

DREAM-GO: the path towards effective short and real-time demand response

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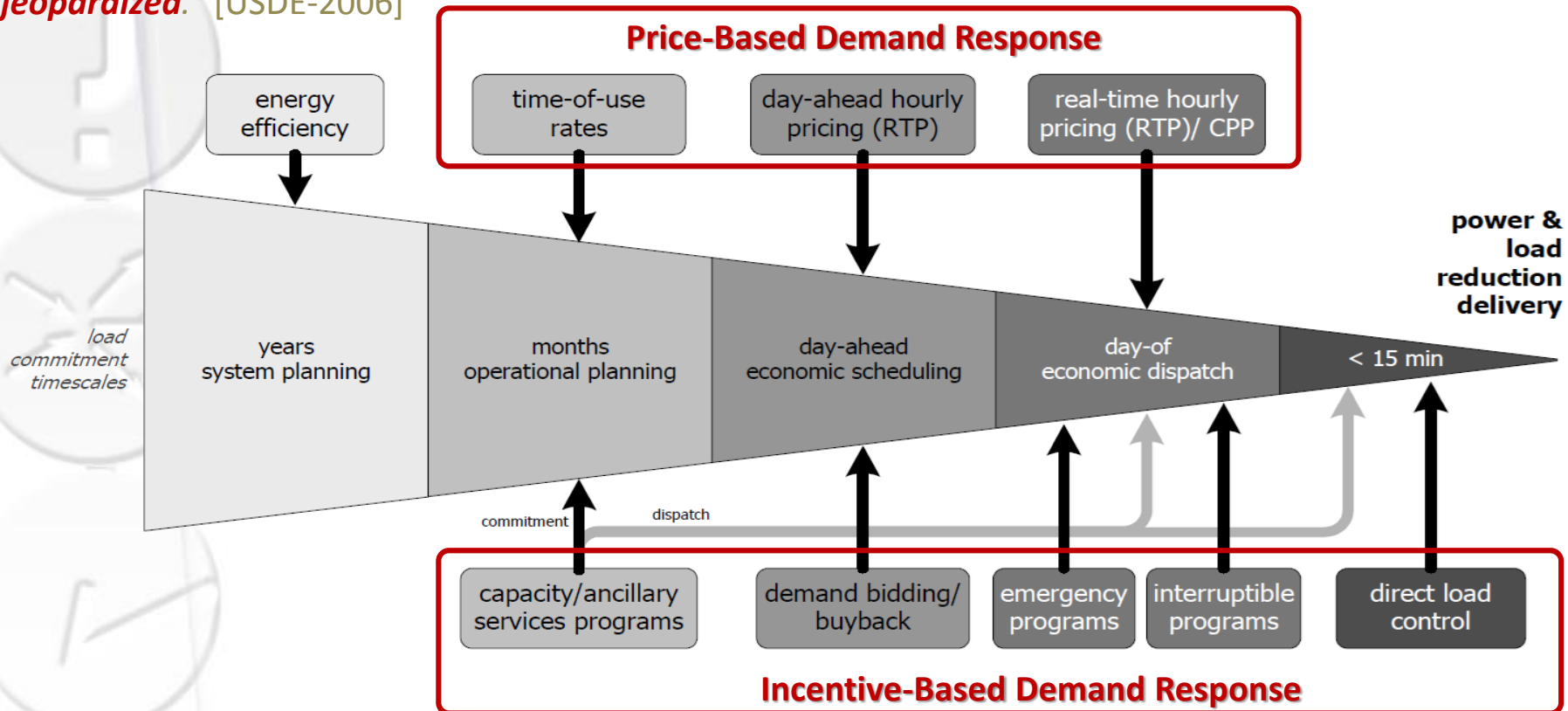
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Zita Vale, Pedro Faria

GECAD - Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development
IPP - Polytechnic of Porto, Portugal

Introduction

*“Changes in electric usage by **end-use customers** from their normal consumption patterns in response to **changes in the price of electricity** over time, or to **incentive payments** designed to induce lower electricity use at times of **high wholesale market prices** or when **system reliability is jeopardized**.” [USDE-2006]*



[USDE-2006] U.S. Department of Energy, “Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them”, USA, February, 2006. Available from: <http://eetd.lbl.gov>

Demand response: Present state



☐ OpenADR

6 types of DR programs:

CPP, Capacity Bidding, Residential Thermostat Program/DLC, Fast DR Dispatch/Ancillary Services, EV DR, and DER DR



☐ ISO/RTO (USA)

Service type:

Energy, Capacity, Reserve, Regulation



*Delivering the energy
needs of today and beyond...*

Summer 2013 (record consumption and use of DR):

18 July, PJM, 1,638 MW

11 September, PJM, 5,949 MW

19 July, ISO-NE, 200 MW (out of 27,359MW)

Demand response: Present state



European Directive Energy Efficiency

DIRECTIVE 2012/27/EU
Art. 15.8

“Member States shall ensure that national energy regulatory authorities encourage demand side resources, such as demand response, to participate alongside supply in wholesale and retail markets”



Regulatory Recommendations for the Deployment of Flexibility Refinement of Recommendations

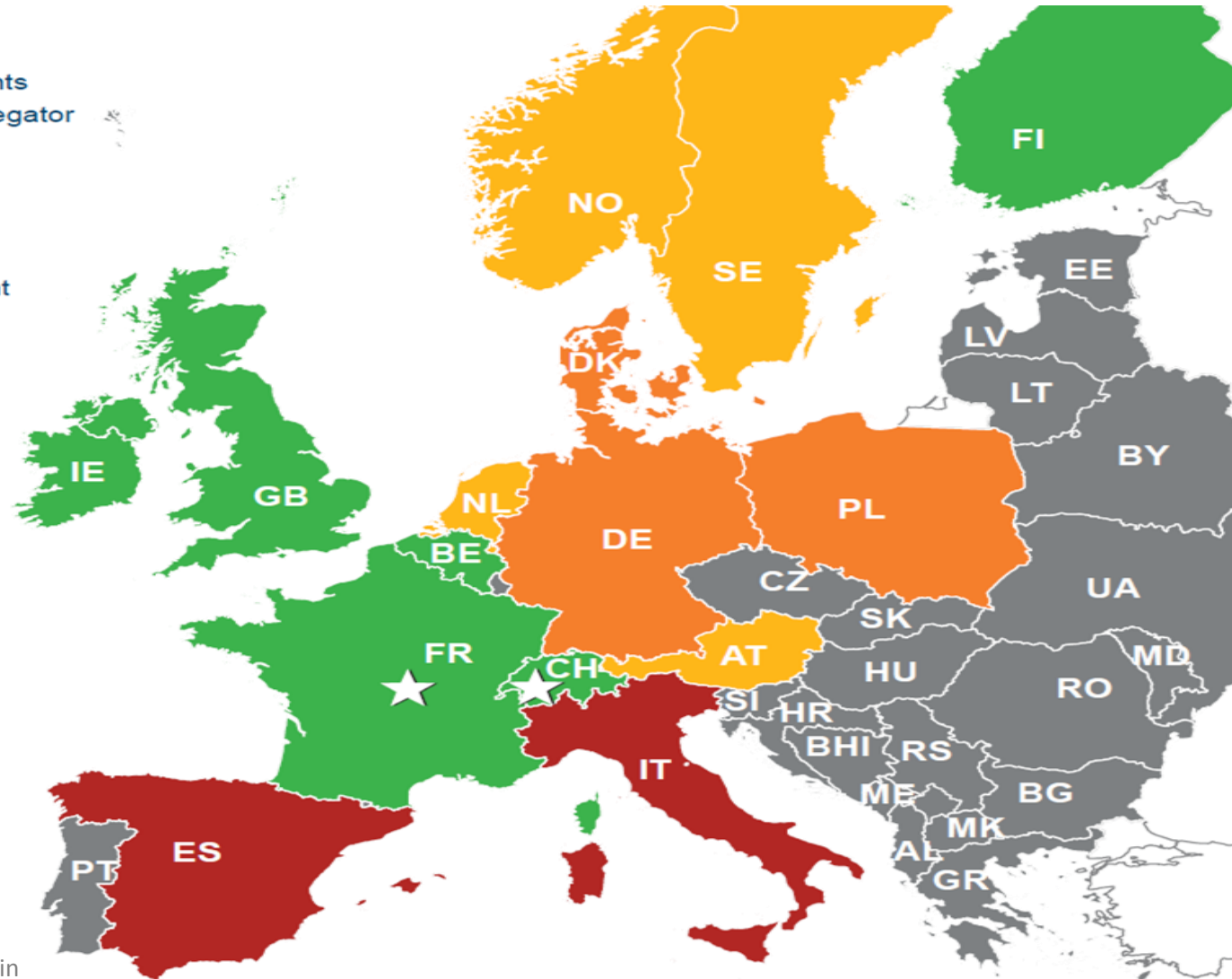


NNEX to EG3 Report

ART GRID TASK FORCE
September 2015

Demand response: Present state

- ★ Commercially active, standardised arrangements between BRP and aggregator in place
- Commercially active
- Partial opening
- Preliminary development
- Closed
- Not assessed



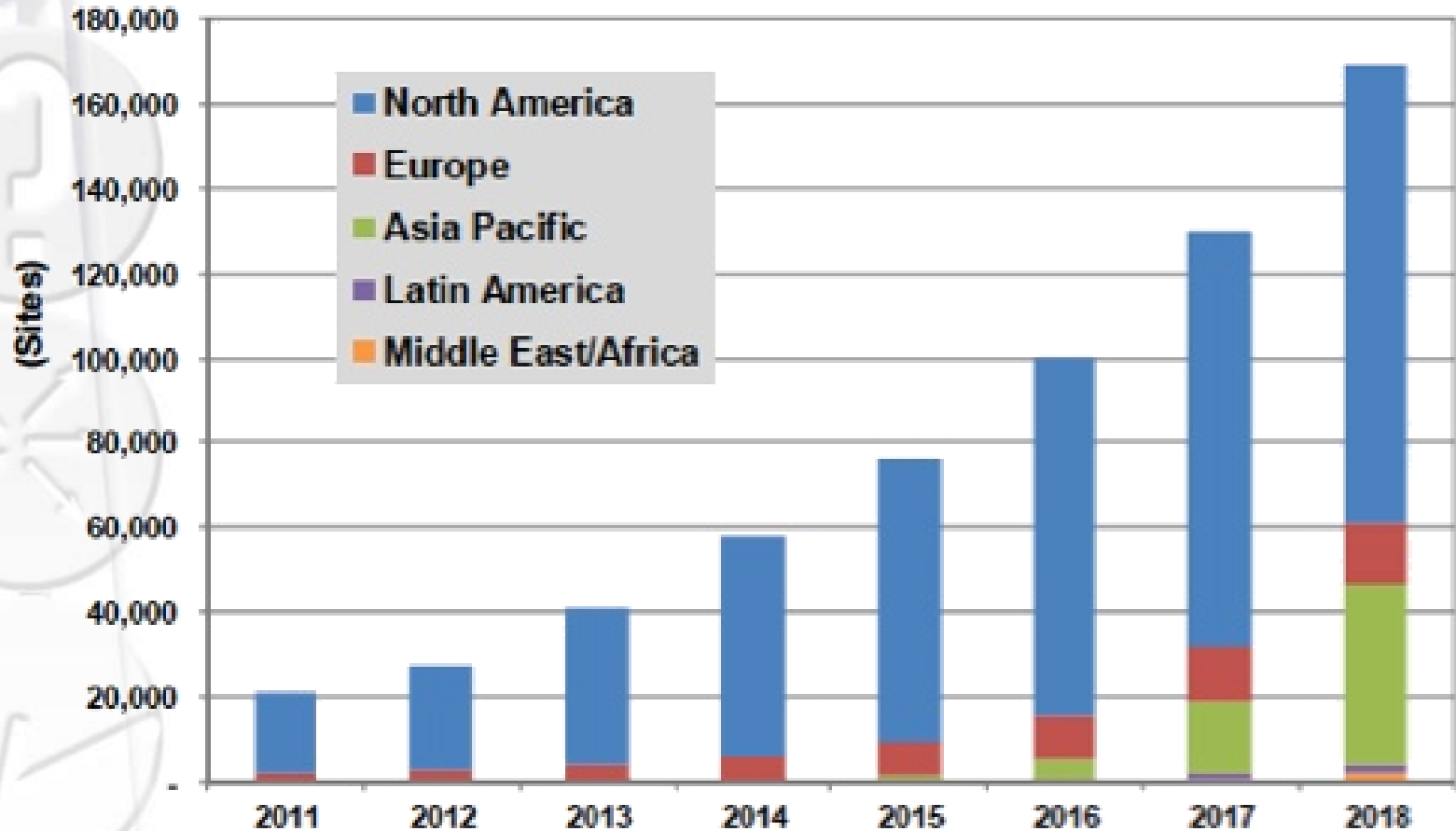
SEDC, "Mapping Demand Response in Europe Today", 2015

Demand response:

Present state ... and the future

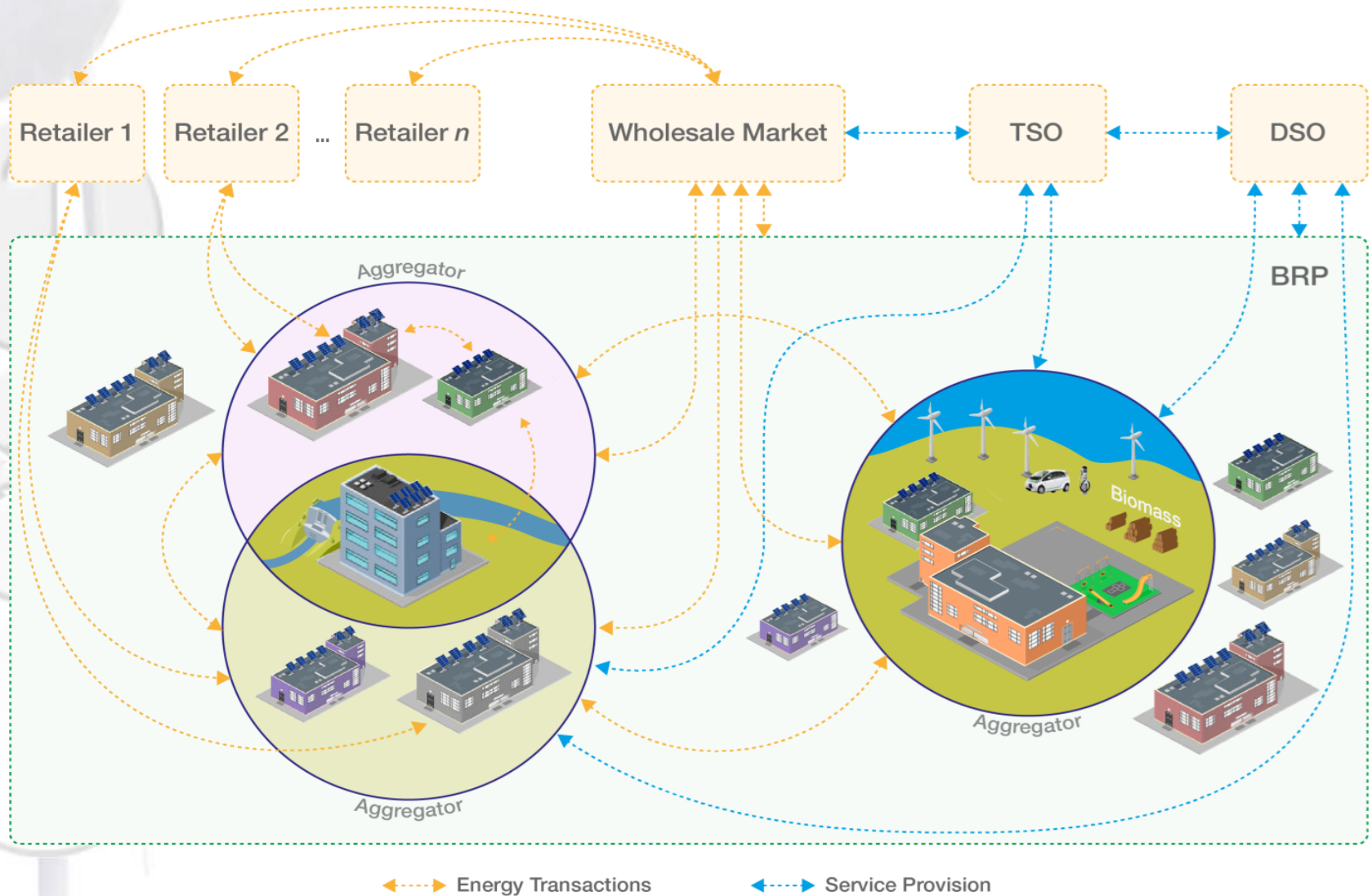


ADR-Enabled Sites by Region, World Markets: 2011-2018

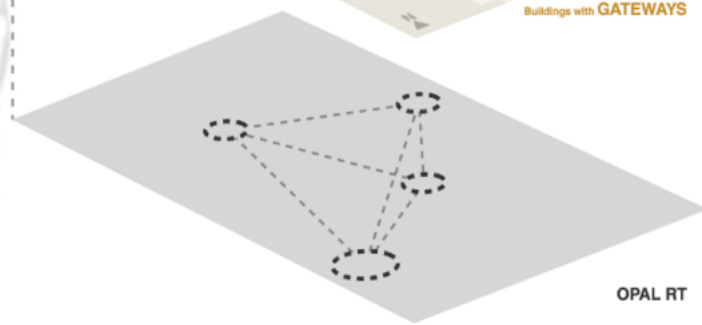
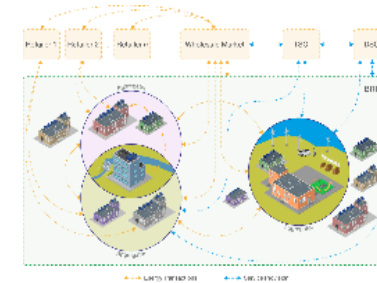
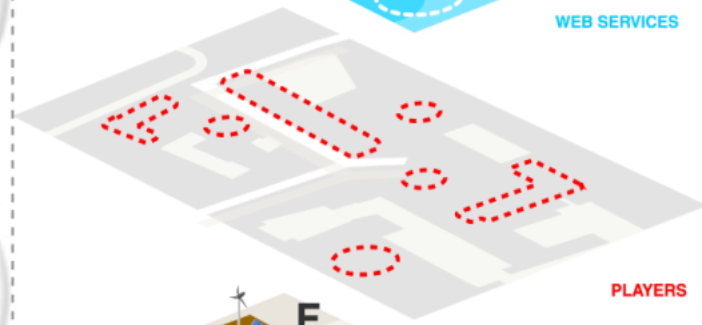
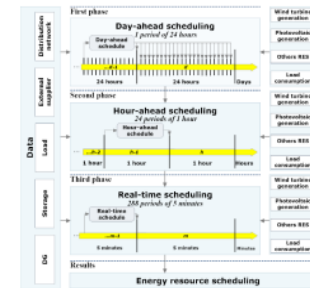


(Source: Pike Research)

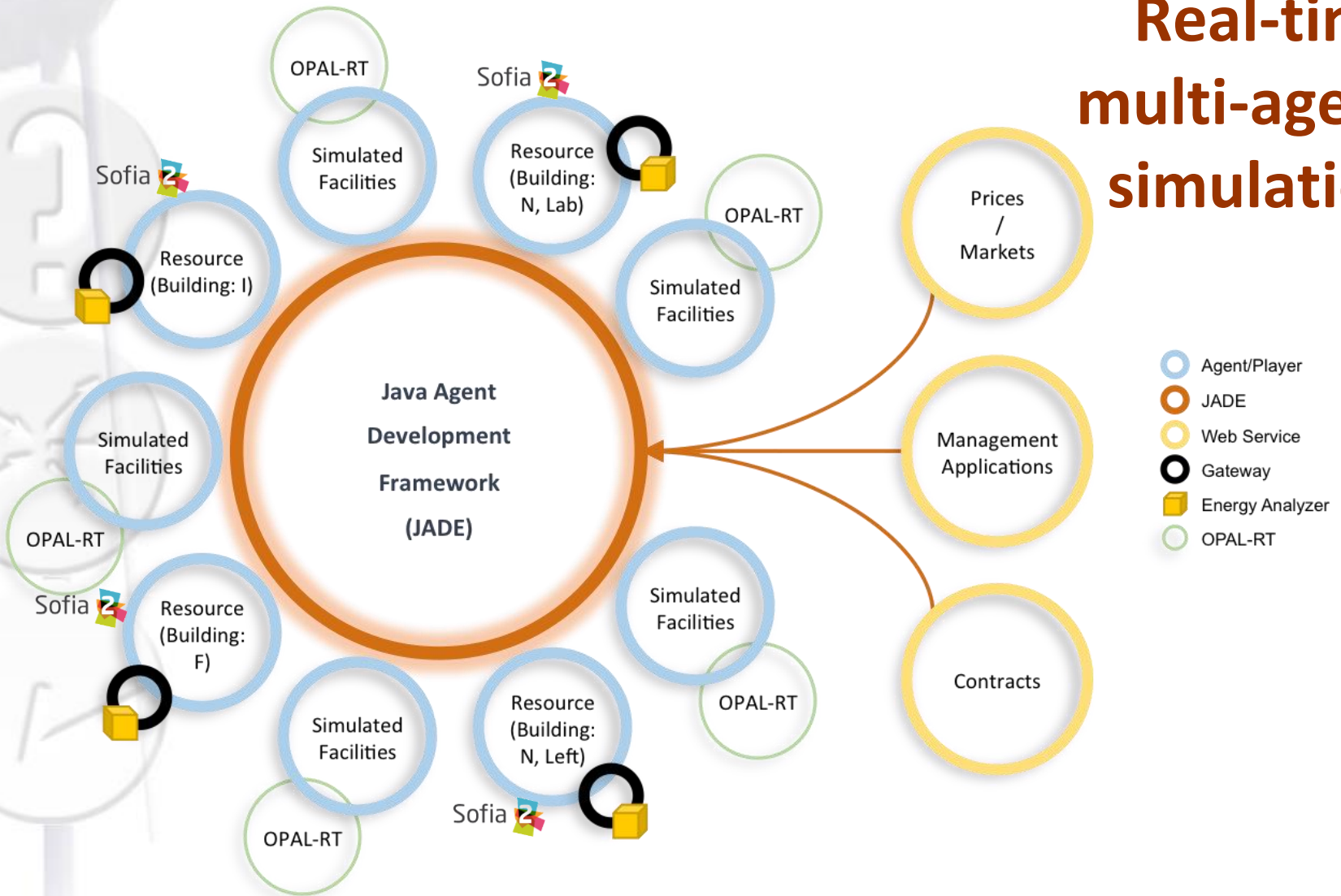
Demand response: A new vision



Demand response: A new vision



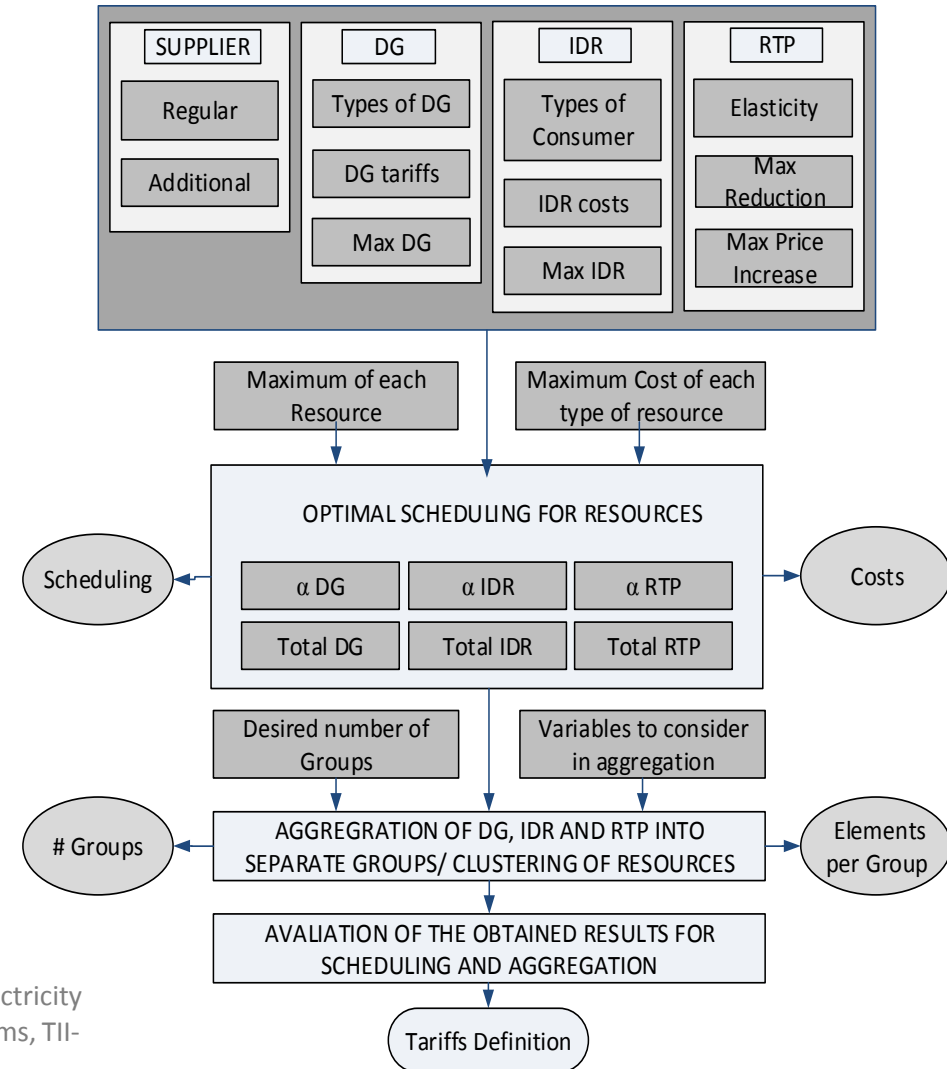
Real-time multi-agent simulation



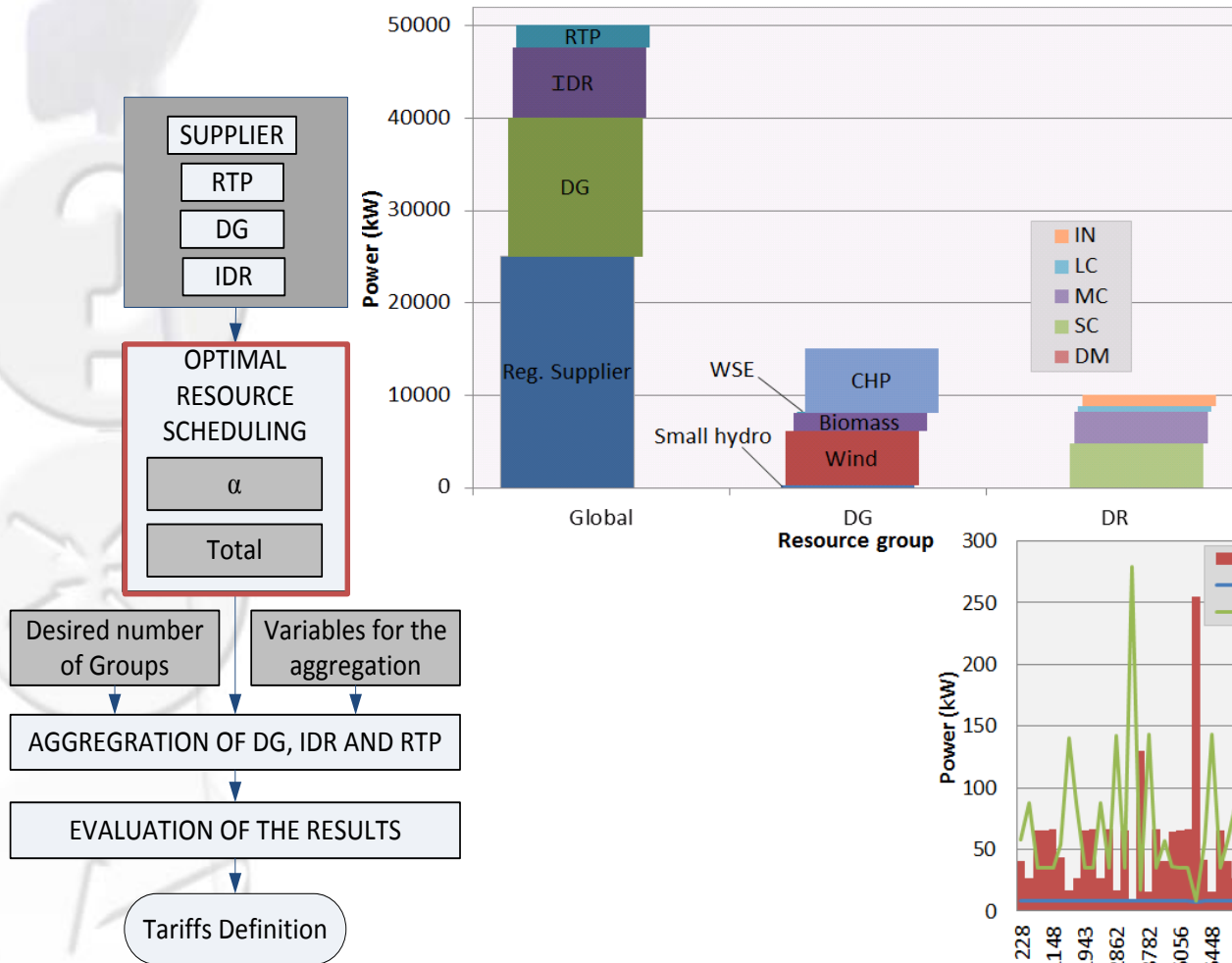
Spreading demand response: an effective approach

■ Wide spreading of Demand Response

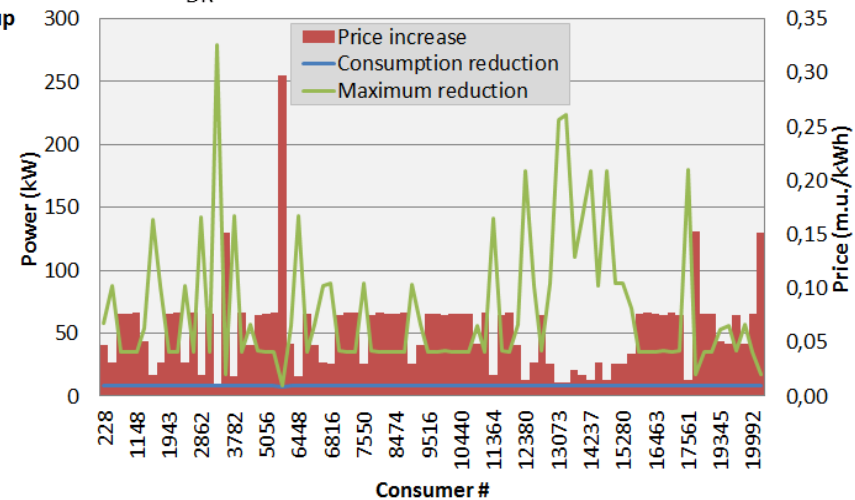
- Business models
- Strategic resource aggregation
- Fair remuneration



Spreading demand response: an effective approach



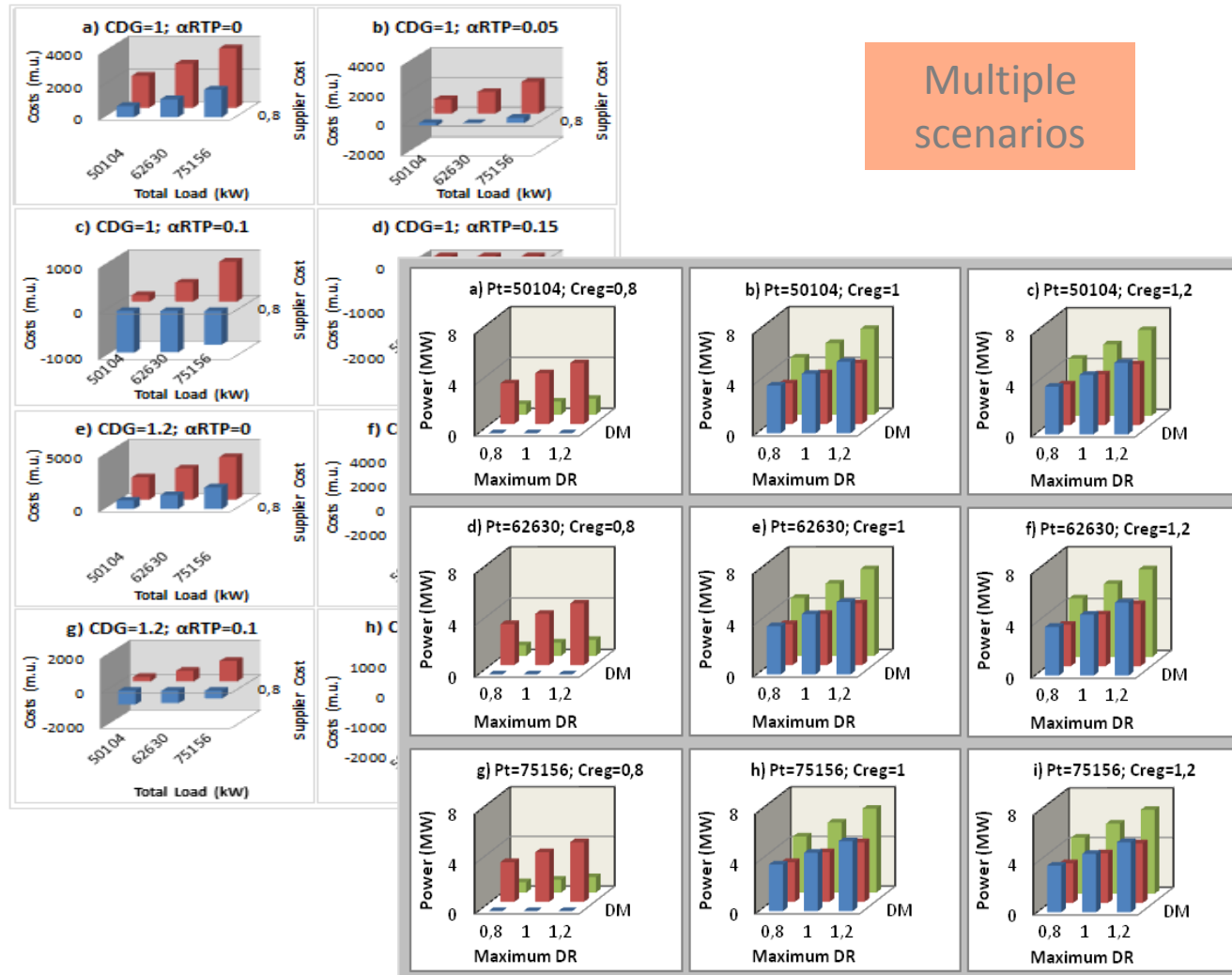
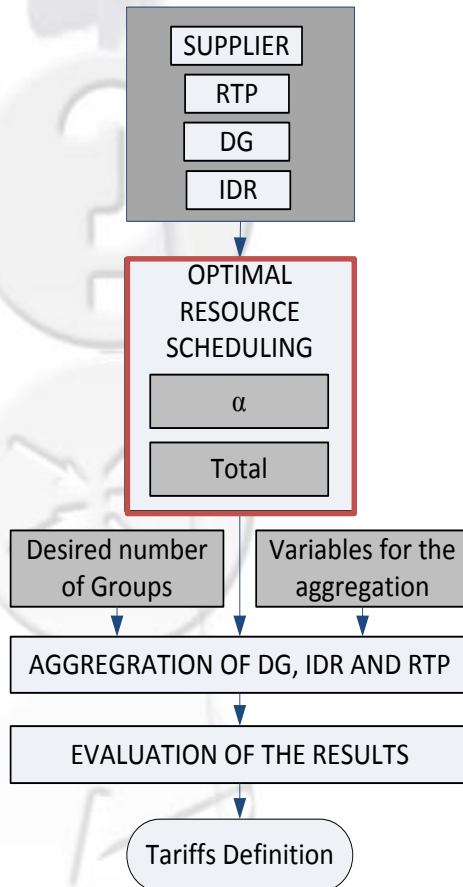
Illustrative scenario



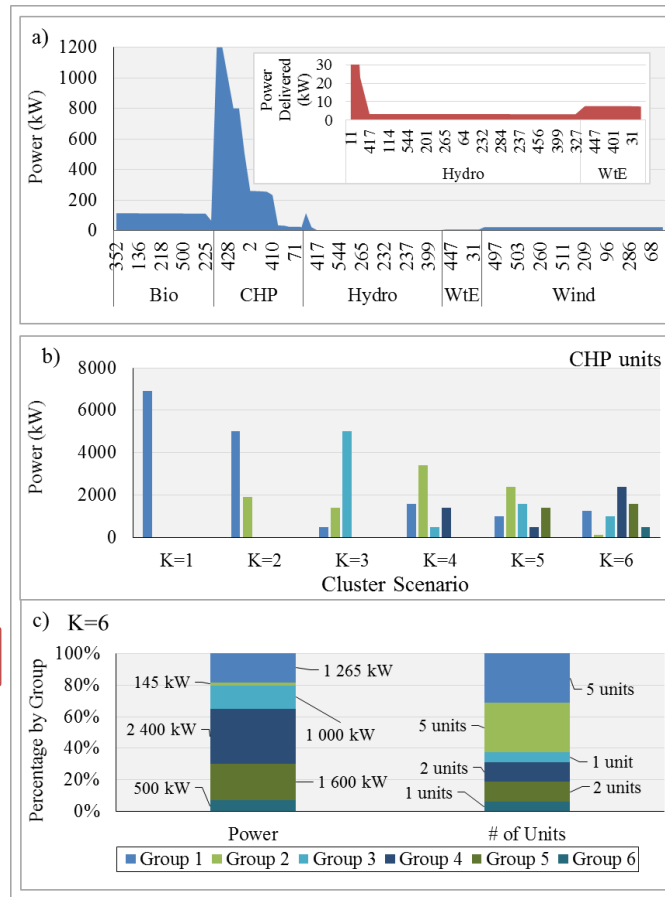
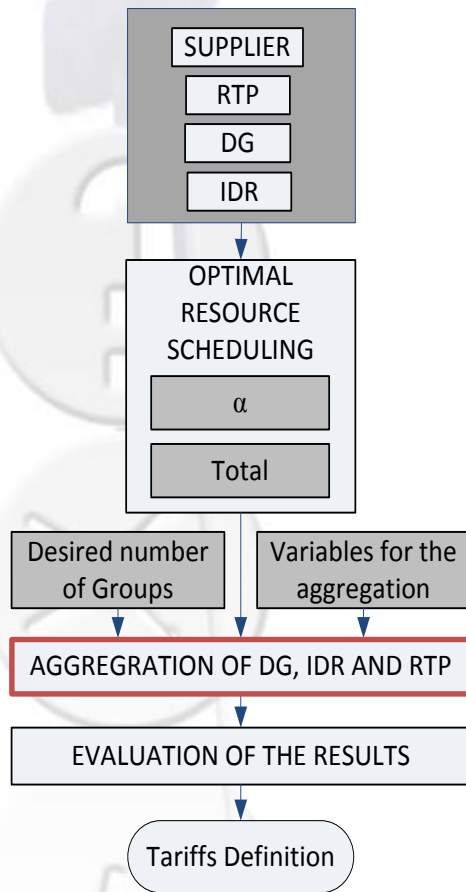
Pedro Faria, João Spínola, Zita Vale, Aggregation and Remuneration of Electricity Consumers and Producers for the Definition of Demand Response Programs, TII-15-0358.R2, 2016

Spreading demand response: an effective approach

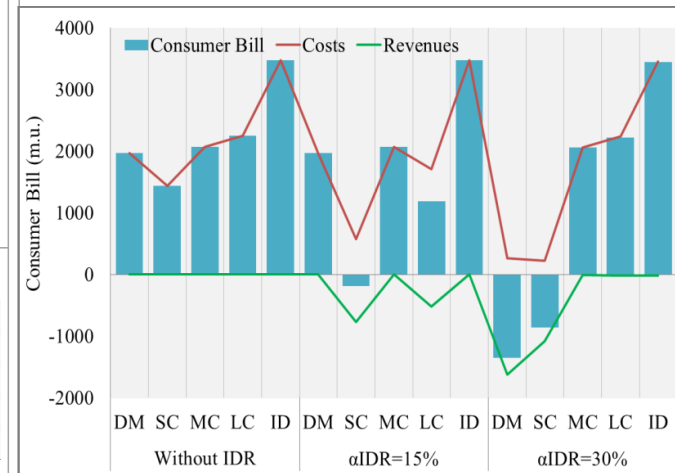
Multiple scenarios



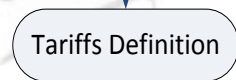
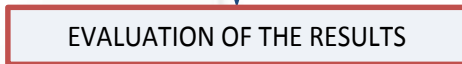
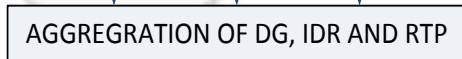
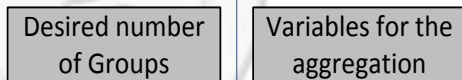
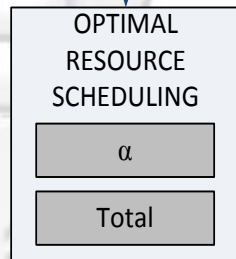
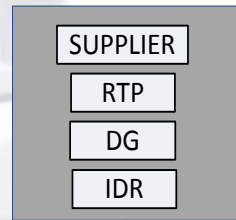
Spreading demand response: an effective approach



Illustrative
scenario



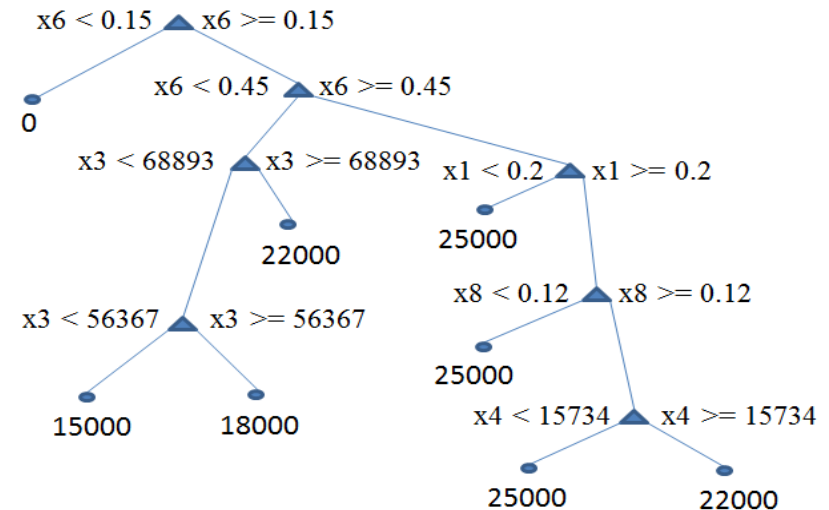
Spreading demand response: an effective approach



Res.	Cluster	Number of clusters					Type	
		1	2	3	4	5		
DG	1	1508	6.20	0.60	1.92	1.24	Wind	480
	2	-	1006	956	4.22	2.95	CHP	8.41
	3	-	-	6.20	0.60	1.92	MSW	3.41
	4	-	-	-	956	0.60	Hydro	10.2
	5	-	-	-	-	956	Bio	196
	Total	1508	1012	963.2	963.1	963.0	-	699
IDR	1	1427	25.2	40.12	65.08	77.76	DM	-
	2	-	1402	1362	1297	1219	SC	766
	3	-	-	25.23	40.12	65.08	MC	517
	4	-	-	-	25.23	40.12	LC	-
	5	-	-	-	-	25.23	IN	-
	Total	1427	1427	1427	1427	1427	-	1284

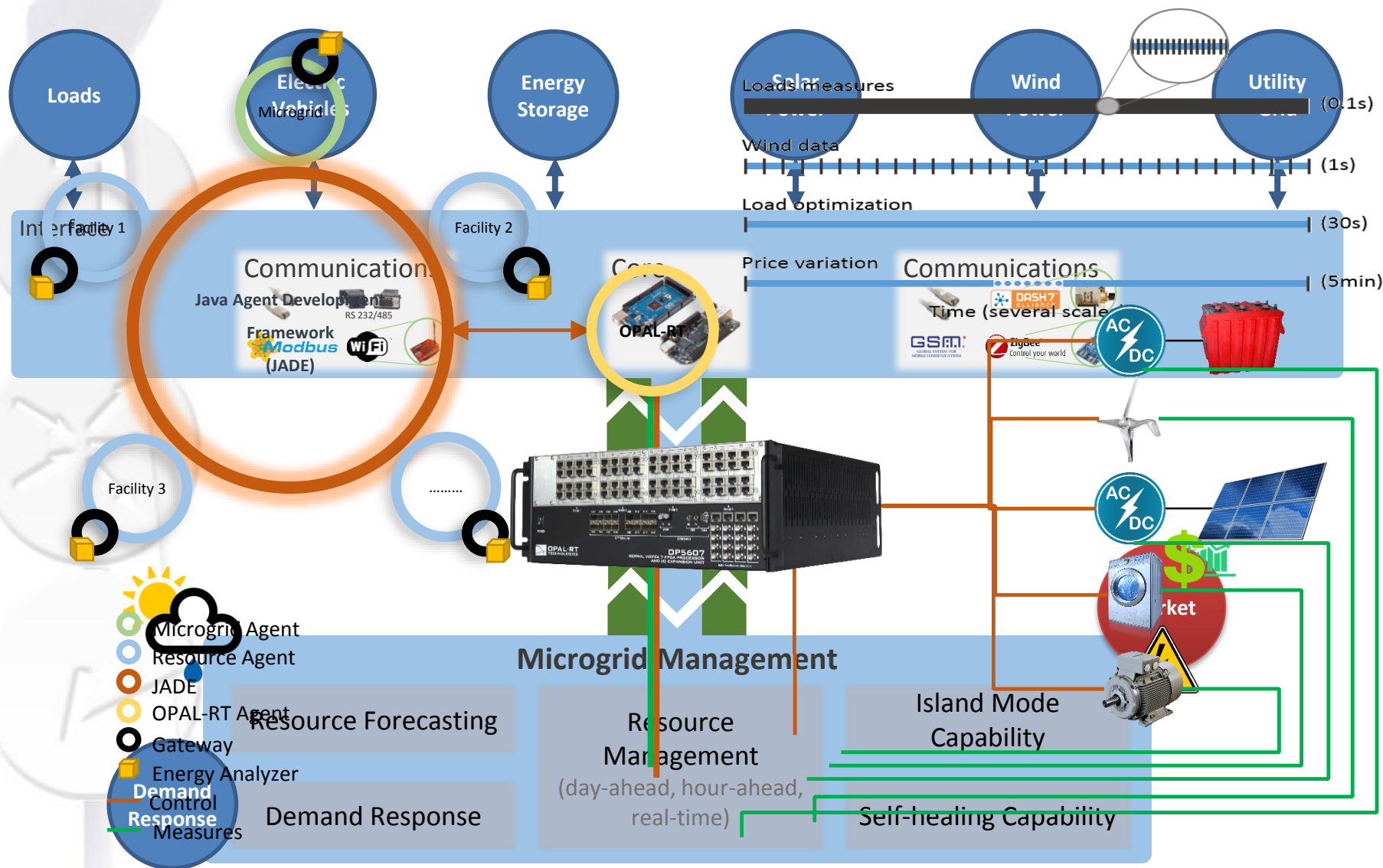
Illustrative scenario

Multiple scenarios



Real-Time Simulation Platform

DREAM-GO



Real-Time Simulation Platform

DREAM-GO

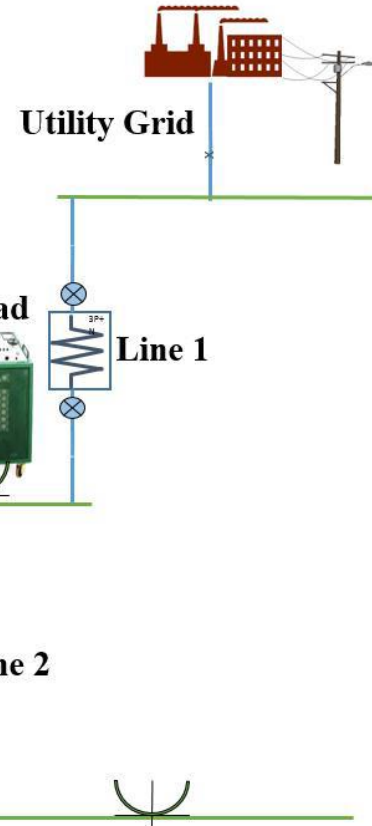


- ⊗ Energy Meter
- ⚡ Switch
- MRTS Power Line

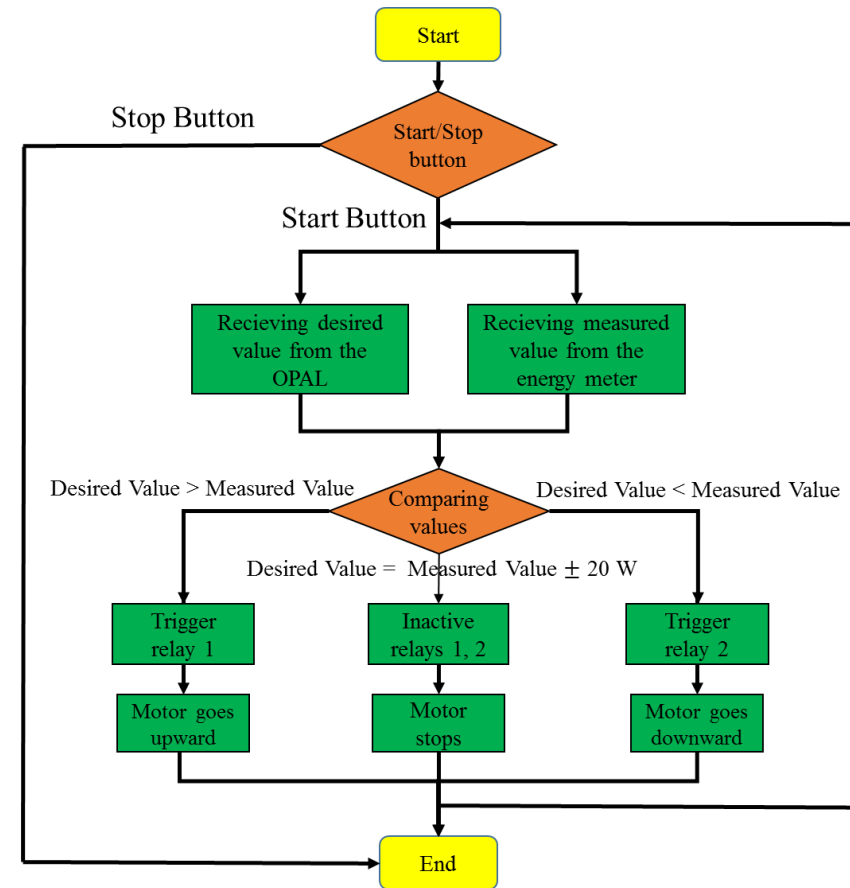
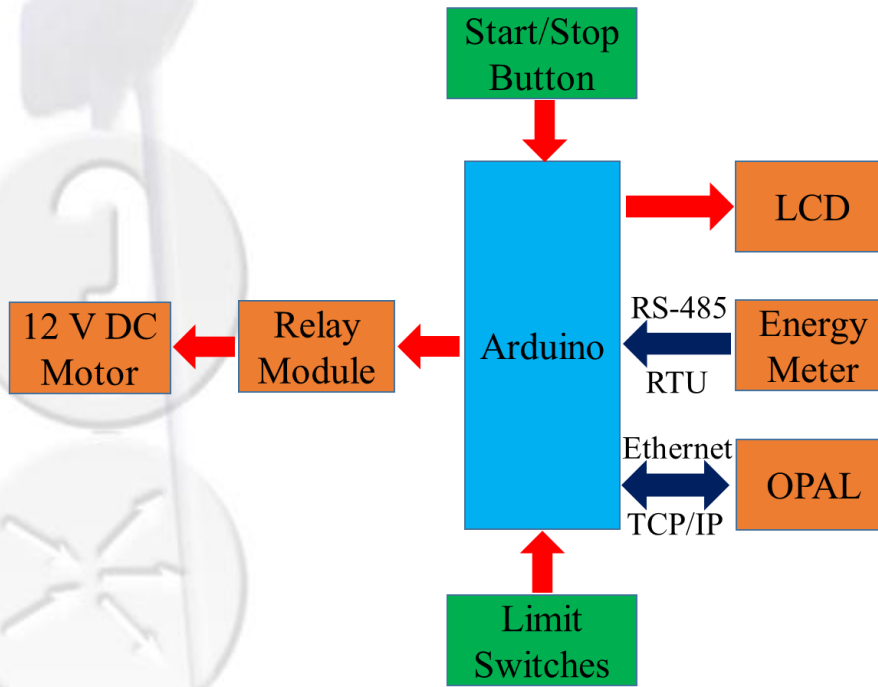
30 kVA Load



4 kVA Load



Real-Time Simulation Platform

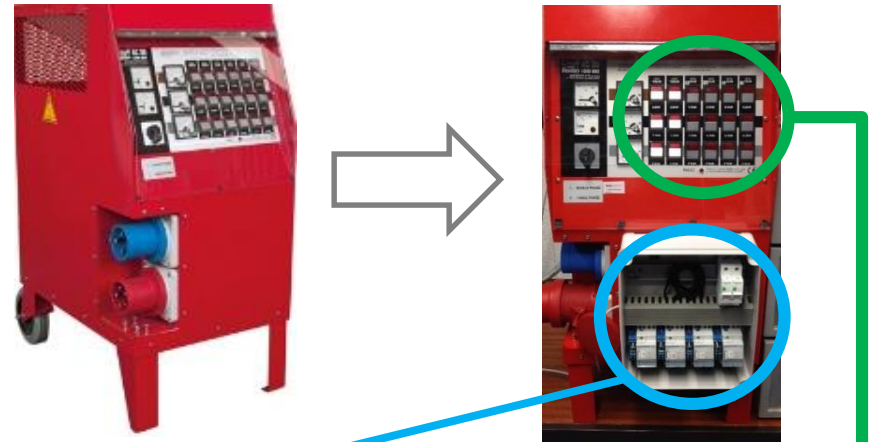


Real-Time Simulation Platform

DREAM-GO

Capacity:

- 30 kW at 400 V in 3 phase mode (50/60Hz)
- 15 kW at 230 V in 1 phase mode (50/60Hz)



Controlling by +12V
Digital Output of OPAL



Real-Time Simulation Platform

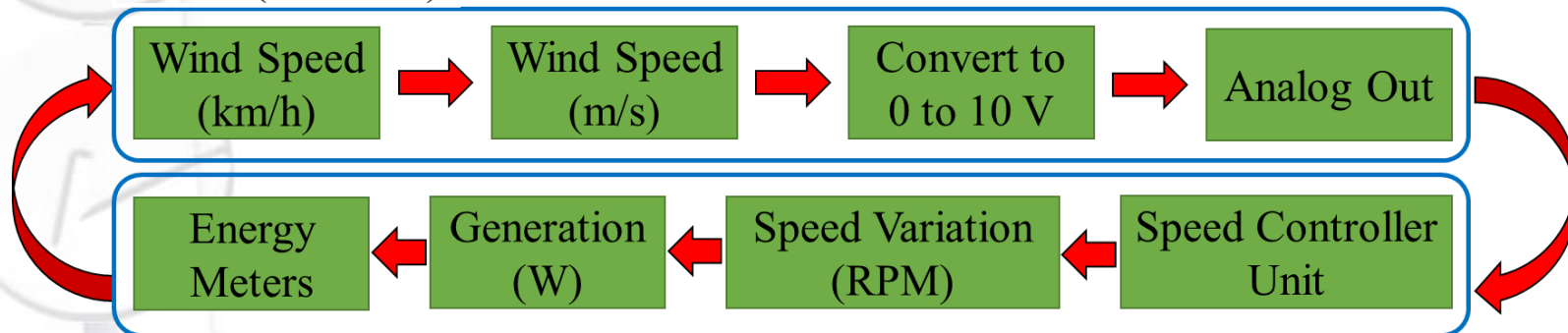
- Asynchronous machine

($U = 3 \times 400 \text{ Vac}$. $I_{\text{max}} = 5 \text{ A}$)

- 0 to 1,2 kW



OPAL (Simulink)



Wind Turbine Emulator

Real-Time Simulation Platform



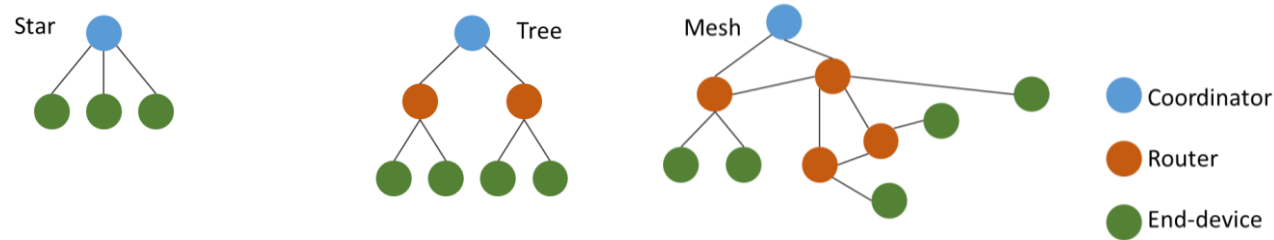
TCP/IP Protocol by IEEE 802.11 Standard



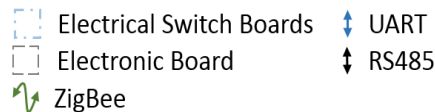
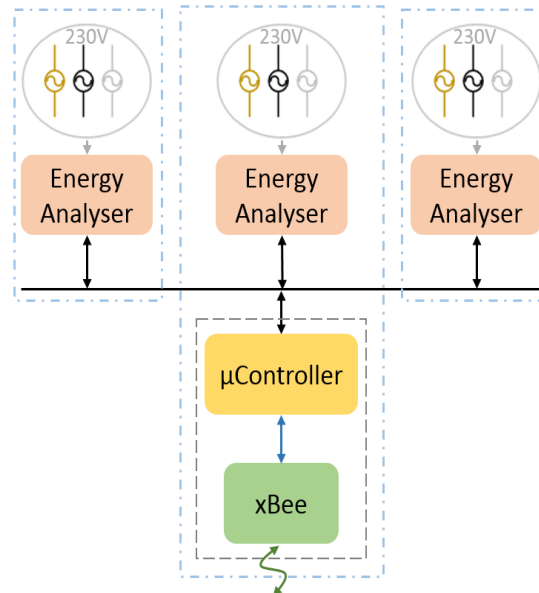
Zigbee



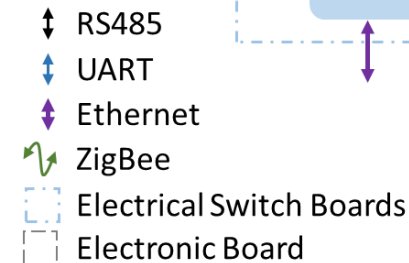
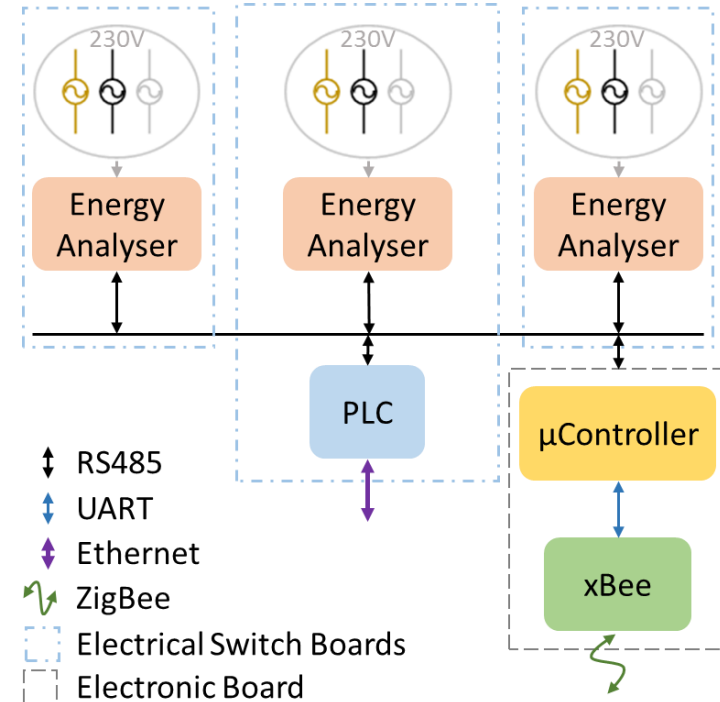
Dash7



Master mode (RS485 master)



Slave mode



Case study - Residential



- ✓ Consumption Data Sets are available on:

<http://sites.ieee.org/psace-idma/data-sets/>

- ✓ For this case study, Private Home 1 is selected

Private Home 1:

Measurement site: Single family housing

Sampling period: 5 minutes

Installation single-phase: 5.75 kVA

Measurement instruments: Chauvin Arnoux 8335

Number of people of house: 3 adult people

Start: 03-June-2011; **End:** 18- June -2011

Different parts of house: 3 bedrooms, 3 toilets, 1 living room, 1 kitchen, 1 laundry room, 1 foyer and hallway;

Major Charges: 1 washer / dryer, 1 dishwasher, 1 electric hob, 1 electric oven, 1 fridge, 1 microwave, 1 extractor, 1 vacuum cleaner, 1 hair dryer, 3 TVs, 1 LCD, 2 laptops, 1 router, 2 electric heaters.

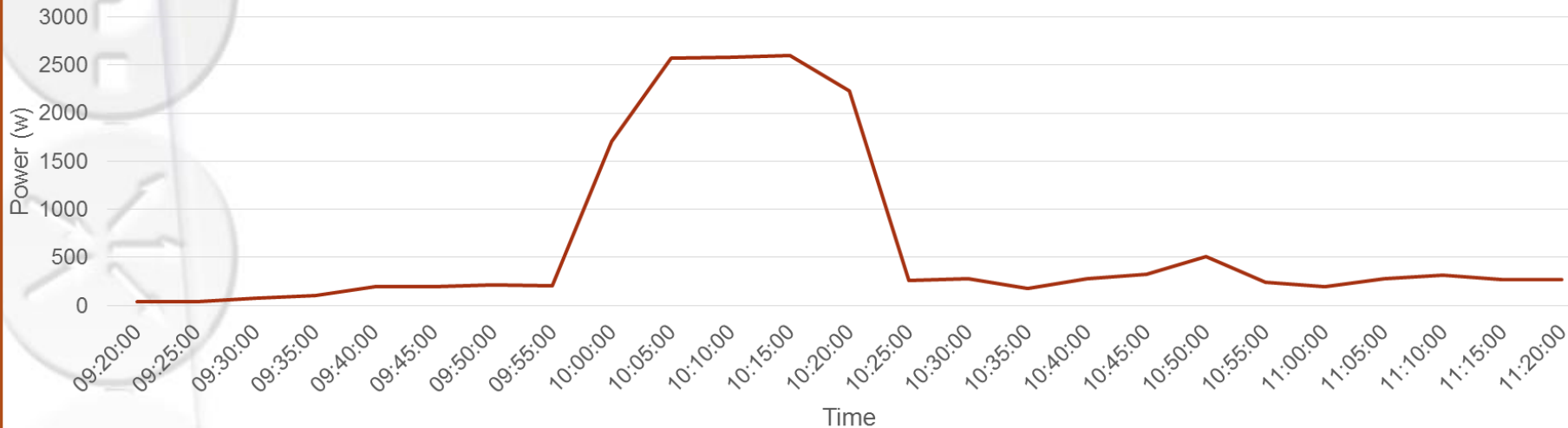
Source	Short description	Link	Contact
Private Home 1 [Canizes, 2015]	Measurement site: Single family housing Sampling period: 5 minutes Start: 03-June-2011; End: 18-June-2011 Installation single-phase 5.75 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 2 [Canizes, 2015]	Measurement site: Single family housing Sampling period: 5 minutes Start: 16-July-2012; End: 26-July-2012 Installation three-phase 6.90 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 3 [Canizes, 2015]	Measurement site: Single family housing Sampling period: 5 minutes Start: 23-January-2013; End: 07-February-2013 Installation single-phase 5.75 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 4 [Canizes, 2015]	Measurement site: Single family housing Sampling period: 5 minutes Start: 06-January-2014; End: 30-January-2014 Installation single-phase 3.45 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 5 [Canizes, 2015]	Measurement site: Single family housing Sampling period: 5 minutes Start: 04-August-2011; End: 18-August-2011 Installation single-phase 6.9 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 6	Measurement site: Single family housing Sampling period: 15 minutes Start: 25-December-2011; End: 15-March-2013 Installation single-phase 10.35 kVA	Download as Excel	zav@isep.ipp.pt
Private Home 7	Measurement site: Single student housing Sampling period: 5 minutes Start: 26-September-2011; End: 03-October-2011 Installation single-phase 6.9 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 8	Measurement site: Single family housing Sampling period: 5 minutes Start: 01-June-2012; End: 15-June-2012 Installation single-phase 3.45 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 9	Measurement site: Single family housing Sampling period: 5 minutes Start: 29-December-2012; End: 12-January-2013 Installation single-phase 3.45 kVA	Download as Excel Download RDF Data Cube	zav@isep.ipp.pt
Private Home 10 [Fernandes, 2013]	Measurement site: Single family housing Sampling period: 1 minute Start: 01-June-2012; End: 30-June-2012 Installation single-phase 17.25 kVA	Download as Excel	zav@isep.ipp.pt
Office 1 [Gomes, 2015]	Measurement site: Office Sampling period: 10 seconds Start: 11-July-2014; End: 17-July-2014 Installation three-phase with university contract power	Download as Excel	zav@isep.ipp.pt
Commercial 1 [Canizes, 2015]	Measurement site: Commercial bar Sampling period: 1 minute Start: 02-July-2014; End: 07-July-2014 Installation three-phase 27.60 kVA	Download as Excel	zav@isep.ipp.pt

Case study - Residential

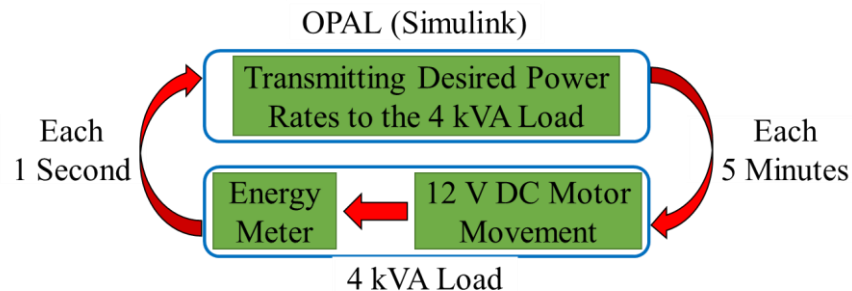
Consumption data of case study 1:

2 hours selected, from 9:20 AM to 11:20 AM, in 10-06-2011

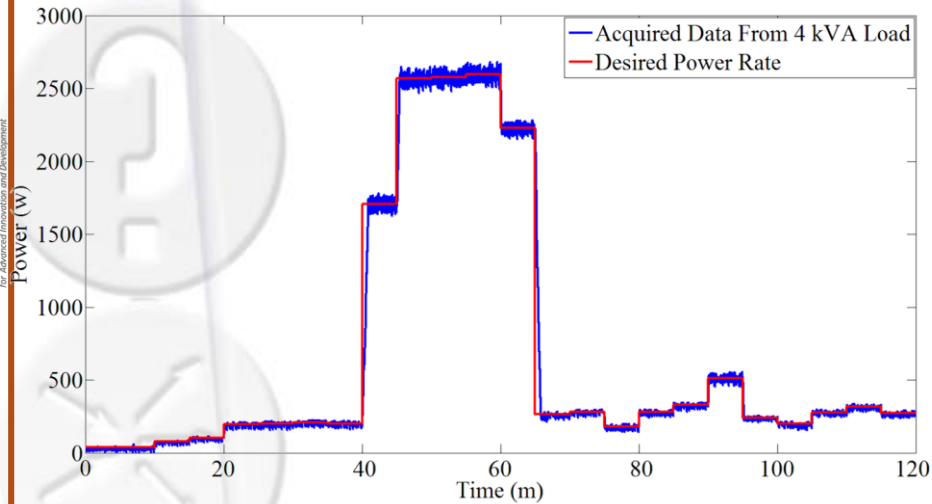
Consumption of Private Home 1



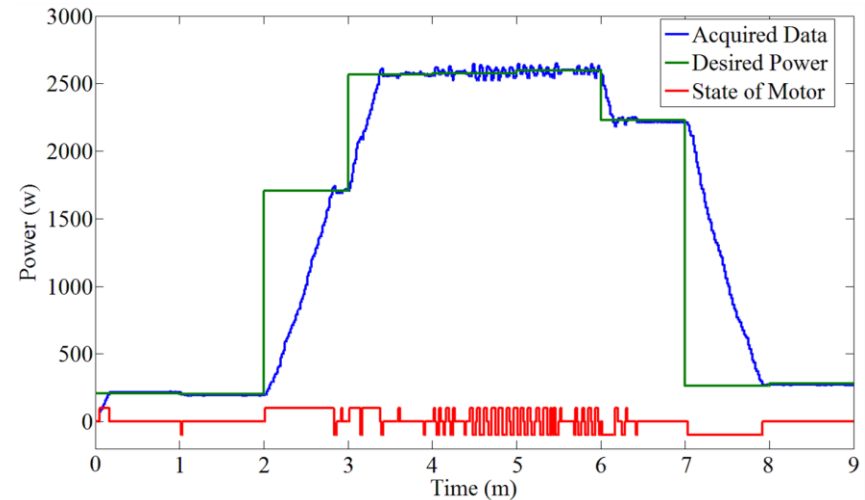
Running Scenario



Case study - Residential



Real-Time simulation of the residential consumption
profile for the period of 2 hours



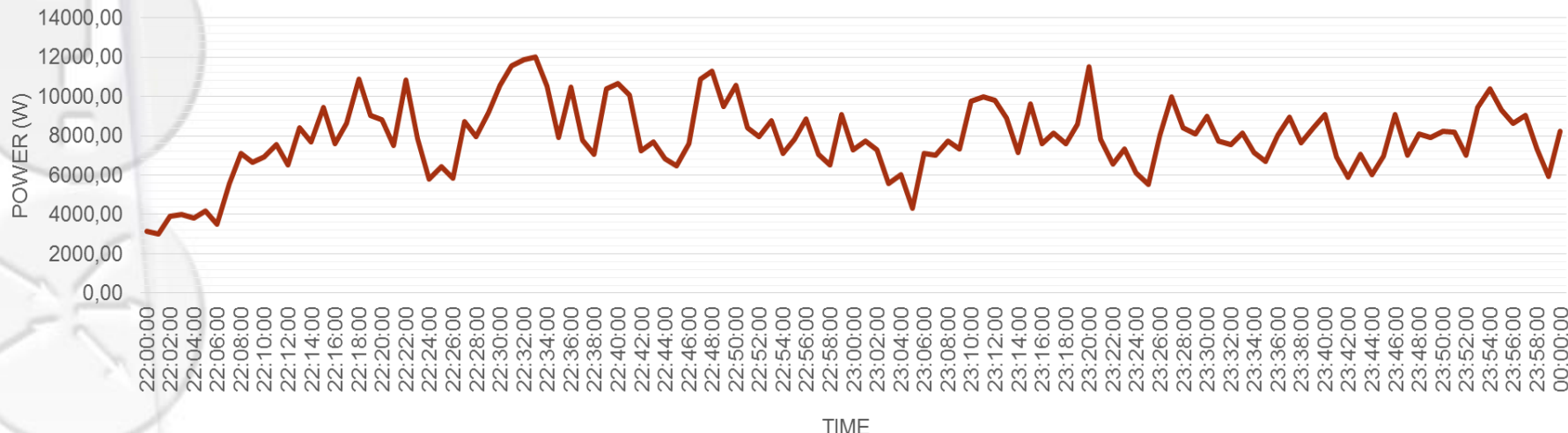
Controlling decision of the 4 kVA load

Case study - Commercial

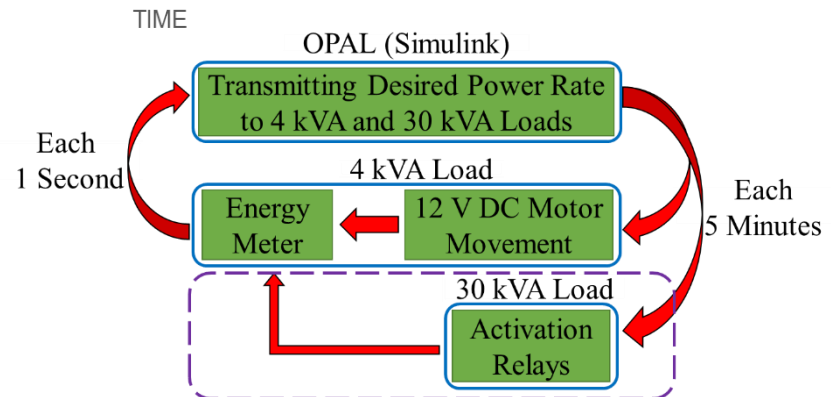
Consumption data of case study 2:

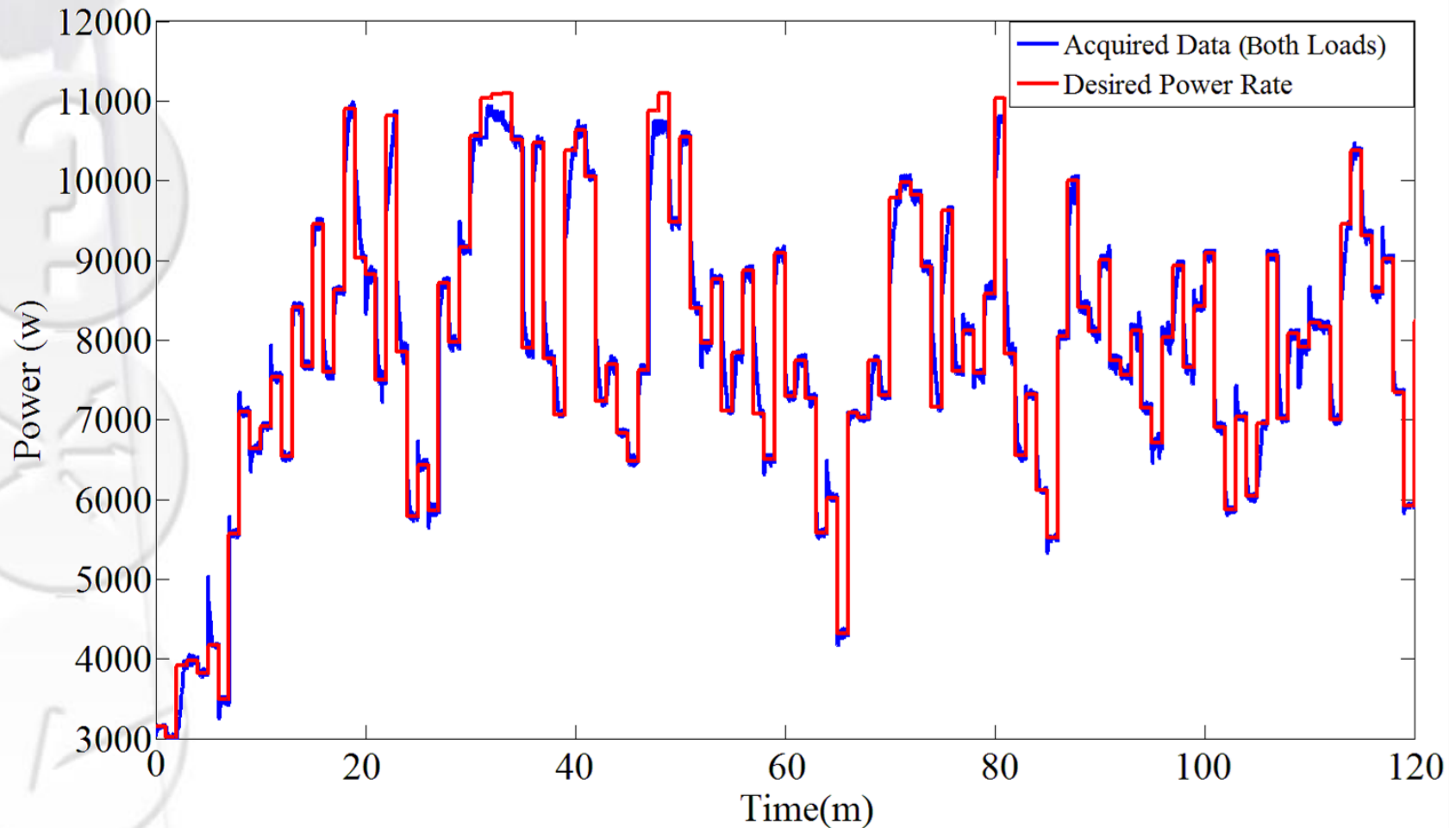
2 hours selected, from 10:00 PM to 00:00 AM, in 06-07-2014

Consumption of the Commercial Bar



In this case study, an integration of the 4 kVA and 30 kW load has been used

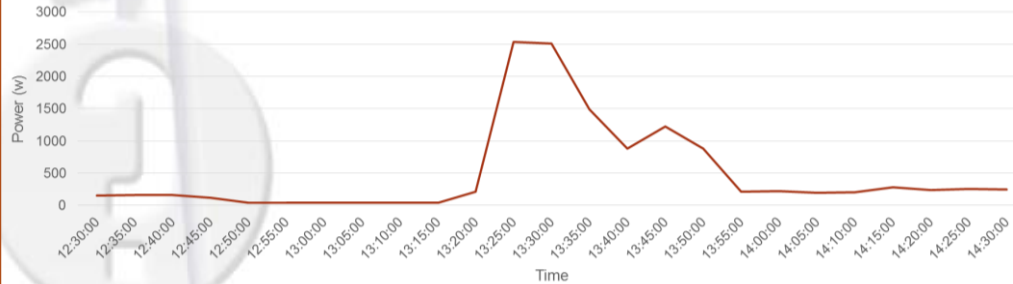




Real-Time simulation of the commercial consumption profile
for the period of 2 hours

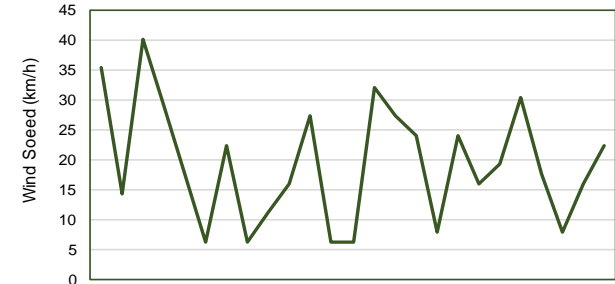
Case study – Domestic active participation

Consumption Profile



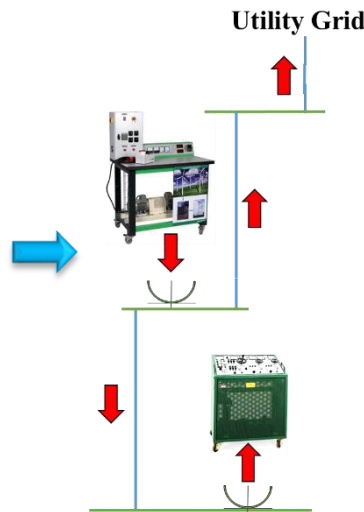
<http://sites.ieee.org/psace-idma/data-sets/>

Wind Speed Data

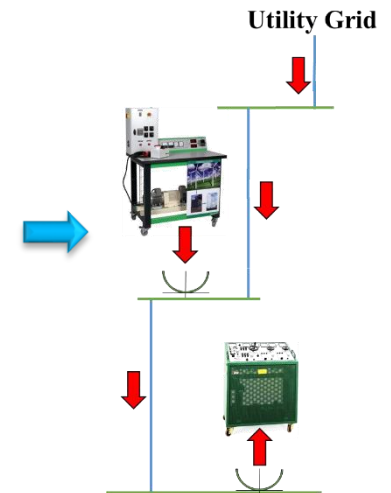


<http://meteo.isep.ipp.pt>

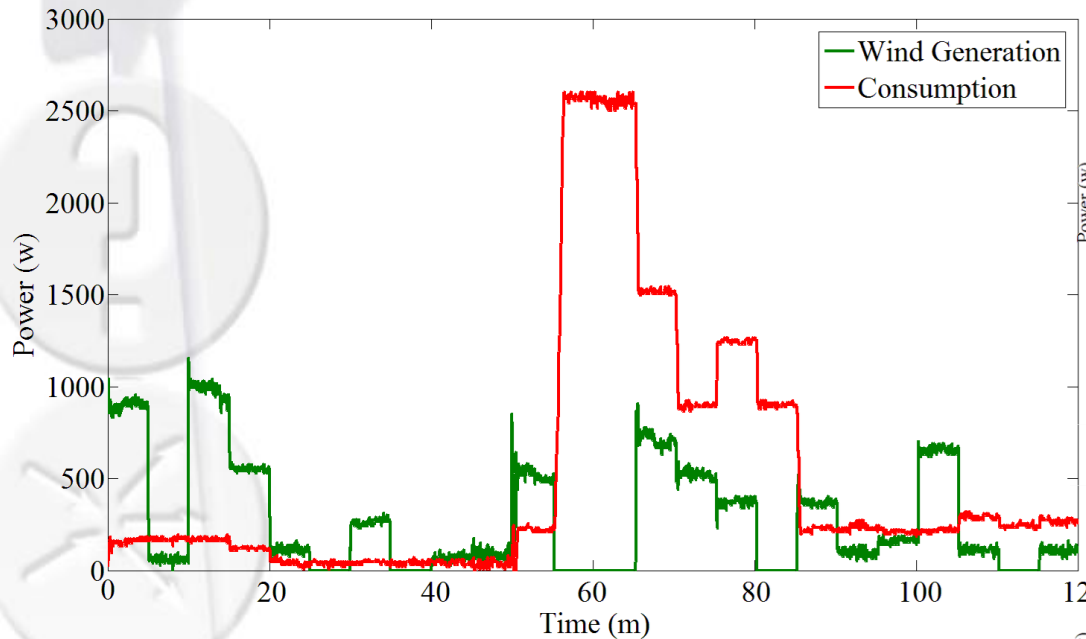
Generation > Consumption



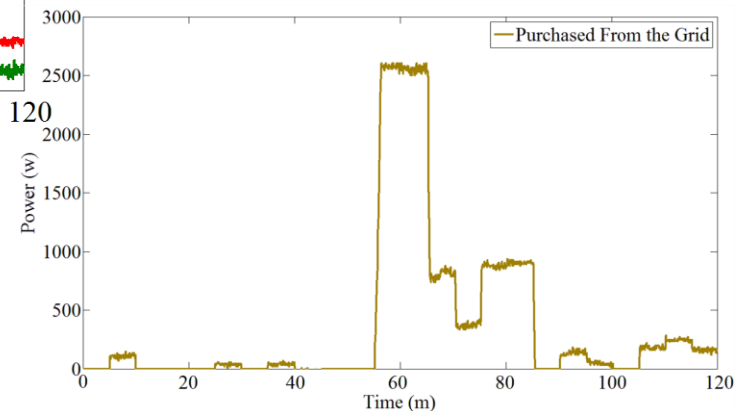
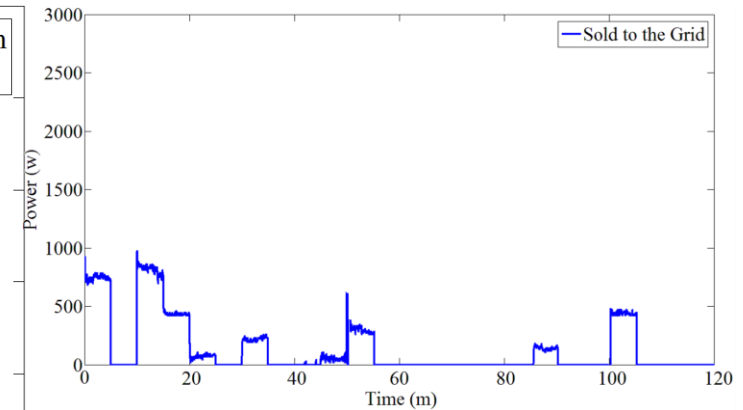
Generation < Consumption



Case study – Domestic active participation



Power Sent Over the Grid



Simulation of the active participation of a residential customer in the electricity grid

Power Purchased From the Grid

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IPP - Polytechnic of Porto, Portugal

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