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

Zita Vale, Pedro Faria

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

Demand response: Present state

- OpenADR
  6 types of DR programs:
  CPP, Capacity Biding, Residential Thermostat Program/DLC, Fast DR Dispatch/Ancillary Services, EV DR, and DER DR

- ISO/RTO (USA)
  Service type:
  Energy, Capacity, Reserve, Regulation

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)
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”
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
Demand response: a demonstration infrastructure

Real-time multi-agent simulation

Java Agent Development Framework (JADE)
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

Spreading demand response: an effective approach

Spreading demand response: an effective approach

Spreading demand response: an effective approach

Real-Time Simulation Platform

- **Microgrid Management**
  - Resource Forecasting
  - Resource Management (day-ahead, hour-ahead, real-time)
  - Demand Response
  - Island Mode Capability
  - Self-healing Capability

**Communications**

- **Inter-Facility**
  - Communication: Java Agent Development Framework (JADE)
  - Facility 1
  - Facility 2
  - Facility 3

**System Components**

- **Loads**
- **Electric Vehicles**
- **Energy Storage**
- **Solar Power**
- **Wind Power**
- **Utility**
- **Energy Analyzer**
- **Control Measures**
- **Real-Time Simulation Platform**

**Agent Frameworks**

- **Microgrid Agent**
- **Resource Agent**
- **JADE**
- **OPAL-RT Agent**
- **Gateway**
- **Energy Analyzer**

**Market Interface**

- **AC/DC Converter**
- **Utility Grid**
- **Loads Measures**
- **Wind Data**
- **Load Optimization**

**Time Scales**

- (0.1s)
- (1s)
- (30s)
- (5min)
Real-Time Simulation Platform
Real-Time Simulation Platform

12 V DC Motor → Relay Module → Arduino

Start/Stop Button → LCD

RS-485 RTU → Energy Meter

Ethernet TCP/IP → OPAL

Limit Switches

Start Button

Start/Stop button

Receiving desired value from the OPAL → Receiving measured value from the energy meter

Comparing values

Desired Value > Measured Value

Desired Value < Measured Value

Desired Value = Measured Value ± 20 W

Trigger relay 1 → Inactive relays 1, 2 → Trigger relay 2

Motor goes upward → Motor stops → Motor goes downward

End
Real-Time Simulation Platform

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
  
  \[(U = 3\times400\text{Vac. } I_{\text{max}} = 5\text{A})\]

- 0 to 1,2 kW

**OPAL (Simulink)**

- Wind Speed (km/h)
- Wind Speed (m/s)
- Convert to 0 to 10 V
- Analog Out

- Energy Meters
- Generation (W)
- Speed Variation (RPM)
- Speed Controller Unit

Wind Turbine Emulator
Real-Time Simulation Platform

TCP/IP Protocol by IEEE 802.11 Standard

Master mode (RS485 master)

Slave mode

Zigbee

Dash7
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.
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

Each
1 Second

Transmitting Desired Power Rates to the 4 kVA Load

Each
5 Minutes

Energy Meter

12 V DC Motor Movement

4 kVA Load
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

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

Real-Time simulation of the commercial consumption profile for the period of 2 hours
Case study – Domestic active participation

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

http://meteo.isep.ipp.pt
Case study – Domestic active participation

Simulation of the active participation of a residential customer in the electricity grid
DREAM-GO: the path towards effective short and real-time demand response

Zita Vale, Pedro Faria

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

This project has received funding from the European Unionís Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 641794