Smart House and Smart Grid
www.smarthouse-smartgrid.eu

2011 IEEE SmartGridComm, European Smart Grid projects workshop
Brussels, 17.10.2011

SmartHouse/SmartGrid

David Nestle, Jan Ringelstein
Fraunhofer IWES, Königstor 59, D-34119 Kassel
Tel.: 0561 7294 – 234, david.nestle@iwes.fraunhofer.de
SHSG Project Goals

- Demonstrate how ICT-enabled collaborative aggregations of Smart Houses can achieve maximum energy efficiency
- Concept:
  Aggregate houses as intelligent networked collaborations instead of seeing them as isolated passive units in the energy grid
- Develop real-life technology with potential for mass application across Europe for enabling energy efficiency gains
- EU co-funded, timeline Sept 2008 – Aug 2011
SHSG Key Issues

- ICT and Interfaces for mass scale integration of Smart Houses into Smart Grids


SHSG Field Tests

FT A: ICT for Smart House mass application scenario

FT B: Smart house roll-out in Domestic cluster

FT C: Smart Houses supporting the grid in emergency cases

Source: http://www.smarthouse-smartgrid.eu/index.php?id=147
SH/SG Architecture Functionalities

Field Trial A
- Mass scalability
- Prosumers with DR
- Market-based control
- RES integration
- Interoperability

Field Trial B
- Variable tariffs
- Automated energy mgmt
- Load shifting
- User acceptance

Field Trial C
- Energy feedback for user
- Black start support
- Grid reliability
- Grid reliability
## Amalgamated Service Architecture
### Basic Concepts

<table>
<thead>
<tr>
<th>Power Matcher</th>
<th>BEMI</th>
<th>MAGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Decentralized decision making</td>
<td>• Decentralized decision making</td>
<td>• Decentralized decision making</td>
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<tr>
<td>• Automated control of production and consumption units</td>
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<tr>
<td>• Decision-making based on centralized market equilibrium</td>
<td>• Decision-making based on centralized tariff generation</td>
<td>• Decision-making based on centralized negotiation</td>
</tr>
<tr>
<td>• Real-time mapping of demand and supply</td>
<td>• Day ahead mapping of demand and supply</td>
<td>• Mapping of demand and supply</td>
</tr>
</tbody>
</table>

Source: The SH/SG Team, 2011
Simulation Team A – Study 1 setup

- 3000 Households, 1500 with micro CHP, 1500 with heat pumps
- Scaling down from 2040 Dutch network scenario
- Offshore wind installed power: 750 ... 1000 kW
- Comparison of operation in 2 November weeks with and without PowerMatcher controlling micro CHP and heat pumps

Source: The SH/SG Team, 2011
Simulation Team A – Study 1 results

Effects of PowerMatcher control:

- Energy Exports reduced by 90 ... 65 % → less need for export capacity
- Energy Imports reduced by 14 ... 21 % → potential CO₂ reduction

<table>
<thead>
<tr>
<th>Offshore Wind</th>
<th>Traditional kWh</th>
<th>PowerMatcher kWh</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 kW</td>
<td>27389</td>
<td>23447</td>
<td>14%</td>
</tr>
<tr>
<td>800 kW</td>
<td>26287</td>
<td>22154</td>
<td>16%</td>
</tr>
<tr>
<td>850 kW</td>
<td>25218</td>
<td>20920</td>
<td>17%</td>
</tr>
<tr>
<td>900 kW</td>
<td>24178</td>
<td>19739</td>
<td>18%</td>
</tr>
<tr>
<td>1000 kW</td>
<td>22194</td>
<td>17478</td>
<td>21%</td>
</tr>
</tbody>
</table>
Simulation Team A – Study 2
Results (cable losses)

- Considering fictive LV feeder, 25 households, 12 with heat pumps, 13 with micro CHP
- Cable loss reduction from 11.7MJ to 7.0MJ by adding PowerMatcher control
  - I.e. 1.3kWh of energy / day or annually 100+ euro / 25 households

Source: The SH/SG Team, 2011
Simulation Team C overview

Simulation for the year 2030 of the autonomous system of Crete for various load control scenarios

- Steady-state simulation
  - economic dispatch
  - load flow analysis
- Transient analysis

The Cretan System:

1. 690MW installed thermal capacity on 3 power plants (Chania, Atherinolakkos, Linoperamata)
2. 166MW installed wind power capacity (December 2009), most on the eastern part of the island
3. Since 2000, wind energy accounts for around 10% of the annual energy demand of the island

Source: The SH/SG Team, 2011
Simulation Team C load control scenarios

**Scenario 1** (Business as usual): no load control actions considered

**Scenario 2** Various levels of controllable load (water heaters & A/C) considered (varying from 10% to 30%)

- Scenario 2A: load control is performed equally to all the regions of Crete
- Scenario 2B: load control is performed primarily to the households of Chania and Iraklio, which are the most populated cities of the island

Reduction of peak demand: as high as 4.49% (annual average) depending on the scenario

Source: The SH/SG Team, 2011
# Simulation Team C results

## CO2 emissions (tonnes) per Scenario – Percent change of CO2 emissions with respect to Scenario 1

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2A</th>
<th>Scenario 2B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>1,467,728</td>
<td>1,465,906</td>
</tr>
<tr>
<td>20%</td>
<td>1,466,253</td>
<td>1,463,738</td>
</tr>
<tr>
<td>30%</td>
<td>1,464,271</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** The SH/SG Team, 2011

## Operational cost (€) per Scenario – percent change with respect to Scenario 1

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2A</th>
<th>Scenario 2B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>215,204,940</td>
<td>214,455,919</td>
</tr>
<tr>
<td>20%</td>
<td>212,843,853</td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>213,694,172</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** The SH/SG Team, 2011

### Transient analysis:
Load shedding supports system frequency from reaching low levels - should be part of a complete protection scheme.

Higher load control penetration level improves CO2 reduction.

An optimum load control penetration level exists. Controller location is relevant.
A Smart House Energy Gateway could provide:
- Energy Management
- Building Automation
- Room heating control
- EV charging control
...
OGEMA Key Facts

- OGEMA defines gateway core specification
- Environment for parallel execution of different applications with access to smart grid data and devices (e.g. controllable loads)
- Standardized data models and services for different home automation systems
- Support of different in-house and smart grid communication systems
- OGEMA defines a public open standard
- Public (open source) reference implementation for quick start
Open Gateway Energy Management Alliance (OGEMA)

Open source
Operating system (e.g. Linux)

OGEMA for Energy management

- Display
- CHP
- Loads
- Smart Meter

Device Control App

Resource Administration

Emergency load shutdown

www.ogema-alliance.org
Open Gateway Energy Management Alliance (OGEMA)

OGEMA features:
- applications from different manufacturers run in parallel
- standardized data models
- flexible and modularized architecture

OGEMA goals:
- develop an open, manufacturer-independent standard
- develop and test open source reference implementation
- pave the way for energy management gateway mass-roll out

OGEMA for Energy management:
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www.ogema-alliance.org
Open Gateway Energy Management Alliance (OGEMA)

OGEMA Services
- Time control
- Resource administration
- Database administration
- Web-Interface
- Logging

Applications
- Freezer Management
- Emergency Power Reduction
- Price-based Management
- Efficiency Analysis

Devices (represented as Resources)
- Freezer
- Micro-CHP
- Electricity Price

Communication drivers
- KNX
- Z-Wave
- IEC61850 MMS
- CIM Web Serv.

Java / OSGi

www.ogema-alliance.org
Thank you for your attention!

http://www.ogema-alliance.org
http://www.modellstadt-mannheim.de
http://www.smarthouse-smartgrid.eu

Dr.-Ing. David Nestle
Fraunhofer IWES, Königstor 59, D-34119 Kassel,
Tel.: +49 561 7294 – 234, Email: david.nestle@iwes.fraunhofer.de

This report is based on a research project partly funded by the EU FP7 project SmartHouse/SmartGrid (Grant no.: FP7-ICT-2007-224628) and by research partially funded by the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety of Germany (Project: moma – Modellstadt Mannheim, FKZ Nr. 0325089A). The authors are responsible for the content of this publication.