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ELECTRICITY CONSUMPTION ANALYSIS & ENERGY EFFICIENCY

INSTITUTO POLITÉCNICO DO PORTO
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First ELECON Workshop
Towards Efficient European and Brazilian Electricity Markets

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ISEP, Porto, Portugal

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Energy Resource Management in Smart Grids

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Outline

- **Short-term Energy Resource Management**
- **Problem formulation**
- **Case study**

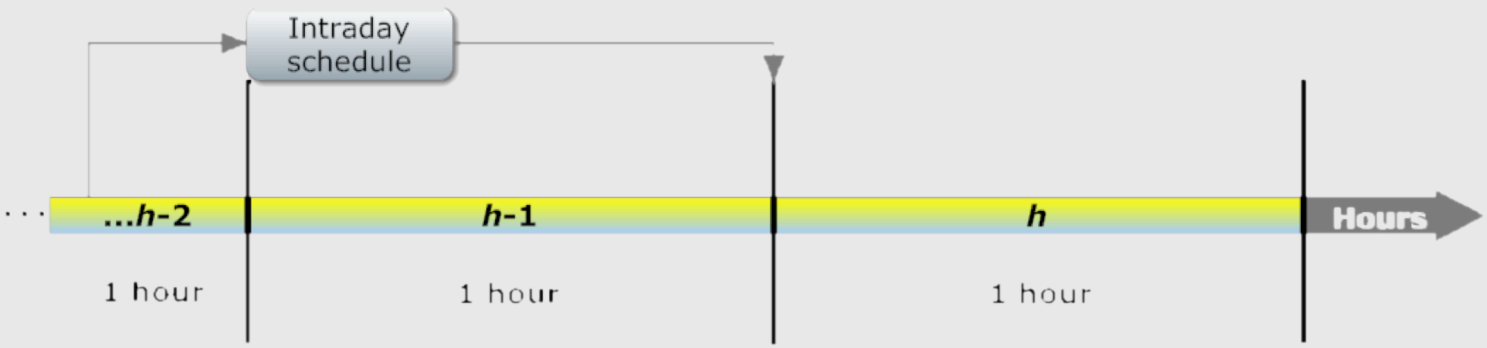
Energy resource management

- **Methodology to support Virtual Power Players (VPPs) in efficient short-term Energy Resource Management (ERM)**

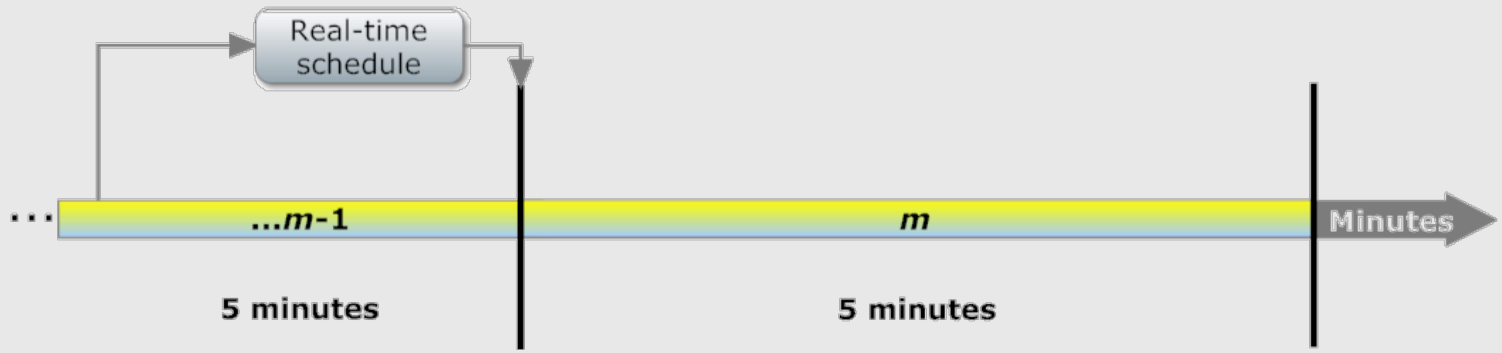
- **Developing a short-term ERM methodology for:**
  - Hour-ahead scheduling — Considering the influence of the day-ahead results
  - Real-time scheduling — 5 minutes of anticipation, taking into account the hour-ahead results and the most recent forecasts

- **The main objective is solve the short-term optimal scheduling:**
  - Maximizing the VPPs profit
  - Test the impact of the intermittent behavior of the large wind farm

- **Hour-ahead scheduling:**
  - The best scheduling for the next hour, taking into account the day-ahead scheduling and the most updated forecasts for the renewable resources and for the consumption (24 periods of one hour)



- **Real-time scheduling:**
  - Considering the influence of the hour-ahead scheduling. In this phase, only the resources that are connected to the network are considered (12 periods per hour)



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Problem formulation

- **Mathematical formulation has been used in the ERM**

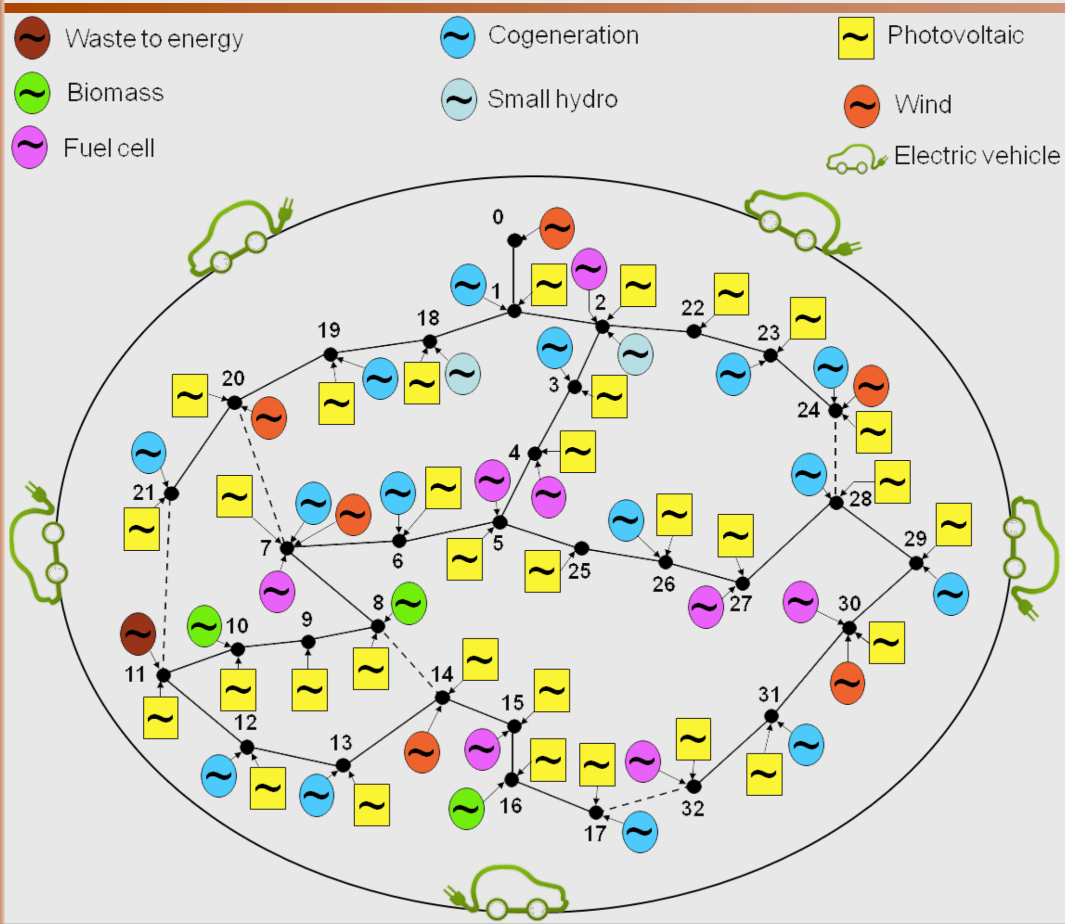
Objective Function

$$
\text{Maximize } f = \underbrace{\left(\begin{array}{l} \underbrace{MP_{Sell(t)} \times P_{Sell(t)}}_{\text{Energy sold to the market}} + \\ \underbrace{\sum_{L=1}^{N_L} MP_{Load(L,t)} \times P_{Load(L,t)}}_{\text{Consumption}} + \\ \underbrace{\sum_{ST=1}^{N_{ST}} MP_{Ch(ST,t)} \times P_{Ch(ST,t)}}_{\text{Storage charge}} + \\ \underbrace{\sum_{V=1}^{N_V} MP_{Ch(V,t)} \times P_{Ch(V,t)}}_{\text{Vehicles charge}} \end{array} \right)}_{\text{Income}} - \underbrace{\left(\begin{array}{l} \underbrace{\sum_{DG=1}^{N_{DG}} c_{DG(DG,t)} \times P_{DG(DG,t)}}_{\text{Distributed generation}} + \underbrace{\sum_{SP=1}^{N_{SP}} c_{SP(SP,t)} \times P_{SP(SP,t)}}_{\text{External suppliers}} + \\ \underbrace{\sum_{ST=1}^{N_{ST}} c_{Dch(ST,t)} \times P_{Dch(ST,t)}}_{\text{Storage discharge}} + \underbrace{\sum_{V=1}^{N_V} c_{Dch(V,t)} \times P_{Dch(V,t)}}_{\text{Vehicles discharge}} + \\ \underbrace{\sum_{L=1}^{N_L} c_{Cut(L,t)} \times P_{Cut(L,t)}}_{\text{DR load curtailment}} + \underbrace{\sum_{L=1}^{N_L} c_{Red(L,t)} \times P_{Red(L,t)}}_{\text{DR load reduction}} + \\ \underbrace{\sum_{L=1}^{N_L} c_{NSD(L,t)} \times P_{NSD(L,t)}}_{\text{Non-supplied demand}} + \underbrace{\sum_{DG=1}^{N_{DG}} c_{GCP(DG,t)} \times P_{GCP(DG,t)}}_{\text{Generation curtailed power}} \end{array} \right)}_{\text{Operation Cost}}
$$

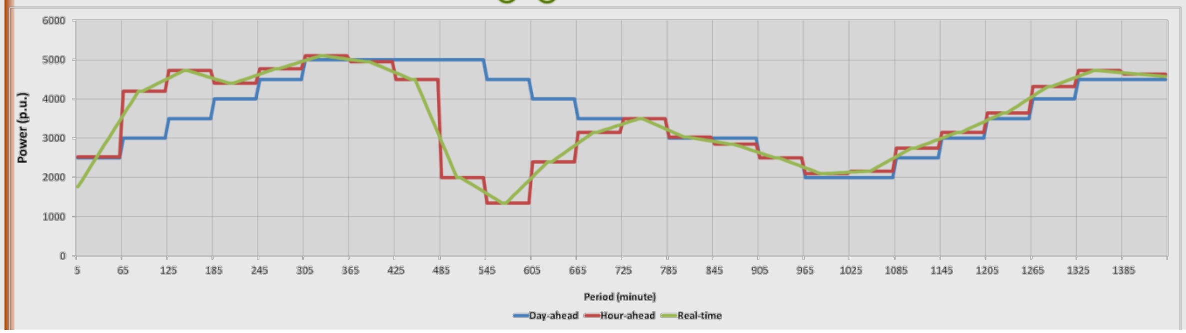
Problem formulation

- **Network active and reactive power balance equations**
- **Voltage magnitude and angle limits**
- **Line thermal limit**
- **Limits of resources:**
  - DG units
  - Storage units
  - electric vehicles
  - external suppliers
  - Demand response reduction and curtailment

Case study



- 33 bus distribution network
- 66 DG units
- 7 storage units
- 218 consumers
- 2000 Electric vehicles
- 1 large wind farm
- 10 external suppliers



Forecast of large wind farm generation

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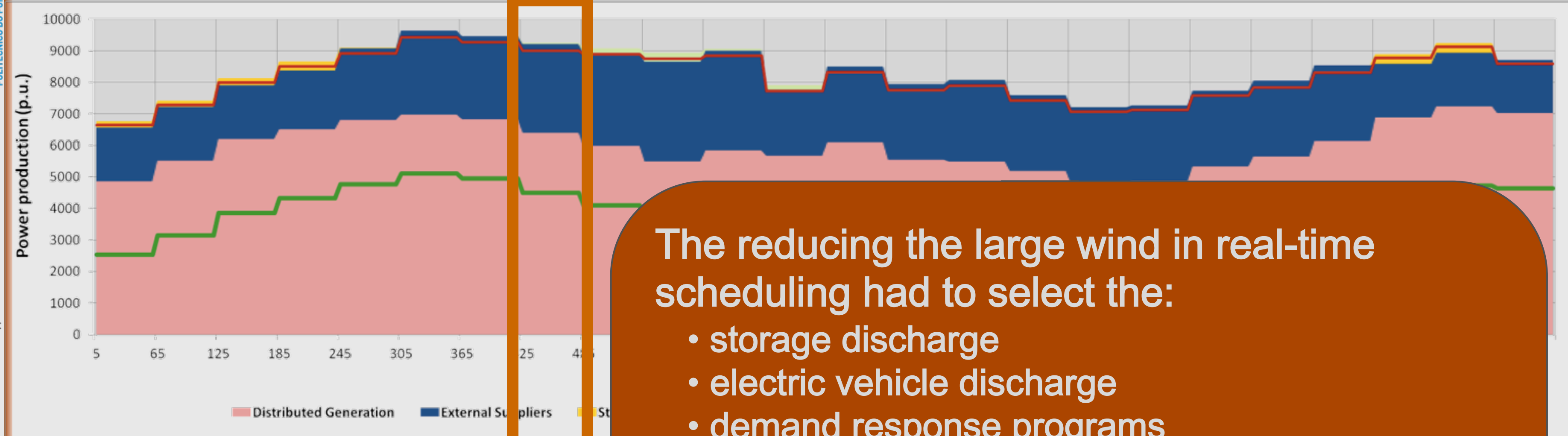
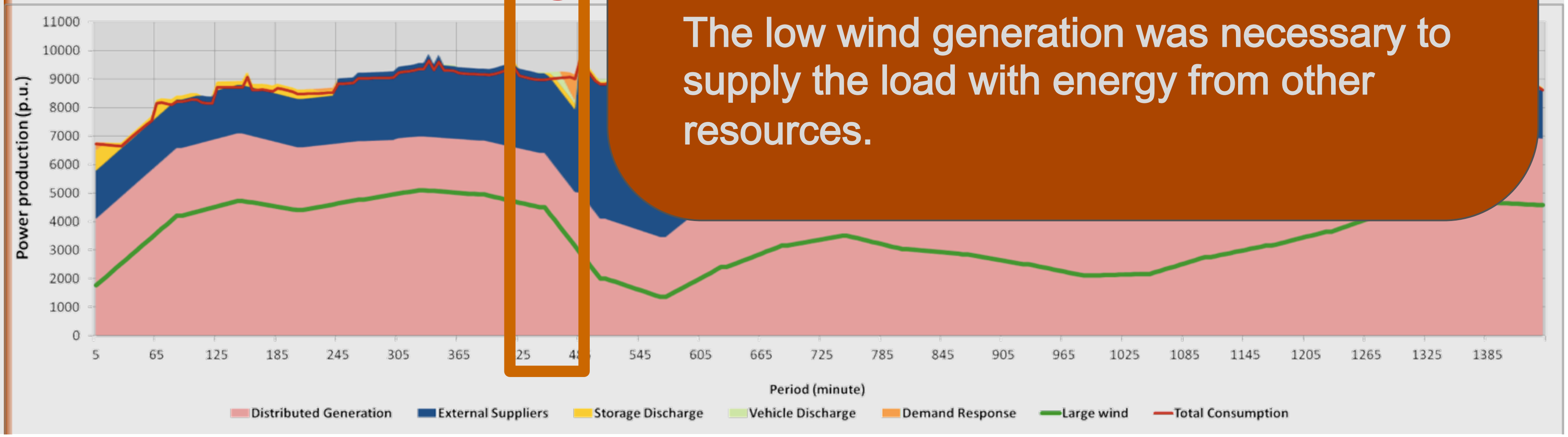
Case study

- **Hour-ahead scheduling**



- **Real-time scheduling**



The reducing the large wind in real-time scheduling had to select the:

- storage discharge
- electric vehicle discharge
- demand response programs

The low wind generation was necessary to supply the load with energy from other resources.

Case study

- **Results**
  - The income keeps approximately equal in the three phases, even when unexpected changes in the large wind generation are considered

	Scheduling		
	Day-ahead	Hour-ahead	Real-time
Income (m.u.)	25 171	25 592	25 746
Cost (m.u.)	16 506	17 022	17 178
Profit (m.u.)	8 665	8 570	8 568

  - The cost increased significantly from the day-ahead scheduling to the hour-ahead scheduling, leading to a reduction in the VPP's profit

Related publications

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Marco Silva, Hugo Morais, Zita Vale
Real-time energy resources scheduling considering intensive wind penetration
European Wind Energy Association 2012 (EWEA 2012)
Copenhagen, Denmark, 16-19 April 2012

Marco Silva, Hugo Morais, Pedro Faria, Zita Vale
Short-Term Scheduling Considering Five-minute and Hour-ahead Energy Resource Management
IEEE Power and Energy Society General Meeting 2012
San Diego, CA, USA, July 22 - 26, 2012

Marco Silva, Tiago Sousa, Hugo Morais, Zita Vale
Real-time Energy Resources Scheduling Considering Short-term and Very Short-term Wind Forecast
11th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants (WIW12)
Lisbon, Portugal, 13-15 November, 2012

Marco Silva, Hugo Morais, Tiago Sousa, Zita Vale
Energy resources management in three distinct time horizons considering a large variation in wind power
EWEA Annual Event 2013 (EWEA 2013)
Vienna, Austria, 4-7 February, 2013

Marco Silva, Hugo Morais, Zita Vale
An integrated approach for distributed energy resource short term scheduling in smart grids considering realistic power system simulation
Energy Conversion and Management, vol. 64, pp. 273-288,
December 2012 (IF: 2.775)

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