The DREAM Project

Decentralized Distribution System Operation Techniques

Results from the Greek Test Cases

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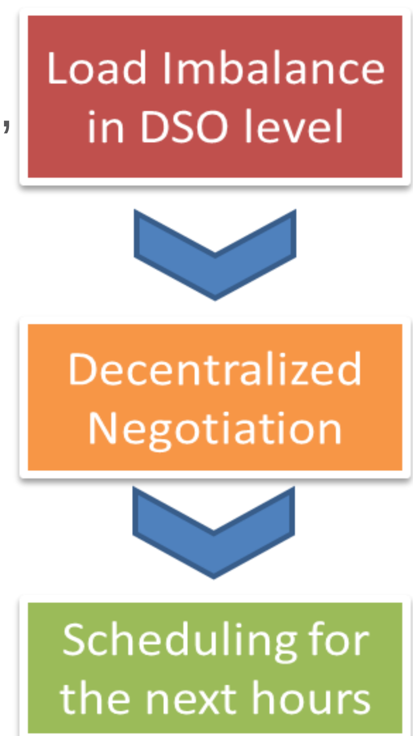
Overview - Scope

- The DREAM project aims at
  - Utilize aggregated flexibility at the DSO level, according to economic incentives in order to compensate short-term power imbalances.
  - Resolve significant deviations from the predicted load/renewable energy generation or other reasons causing imbalances.
  - Evaluate the decentralized balancing market
  - Resolve network contingencies (i.e. voltage control, congestions, etc.) using distributed optimization techniques (using Agent-based, scalable and robust implementation)

Employ aggregated flexibility to resolve imbalances

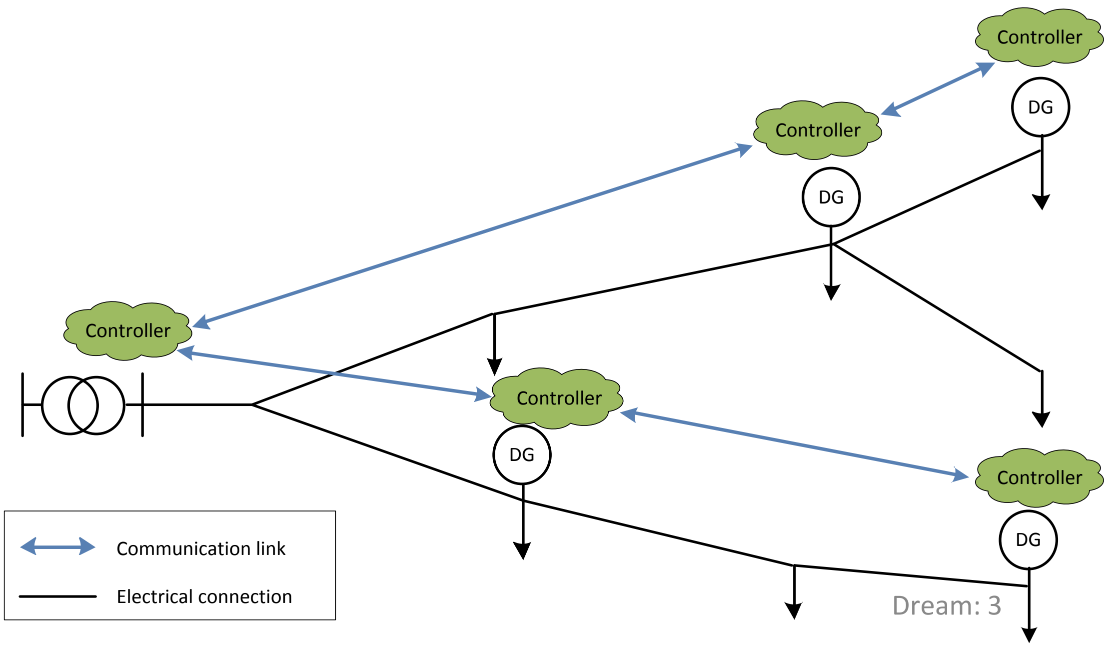


Introduction

- Distributed Control of the Power System
- Peer to Peer Communication
- Use of sensor networks (smart meters?) in Power Systems as:
  - mesh overlay networks above the existing infrastructure

✓ Large number of “low-cost” devices, for measuring, monitoring, controlling and event detection

✓ Low requirements for infrastructure investment



Advantages of Distributed Architecture

- Large scale applications require scalability! (too complex problems to be solved efficiently)
- Privacy matters
- Dispersed solution to locally caused problems, no need for central coordination
- Increased robustness
- Tolerance in communication delays
- Scalability - Extensibility – "Plug-and-play"

Greek Facilities Goals

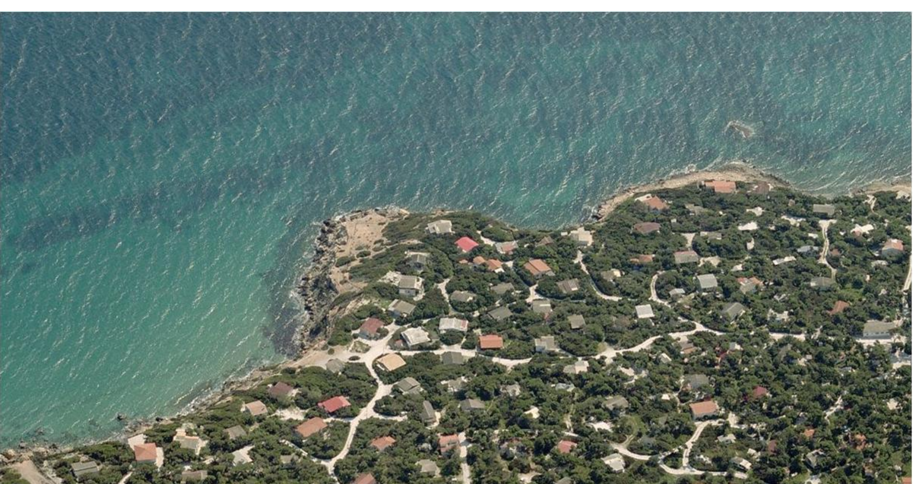
Improvements and Goals of the DREAM concept for HEDNO:

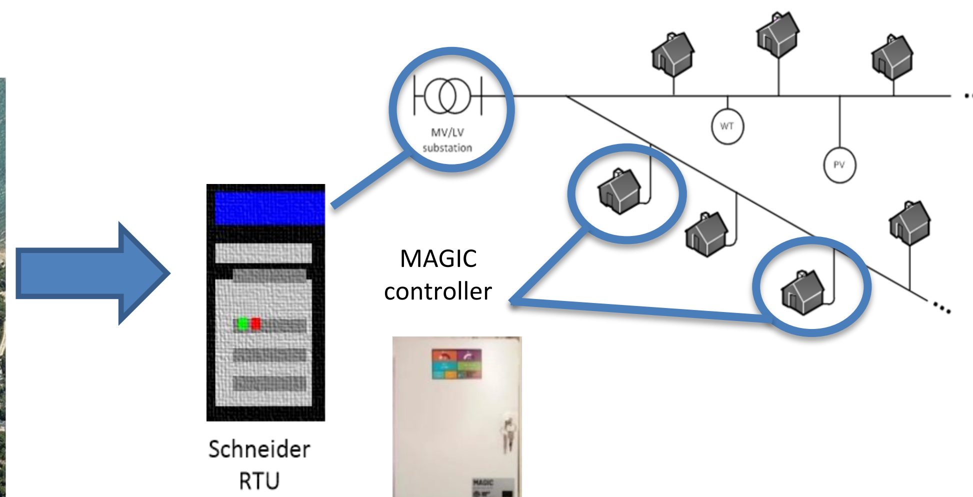
- Goal No. 1: Reduction of energy production cost.
- Goal No. 2: Aggregation and provision of flexibilities for the day-ahead market.
- Goal No. 3: Reduction of the voltage profile variability and congestion management
- Goal No. 4: Demonstration that DREAM can help to improve the efficiency of the operation of the distribution network.

Meltemi Community Smart Grids pilot site

- **Objectives**
  - **Reduce voltage profile variability in LV level**
  - **Aggregate and provide local flexibilities to enable their participation in national markets**

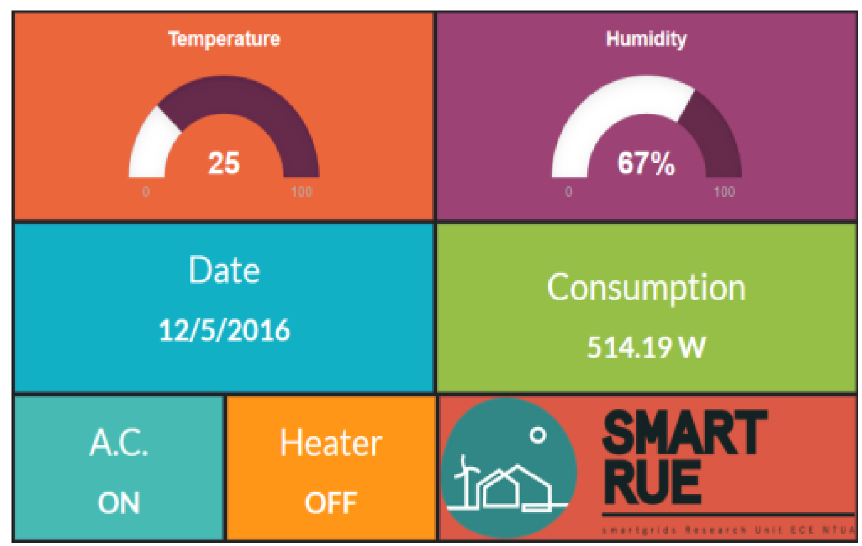
- **Trial infrastructure**
  - Test field of a LV seaside camping side on the mainland
  - 1 secondary substation with a DREAM advanced RTU (executing JAVA)
  - Flexible LV devices in the households



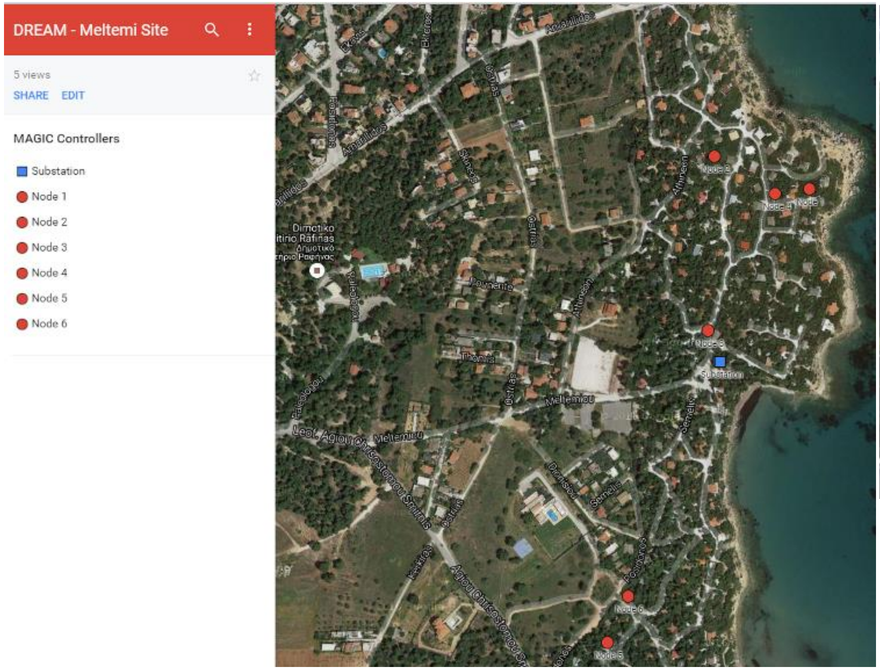


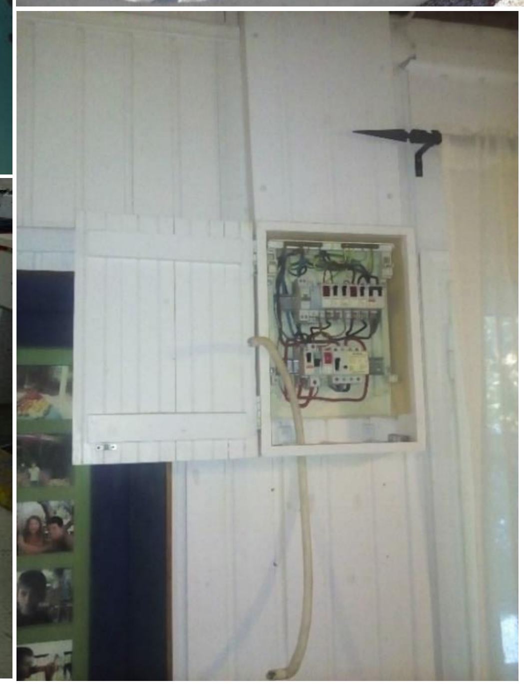
Intelligent Load Controllers

- Connected on the electrical boards of the house
- Measure the power consumption
- Control household appliances
- Communicate using the local LAN
- Implement Distributed Optimization Algorithms
- Negotiate and make decisions to support the grid operation



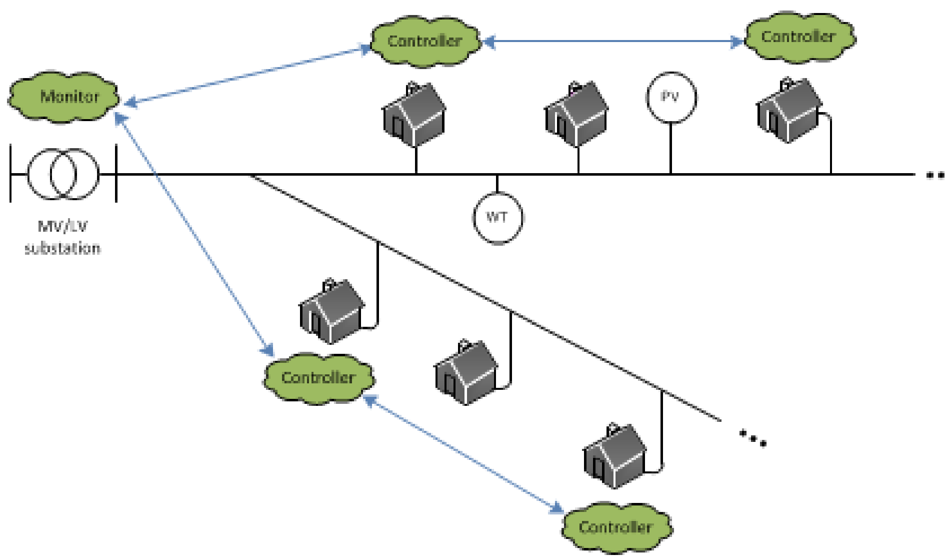
Meltemi pilot Site





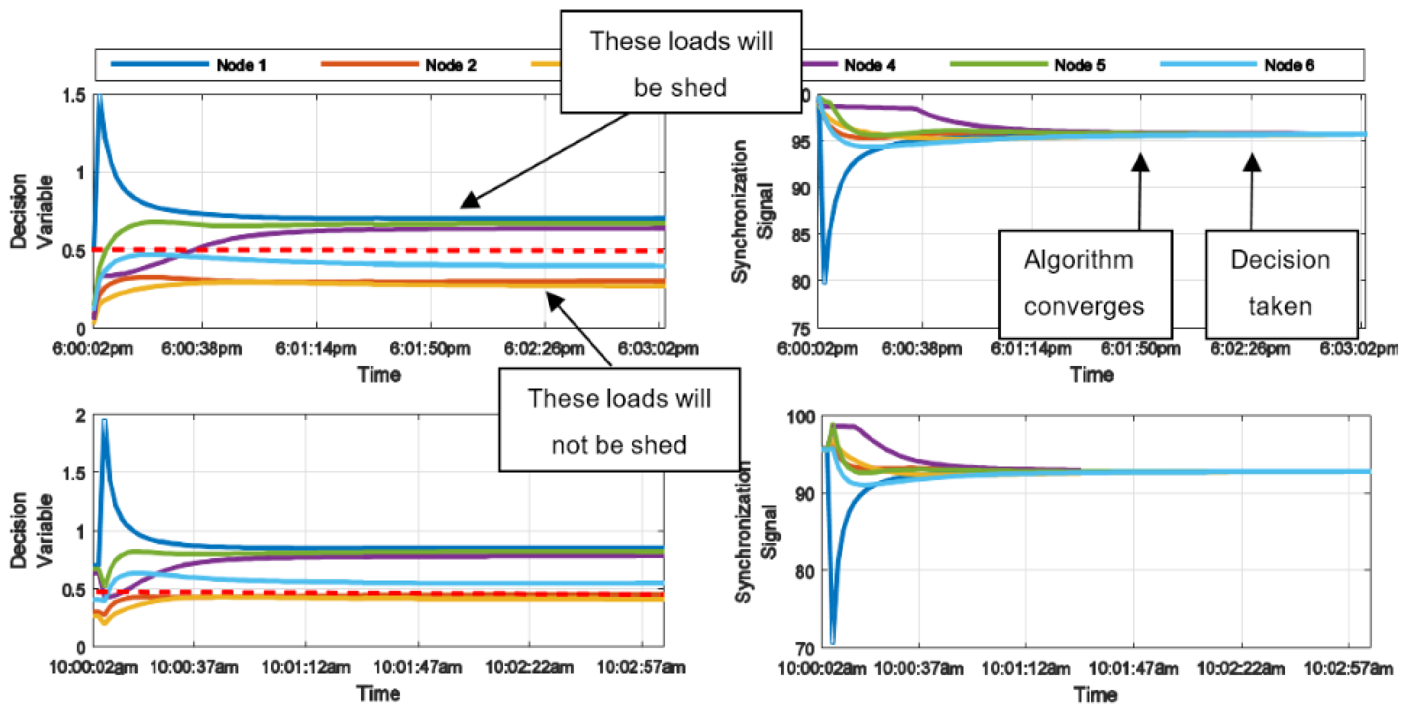
Applications in Meltemi

- Congestion Management and Voltage Control were tested
- Peer-to-peer communication between the controllers utilizing the local LAN
- Active power curtailment by controlling the household appliances
- *Distributed optimization algorithms were developed and tested using the JADE MAS platform*



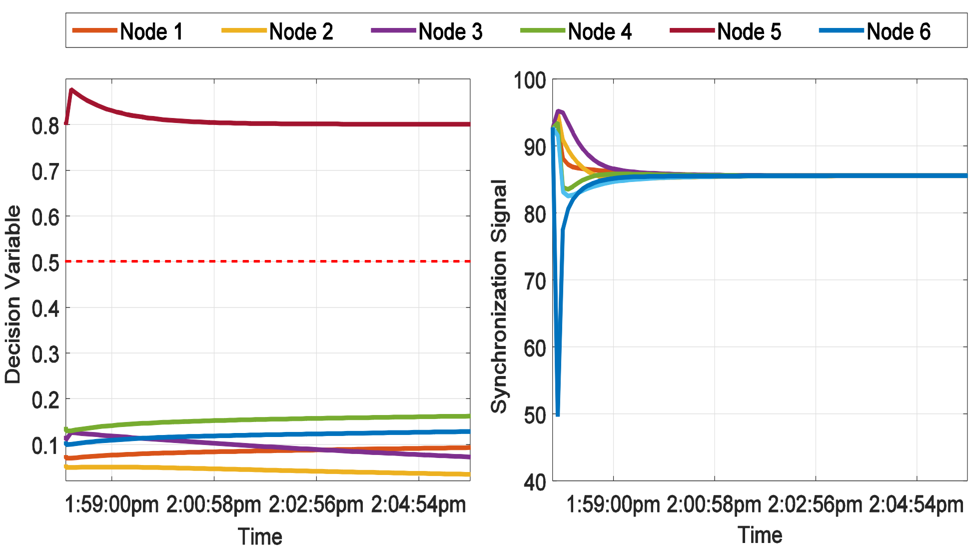
Decentralized Congestion Management

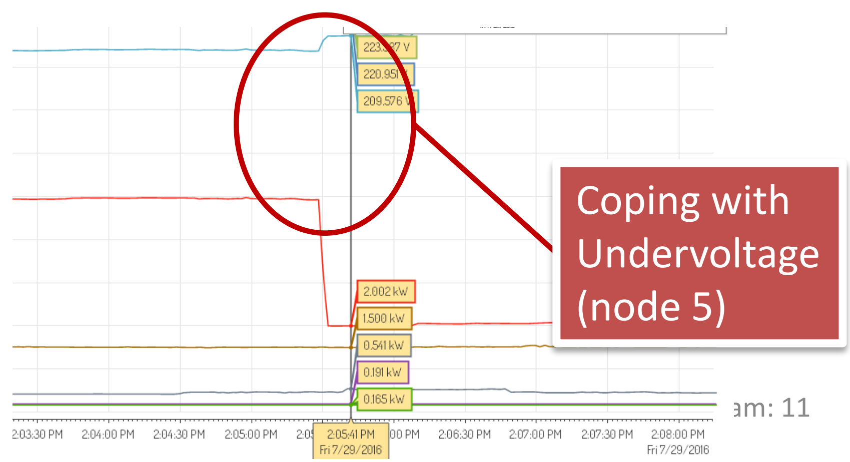
- The triggering event is a deviation from the initially scheduled aggregated demand curve.
- The DSO agent (located at the substation) informs the customer agents, to proceed to a reduction of power
- The prosumers negotiate in order to arrive at an agreement regarding the amount of power to be altered



Decentralized Voltage Control

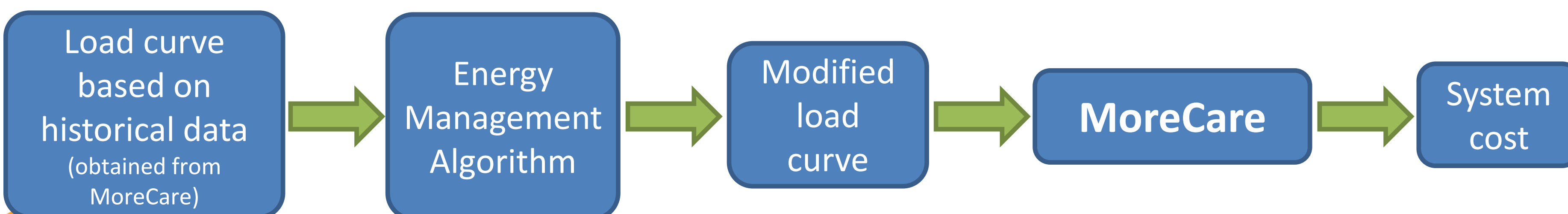
- Allocation of the amount of active power to be altered per participating entity in order to cope with voltage violations
- In this case, the voltage margin of node 5 is violated, an event that triggers the voltage control algorithm.
- Takes as inputs the available flexibility per household and their voltage sensitivities





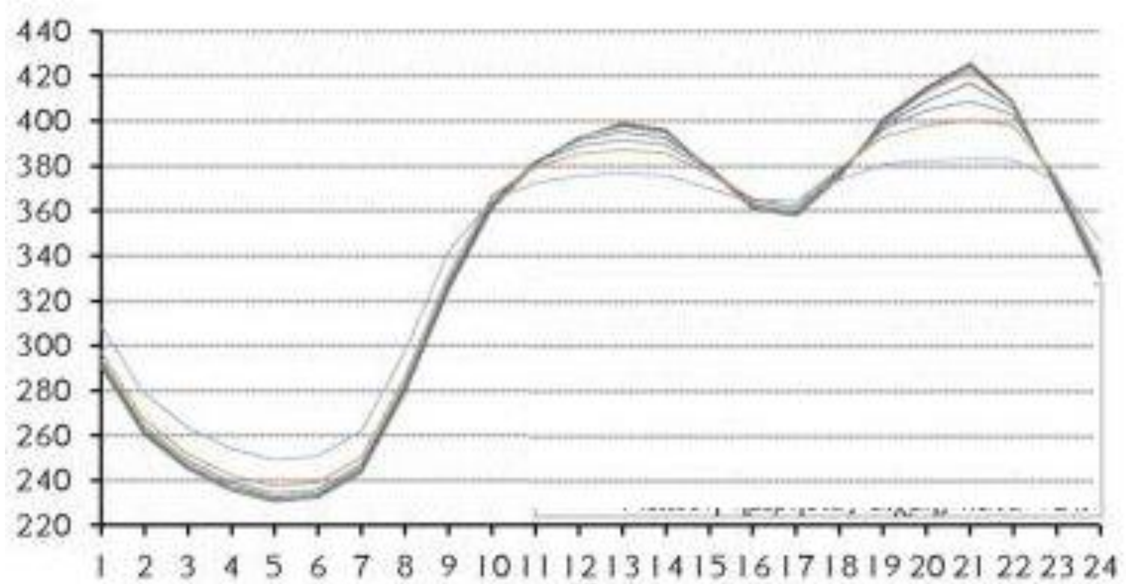
Facility 2 - Crete Island

- Day-ahead simulation of the operation of the electrical system of Crete
- Energy Management System “eCare” is used for on-line simulation
  - Input data: forecasting of RES production, system configuration, load curve
  - Output: unit commitment and economical dispatch, operational system cost
- The energy management algorithm can test various scenarios.
- Economic impact of each scenario is quantified in monetary units using the utilities offered by “eCare”.
- Communication between various components for data interchange.



Facility 2 - Crete Island Scenarios

- Baseline: no energy management technique is applied (business-as-usual) --> historical data regarding system load curve
- Energy management scenario: application of energy management algorithm --> modified load curve



Facility 2 – Results

- Quantification of the impact of the DREAM framework by performing day-ahead simulation of the hourly operation of the electricity system.
- Flexibility available on the demand side incurs changes in the total system load curve, thus affecting the entire scheduling of the electricity systems.

Scenario	Basic	-1%	-2%	-4%	-6%	-8%	-12%
Peak Load	579,4	573,6	567,8	556,2	544,6	533	509,9
Cost Reduction (%)	---	-0,03	-0,09	-0,15	-0,28	-0,41	-0,94
Cost reduction (M€)	---	-0,2	-0,6	-0,9	-1,6	-2,4	-5,5
Wind Curtailement (%)	9,2	9	9	9,1	8,3	8	7,2

Concluding Remarks

- The advantages of the decentralized architecture were highlighted:
  - Easy deployment
  - Scalability
  - Plug and play
- Good accuracy of the distributed algorithms
- The Java based implementation of the MAS platform simplified the interoperability of the different systems.
- The communication availability, was proven to play a significant role during the tests.
- Even though a small number of houses participated in the experiments, the algorithms were in most cases able to fulfill satisfactorily the objectives set by the distribution grid.

Questions?


Market benefits for customers


Smarter Distribution Grids


Better use of renewable sources