Smart grids and de-carbonising the power sector

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Structure of talk

• Smart Power Networks
• National energy policies
• 2020 targets – 35% of electrical energy from Renewables
• 2030-50 - De-carbonising the power sector
• Role of Smart Networks and research questions for the universities
Networks today…

- **Transmission Grid (765/400 kV)**
- **Power Plants**
- **Switching Substation**
- **Sub-transmission Grid (90/63 kV)**
- **Distribution Grid (20 kV, 230 V)**
- **Service Transformer (380V-220V)**
- **Substation**
- **Service Transformer (380V-220V)**
Development of European energy carrier networks

Massive investments in energy infrastructure anticipated

Significant increase in infrastructure required for an effective market

Source: IMAGE/TIMER model (EEA, 2005).
European Environment Agency
http://reports.eea.eu.int/eea_report_2005_1
Copyright EEA, Copenhagen, (2004)
Facing new issues

**Technical**

- e.g. congestion, ageing, technology development

**Environmental and socio-economic**
Drivers for innovation

Efficient and cleaner technologies
Climate change
Emission trading

Efficiency and Competitiveness
Low prices and efficiency

Reliability, Quality and Protection
Capacity

Regulation of market
Primary energy sources

ENVIRONMENT

INTERNAL MARKET
SECURITY OF SUPPLY
The concept of “Smart Power Networks”

- “Smart” coexistence of central and decentralised generation with lower carbon generation and efficient demand/response
- Load trading and cost optimisation by means of dialog towards time-variable tariffs and variable incentives depending on present load
- Customer integration based on bi-directional communication and large flow of information
Key opportunities of “Smart Power Networks”

- **Security of supply** – efficient mix of centralised with decentralised operation allows the use of domestic energy resources, **whilst maintaining** a high level of reliability and quality of supply.

- **Climate change** – higher **efficiency** in energy **transport and use** of RES and cleaner Distributed Generation, incl. CHP, results in a real contribution to reduce emissions.

- **Competitiveness of Industry** – stimulate innovation of network and associated ICT represents a positive effect, worldwide.
Contemporary policy context

- **2020**: Many countries now have ambitions to increase the share of Renewables in electricity generation to around 35% of electrical energy.
- **2050**: There appears to be an emerging consensus that cuts in GHG emissions of more than 80% are required, and that this will require the de-carbonisation of the power sector.
2020:
UK Renewable Energy Strategy

Source: DUKES 2007
Features of the 2020 electrical energy supply system?

• 30-35% of electrical energy from Renewables based on established technologies.
• For the UK, the dominant technology is likely to be onshore and offshore wind.
• One scenario projects 14,000 MW of onshore and 14,000 MW of offshore wind.
• Major transmission circuits traditionally take 10 years to permit and construct.
Challenges for 2020 - Generation

• Increased plant margin and hence reduced running hours (and therefore profitability?) for some generation
• Considerable use of flexible and probably less efficient thermal plant
• Smart Networks: increase demand side participation though Smart Metering
National Grid 2020 “Gone Green” scenario

Gone Green Scenario 2020/2021
(capacity mix)

- 34.6, 35% Gas
- 19.8, 20% Coal
- 61GW Demand
- 29.1, 29% Nuclear
- 6.9, 7% Wind
- 5.5, 6% Other Renew
- 3.3, 3% Other
Challenges for 2020 - Transmission

• Major new transmission capacity required for both offshore and onshore wind

• Smart network options include:
  – New DC transmission technology
  – New AC transmission technology
  – Change in management of transmission system (allocation of transmission rights and security of supply standards)
Getting Renewables from Scotland

Option – Offshore HVDC

- Illustration of radical thinking now being undertaken.
- Multi-terminal Voltage Source HVDC transmission connecting both on-land and offshore wind farms.
- Alternatives are on-land reinforcement of North South circuits as well as more effective management of existing assets.
Challenges for 2020 - Distribution

• Much on-shore low carbon will be connected at less than 150 kV (Distribution)
• Major equipment renewal programme required – but still no clear vision of the future
• At present very limited use of ICT
• Active Smart Networks
**Distribution systems**

- **Active Management**
  - The primary purpose is to maximise the utilisation of distribution network assets with increasing penetration of DER
UK Climate Change Committee
December 2008

• Emission reductions written into primary legislation
• 2050 target: 80% GHG emission reduction (based on 1990 levels)
• Decarbonisation of the power sector, starting now and through 2020s. Dominant Technologies likely to be Renewables (e.g. wind, tidal), nuclear and CCS
Features of the de-carbonised power sector

**Generation**
- Renewables and constant output plant (CCS and nuclear)
- Large plant margins limited by use of DSP and storage
- Variable energy pricing with active customer involvement
- Aggregation of local generation

**Transmission/Distribution**
- Local micro-generation and DG connected to Distribution
- Large-scale remote renewables requiring new transmission links
- Active control of transmission and distribution networks to limit capacity required
- Much greater use of ICT on Distribution.
Some pressing research questions

• How are smart meters to be used?
  – Demand reduction, frequency control, reserve, peak shifting?

• How can millions of small generators and controlled loads be co-ordinated?
  – Does complexity science help us?

• How to communicate to domestic customers for Demand Side Participation?
  – What level of information do we need and want?

• Will a market solution work for both operation and planning of Smart Networks?