EcoGrid EU
A Real-Time Smart Grid Demonstration in Denmark

IEA DSM Agreement, Task XVII
Arnhem, 25th April 2012

George Huitema
EcoGrid Coordinator TNO
TNO, The Netherlands
Content

- The Challenges of Tomorrow
- What is EcoGrid EU?
- The Real-time Market Approach
- End-user Involvement
- Conclusion
The Wind Power Challenge
An illustrative case from Denmark

Today (2008)

20% wind power

Wind power covers the entire demand for electricity in 200 hours (West DK)

Tomorrow (2025)

50% wind power

In the future wind power will exceed demand in more than 1,000 hours

Consequence: an increasing need for balancing services
EcoGrid EU in Brief

- **Project:**
  - EU FP7 Project
  - Total budget: 24 million Euro (EU funding 12 million Euro)
  - Demonstration > 50 % of budget

- **Demonstration:**
  - A *large scale* demonstration of a real-time market place for distributed energy resources
  - A demonstration of a *real* power system with more than 50 percent renewable energy
  - *Participation of small consumers and local producers* in the power market

- Preparation for a *fast track* towards European real-time market operation of RES & DR
EcoGrid EU Partners

Executive Subcontractors

- Sweden
  - Landis + Gyr
  - Maj Dang Trong Analise

- Norway
  - SINTEF ER
  - Tallinn University of Technology (TUT)
  - IBM Benelux
  - Austrian Institute of Technology (AIT)

- Denmark
  - Energinet.dk
  - Østkraft
  - DTU-CET

- Belgium
  - Elia
  - Eandes
  - Ores

- Germany
  - Siemens
  - EnCT

- Spain
  - LaBein

- Norway
  - Maj Dang Trong

- Estonia
  - Tallinn University of Technology (TUT)

- The Netherlands
  - ECN
  - IBM Benelux

- Austria
  - Austrian Institute of Technology (AIT)

- Switzerland
  - IBM Research
Bornholm – a Unique Test Site

- Demonstration in a “real” system with 50% RES
- High variety of low carbon energy sources
- Several active demand & stationary storage options
- Interconnected with the Nordic power Market
- Strong political commitment & public support
- Operated by the local municipal owned DSO, Østkraft
- Eligible RD&D infrastructure & full scale test laboratory
# Key Numbers for Bornholm

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customers</strong></td>
<td></td>
</tr>
<tr>
<td>Number of customers</td>
<td>~28,000</td>
</tr>
<tr>
<td>Number of customers (&gt; 100,000 kWh/year)</td>
<td>~300</td>
</tr>
<tr>
<td>Total energy consumed</td>
<td>268 GWh</td>
</tr>
<tr>
<td>Peak load</td>
<td>55 MW</td>
</tr>
<tr>
<td><strong>Low-carbon energy resources</strong></td>
<td></td>
</tr>
<tr>
<td>Wind power plants</td>
<td>30 MW</td>
</tr>
<tr>
<td>CHP/biomass</td>
<td>16 MW</td>
</tr>
<tr>
<td>PV (roll-out under project)</td>
<td>1.0 MW</td>
</tr>
<tr>
<td>Biogas plant</td>
<td>2.0 MW</td>
</tr>
<tr>
<td>Electric vehicles (under roll-out)</td>
<td></td>
</tr>
<tr>
<td><strong>Grid</strong></td>
<td></td>
</tr>
<tr>
<td>60 kV grid</td>
<td>131 km</td>
</tr>
<tr>
<td>Number of 60/10 kV substations</td>
<td>16</td>
</tr>
<tr>
<td>10 kV grid</td>
<td>914 km</td>
</tr>
<tr>
<td>Number of 10/0.4 kV substations</td>
<td>1006</td>
</tr>
<tr>
<td>0.4 grid</td>
<td>1,887 km</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
</tr>
<tr>
<td>Fiber network between 60/10 kV substations</td>
<td>131 km</td>
</tr>
<tr>
<td><strong>District heating</strong></td>
<td></td>
</tr>
<tr>
<td>Number of district heating systems</td>
<td>5</td>
</tr>
<tr>
<td>Total heat demand (in 2007)</td>
<td>560 GWh</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td></td>
</tr>
<tr>
<td>Normal operation mode</td>
<td>Interconnected Nordel</td>
</tr>
<tr>
<td>Island operation capability</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
The Scope of a Real-time Market

The EcoGrid Real-time Market will be an integrated part of the current power markets and supports the need of direct control options on a very short time scale.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Days</th>
<th>Hours</th>
<th>Minutes</th>
<th>Seconds</th>
<th>Now</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days-ahead (Elspot)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intra-day (Elbas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulating power market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Direct control
- Inertia
- Frequency-controlled reserves
- EcoGrid Real-time Market
An Additional Source of Regulation Capacity

The current system:
- TSOs obtain a certain quantity by selecting/accepting bids
- Include only large producers, large consumers and aggregated smaller units (minimum 10 MW)
- Loads are “updated” every 15 minutes

The new real-time market:
- No restriction on the size of units (MW)
- TSOs set a price every 5 minutes that result in a certain quantity of fast(er) response from smaller units
How does the Real-time Market Work?

- DER and flexible demand will respond to variable electricity prices through *broadcasted* price signals:
  - Step 1: Electricity price from the existing day-ahead Elspot market is sent to the end-user - soon after clearing (= forecast of “real-time” price)
  - Step 2: During the day the price signal is updated in real-time, i.e. every five minutes – to reflect the need for up or down regulation (if no imbalances the real-time price = the day-ahead Elspot price)

- The real-time price is set by a Real-Time Market Operator (RTMO) on the basis of the need for balancing resources

- The RTMO could be the TSO(s)
Day-ahead Market Price (Spot) and Real-time Price
Real-Time Market Process
System Balancing

1. Set price based on need for correcting system balance

2. Publish price to users (price is the final settlement price)

3. Production and consumption can choose to react

4. Monitor response, back to 1

- Important: The published price is the final settlement price.
The EcoGrid EU Architecture

New power market architecture requirements:

- Installation of automatic “smart controllers” in DER devices
- Smart Meters to manage “real-time” price signals
- Modern ICT infrastructure to transmit price signal to market participants and operational units
End-user Involvement

- Easy for the consumer
  - The price is always known (each five minutes)
  - In principle possible to respond by manually turning off electric appliances, but...

- Appliances equipped with automatic end-user “smart controllers” will do most of the job!

- The requirement of end-user involvement:
  - Understandings of the potential benefits of participation (economical/energy savings/environment)
  - Accept/make contracts based on predefined “preferences”

- ETP Strategic Research Agenda 2035: Alliander/TNO Smart Retail & Consumer Technologies; See [http://www.smartgrids.eu/](http://www.smartgrids.eu/)
2000 Participating Customers in the Demonstration

Reference Group
- 200 households with a smart meter
- No access to specific information or “smart” equipment

Manual Control
- 400-500 households with a smart meter
- Receiving market price information
- Must move their energy consumption by themselves

Semi automatic Control
- 700 semi automated households with a smart meter
- 1-2 reactive appliances responding to price signals
- All houses have heat pumps or electric heating

Automatic Control
- 500 fully automated households with a smart meter
- Multiple connected appliances - all responsive to price signals

Smart businesses
- 100 commercial/public customers with a smart meter
- Including small business units and the public customers
- 4 connected smart appliances

---

PowerMatcher (TNO/IBM)  DEMS (Siemens)
WP structure
Conclusion (1)
New Solutions = New Challenges

- New settlement “challenges” in the real-time market:
  - Meters should handle 5-minutes interval readings
  - Large amount of data should be managed in the settlement process

- Replication challenges:
  - Many countries have deployed meters with 15 minutes/hourly reading
  - The real-time concept must be adapted to those conditions

- End-user acceptance
  - New intelligent home installations are required
  - The concept is based on automatic control (no manual actions required)

- “What’s in it for me”?
  - How to make the system attractive for the small consumers/small RES units
  - Keep transaction costs on an acceptable level
Conclusion (2)

- The PowerMatcher (TNO contribution)
  - Efficient energy management for the smart grid
  - Field-proven technology
  - PowerMatcher: www.PowerMatcher.net

- EcoGrid.EU
  - Demonstrates the Smart Grid Future on Bornholm isle
  - Novel real-time market integrates smaller end-users
  - User centric-approach
Thanks

george.huitema@tno.nl
koen.kok@tno.nl