CASSANDRA: A simulation-based, decision-support tool for energy market stakeholders

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Current Power Grid Structure

Hydro

Nuclear

Thermal

Large Scale Generation

Transmission

HV/MV Power Substation

Distribution (Demand Side):
- Consumption
- Small Scale Generation

Current Power Grid Structure:
- Consumption
- Small Scale Generation
- Transmission
- HV/MV Power Substation
- Distribution (Demand Side)

Large Scale Generation

HV/MV Power Substation

Distribution (Demand Side)
Demand Side – Current Status

- HV/MV Power Substation
- Small Industry
- Residential
- Commercial
- Residential
- Commercial
- Residential

MV/LV Power Transformer

Overhead or Underground Power Lines

MV/LV Power Transformer

Commercial

HV/MV Power Substation

Small Industry

Residential

Commercial

Residential

Commercial
The Consumer...

- A consumer that may have the ability to produce relatively small amounts of energy: also known as prosumer
- Individual consumption is trivial with respect to the consumption of "bigger" players (Industrial, Commercial, Public Service, Recreational)
- Small-scale consumer is > 30% of consumption (source: Hellenic Ministry of Development, 2011)
- In fact, consumer modeling is too difficult to achieve, due to:
  - The lack of respective metering equipment (i.e. smart meters)
  - The lack of ability to model consumer activities
  - The lack of ability to model response to incentives (Demand response)
Power Systems – the near future

- Decentralized, small-scale production sites
- Renewable energy
- Market liberation
- Smart grid
- More players involved

Big market potential unexploited!

- Lack of tools for modeling the new Power System status
- Inability to aggregate the market power of small-scale consumers
- Necessity for dynamic models for assessing the impact of actions and policies to be applied
Filling in the gap...Cassandra-Energy!

A software platform for modeling the energy market from an end user perspective

- Main Cassandra objectives:
  - Theoretical and software modeling of stakeholders in terms of energy profiles and consumption patterns, as well as their interactions
  - Increase the market power of low level consumers through Consumer coalitions (Consumer Social Networks - CSNs)
  - A Key Performance Indicator (KPI) methodology, in order to assess energy performance and CO₂ emissions reduction
  - A modular, expandable Software platform to model and benchmark scenarios and act as a Decision making tool.
Cassandra platform

- Disaggregation of load curves
- Modeling of individual appliance consumption
- Learning of complex consumption and activity models
- Modeling distribution network aspects
- Incorporation of demographics
- CO₂ emissions and environmental impact modeling
- Extensive simulation capabilities
- Simulation of demand response capabilities
- Observation of simulated load curves and features at all levels of detail (individual appliance -> entire world)
Individual small scale consumers

- Policies and consumption programs cannot be enforced
  - Modeling of acceptance
  - Consumer utility vs gain from incentives
  - Modeling based on consumption activity (not based on appliance switching)
- Ability to simulate targeted incentives to consumer groups
- Ultimately, ability to simulate a wide range of demand – response programs
- Ability to adjust models based on measurements
Going even further: CSNs

- Consumer has the option to selectively join coalitions (Consumer Social Networks) and respond to incentives

**CSN Response adjusting the Load Curve**
Cassandra Modules

Cassandra - A simulation-based, decision-support tool for energy market stakeholders

Konstantinos Vavliakis - Simutools 2015 - Wednesday 26th August
Cassandra Training Module
CASSANDRA - A simulation-based, decision-support tool for energy market stakeholders

Cassandra Screenshots
Stakeholder benefits

- Aggregators and service providers
  - Model consumption, model consumer response to targeted incentives, support decisions and planning of novel products and services
- DSOs
  - Simulate the network load at any point in the distribution grid
  - Understand why load peaks are observed and simulate solutions
- Individual organizations, universities, municipalities
  - Model consumption policies, the gain in power reduction and the impact on the satisfaction of consumers
  - Optimize consumption by constructing an effective consumption program
Cassandra pilots (1/2)

Pilot Case 1: Commercial centre

- Commercial centre in northern Italy
- 3-floor building with multiple stores
- MV-LV transformer and PV panels

Objective: Consumption analysis and reduction

Incentives/instructions

Cassandra

- Load disaggregation and activity modeling
- Multiple scenarios
- Decide on optimal incentives and instructions

Building

Individual stores

Measurements
Cassandra pilots (2/2)

Pilot Case 2: Residential building

- Multi-residential building in Luleå, Sweden
- Individual measurements from each residence
- Building management board

Objective: Consumer social networks with increased market power

- Load disaggregation and activity modeling
- Formation of consumer groups
- Simulation with targeted incentives
- Consumer response modeling
- Multiple objectives: Energy consumption, power consumption, cost, CO₂ emissions
Find more at...

- **Web:**
  - www.cassandra-fp7.eu

- **GitHub:**
  - www.github.com/cassandra-project

- **YouTube:**
  - www.youtube.com/watch?v=dcr033ZrmN8
Questions?

Thank you