Smart Grid Research in a Danish Perspective

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Smart Grids in Denmark

- Transformation towards a sustainable energy system is of utmost importance for society
  - Climate, Security of supply, Green growth
  - DK: Wind doubles to 50% in 2020; 100% RES in 2050 (ref: DK Government)

- DK: Electricity expected to doubles to ~70% of the total energy system (ref: DK Climate Commission) New technology and development of a Smart Grid is a prerequisite for efficient integration of high share of renewable energy

- Situation in Denmark
  - Wind power generation equals 26% of demand (2011)
  - The EU country with the highest share of the export within energy technology
  - 22% of EU’s Smart Grid R&D projects takes place in Denmark (ref: EU)
  - National smart grid network established and national smart grid strategy to be launched
Center for Electric Power and Energy (CEE)  
Department of Electrical Engineering

- CEE established 15 August 2012 as a merger of existing units:
  - Center for Electric Technology, DTU Electrical Engineering
  - Intelligent Energy Systems, Risø National Laboratory for Sustainable Energy

- Main competences
  - Electric Power Engineering
  - Automation and control
  - Information and Communication Technology

- A strong university centers within its field
  - Staff: 85 persons incl. PhD-students
  - Covers discipline oriented research as well as national lab type application-driven research and proof-of-concept

- Strategic partnerships

Selected National and International Collaboration Partners

- Academic partners:

- Commercial and industrial partners:

- International networks:

+ SME’s
Some Main Research Challenges (and The Danish Wind Power Case)

Balancing:

Changed Generation Landscape:

Stability and Reliability:

Cost effective solutions:
Research Objective and Fields

Development of a reliable, cost effective and environmentally friendly electric power and energy system based on renewable energy sources

- Electric Components
- Energy Resources, Services and Control
- Energy System Operation and Management
- Electric Power Systems
- Electricity Markets

PowerLabDK
Comprehensive Experimental Facilities for Electric Power and Energy

- Industrial stakeholders: Flexible multi-purpose laboratories
- National support: Large-scale power system (1:10)
- Investment: 18 M€

• Industrial stakeholders:
  - ABB
  - Siemens
  - DONG
  - VESTAS
  - IBM

• National support:
  - 27,000 Customers
  - 33% Grid Power
  - 50% Renewable Energy
  - Islanding capability

• Investment: 18 M€
  - Hereof industrial funds: ~4 M€
LabGrid

21 LabCells
Sources up to 600 kVA

3 x 250 A
backbone
3 x 3 x 125 A
feeders

Cables:
1,931 m / 6,123 kg

www.powerlab.dk

Electric Lab
Power and energy technologies for the intelligent grid

Intelligent Control Lab
Power system simulation, control and supervision

www.powerlab.dk
**SYSLAB at Risø Campus**

- A platform for DER research and testing
- Flexible experimental setup
- Several RES units
- Embedded computing power and flexible communication
- Very flexible control possibilities

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**Bornholm Full-Scale Laboratory (1% of DK)**

33% Wind Power Penetration; 28,000 Customers

Local Energy Strategy
- Political & public drive

Energy resources:
- Wind power
- Biogas plant
- Combined heat and power
- District heating
- Solar power
- eMobility

Features:
- Nord Pool market (DK2)
- Islanding capability
Bornholm Islanding Experiment

Wind Power Penetration

Electric Power output
"Conventional Plant"

System Electric Frequency

Autonomous V- and f-services from demand

Central Control Room

Unreliable Data Network

Intelligent Load Controller

Real-time Measurements and Commands

Real-time Measurements (V,f)
System Reserves Provided by Frequency Responsive Electricity Demand

- Field test w. 200 residential, commercial and industrial demand units

\[ T_{\text{high}} = T_{\text{normal}} + k(f - f_0) \]
\[ T_{\text{low}} = T_{\text{normal}} - k(f - f_0) \]

- Results
  - Demand can with maintained energy service deliver reserves which today are delivered by large power plants
  - Pay pack time = 1-2½ year w/ 1 kW unit
  - Ease of implementation, supporting commercialization


EcoGrid EU

Large-scale demonstration of the future intelligent distribution system

- Integrated research and large-scale demonstration of Smart Grids
- ~2,000 active customers
- EU fast-track to Smart Grids
- 2011-14
- 21 million Euro

Awarded Best Sustainable IT project 2012 by Arnold Schwarzenegger et. al
Extention of the Electricity Market Solutions
Smaller Participants and Shorter Time Constants

Control-by-price Concept with 5 min Real-time Market

Lab. setup with micro CHP:

Measurements:

Increased income = 7.3% wo/ comfort changes (and very simple algorithm)

Congestion Management in Distribution Grid by 5 min Dynamic Grid Tariffs

Ref: IEEE ISGT Europe, 2011.

Smart Grid related Activities at Bornholm

Some ME 40 invested in Smart Grid related technologies at Bornholm.
iPower - Strategic Platform for Innovation and Research
30+ partners, 5 years

www.ipower-net.dk

DTU Electrical Engineering, Technical University of Denmark

4th IEEE PES Innovate Smart Grid Technologies Europe 2013

Copenhagen, Denmark 6-9 October 2013

Hosted by Technical University of Denmark

Bringing industry and academia together

More information: www.ieee-isgt-2013.eu
Thank you!

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