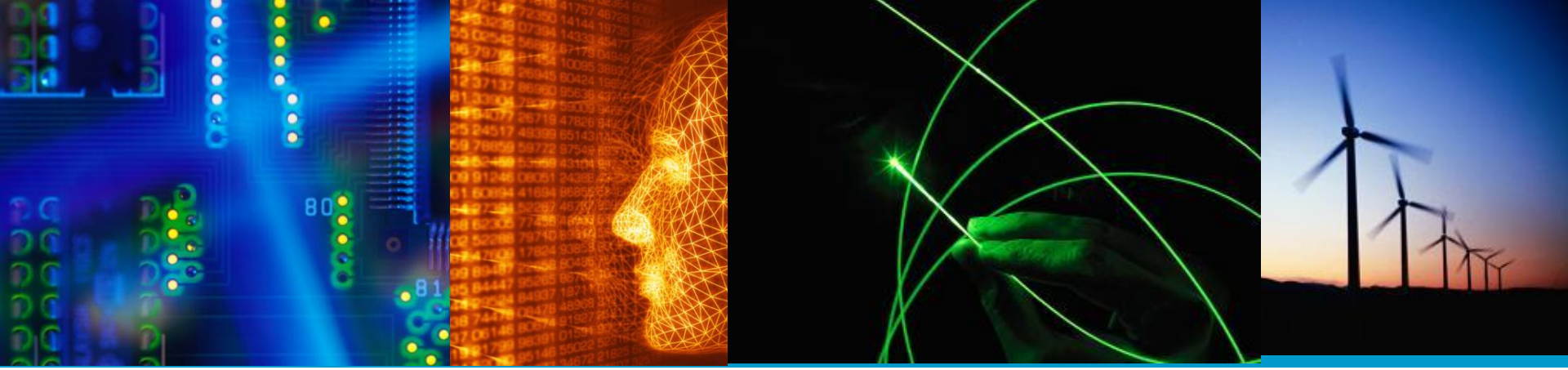

INESCTEC
TECNOLOGIA E CIÊNCIA
LABORATÓRIO ASSOCIADO
COORDENADO POR
INESCPORTO

Novos Desafios do Sector Elétrico (Renováveis, Mobilidade Elétrica, SmartGrids)

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V Conferência Annual da RELOP

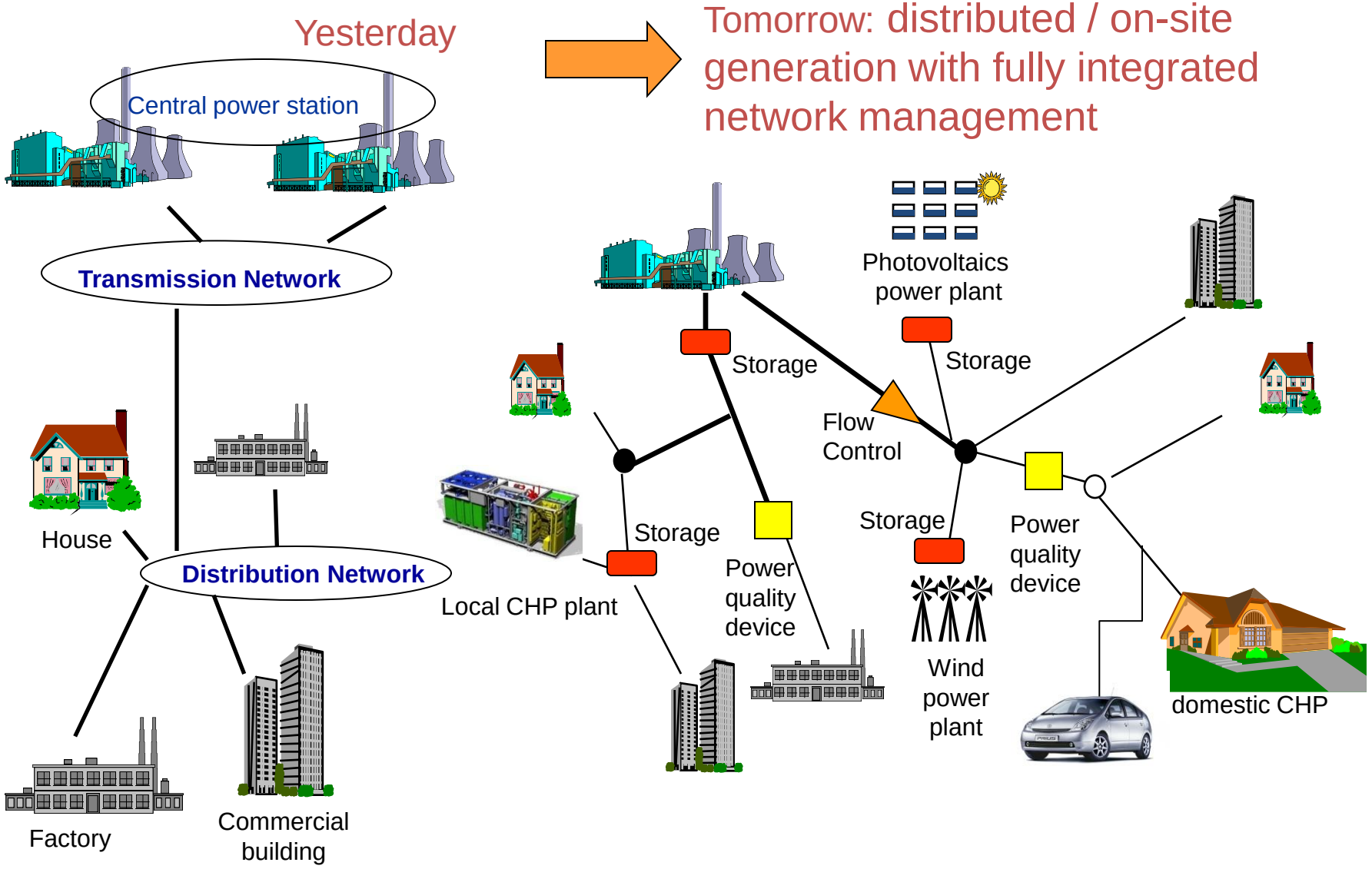
Introduction

- Driving forces for the future development of the electric energy systems:
  - **1) Environmental issues**: (reduce emissions by replacing fossil generation by zero emission generation, reduce network losses), minimize visual impacts and land use.
  - **2) Replacement of old infrastructures** (generation and grid)
  - **3) Security of Supply**
  - **4) Increase quality of service** (more automation and remote control)
  - **5) Electricity market liberalization** (energy and services)

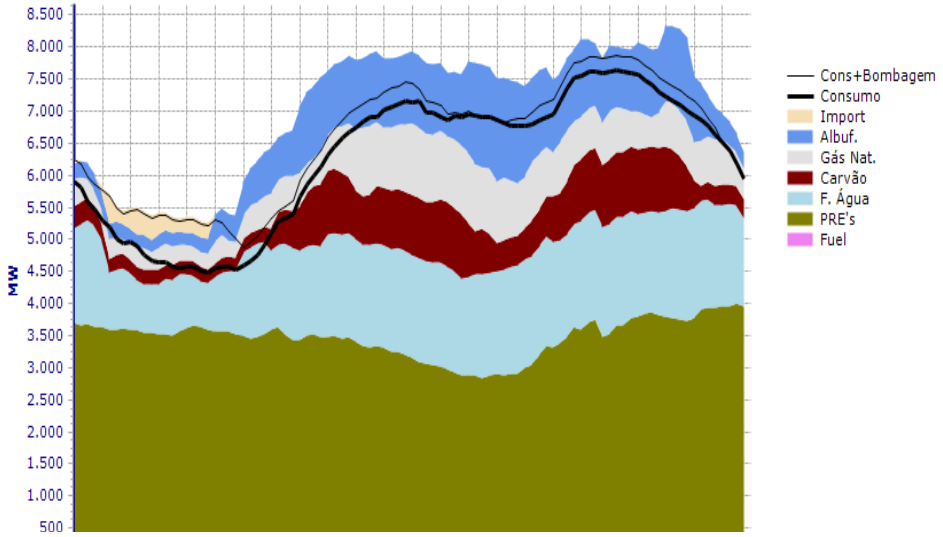
  - **1) Increase renewable generation**
  - **2) Increase Distributed Generation**
  - **3) Exploit flexibility from the side of the consumption (including EV)**

ADOPTION OF A SMART GRID PARADIGM

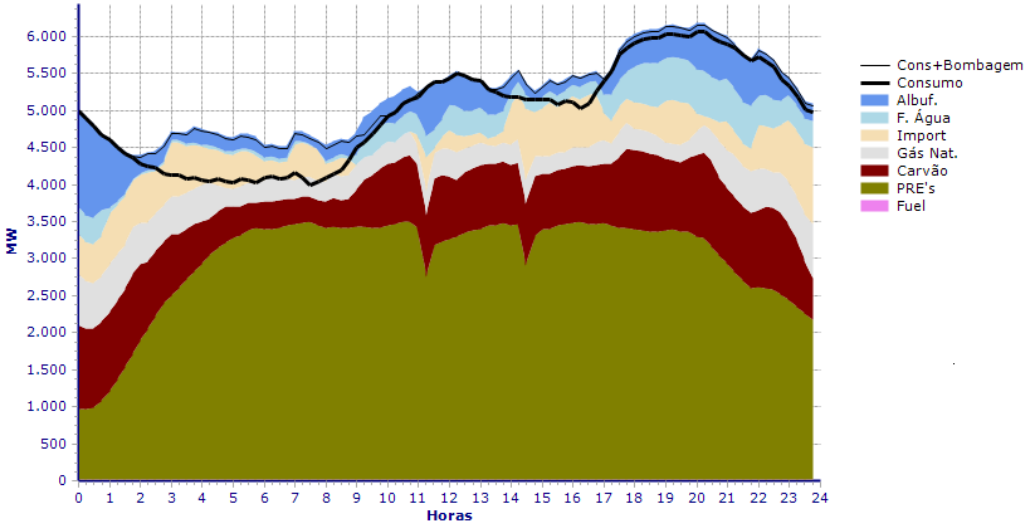
Changes in the Electric Power Industry

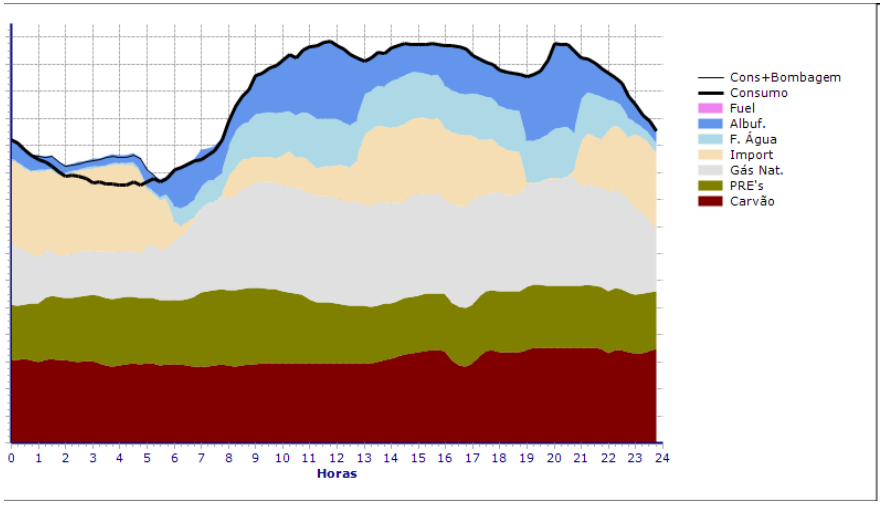


The Variability of the RE Generation



Different generation profiles from RE





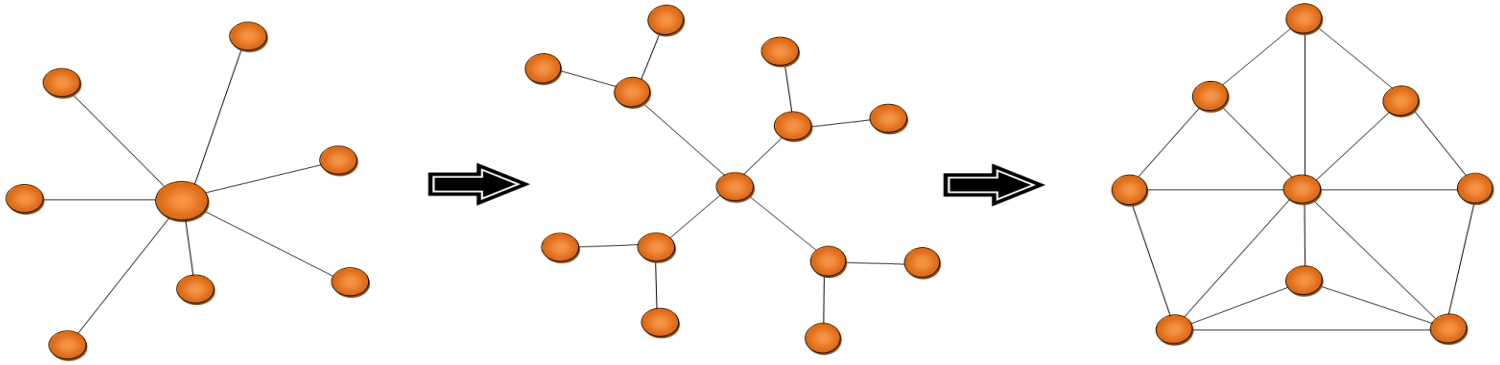
http://www.centrodeinformacao.ren.pt/PT/InformacaoExploracao/Paginas/EstatisticaDiariaDiagrama.aspx

What is expectable from a Smart Grid

- **Definition:** A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it - **generators, consumers** and those that do both - in order to efficiently deliver sustainable, economic and secure electricity supplies.
- Main characteristics of a SmartGrid
  - Two way communication everywhere
  - Extensive use of sensors
  - Control over power flows
  - Adaptive protections, semi automated restoration, self healing,
  - System capacity extension to the limits (dynamic monitoring)
  - Large penetration of DG and intermittent power sources (millions of μgenerators)
  - Full price information, dynamic tariffs, active demand response
  - Integrated demand side automation.

Increased efficiency of operation

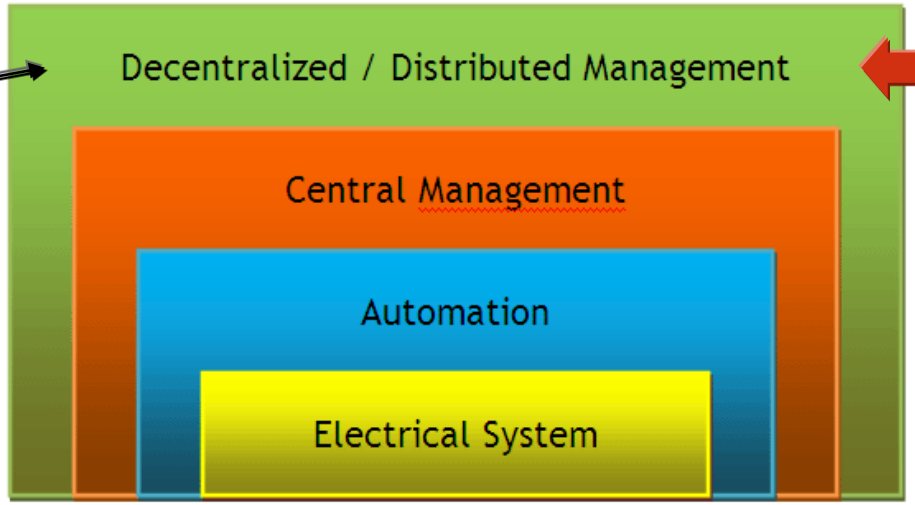
Conceptual Understanding of a Smart Grid



Centralized Decentralized Distributed

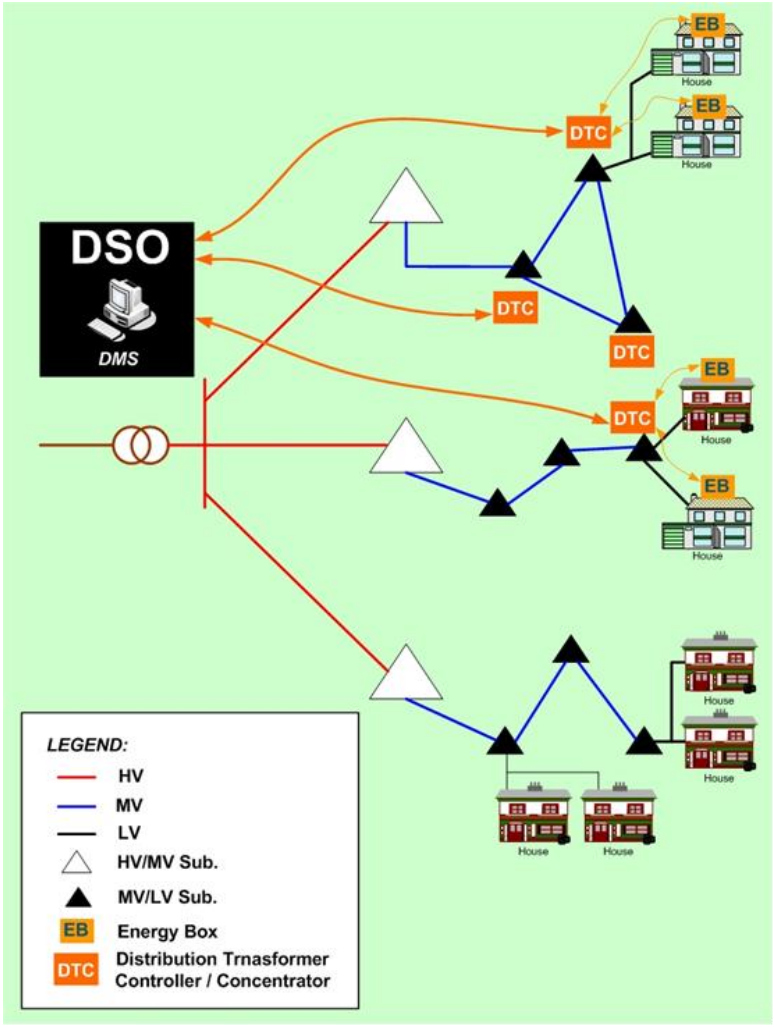
SmartGrid

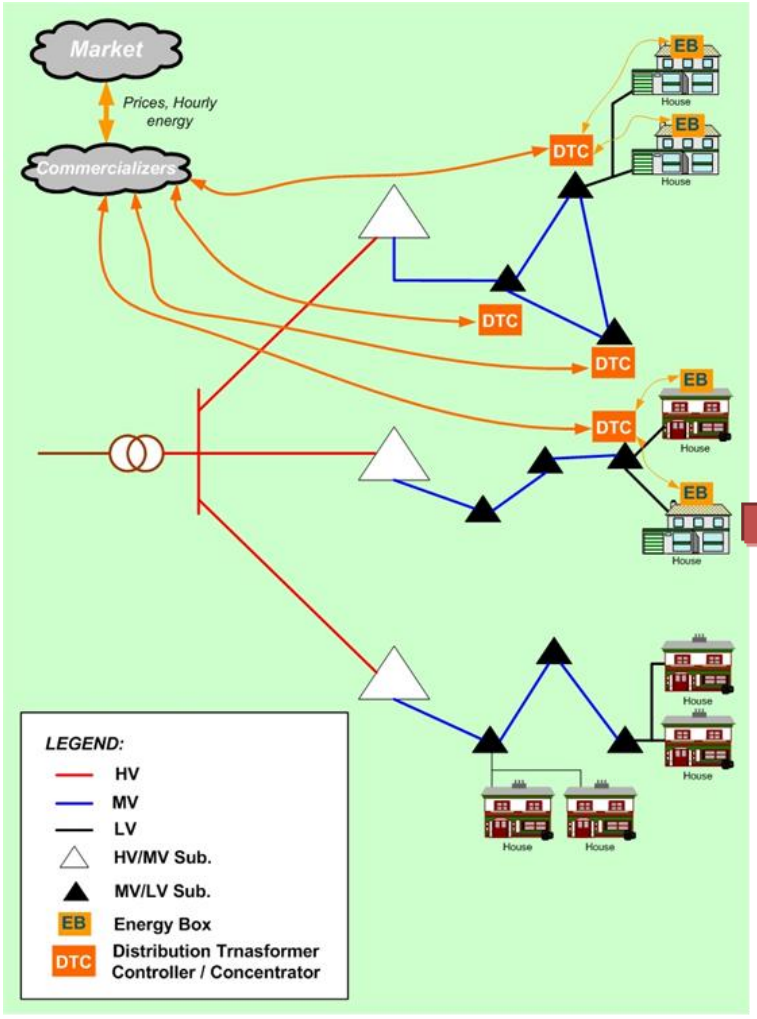
Sensors and actuators



Generation + Grid

SmartMetering infrastructure helps to technically manage dist. resources

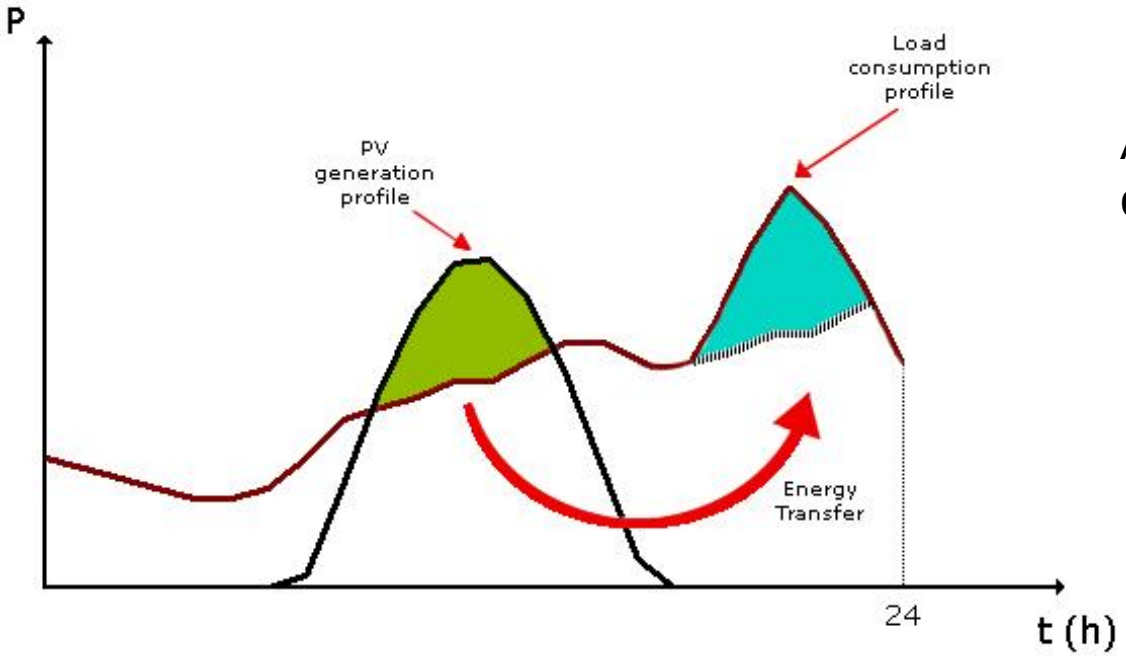




ICTs

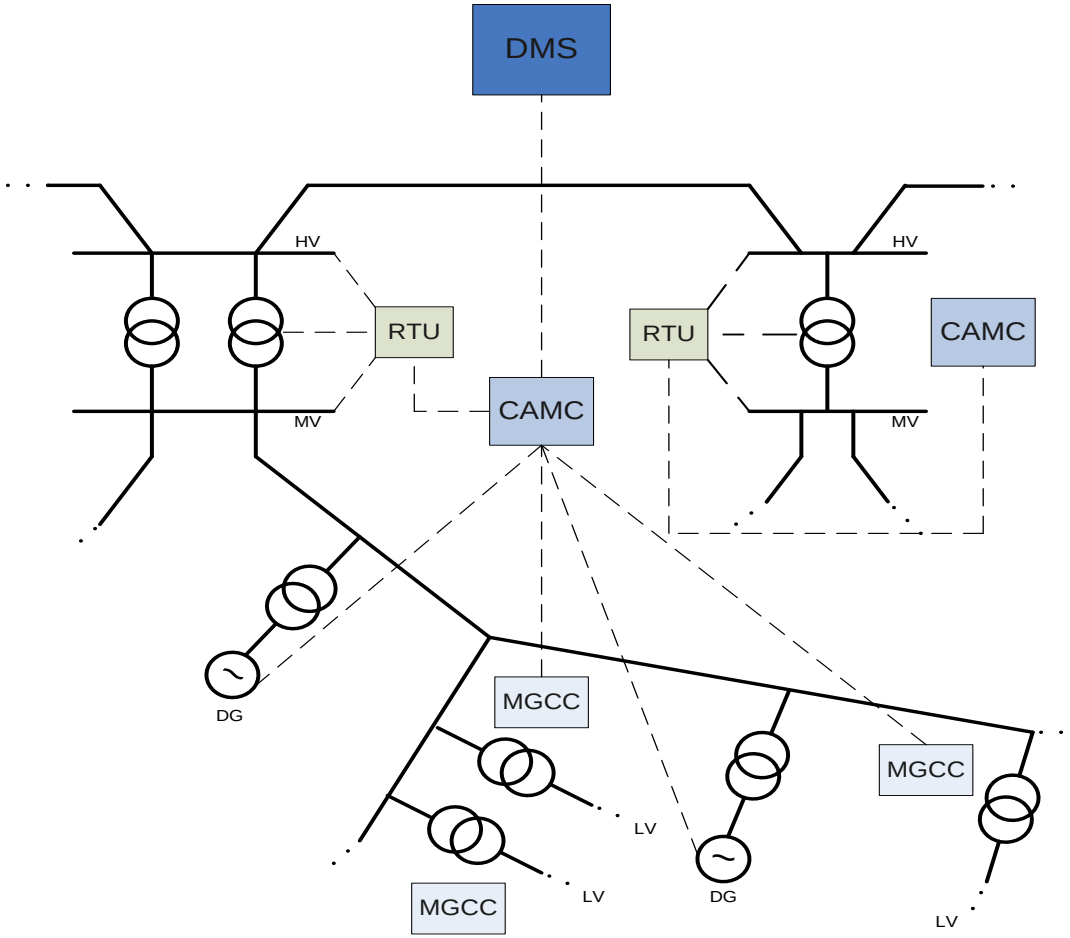
Increase in Distributed Storage

- Large scale distribute storage will turn into a reality in the years to come:
  - PHEV / EV
  - Stationary storage
- Storage will be used to help manage the distribution grid in steady state and emergency operation (islanding, restoration)

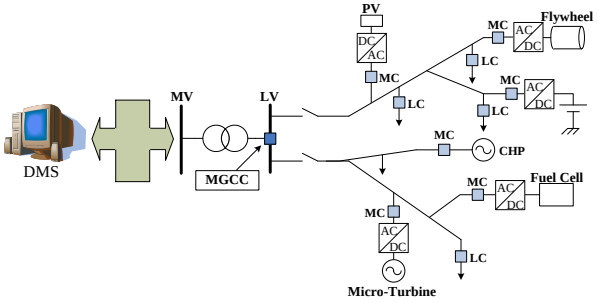


Additional business opportunities.

New Control Architectures (Distribution Grid)

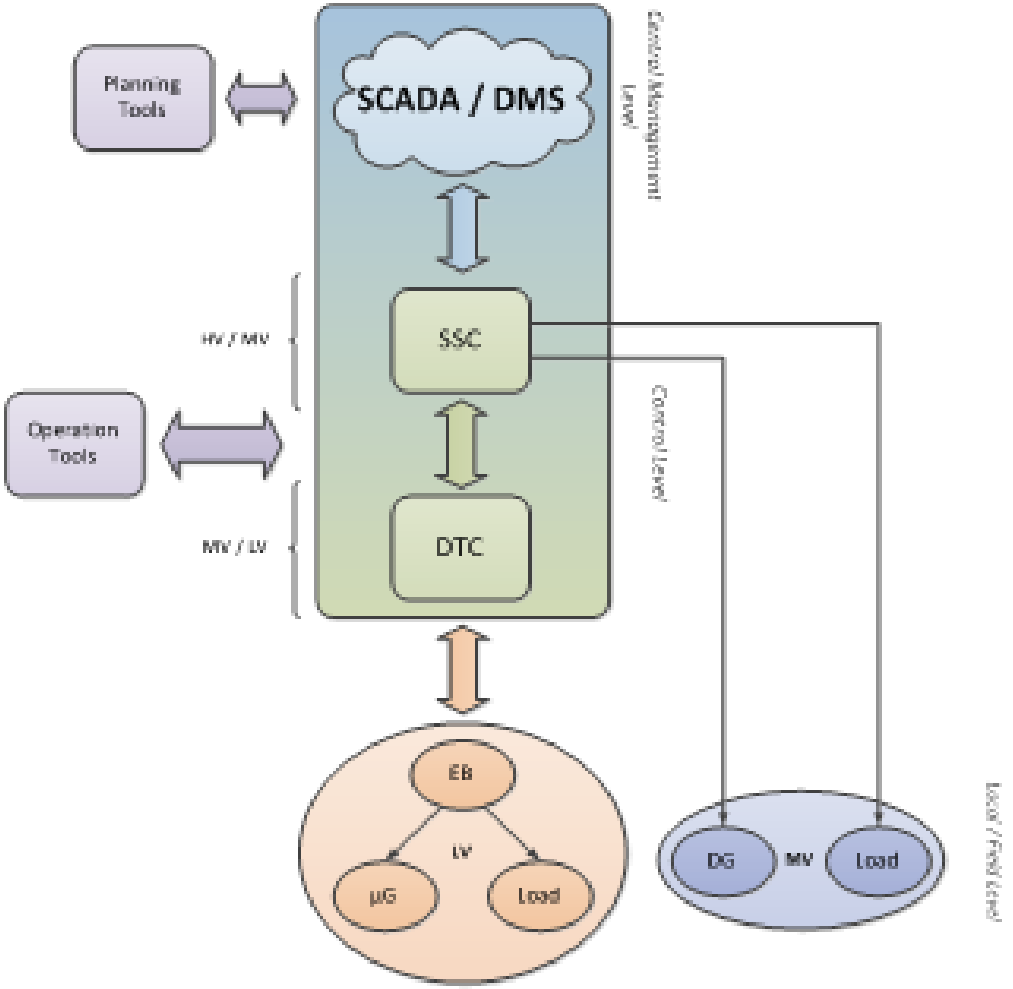


DMS – Distribution Management System
CAMC – Central Autonomous Management Controller
MGCC – MicroGrid Central Controller
RTU – Remote Terminal Unit

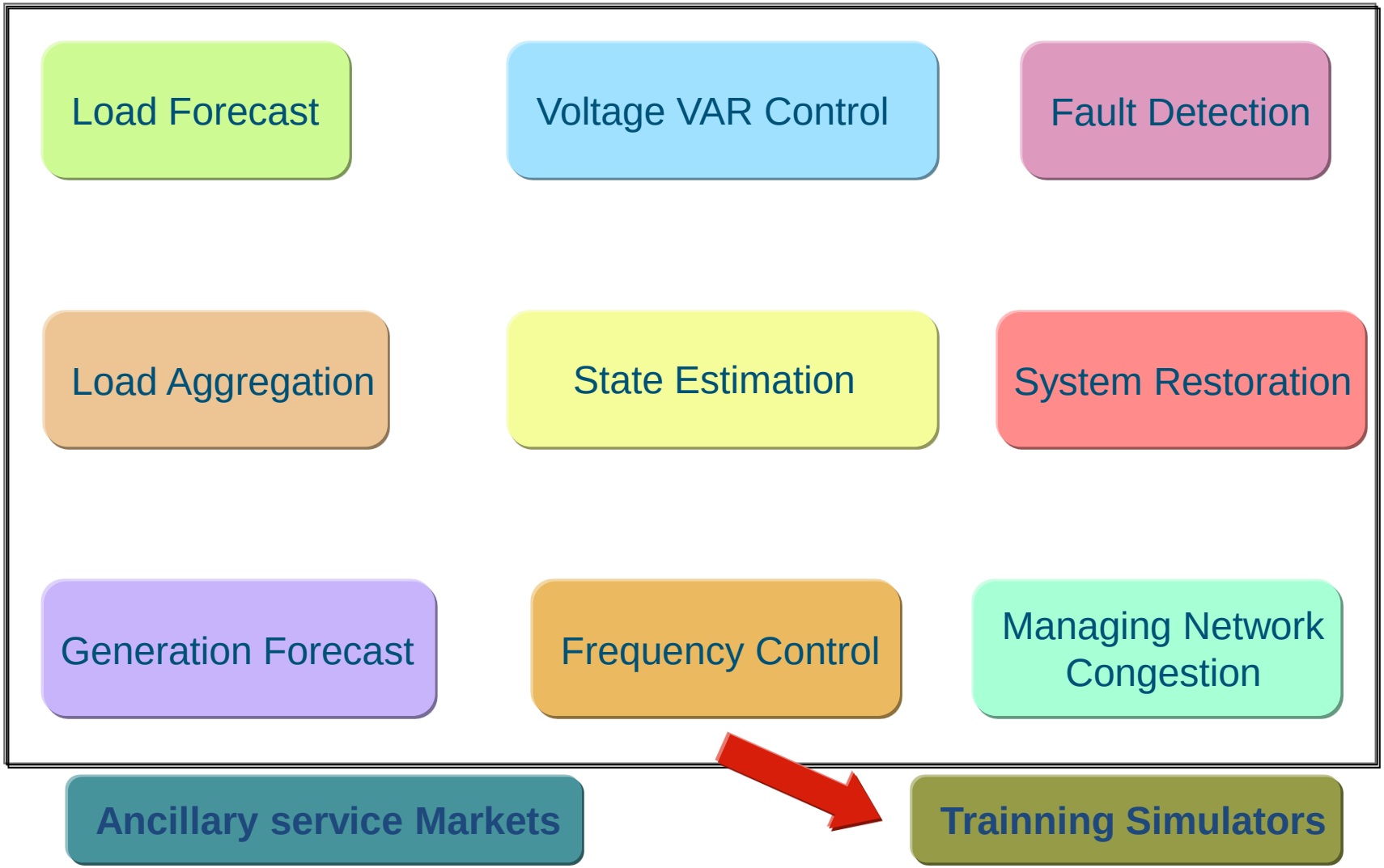


New control and Management architectures

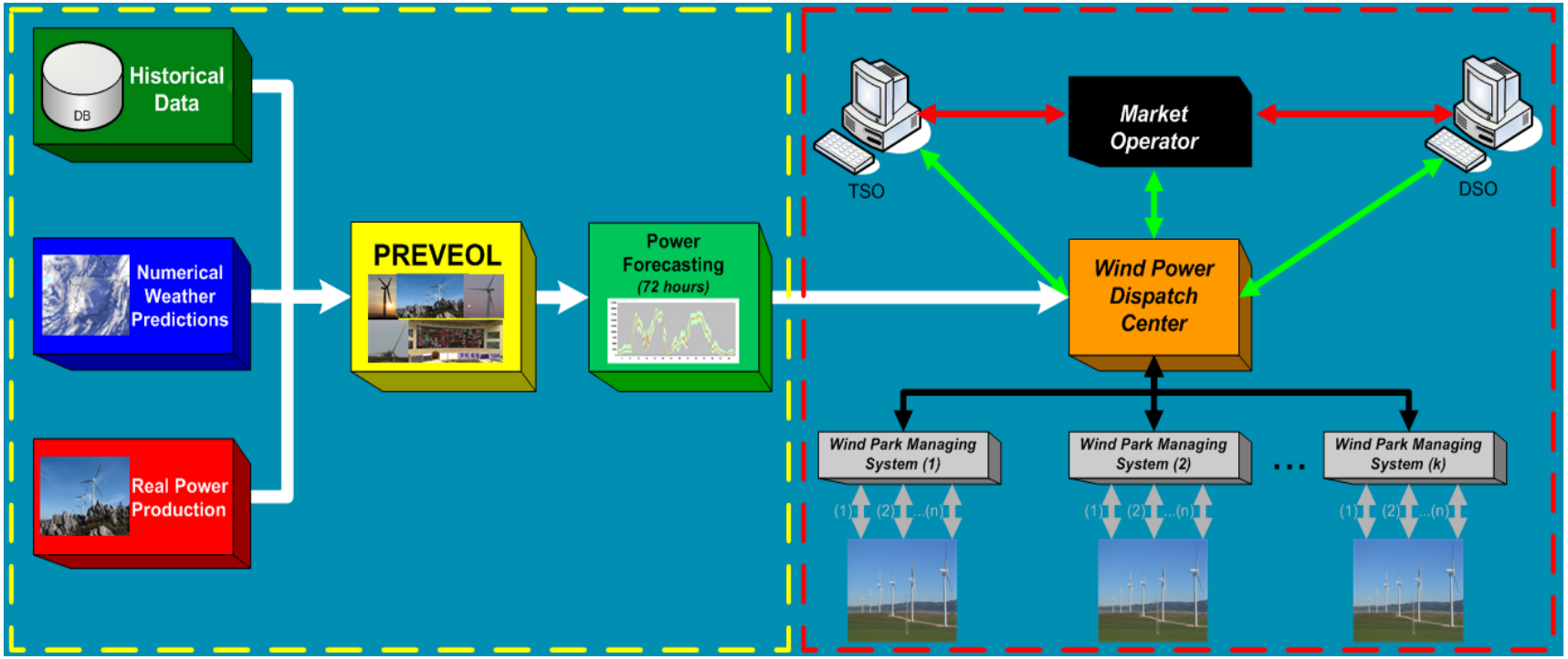
- A new control and management architectures with several layers:



New DMS Operation Functionalities



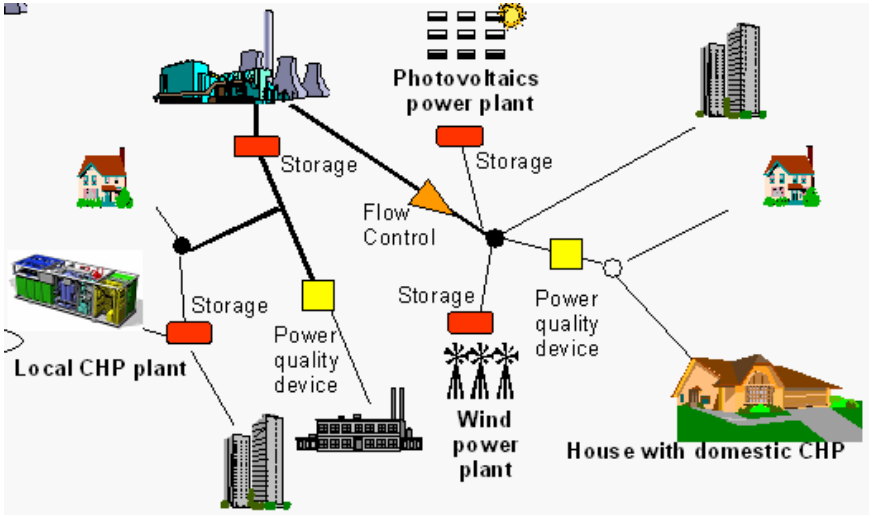
New DMS Operation Functionalities

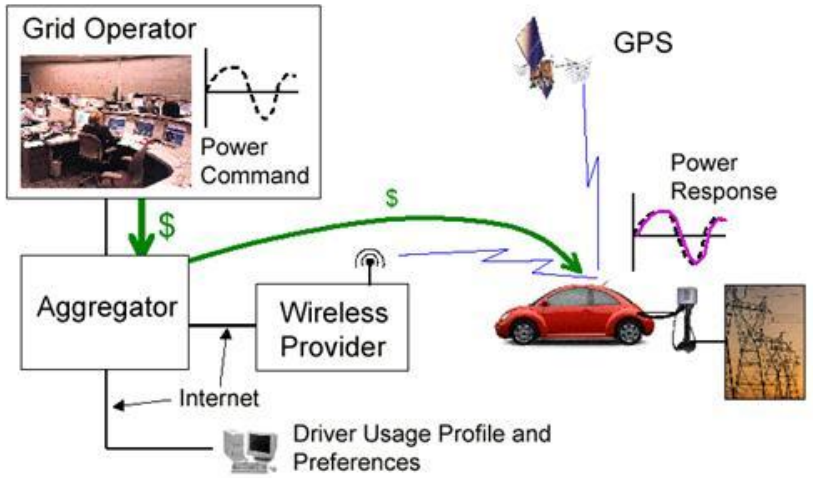


Forecasting tools: example – wind power forecasting

Additional chalanges for the electric power industry

- **A new revolution is on the way – PHEV and the V2G concept:**
  - These electric vehicles will require the use of electric batteries with capacity to store energy, PHEV will either be:
    - Controllable charges that absorb energy and
    - Storage devices that may provide electricity to grid.

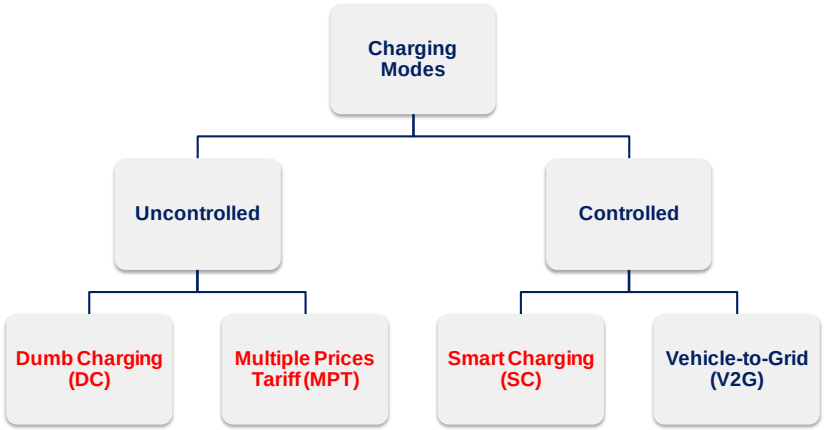




Conceptual Framework for EV Integration Into Electric Systems

Possible EV charging approaches and drivers' behaviours

➢ Charging approaches:



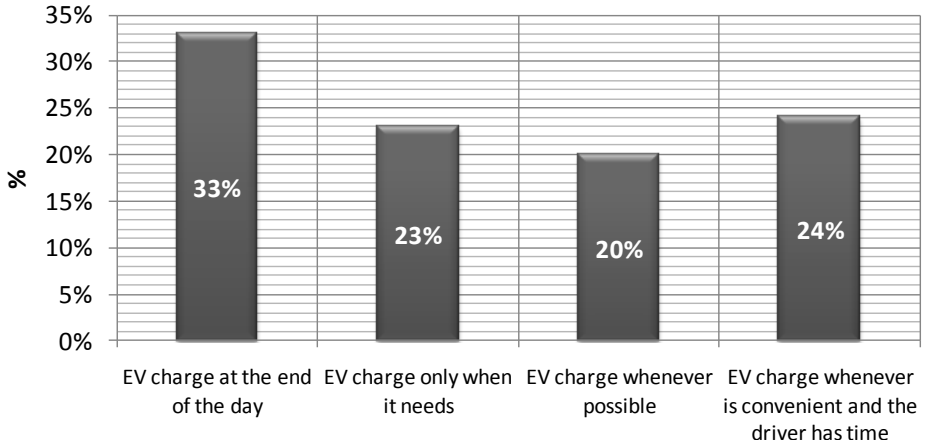
EV electricity cost

Dumb Charging - EV owners are free to charge their vehicles whenever they want; electricity price is constant along the day.

Multiple Prices Tariff - EV owners are free to charge their vehicles whenever they want; electricity price is not constant along the day.

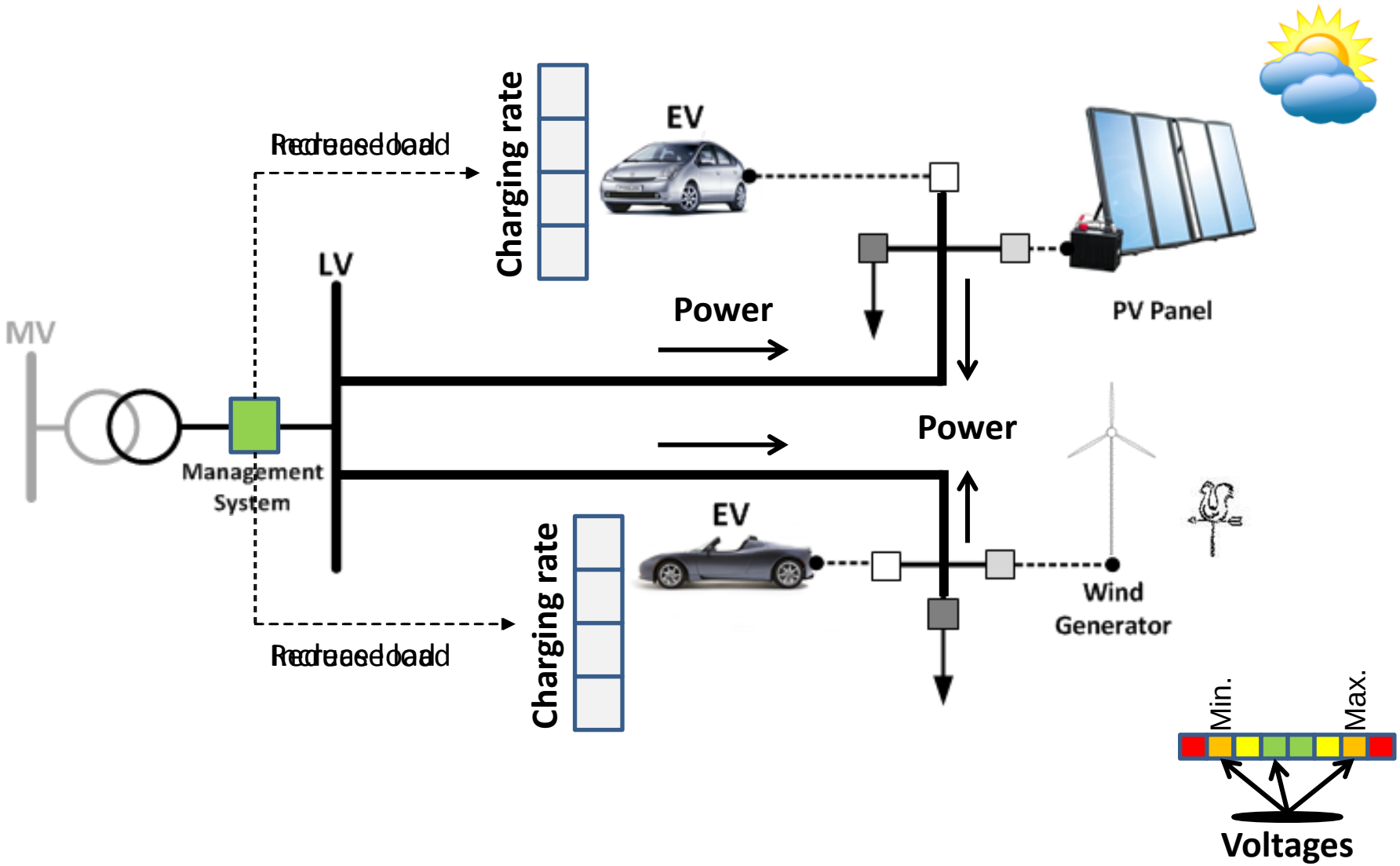
Smart Charging - envisions an active management system, where there are two hierarchical control structures, one headed by an Aggregator and other by the DSO, that control EV charging according to Aggregator's market negotiations or according to the grid's needs.

➢ Drivers´ behaviours:



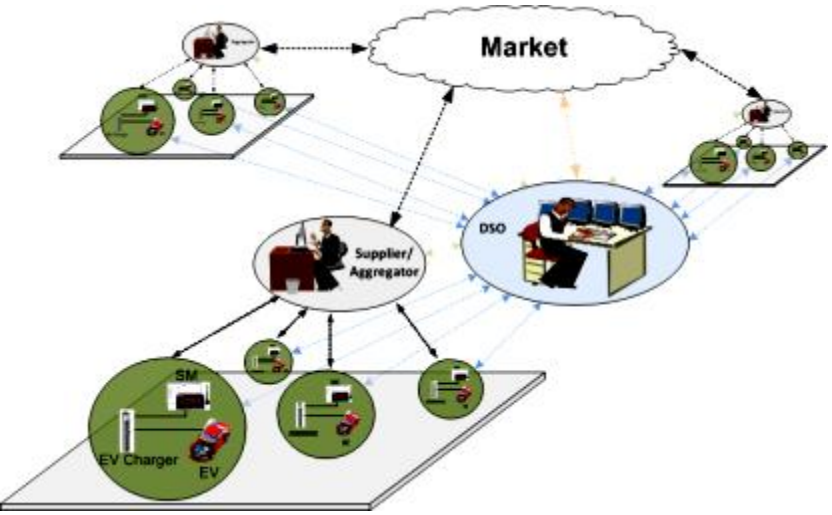
Behaviours defined according to the findings of a survey made within the framework of the MERGE project

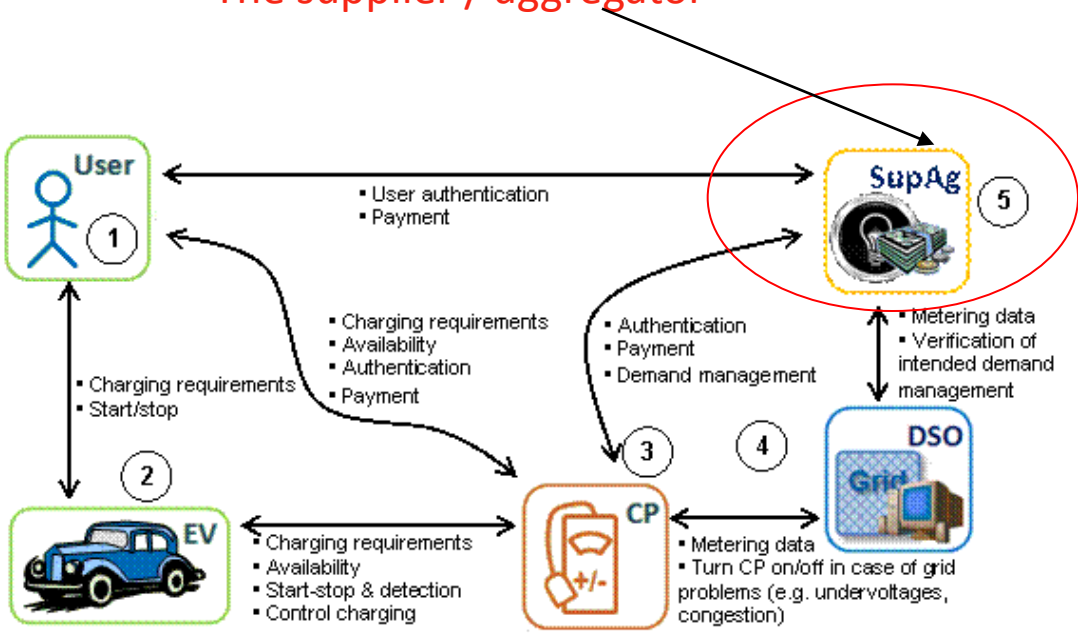
Technical Challenges – Integrated Management of EV and RES



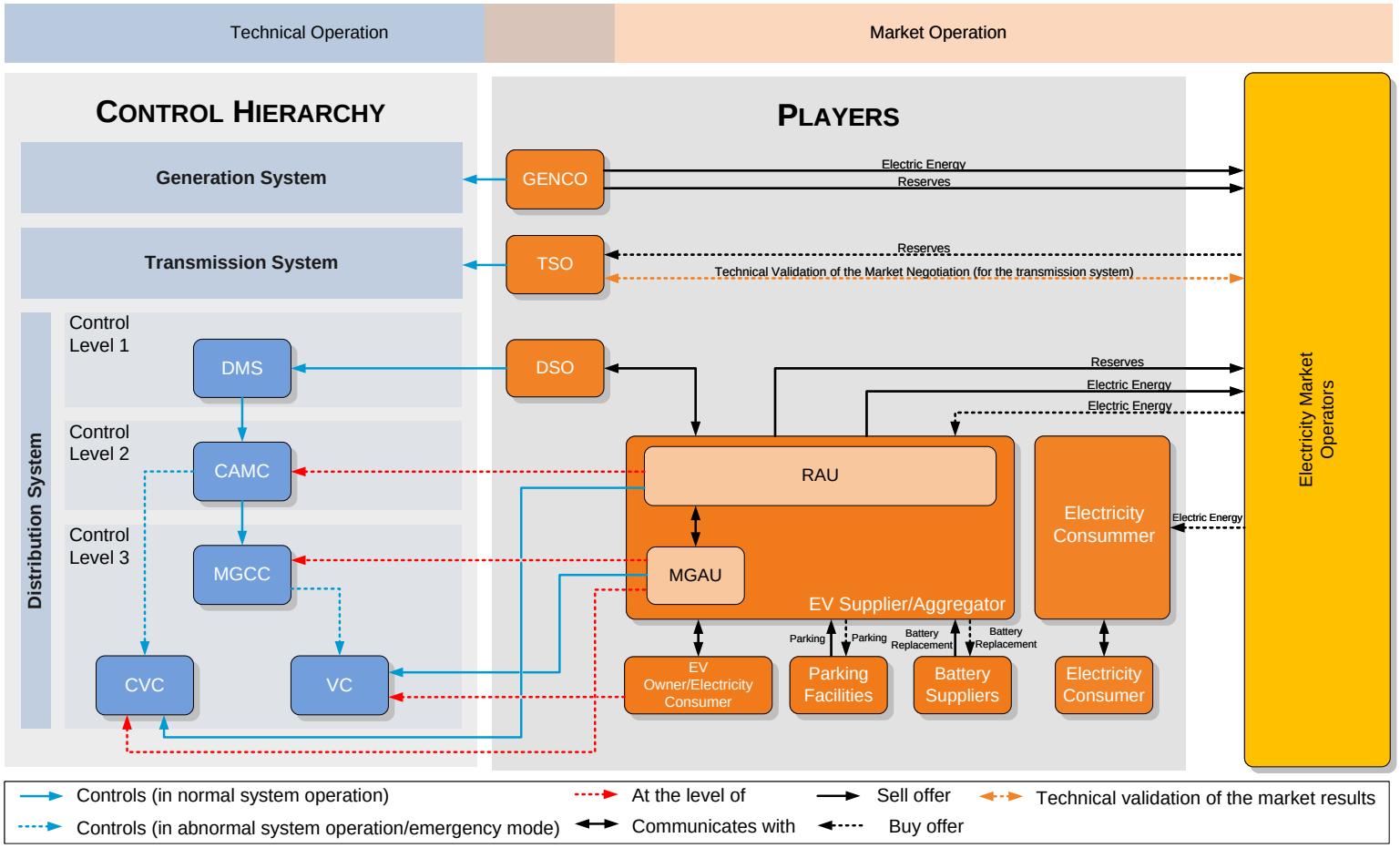
Conceptual Framework for EV Integration Into Electric Power Systems - Overview of the different information flows

An ICT model needs to be developed, identifying the involved parties and the associated information flows.



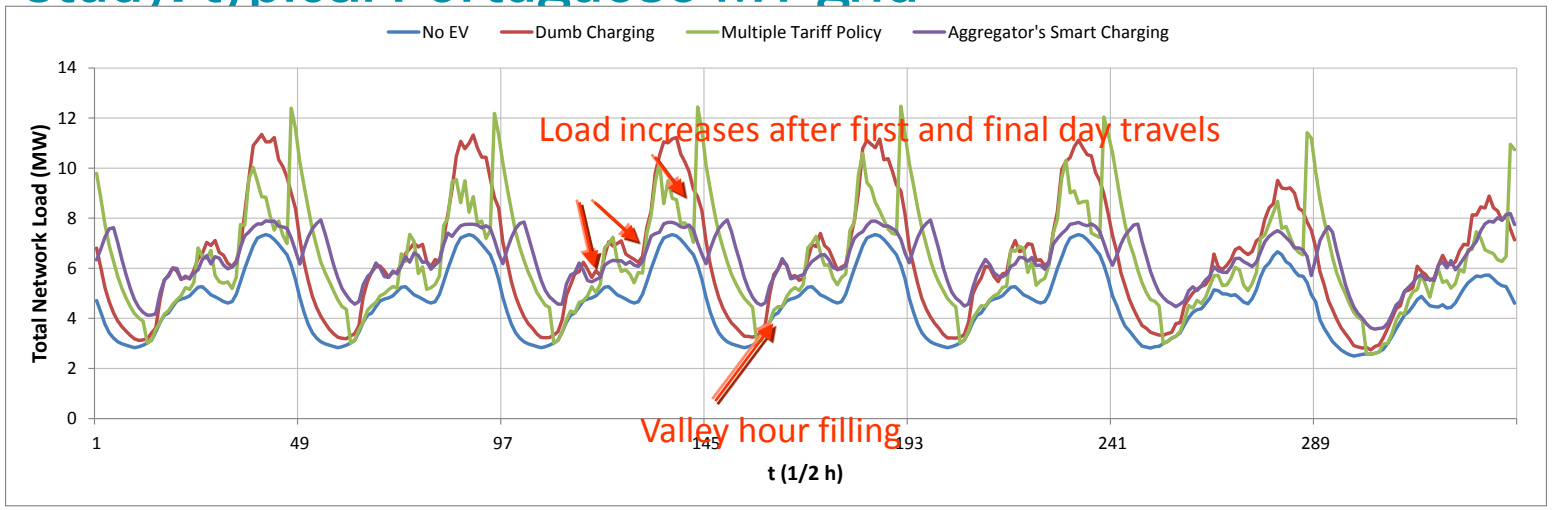


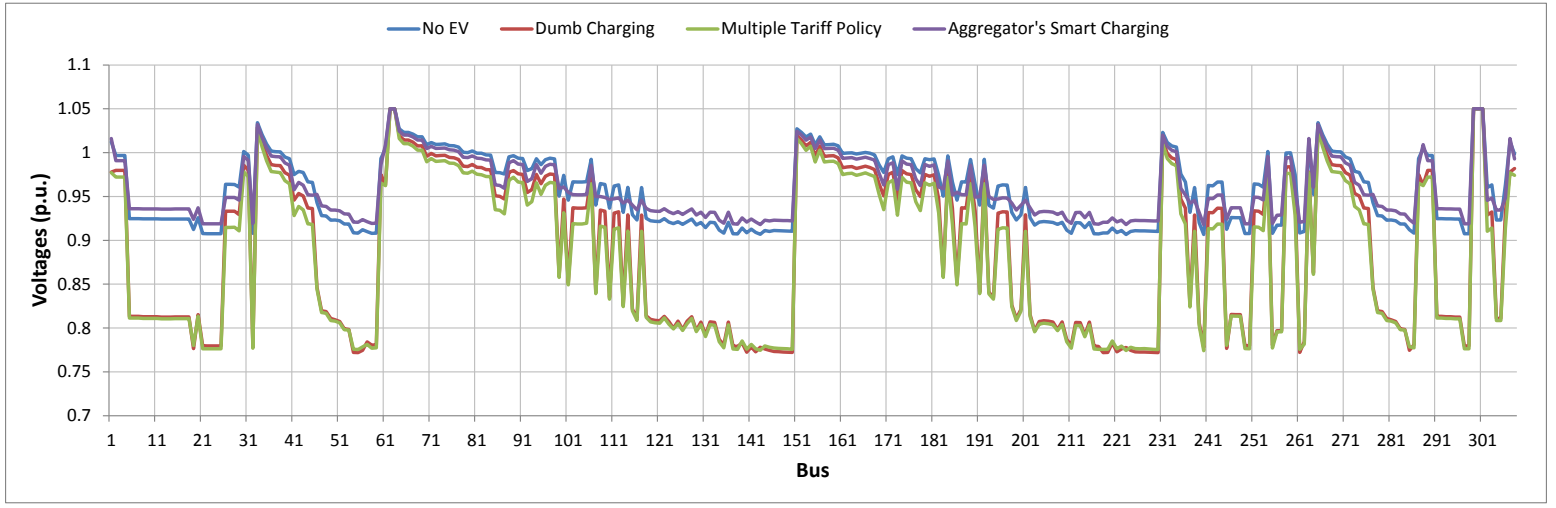
Conceptual Framework for EV Integration Into Electric Power Systems - Interconnected systems



DMS – Distribution Management System CAMC – Central Autonomous Management System MGCC – MicroGrid Central Controller CVC – Cluster of Vehicles Controller VC – Vehicle Controller

Evaluation of EV Impacts in Distribution Networks – Case study: typical Portuguese MV grid



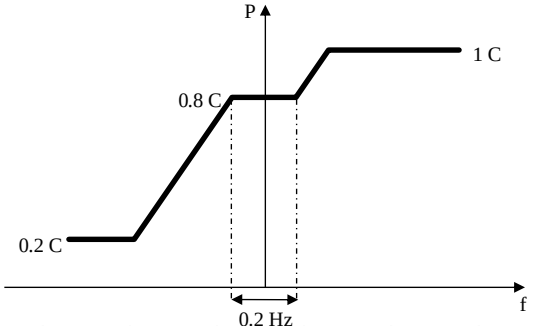


Reserve Provision with EV

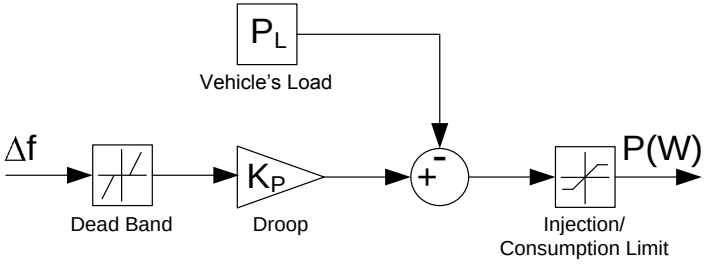
Local Droop Control and Automatic Generation Control (AGC)

PRIMARY FREQUENCY CONTROL

Droop Control for EV

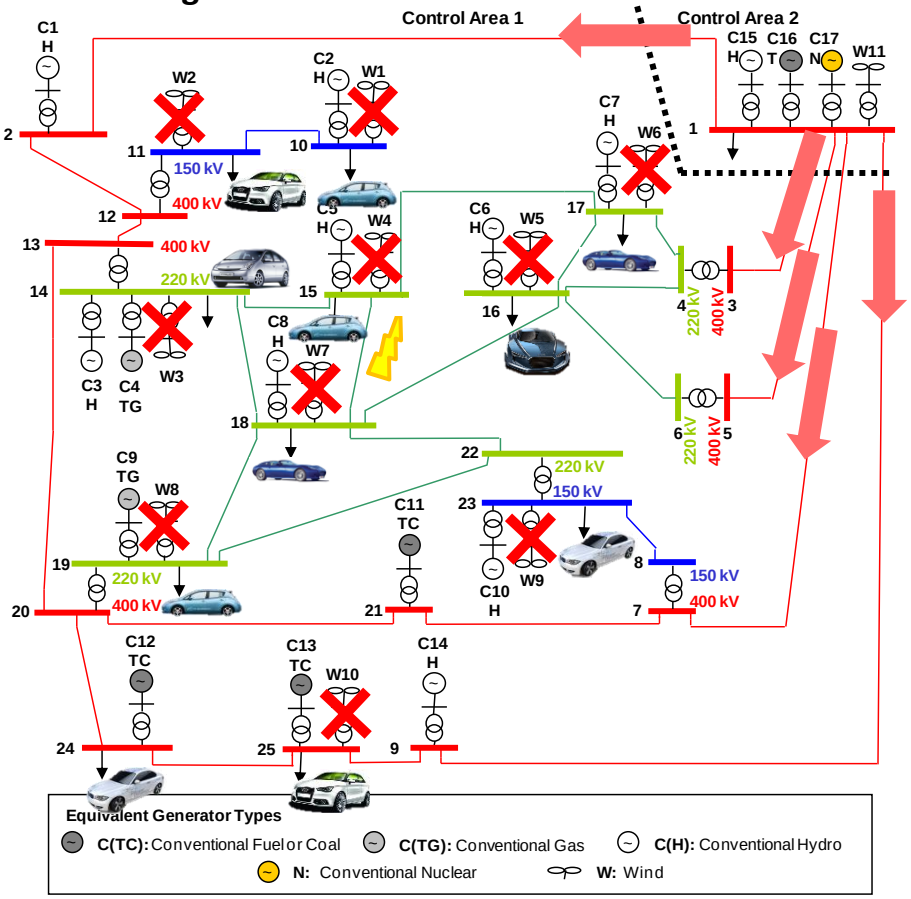


Control loop for EVs active power set-point



SECONDARY FREQUENCY CONTROL

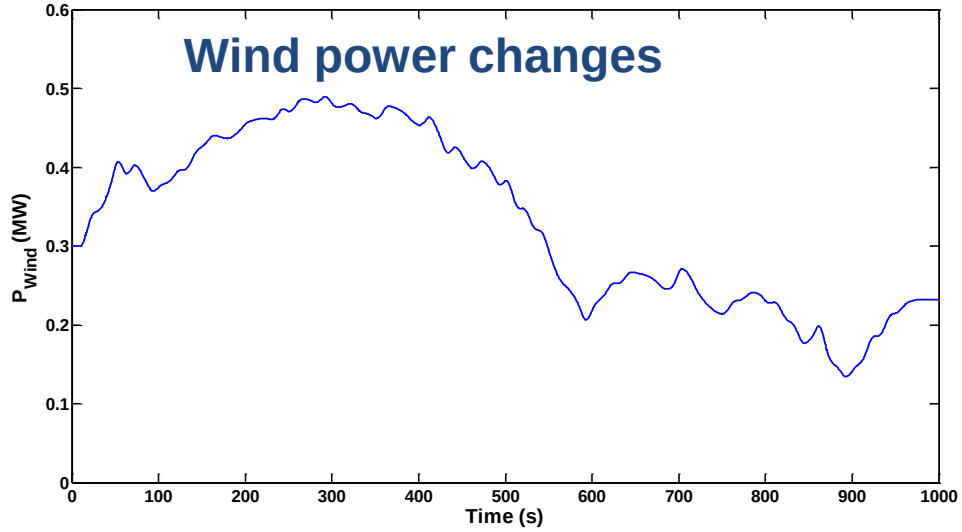
Simplified Portuguese Transmission Network

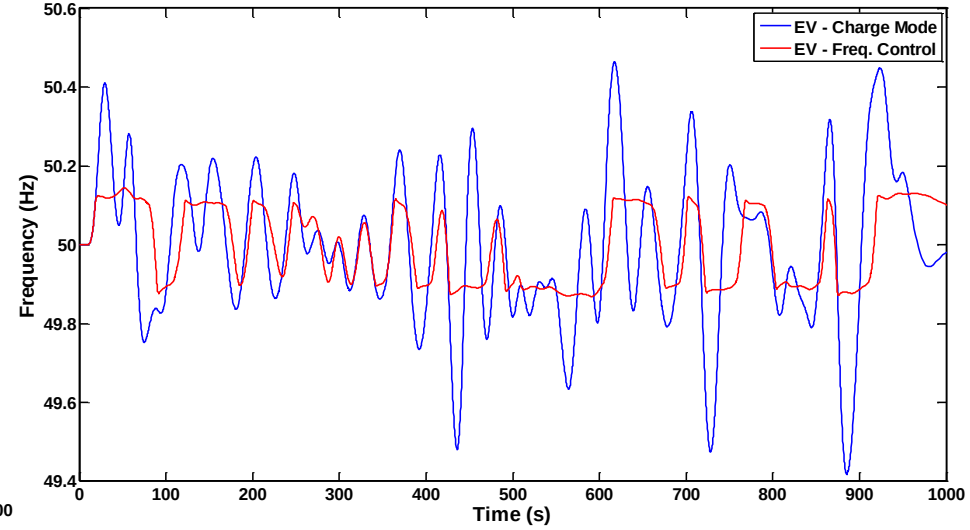


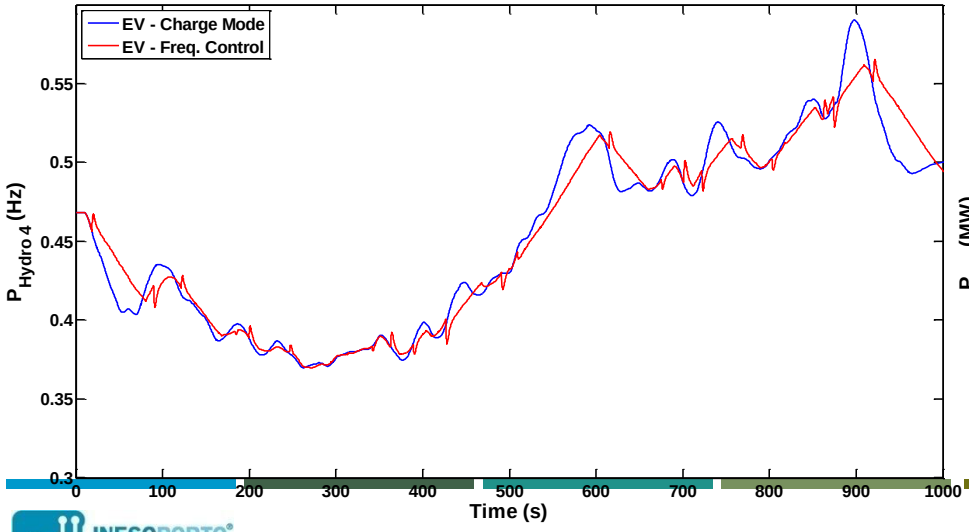
RES variability and grid disturbances that involve specific RES unit behavior will be easily accommodated through the response of flexible EV charging

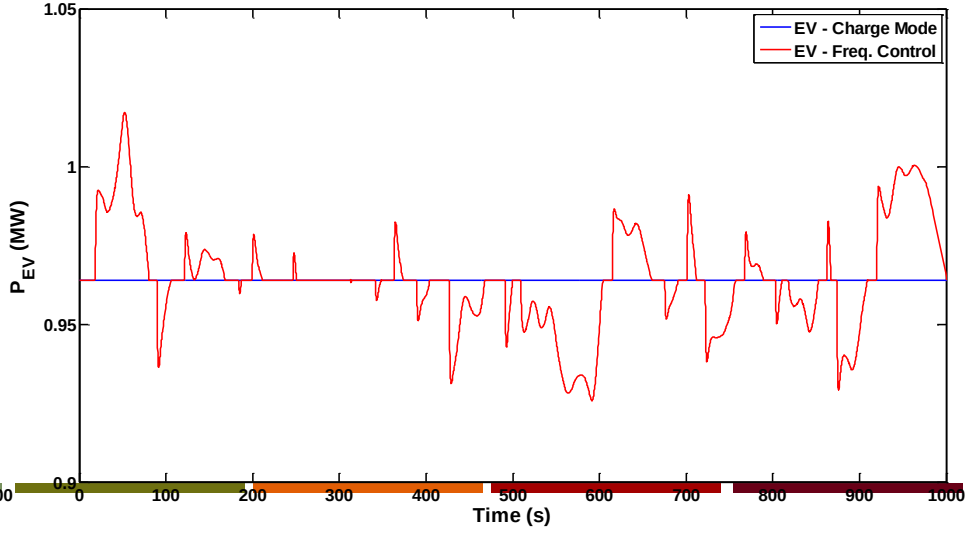
Reserve Primary Reserve

Frequency Control with EV



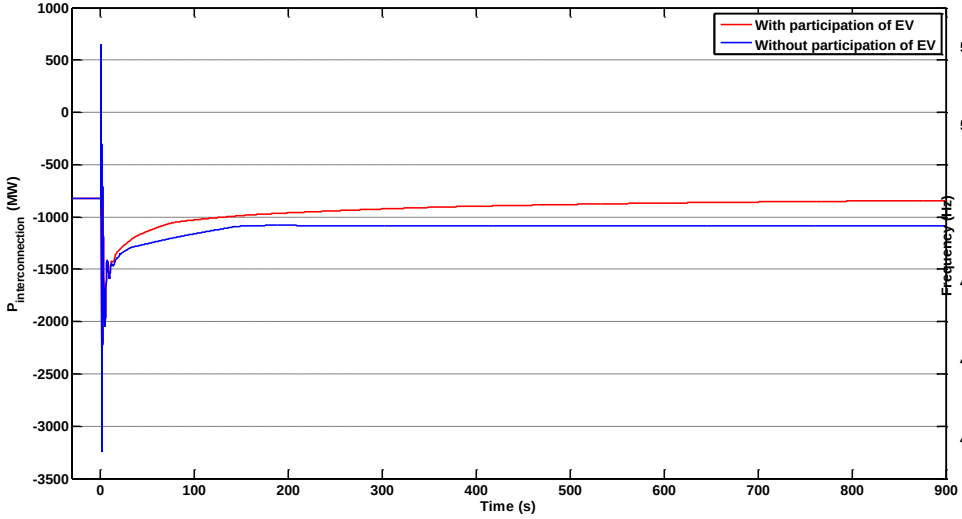


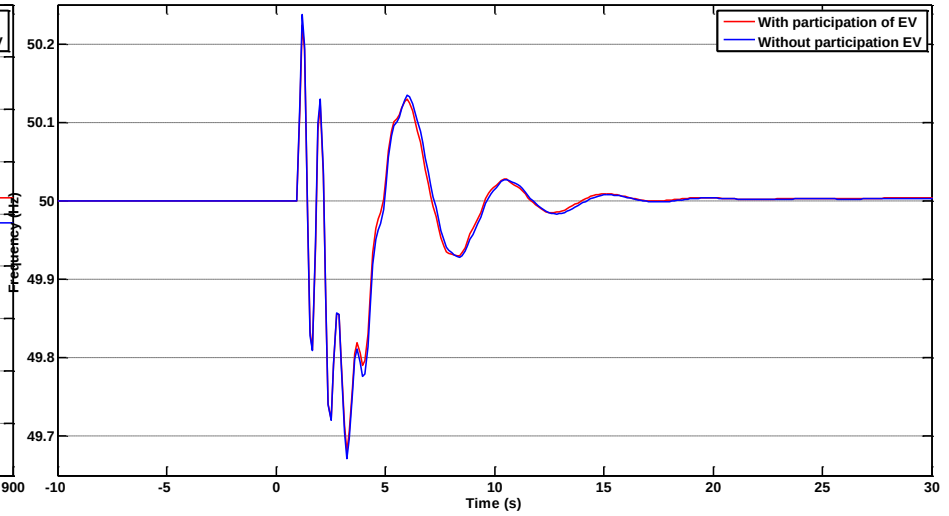


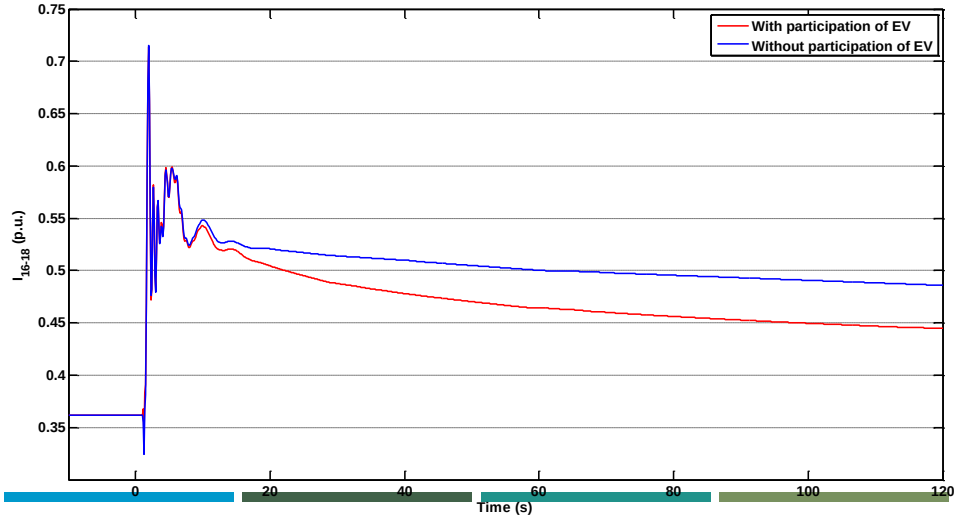


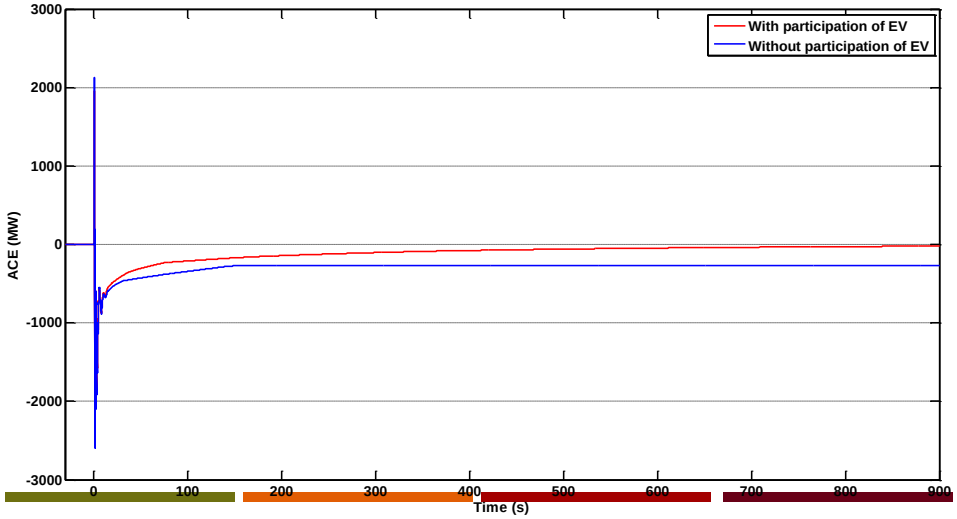
Secondary Reserve

AGC Operation with EV

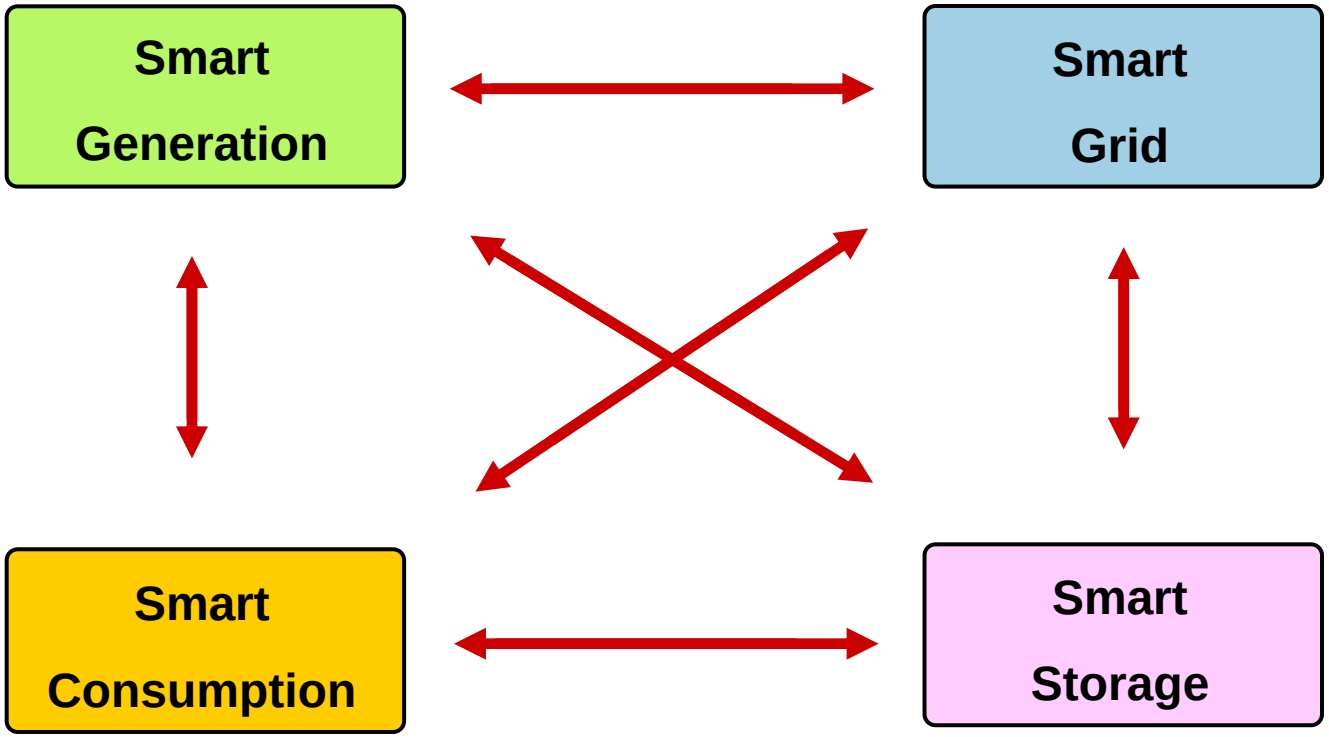








Smart Players



The success of the shift requires:

Smart Regulation

- New challenges for the Regulator:
  - Define rules for flexibility
  - These rules should ensure the supply of sufficient flexibility resources:
  - Calculate the value of flexibility
  - Quantify the needs for flexibility

  - **A new regulatory framework**
    - Regulate Innovation
    - Existing regulation has enough mechanisms to promote innovation?

CONCLUSIONS

- Smart Grids will be the fundamental **service platform** for future years.

- This service platform will act as a catalyst for current green technologies (e.g., energy efficiency, demand response, distributed storage) and emerging green technologies (e.g., photovoltaic, energy storage, plug-in hybrid electric vehicles).

- The integration, in an efficient way, of large shares of renewable energy sources requires a set of new technical solutions (→ investments that need to be recognized) and new operational rules to be defined.

- Significant Technology risk exists that can be mitigated by a managed development process and pilot deployments (need to be recognized by regulators).

- The presence of Electric Vehicles, if properly managed, can:
  - provide several ancillary services;
  - allow a larger integration of renewable power sources;
  - increase system robustness of operation.