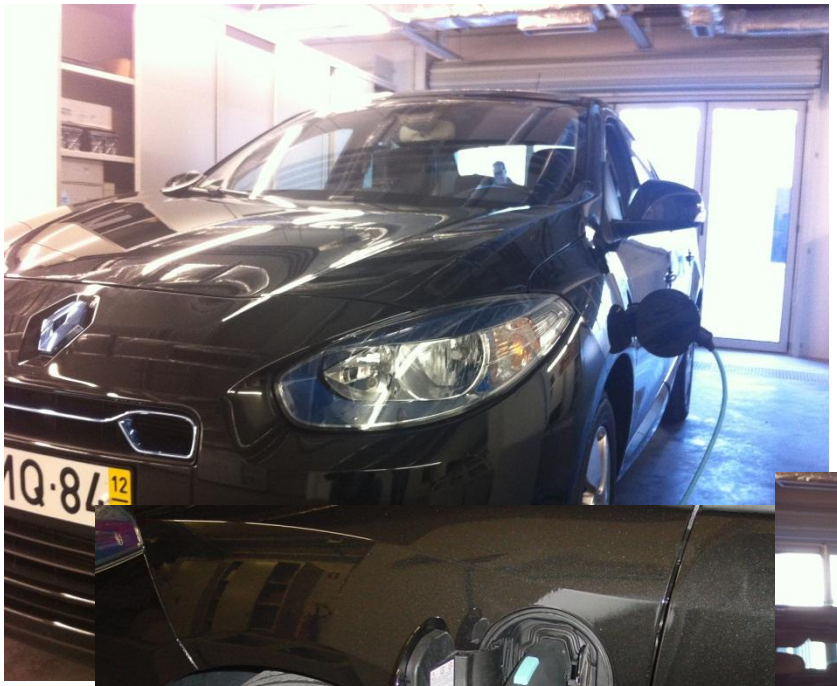
- **Different active devices under the Smart Grid / Smart metering concepts within a Laboratorial infrastructure**



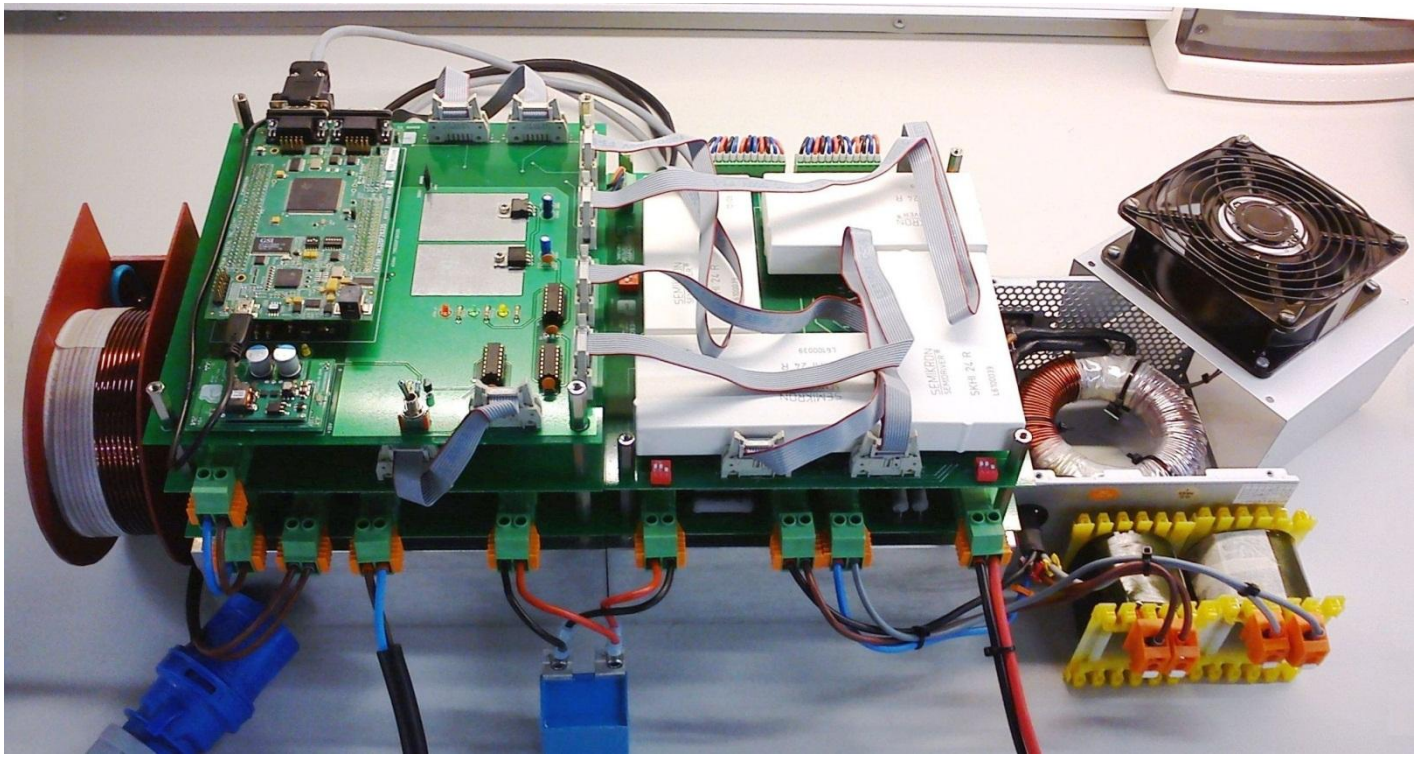
Laboratory of micro-Grids and EVs
General Configuration



EV DOMESTIC CHARGER



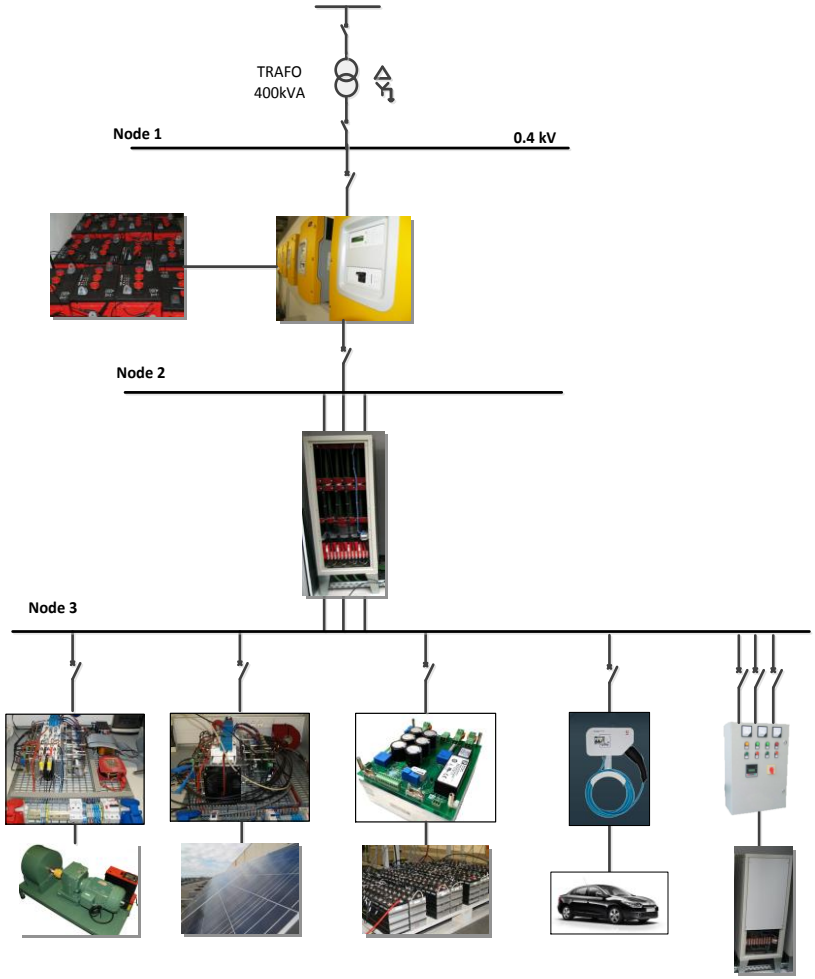
EV Charger Prototype



- Full power bidireccional
- BMS Communications by ECAN Bus

MICROGRIDS AND ELECTRIC VEHICLES LABORATORY FACILITIES

Experimental test system



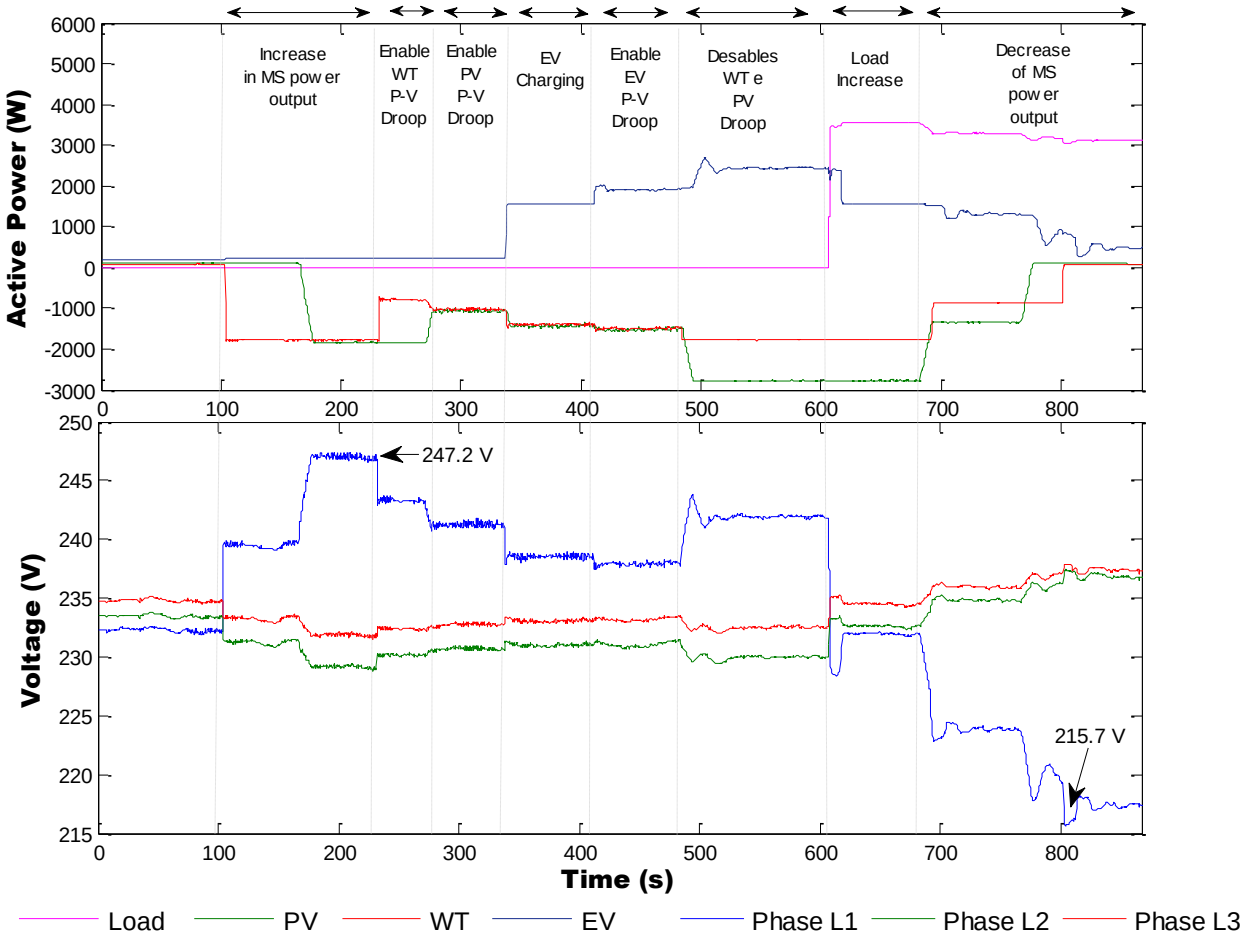
Test system configuration:

- Two PV strings connected to a DC/AC solar power converter prototype.
- The wind-turbine emulator.
- EV charger prototype.
- 27 kW resistive bank.
- MG node is interconnected to the main grid through a 100A LV cable emulator, which has a 0.6 Ω resistance.

Experimental tests:

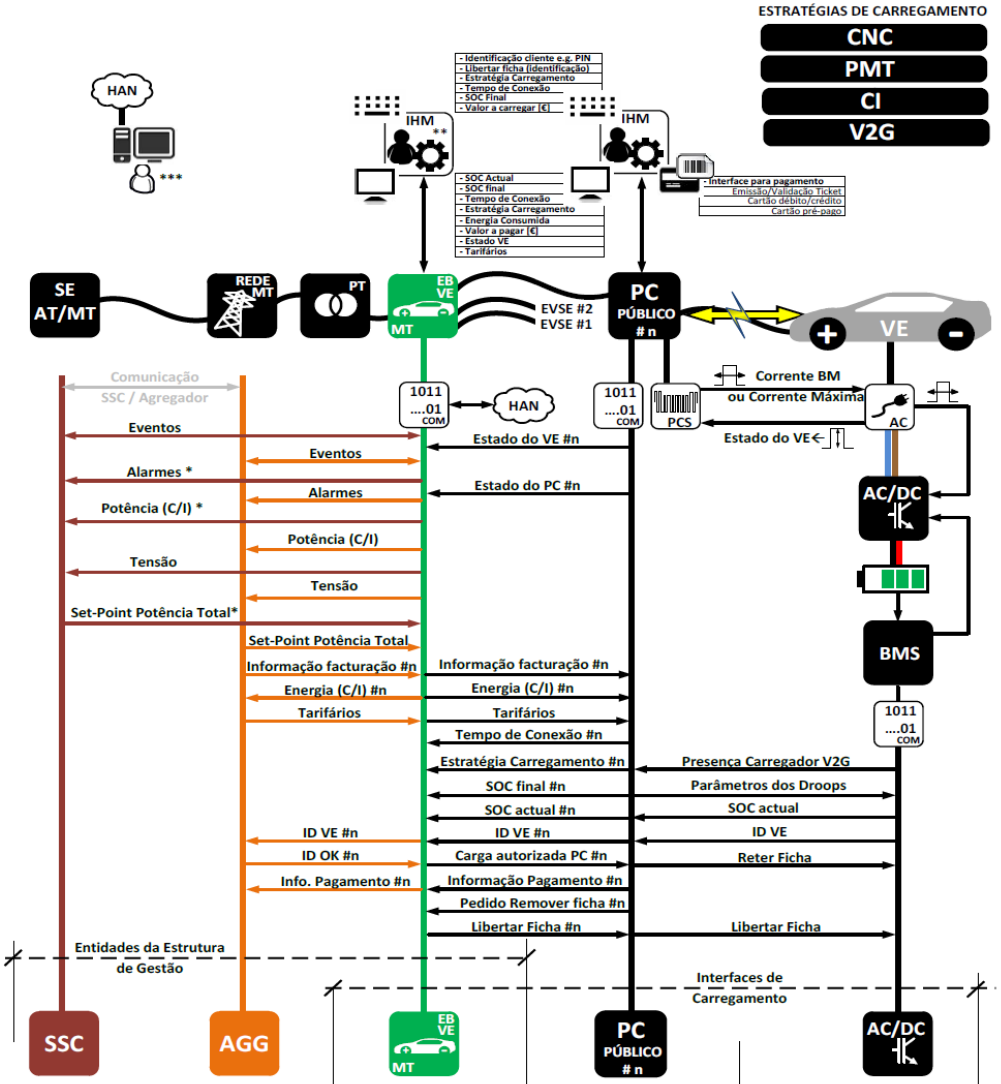
- **Interconnected mode of operation** – Test voltage regulation strategies.
- **Islanded mode of operation** – Test frequency regulation strategies.

Interconnected Mode of Operation: Voltage control



INTERFACES SPECIFICATION

- **EV Interfaces:**
  - **Public charging**
  - **Private charging**



CONCLUSIONS

- Simulation tools for the evaluation of the impact of EVs in power system operation.
- Innovative hardware and software solutions to control and manage EVs → protypes → smart grid environment.
- Advanced communication solutions.
- Laboratories to serve as a test bed are needed to prove and test new control concepts and solutions → **services and goods.**