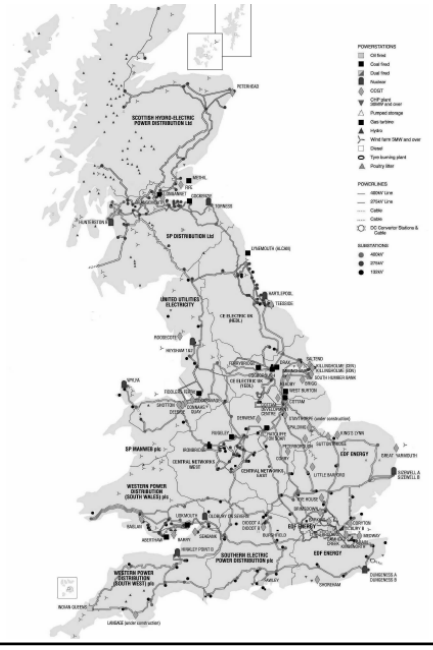
Distributed Generation System Integration in Distribution Networks in the UK

Dr Graham Ault
Institute for Energy and Environment

On behalf of BERR / SEDG

Overview

- DG in the UK
  - DG trends
  - Connection arrangements
  - DG Integration Support Mechanisms
- SmartGrid and Active Network Management Definitions
- Ongoing activities:
  - Distribution Working Group (DWG)
  - Govt. funded DG research centre (SEDG)
  - Review of international activities
- DG Integration with ANM in UK
  - Case Study
- Conclusions



DG trends in UK

- ST, CCGT, Nuclear make up >75GW of 83GW UK generation capacity
- 60 GW peak demand and 405 TWh electricity production
- Industrial/commercial on-site generation: 8GW (*6.3 GW in 2002*)
- Hydro: 1.4 GW
- Other Renewables: 2.2 GW (*1.1 GW in 2002*)
- CHP: 3.9/5.5 GW (130 large units, >1500 total schemes)

DG Connection arrangements in UK

- Connection application process for DG developments:
  - DNO connection study and connection cost
  - Regulated timescales for response (but not for actual connection)
  - GB Technical standards cover planning, operation, protection, etc. (G59 and G75)
- LV connected micro-DG
  - Simplified connection process (G83)
- DG owner/operator contracts with energy retailer for energy off-take
- DG owner/operator arranges incentives separate from DNO
  - Govt. departments for capital grants
  - Regulator (Ofgem) for Renewable Obligation Certificates (ROCs)
- DG owner/operator pays Generation Distribution Use of System Charge (GDUoS) to DNO for use of distribution infrastructure
- DNO has possibility to contract ancillary services from DG
- Active management of generation already in place in small number of cases

Registered Power Zones: Overview

- Introduced to encourage DNOs to apply technical innovation
- Specifically apply to DG connection
- DNOs to deliver cost effective means for connecting and operating DG
- RPZ must have generator participation
- Innovative approach must be evident:
  - Equipment
  - System design
  - System operation
- Transparent reporting of RPZ outcomes to promote best practice

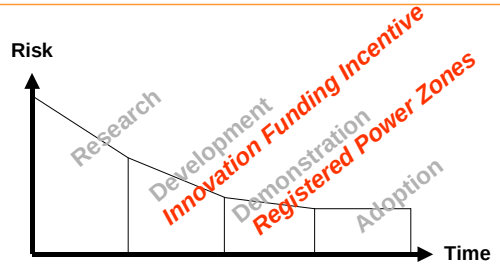
Registered Power Zones: Relationship to IFI

- Innovation Funding Incentive (IFI)
- Objective to encourage R&D activity in DNOs
- DNOs allowed to spend up to 0.5% of regulated revenue on eligible R&D activity
- Typical DNO has revenue of £250m p.a. leading to an upper limit of £1.25m R&D spending

RPZ/IFI Relationship

ofgem

The innovation process



IFI & RPZ – Targeted incentives for network companies

CHPA 10 May 05

Registered Power Zones: Benefits

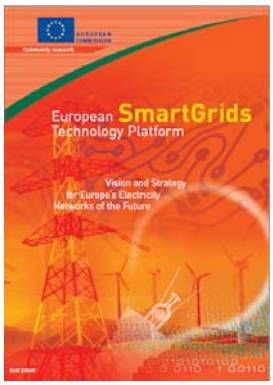
- DG Incentive: 1.5 £/kW/year
- 80% pass through of DG connection costs
- RPZ multiplies the DG Incentive by Three: Additional 3 £/kW/year
- Benefit to generation developers from more cost effective connections

- Example: 10 MW scheme earns the DNO £30k per year for 5 years

GB Distribution Working Group

- Part of the Govt./Regulator chaired Electricity Networks Strategy Group (ENSG)
- Had four main projects:
  - Horizon scanning
  - Network design
  - Active network management (ANM)
  - Micro-generation
- ANM project initially focused on meeting low carbon objectives
- ANM project now focused on working to enable SmartGrids in GB (an important aspect of which are the binding EU targets for renewable generation)
- ANM project members:
  - Distribution Network Operators (DNOs)
  - Generation Developers
  - Manufacturers, Technology Developers, Vendors
  - Academics

EU SmartGrids agenda



Strategic Deployment Document (2008)

- EU wide vision and research and deployment agenda for moves towards smarter grids
- 'Flexible, Accessible, Reliable, Economic'

SmartGrid: Proposed Definition

A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it (generators, consumers and those that do both) in order to efficiently deliver sustainable, economic and secure electricity supplies.

Feedback on this and next two slides is positively encouraged!

SmartGrid Definition: Detail

- *A SmartGrid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies to:*
  - *better facilitate the connection and operation of generators of all sizes and technologies*
  - *allow electricity consumers to play a part in optimising the operation of the system*
  - *provide consumers with greater information and choice in the way they secure their electricity supplies*
  - *significantly reduce the environmental impact of the total electricity supply system*
  - *deliver enhanced levels of reliability and security of supply*

Definition: Active Network Management

'a network where real-time management of voltage, power flows and even fault levels is achieved through a control system either on site or through a communication system between the network operator and the control devices'

DG Research Challenges for the UK

- Renewable Generation:
  - Intermittency
  - Location
  - Technology
- Distributed Generation
  - Integration rather than connection
  - Move from passive to active management of distribution networks
  - Coordinated management of DG and demand
  - Market and commercial structures to maximise benefits from DG and DSM

Sustainable Electricity and Distributed Generation (SEDG) Research Centre

- These issues form the context for the SEDG research centre:
  - Established in 2003 to support the achievement of govt. targets for DG and renewables
- SEDG Research Framework:

1. Generation capacity adequacy
2. Real time system balancing
3. Transmission and distribution networks requirements
4. System stability
5. Role of enabling technologies
6. Technical, commercial and regulatory framework

International Review of Active Network Management Research → Deployment

- 1st Review (2006) focusing on Research, Development and Demonstration:
  - Sponsored by the GB Distribution Working Group 'Active Network Management' project
  - Funded by Department of Trade and Industry
- 2nd Review (2008) focusing more on Deployment:
  - Update on 1st review in research, development and demonstration activities
  - Sponsored by the GB Distribution Working Group 'Active Network Management' project
  - Funded by E.On Central Networks – Distribution Network Operator

Register of Active Networks Solutions

Project ID	Project Title	Lead Organisation	Partner Organisations	Funding Source	Activity Type	Activity Status	Start and completion dates	Country	Classification of technical focus	Summary of Technology/ Activity	Deployment Summary	Impact of Technology/ Activity	Contact details
001	"Embedded Controller" for Active Management of LV Distribution Networks	Econnect ltd	University of Northumbria at Newcastle, VA Tech and T&D UK ltd and YEDL	DTI Technology Programme: New and Renewable Energy. Contract number: K/EL/00334	Research & Development	Completed	2004 - 2007	UK	Voltage Control, Fault Level Management, Power Flow Management	Modelled and simulated the effect of the connection of small-scale embedded generation to LV Distribution Networks through a range of scenarios. Simulation data used to develop design specifications for "Embedded Controller", leading to the building and testing of a prototype. Project successful in defining design specifications for effective prototype "Embedded Controller", proven through simulation and testing of a lab-based prototype.	-	Has provided design specifications for development of a production prototype Embedded Controller, development of the controllers is outside scope of project.	http://www.econnect.co.uk/
002	Voltage Control Policy Assessment Tool	EATL	Central Networks, EDF Energy, Central Electric, Scottish Power, United Utilities	EATL STP Project	Research & Development	Completed	2004	UK	Voltage Control	Develop effective policies for applying voltage control technologies for enabling increasing connections of small generators. This project is developing a tool for DNOs to assess new approaches and find the best that allows maximum connections at the lowest cost for the developer, customer and DNO.	-	-	http://www.eatechnology.com/
	Enhancing protection and		Central Networks, EDF Energy,		...rch	...ted	...		...ion rs ...ions trol)	Defining best practice management of protection and control systems to enhance			...eatechnology.com/

- 121 distinct projects with greater numbers moving towards deployment (in UK and elsewhere)

Overview of Register Contents: Active Networks

- UK DNO (Innovation Funding Incentive - IFI) projects
- UK Registered Power Zones (RPZs)
- UK Government (DTI) funded projects
- UK Research Council and Carbon Trust
- EU 5th and 6th Framework programme
- US DoE and National Labs
- Japanese research programmes
- Manufacturers and Consultants

Technical areas in Active Networks

- Active Management Planning
- Communications and Control
- Demand Side Management
- Fault Level Management
- Future Technologies
- Modelling and Analysis
- Power Flow Management
- Power Quality
- Protection Systems
- Storage
- Voltage Control

Demonstrated ANM concepts: Voltage Control

- GenAVC and other voltage control relay input parameter adjustment techniques successfully demonstrated and deployed
- In-line voltage regulation (LV/MV) technologies successfully demonstrated
- Reactive power management through power electronics technologies (D-VAR and D-Statcom) now emerging in network operators in GB and elsewhere
- Voltage control devices being tested in Japan

Demonstrated ANM concepts: Power flow management

- Scottish & Southern Energy, EdF Energy and Scottish Power have post fault tripping schemes implemented
- Power Matcher technology for management of generation, storage and DSM tested in the Netherlands
- PoMS power management device from the EU DISPOWER project demonstrated at the community scale

Demonstrated ANM concepts: Power flow management

- Virtual Power Plant concept has been demonstrated and shows potential for wider application
- Commercial arrangements including interruptible contracts tested in Greece
- DG management schemes tested in the US
- Dynamic line (Central Networks for OHL and Belgium for UGC) and transformer rating schemes deployed

Demonstrated ANM concepts: Communication and control

- EATL and Scottish Power studies showed that existing SCADA infrastructure could underpin further active networks development
- DMS systems from major vendors now being linked into real active network management schemes (e.g. AREVA e-terra on Crete)
- … and other trials under way in areas such as DSM and fault current limitation

Active Networks Register

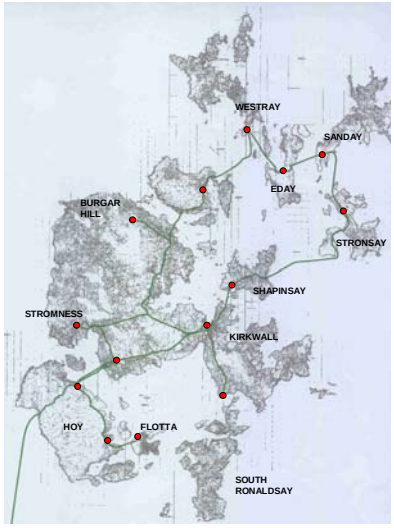
- Good (and growing) range of active network technology R&D underway
- R&D covers many technological areas
- Difficulties in 'registering' industrial R&D and innovative deployment
- Growing level of demonstration and deployment activities

Active Network Deployments under RPZs

- **Central Networks** – Skegness & Fens RPZ
  - Dynamic line ratings to enable higher power export when ambient conditions allow more current flow in a given circuit (132kV)
  - Installation/commissioning ongoing
- **EDF Energy** – Martham Primary RPZ
  - Voltage control in Norfolk rural overhead network with the GenAVC device (11kV).
  - Operational.
- **Scottish Hydro Electric Power Distribution** – Orkney RPZ (33kV)
  - Final control/communication development
  - Operational in 2008

Case study: Context

- Orkney Min/Max demand: 8/31MW (11,500 customers)
- 33kV submarine cables: 2 x 20MW import/export
- Existing generation a mix of wind, wave and gas.
- Reactive compensation equipment installed (including DVAR)
- Generation related congestion managed

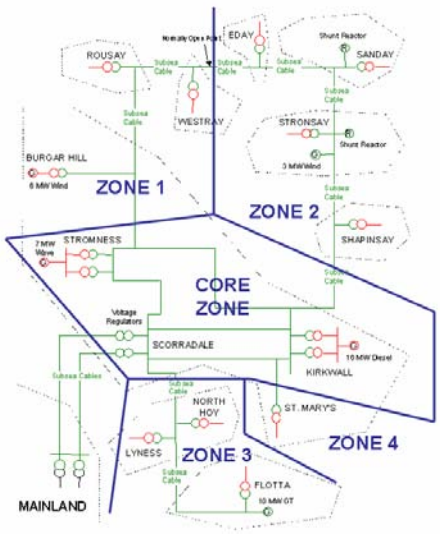


Case study: Timescales

1. DTI funded study – 2004
   - Established benefits from active network management, some details of technical solution and estimated potential economic generation connection
2. RPZ application – 2005
   - Sets out the generators involved, connection barriers, traditional solutions, innovative solutions, costs, etc.
3. Technical and commercial development – 2006-2008
4. Prototyping and Trial – November 2006
5. Full deployment – 2008
6. Commercialisation

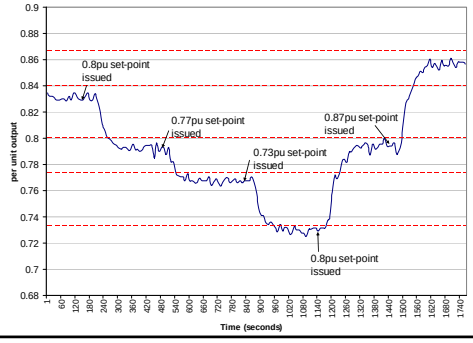
Case study: Concept

- Reactive compensation equipment solves almost all voltage problems (area for future consideration)
- Each zone has a thermal limitation on generation output at any given time
- Whole system has a further thermal limit on generation output
- Real time control of wind and marine generating units based on measurements and control logic.



Case study: Trial

- Prototype ANM scheme elements deployed
- Communications and control logic proven
- Closed-loop control achieved
- Output of wind farm regulated below issued set-point
- Response of WF observed



Case study: Full Deployment

- Design and coding of the full ANM scheme ongoing at present
- Commercial arrangements under development / negotiation (DNO ←→ DG ←→ ANM Solution Provider)
- Full deployment, commissioning and go-live in June/July 2008

Conclusions

- DG has developed more slowly than previously expected in UK so uncertain DNO business drive for ANM/SmartGrids
- Support for innovative DG integration RDD&D activities available
- Some national coordination of DG Integration developments (DWG-ANM, SEDG)
- Possible areas for further SmartGrid demonstration:
  - LV based DSM/DG/Storage/Metering active network concepts
  - MV/HV integrated network management (e.g. multiple elements in scheme and different technologies)
  - Trials rigorously evaluated: technically, commercially and economically

More information …

Graham Ault: g.ault@eee.strath.ac.uk

2006 Active Network Management register and report:
http://www.ensg.gov.uk/assets/dgcg000790000.pdf

2008 Active Network Management register and report coming soon