The birth of a **EU**ropean **D**istributed **En**E**r**gy **P**artnership

that will help the large-scale implementation of distributed energy resources in Europe

eu-deep

"ICCS/NTUAs Contribution in EU-DEEP Project"

DER _LAB Phd and Researchers Seminar

4th of November 2009

Library Building, NTUA Campus

Speaker: Thomai Tomtsi / ICCS-NTUA/ GREECE

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Structure of the Presentation

- General information about EU-DEEP Project
- Presentation of EU-DEEP different Work Packages and Tests
- Presentation of the Tasks implemented in Greece and in which ICCS/NTUA was involved
    1. *Test Field 2*
    2. *Task Force 3 Experiment Campaign*

General information about EU-DEEP

- **EU-DEEP**, means **EU**ropean **D**istributed **E**n**E**rgy **P**artnership

- It was a Research and Development Project, initiated by 8 European Utilities and coordinated by GDF SUEZ

- It was a 5 years long project, started in January 2004 and ended in June 2009

- The total budget was of almost €30M, half of which was funded by the European Commission Sixth Framework Program for Research and Technological Development

General information about EU-DEEP

- EU-DEEP consortium included 42 partners from utilities, manufacturers, research centres & academic institutions, business developers, investors and regulators

- Some of the partners were: GDF SUEZ, SAFT, Technofi /(France), Bowman Power Systems (UK), Electricity Aythority of Cyprus, Iberdora, Labein, IIE-UPV/(Spain), Siemens PSE /(Austria), RWE /(Germany), EPA Attikis, ANCO, CRES, RAE, AUTH, ICCS-NTUA /(Greece) e.t.c

- The single overarching ***goal*** of the project was:

"To design, develop and validate an innovative methodology, based on future energy market requirements and able to produce innovative business solutions for enhanced DER deployment in Europe by 2010"

Presentation of EU-DEEP different Work Packages

In order to reach the goal, the project work flow was organized along two dimensions:

- Eight technical work packages (WP), each focusing on a specific issue or type of activity and

- Three task forces set up to develop one specific business model each, using methodologies and tools developed in the work packages 1 to 8.

Presentation of EU-DEEP different Work Packages

The 8 WPs and their respective research fields were as follows:

1. WP1: Demand segmentation and modelling
2. WP2: Grid and Market integration
3. WP3: Local Trading Strategies
4. WP4&5: Technology validation (Field Tests)
5. WP6: Training
6. WP7: Dissemination Activities (Conference, Website, book e.tc)
7. WP8: Business modeling

Presentation of EU-DEEP different Work Packages

Task Force 1: *the experiment was based on a set of real loads and generators aiming to estimate the cost and value of small-scale (10 kW to 1.5 MW) load management aggregated in UK industrial and commercial market segments (conducted by GDF SUEZ ENERGY UK)*

Task Force 2: *where the aggregation of 10 Micro-CHP units installed in selected residential buildings in Germany was tested under real conditions in order the business case of Micro-CHP aggregation to be validated (conducted by RWE in Berlin in cooperation with GASAG)*

Task Force 3: *the experiment was more technology-oriented, the Multi-Agent Software technology, a decentralised control architecture for aggregation was tested in real-time on a portfolio of real customers from Athens, including both demand response and generation (conducted by SUEZ TRACTEBEL in cooperation with ICCS/NTUA and CRES)*

Presentation of EU-DEEP different Work Packages

Test Field 1: a 12 kW-CHP engine had been installed in “Gaz and Electricity of Grenoble” (GEG, Grenobles Local DSO) office building in France. The test was led by GDF SUEZ and the objectives were:

- *to assess the potential of the “office building” market segment in Nothern Europe, identified as one of the most promising segments for DER*
- *to design a fully integrated system comprising all the different DER components*
- *to test and assess the corresponding cost of the automatic islanding-reconnection to the network in case of grid failure.*

Tasks implemented in Greece-Test Field 2

Test Field 2: a gas micro turbine of 80 kWe had been installed in the School of Applied Mathematics and Physics (*SEMFE*) inside NTUA Campus.

- EPA Attikis (Gas distribution company of Attiki) was responsible for the set up and operation of the experimental installation from February to December 2008

- the test targeted the same objectives as the first one but with an increasingly complex implementation including tri-generation and storage issues

- some of the partners involved: Bowman Power Systems, SAFT , ANCO, LABEIN and ICCS/NTUA (responsible for reporting the current electrical status of the site and take all decisions concerning electrical interventions to the site).

Tasks implemented in Greece-Test Field 2

The installation was consisted of:

- *a gas micro turbine of 80 kWe and 135 kWth*
- *an absorption chiller which uses the thermal load of exhaust gases, producing chilled water for air-conditioning during the summer period*
- *a Static Switch which automatically separated critical and non critical loads*
- *2 Lithium-Ion Batteries (43 kWh each) and inverters (60 kW each)*
- *controllers and control software*
- *Meters for natural gas consumption, electricity consumption, solar radiation and temperature*

Tasks implemented in Greece-Test Field 2

- The Tri-generation installation could operate in two ways:

1. Connected to the grid: *providing electricity to the internal low voltage network of SEMFE and thermal /cooling energy during the winter and summer period respectively*
2. In isolated mode: *in case of grid failure the static switch disconnected the main grid and the CHP/Batteries System provided electricity to the critical loads of the site (emergency lighting , 20kW)*

- The Storage system *was mainly used to feed the critical loads until the CHP Unit starts its operation*

- Around 10 different operating scenarios of the installation *had been tested in which electricity prices from several European countries (e.g from APX) had been used*

Tasks implemented in Greece-Test Field 2

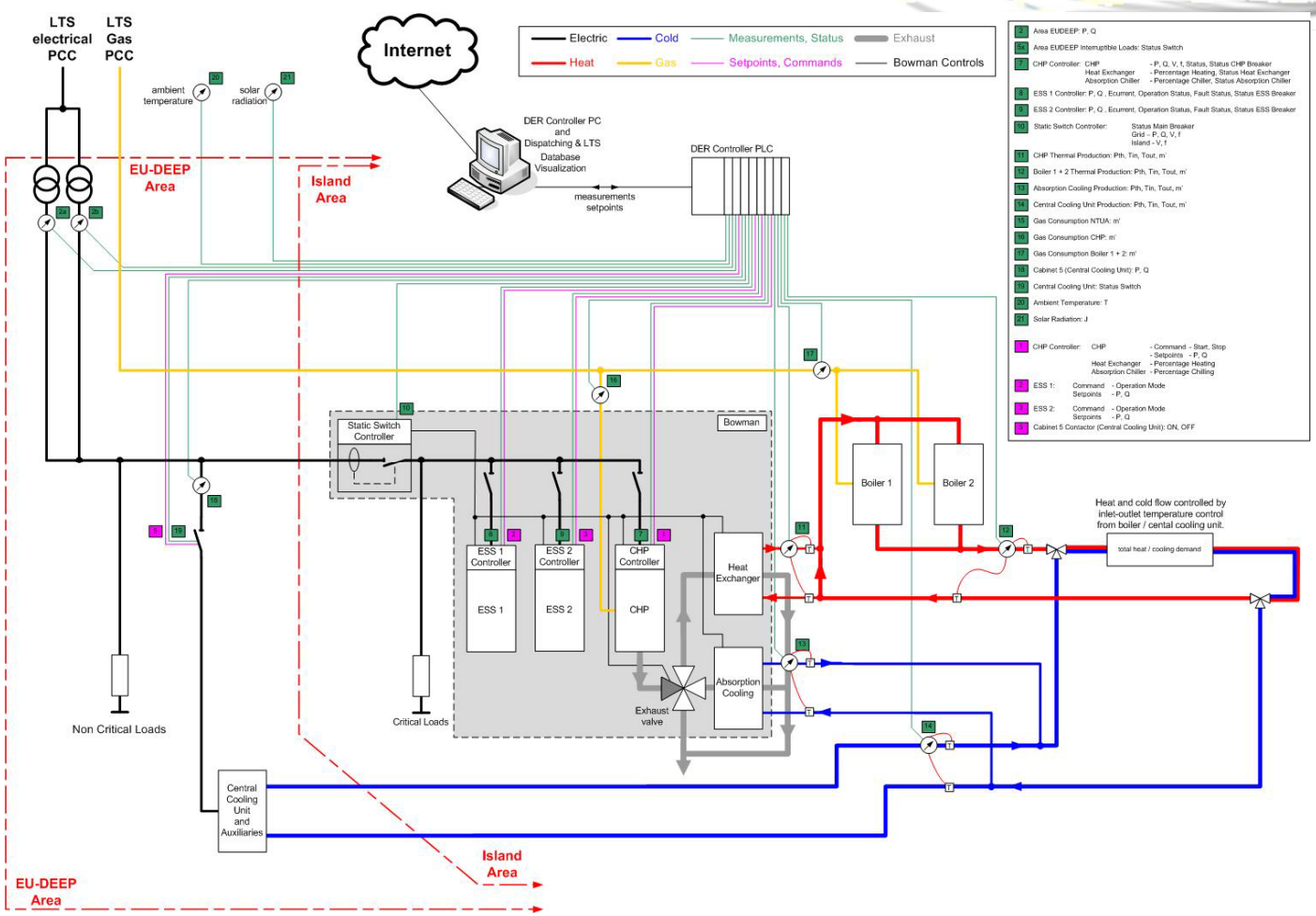


Fig.1 : Schematic diagram of the installation

Tasks implemented in Greece-Test Field 2

Fig.2 : View of the installation

Tasks implemented in Greece-Task Force 3

Main characteristics of Task Force 3:

•Based on the idea of leveraging on the flexibility of aggregated CHP units and demand response to extend the conventional Energy Service Company business (ESCOs).

•Technology-oriented, in the frame of the above idea the Multi Agent System (MAS) Software developed by the Laboratory of Electric Energy Systems of NTUA had been implemented for the de-centralized control of DG units and loads, ***for the first time , in real clients environment.***

Tasks implemented in Greece-Task Force 3

The clients assumed are:

CRES Site

CHP 80 kW
Load <10kW, PV 1.1kW & Battery Unit 4.5 kW

NTUA Site

Loads 5kW & PV 22kW unit.

Meltemi Holiday camp

Loads 3kW

Tasks implemented in Greece-Task Force 3

The following scenarios were implemented aiming to test and compare central versus decentralized control:

Scenario 1: *All of consumption is non-flexible. Test how production units adjust their output in order to participate in the market in a* ***coordinated*** *way.*

Scenario 2: *All of generation is non-flexible. Test how controllable loads adjust their consumption in order to follow the production limits.*

Scenario 3: *The whole system participates in the market* ***as a single entity*** *trying to maximize its overall gain. Generation and consumption are controllable.*

Scenario 4: *Meltemi, CRES and NTUA participate in the market* ***as three entities (MASs)*** *that may cooperate or not. Test how a large number of agents can be organized and communicate in a harmonic way.*

Tasks implemented in Greece-Task Force 3

The conclusions derived:

Scenario 1: The agent-based algorithm had the ability of adding (or taking out of service) new production units, without having to re-calibrate the whole control system from scratch (plug-and-play capability). This property will be important for future implementations, where many small production units (RES, CHP, etc.) will be connected to the distribution system.

Scenario 2: Main objective was to perform load shedding in a more fair way. The goals have been achieved, since the agents were able to decide on themselves , after a negotiation, which load should be shed, according to the consumption of each load and the total power available. No load should be shed for a second time, until every load has been turned off at least once.

Tasks implemented in Greece-Task Force 3

The conclusions derived:

Scenario 3: Proved that the agents have the ability to learn from their environment. Given only the buy and sell prices of electric power, the agents were able to identify when it is more profitable for them to produce or to consume energy. The algorithm was quite fast, since it required less than 30 seconds in order to find the best strategy for the next 24 hours.

Scenario 4: Proved that the agents can be organized in a hierarchical way and different actions could be performed in the different levels of organization. With the Scenario 4 perspective, we are given the opportunity to organize the agents into different groups. In this way, we could add to our control system as many control units we wish (scalability), without increasing in a great extent the execution time of the algorithm.

Tasks implemented in Greece-Task Force 3

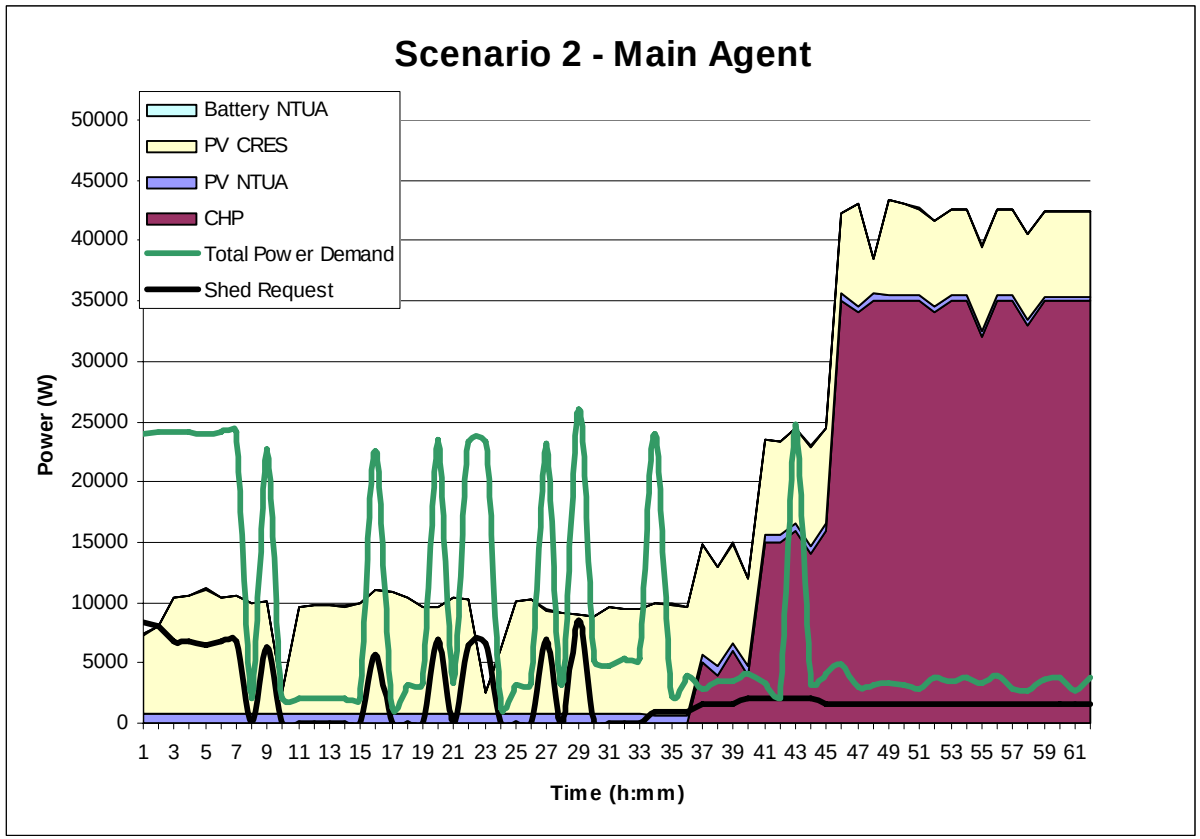


Fig. 3 : Scenario 2 – Total Power Production and Amount of Load Requested To Be Shedded

Tasks implemented in Greece-Task Force 3

Furthermore, In the frame of TF 3 :

- flexibility tests were implemented by CRES in all the sites

- ICCS/NTUA participated also in the tests

- the main purpose of these experiments was the investigation of how the characterized as “flexible” loads of each site as well as the sites occupants respond to certain interruptions

- during the tests, load interruptions were performed in all the sites based on different criteria such as weather conditions and site occupation

Tasks implemented in Greece-Task Force 3

•the time intervals between interruptions as well as the duration of each interruption were based on the nature of the flexible loads and the dynamic response of each site

•in two of the sites the interruptions had been performed with commands sent via mobile telephony messages

•before each interruption all sites had prior knowledge of it by phone and the right to refuse the interruption request

•sociological study had been conducted in order the conditions for a social insertion of flexibility and DG Systems in Greece to be specified

Tasks implemented in Greece-Task Force 3

➢ **CABSON** (Centralized Approach Based Simulator Of NTUA)

• CABSON is a deterministic tool

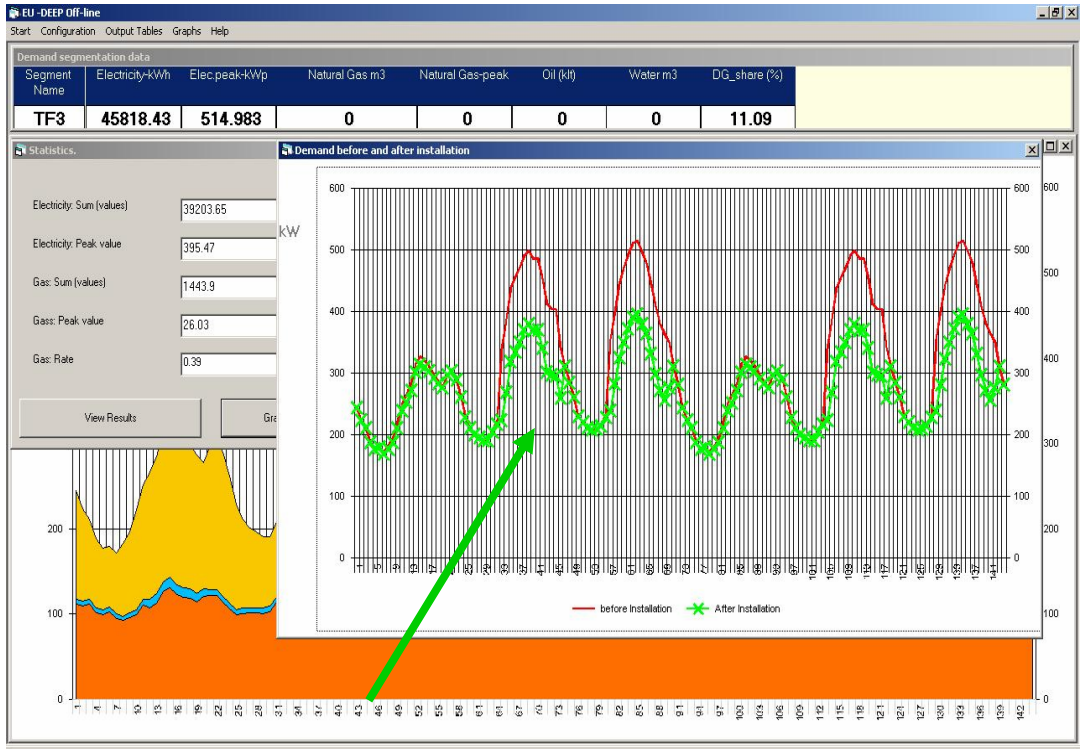
• it uses typical demand curves to simulate the impact of one or more DG units, either in electricity or CHP mode, in one site (actual or even in virtual power plant mode), on the resources demand, operating cost and emissions avoidance

• it can simulate the impact of controllable loads (ON/OFF decisions) and storage devices operation in cycling mode

• it is an internal tool but with prospects of commercialization

• it has a planning horizon of 144 steps

Tasks implemented in Greece-Task Force 3



Change in demand due to DG

Fig. 4 : Representative screenshots from CABSON

Last but not least

for those who are interested to acquire more details about EU-DEEP:

- www.eudeep.com
- EUDEEP Results book includes the results from all the WPs . Order via the website