Future Network Operation
“Active Networks”

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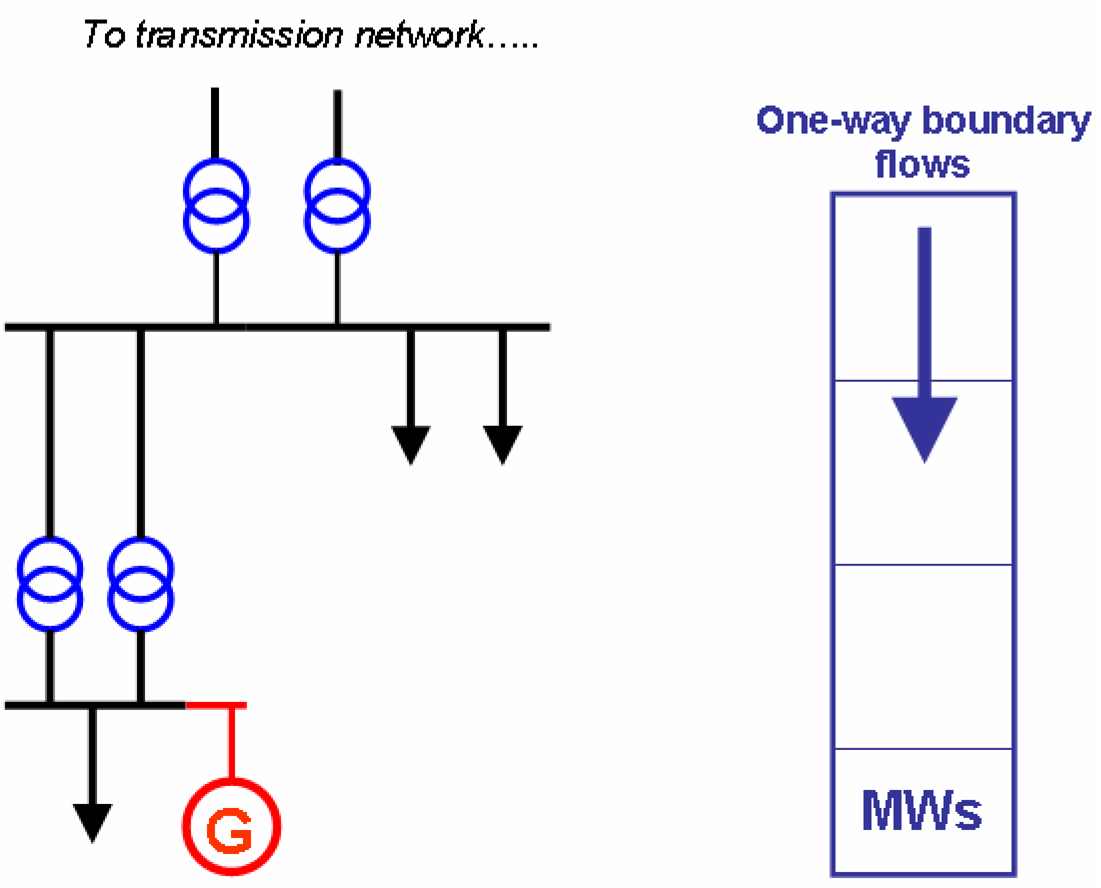
Overview

- Drivers for change in today's distribution network
- What is Active Network Management?
- Registering ANM progress
- ANM Case Study – The Orkney RPZ
- Challenges to widespread ANM
- Implications of widespread ANM

Distribution network of today

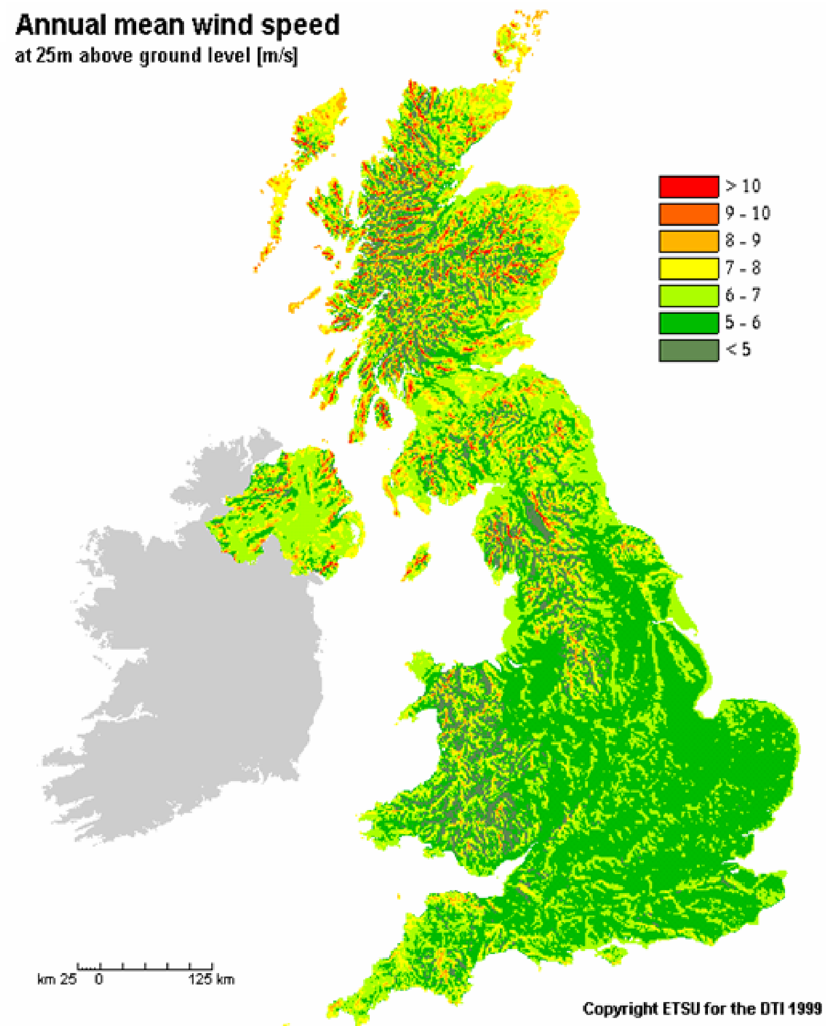


Source: Ofgem

Drivers for change in networks

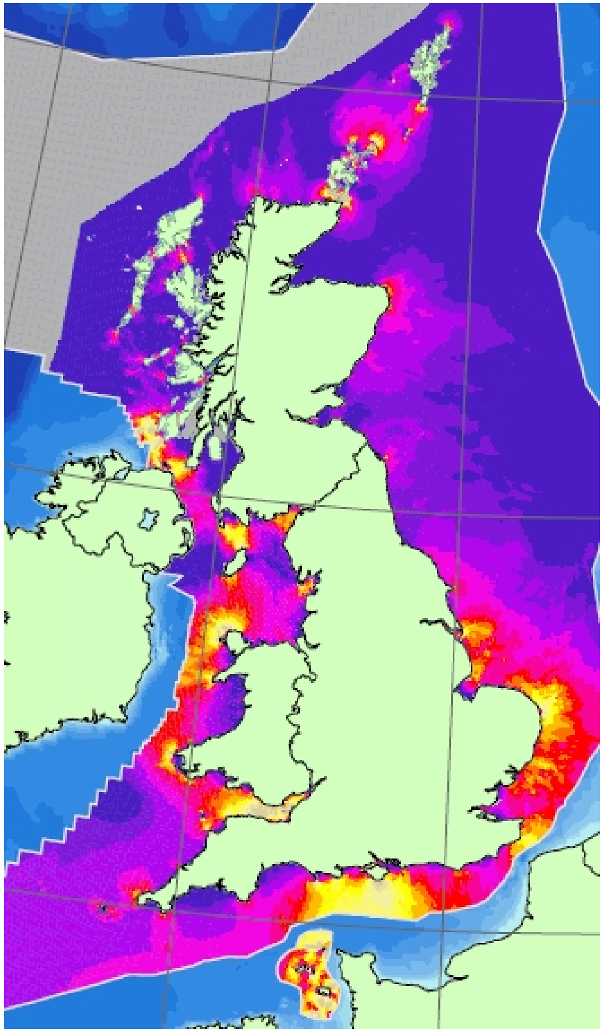
- Modern energy policy
- Increasing consumer awareness
- Growth in distributed generation
- Generation from renewable sources
- Location of renewable resource
- New technologies
- Security
- Smart meters
- ……………..

UK Transmission Infrastructure

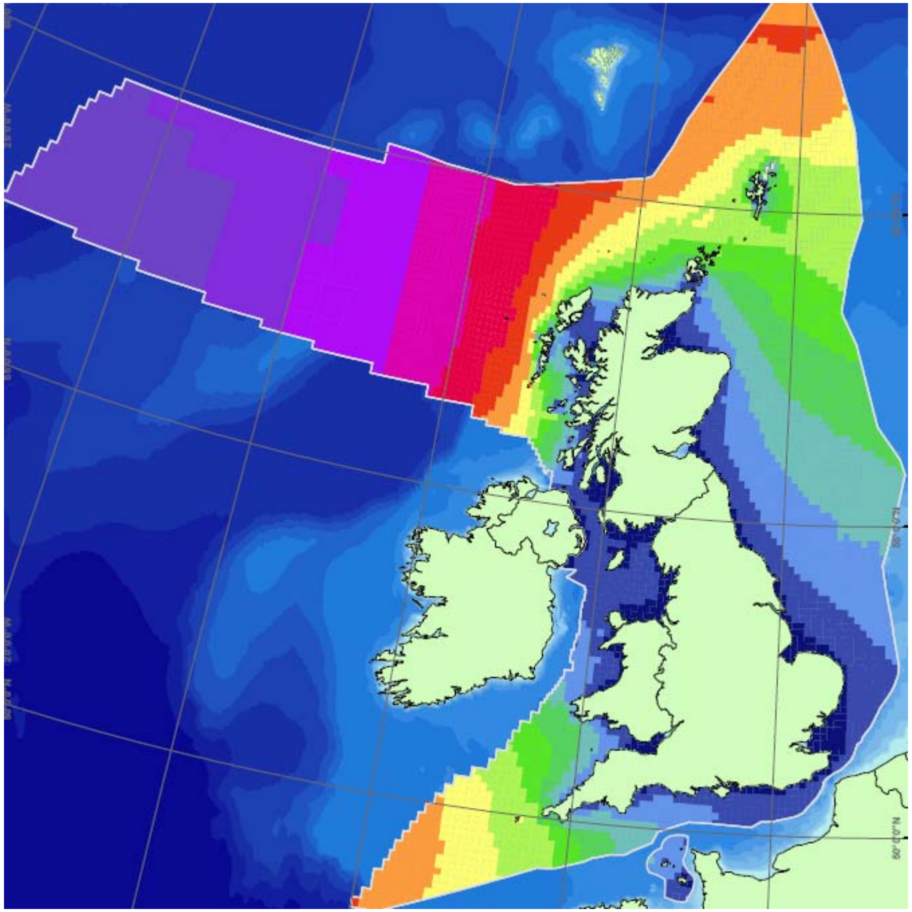


UK Marine Renewable Resource

Tidal



Wave



(DTI Atlas of UK Marine Renewable Energy Resources)

UK Wind Energy Resource

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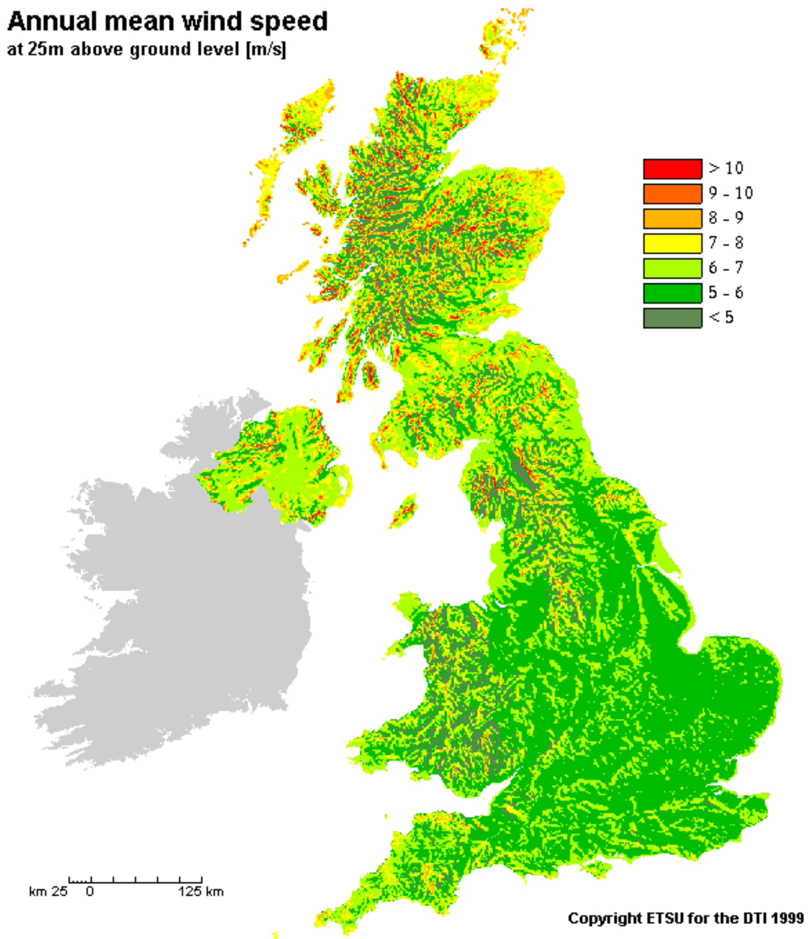
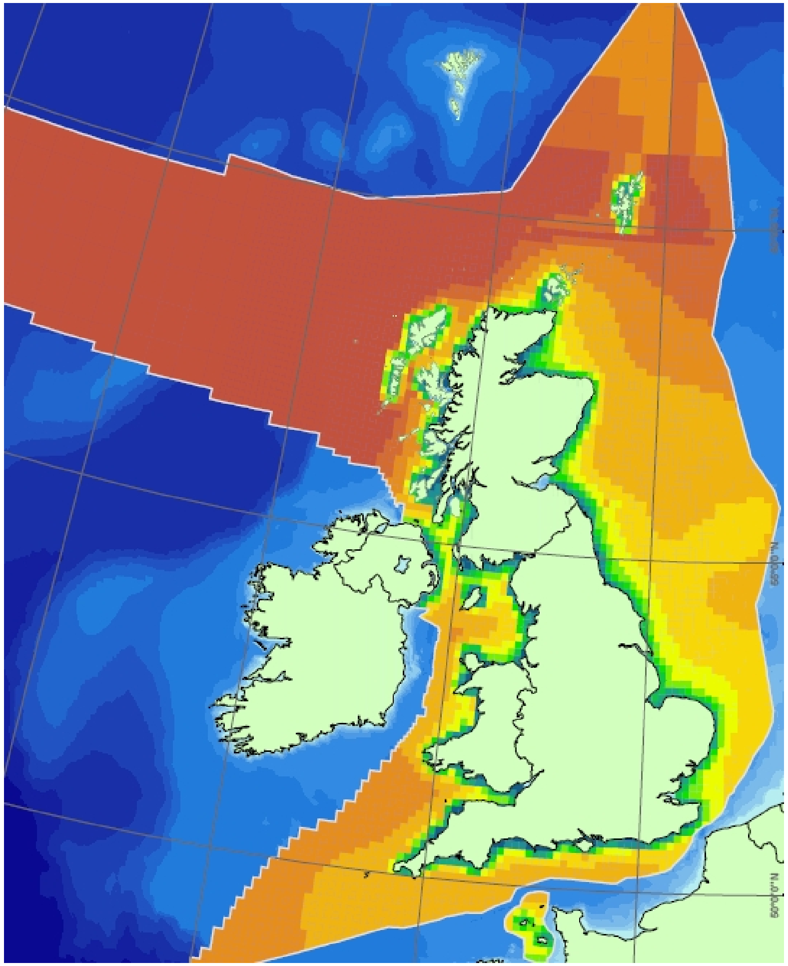
Onshore



Offshore



(DTI Atlas of UK Marine Renewable Energy Resources)

Renewable Energy in the UK

- How can the renewable resource be accessed?

Network reinforcement?

- Expensive…
- Time consuming...
- Interactive applications…
- Complications of the planning process…
- Who pays?

- Is there an alternative to network reinforcement?

Active Network Management (ANM)

- Solutions are emerging
- Can be economically preferable
- Technically feasible
- Some long term uncertainty and issues to be resolved

Active Network Management (ANM)

ANM is concerned with the same technical challenges as the connection and operation of DG

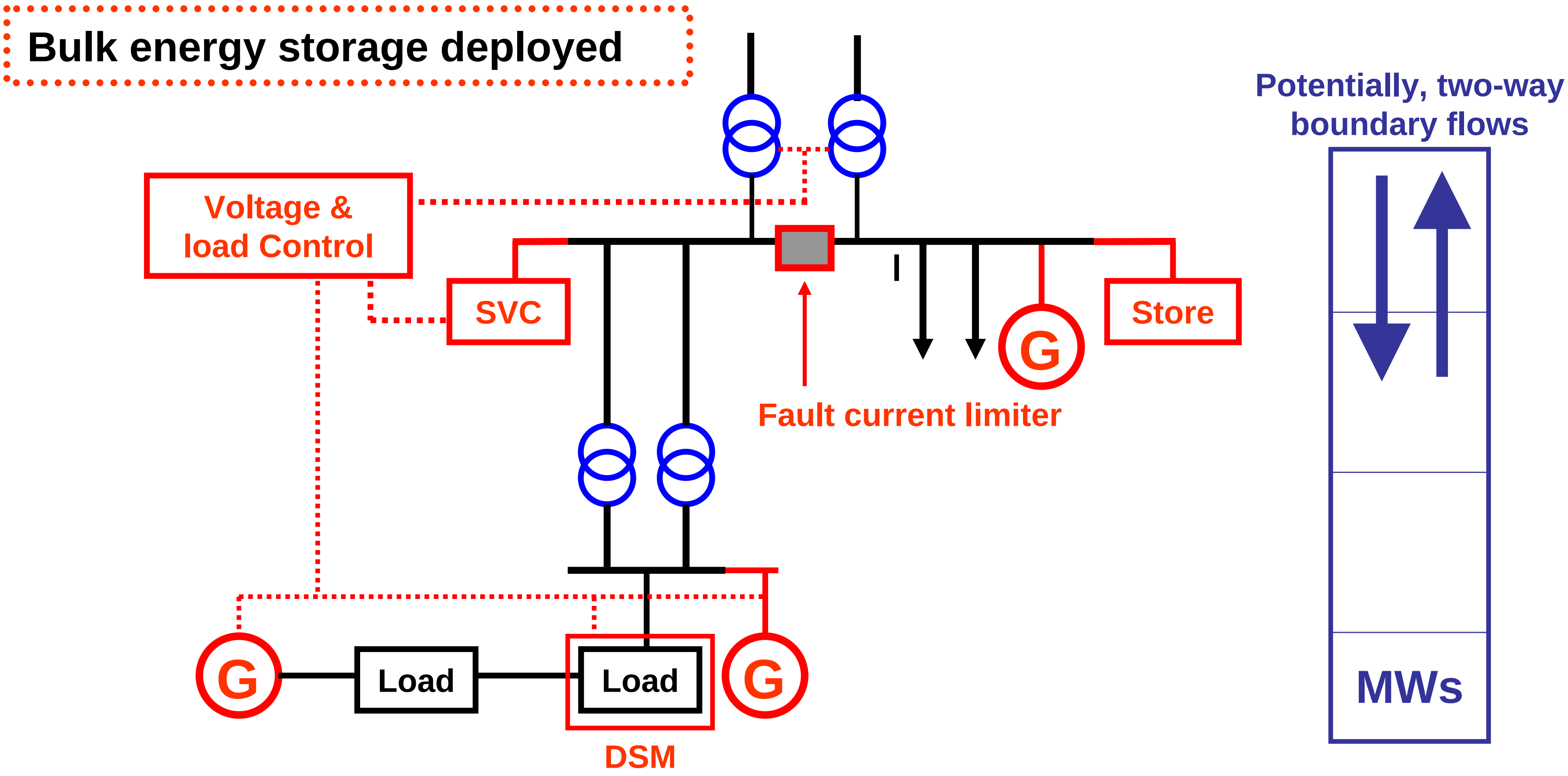
Main technical challenges:

- Voltage control
- Fault level management
- Network security
- Power flow management

Some additional challenges:

- Planning
- Communications
- Other technical impacts (power quality, protection systems, etc)
- Islanding

Distribution network of tomorrow……



Source: Ofgem

The day after tomorrow……

Active Network Management

Dispatch

Network reconfiguration

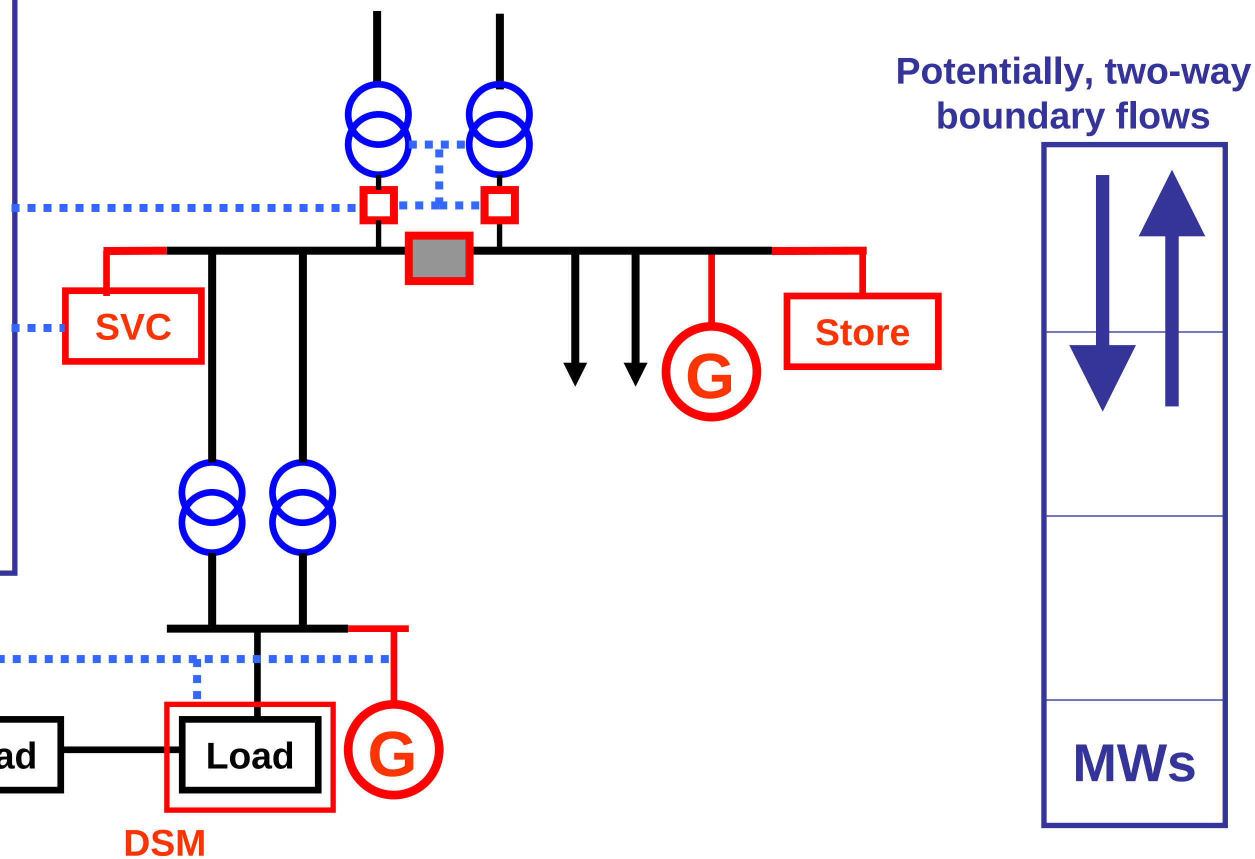
Dynamic constraints

Fault level management

Power flow management

Demand side management

Active voltage control



Source: Ofgem

How much progress has been made?

Project Summary: ANM Register

Aim: To provide clear statements of the status of recently completed, ongoing and planned active network management field pilot and trial activities, international developments in related areas, and research, development and demonstration activities

Key Outcomes:

- Register of 105 distinct international activities (complete with project web links)
- Register provides “way in” to ANM community for interested parties
- Analysis of register contents and list of recommendations
- Over ¾ of ANM activities at the R&D stage
- Updated register for release in early 2008 – focused more on deployment
- Register available online:

www.berr.gov.uk/files/file33116.pdf
www.ensg.gov.uk/index.php?article=95

Example of ANM Register content

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Register of Active Management Pilots, Trials, Research, Development and Demonstration Activities

Project ID	Project Title	Lead Organisation	Partner Organisations	Funding Source	Activity Type	Activity Status	Start and completion dates	Country	Classification of technical focus	Brief Summary of Activity	Contact details	Report Link (URL)
01	"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	R&D	O	2004 - 2007	UK	VC FLM PFM	To research and develop a small-scale "embedded controller", model and evaluate its performance. To develop design specifications for a full-scale "embedded controller" suitable for LV distribution networks.	http://www.econnect.co.uk/	http://www.dti.gov.uk/renewables/publications_pdfs/pp204.pdf
02	Skegness / Boston Registered Power Zone	Central Networks	-	Registered Power Zones initiative, Ofgem, UK	T	O	2005	UK	PFM	Dynamic ratings are calculated using real-time load and local temperature information. This allows the thermal capacity of the network to be utilised more effectively for accommodating increased connections of wind energy. An additional 90MW of generation may connect, which will be subject to curtailment based on the breaching of the dynamic thermal capacity.	Rebecca Middleton Tel: 02476425779	http://central-networks.co.uk/Content/Media/media_press_detail.aspx?NewsId=387
03	Facilitate Increased Generator Connections to the Orkney Distribution Network	Scottish Hydro Electric Power Distribution Ltd	University of Strathclyde	DTI Technology Programme: New and Renewable Energy. Contract number: K/EL/00311	R	C	2003 - 2004	UK	PFM	Initial specification of active power flow management scheme. Scheme works through the identification of control zones and available capacity for export from the Orkney distribution network. Power flows are managed using operating margins and generator output regulation and tripping. Results in capacity for around 3x firm generation to connect.	David.Telford@scottish-southern.co.uk	www.dti.gov.uk/renewables/publications_pdfs/kel00311.pdf

Registered Power Zones (RPZ)

- Introduced by UK regulator (Ofgem) to encourage DNOs to apply technical innovation
- DNO submits RPZ application to Ofgem
- 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 Benefits

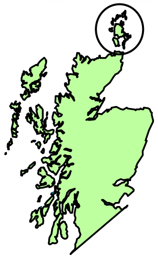
- DG Incentive: 1.5 £/kW/year
- 80% pass through of DG connection costs
- RPZ multiplies the DG Incentive by three: Additional 3 £/kW/year
- Benefit to generation developers from more cost effective connections

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

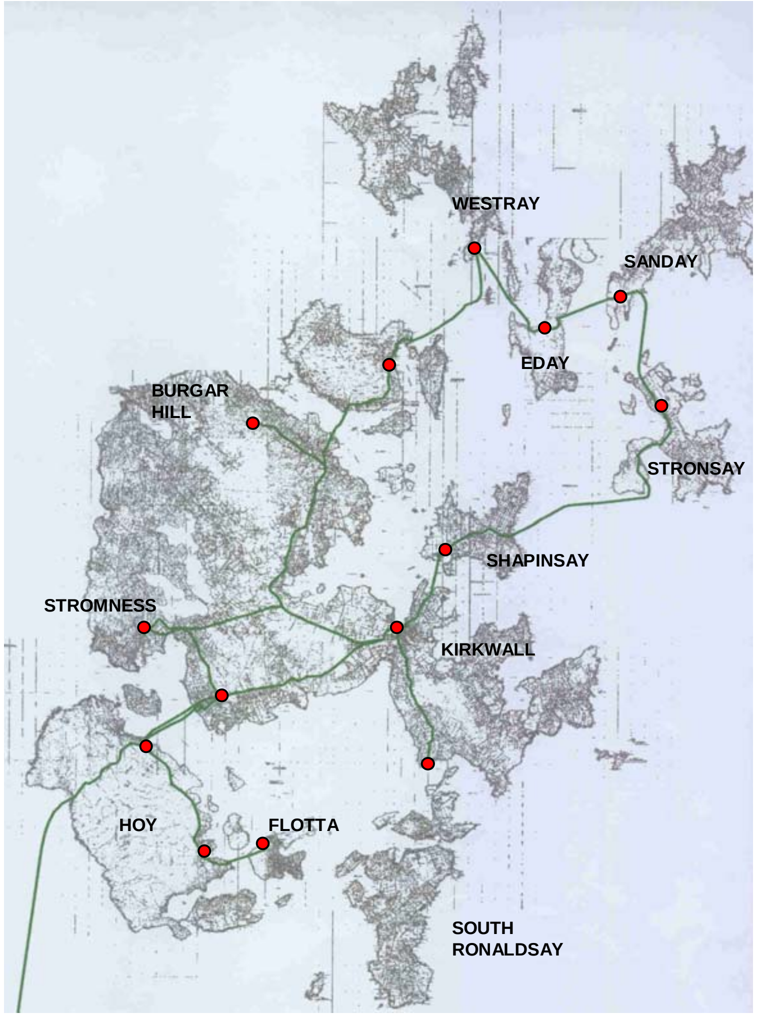
Registered Power Zones: Progress

- **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)
- **EDF Energy** – Martham Primary RPZ
  - Voltage control in Norfolk rural overhead network with the GenAVC device (11kV)
- **Scottish Hydro Electric Power Distribution** – Orkney RPZ (33kV)
  - Active power flow management of multiple generator units within network thermal constraints

ANM Case Study: Orkney RPZ



- 6 miles off North-Scotland
- 11,500 customers
- Min/Max demand: 8/31MW
- 33kV submarine cables: 2 x 20MW import/export
- Existing generation a mix of wind, wave and gas
- Firm Generation (FG) connected
- Non-Firm Generation (NFG) allocated
- Reactive compensation equipment installed (including DVAR)



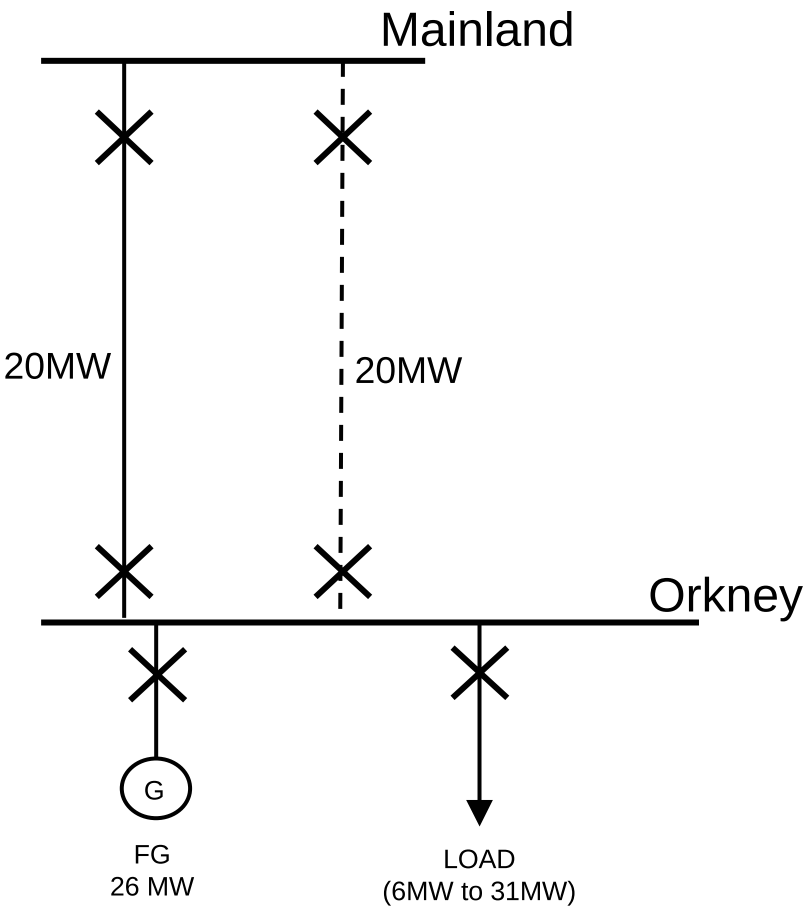
Orkney RPZ

Wind Farm at Burger Hill, Orkney

Tidal device test facility at the Fall of Warness, Orkney

Wave Device test facility at Billia Croo, Orkney

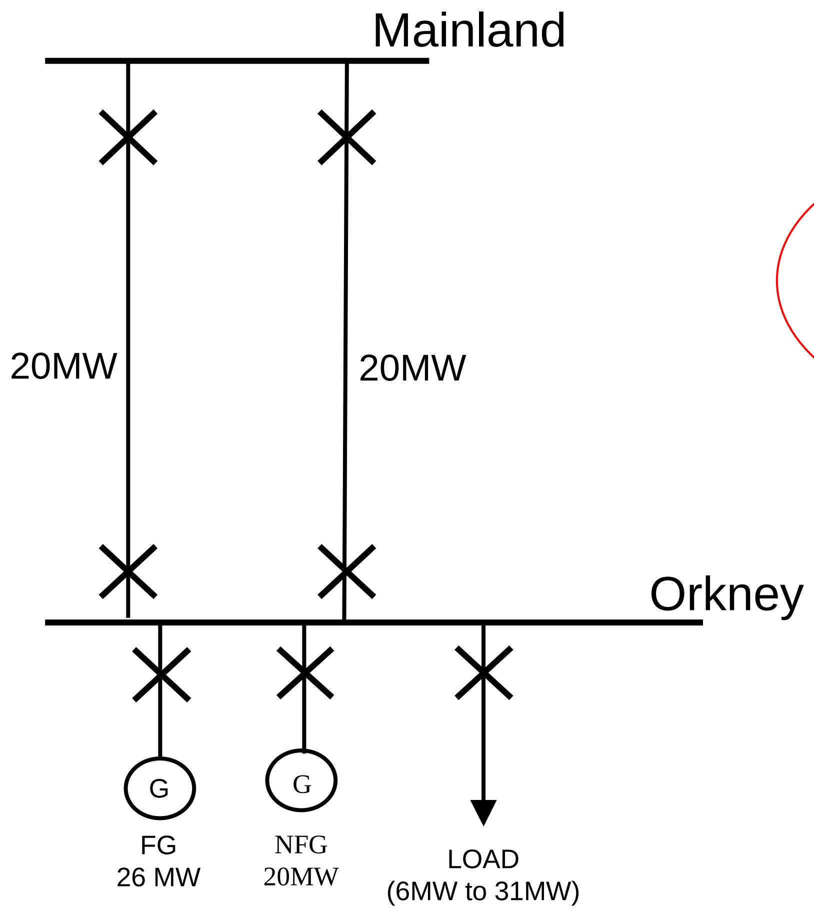
Firm Generation (FG)



FG = (N-1 circuit capacity) + (local minimum load)

FG = 20+6 = 26MW

Non-Firm Generation (NFG)

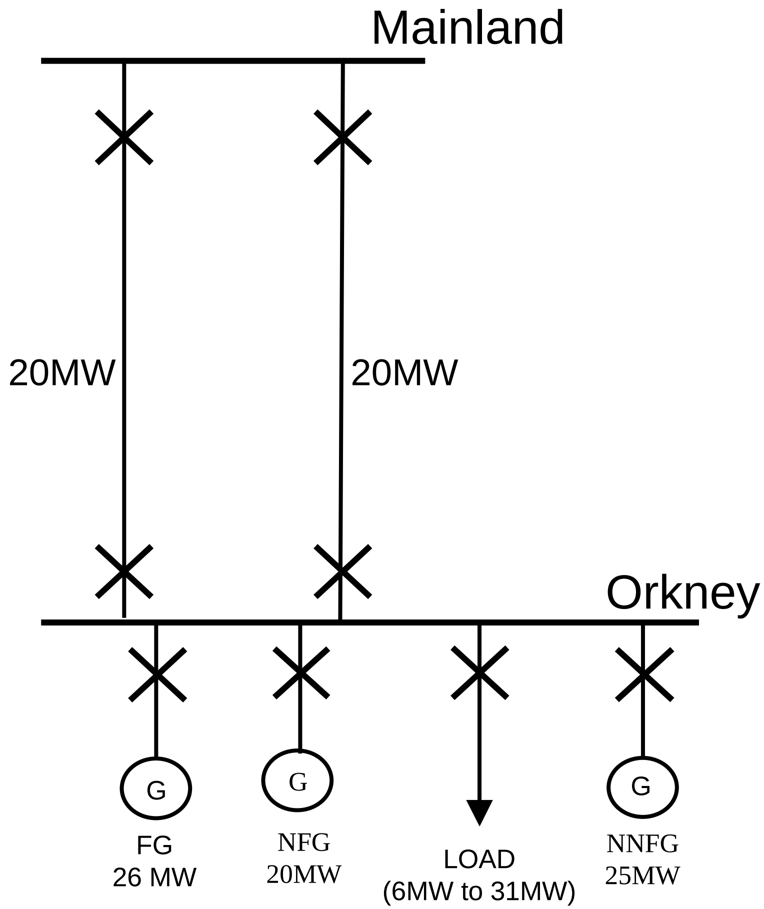


Intertrip NFG for N-1 contingency

NFG = Capacity of circuits + local minimum load - FG

NFG = 20+20+6–26 = 20MW

New Non-Firm Generation (NNFG)

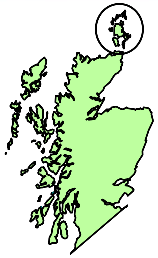


NNFG enabled by ANM scheme

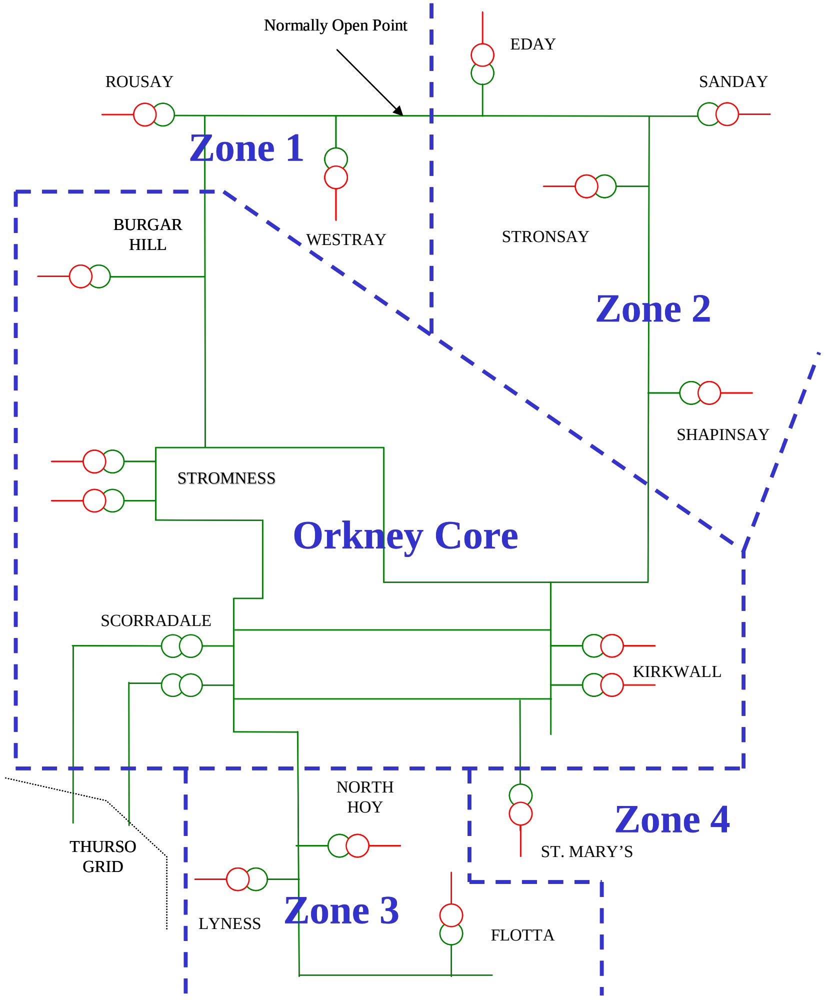
NNFG = Capacity of circuits + local maximum load – FG – NFG

NNFG = 20+20+31-26-20 = 25MW

Orkney ANM Scheme

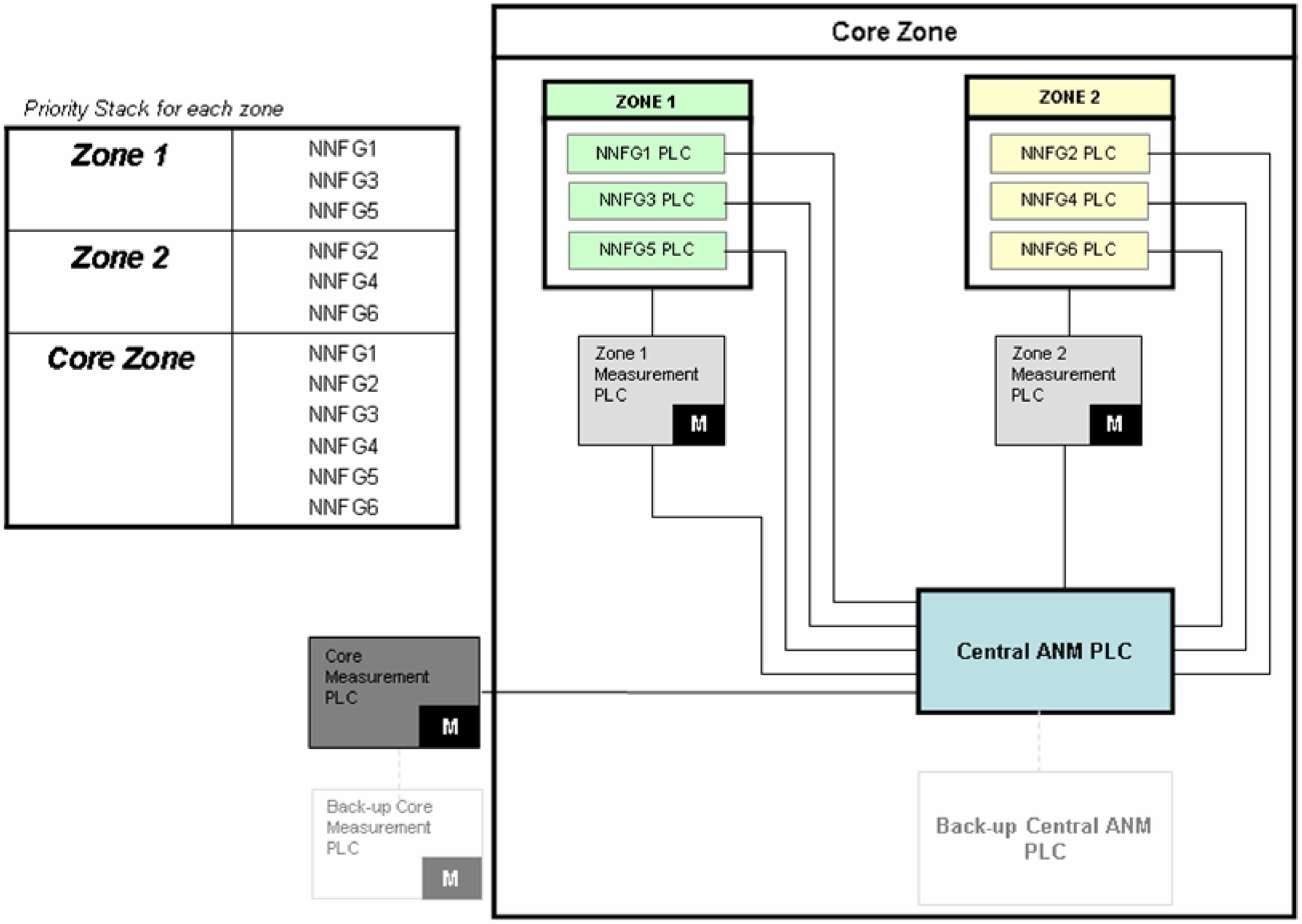


- Separate network into ANM control zones
- Zones may be nested within one another
- Each zone has a thermal limitation on generation output at any given time
- Whole Orkney system has a further thermal limit on generation output
- Real time control of wind and marine generating units based on measurements and control logic



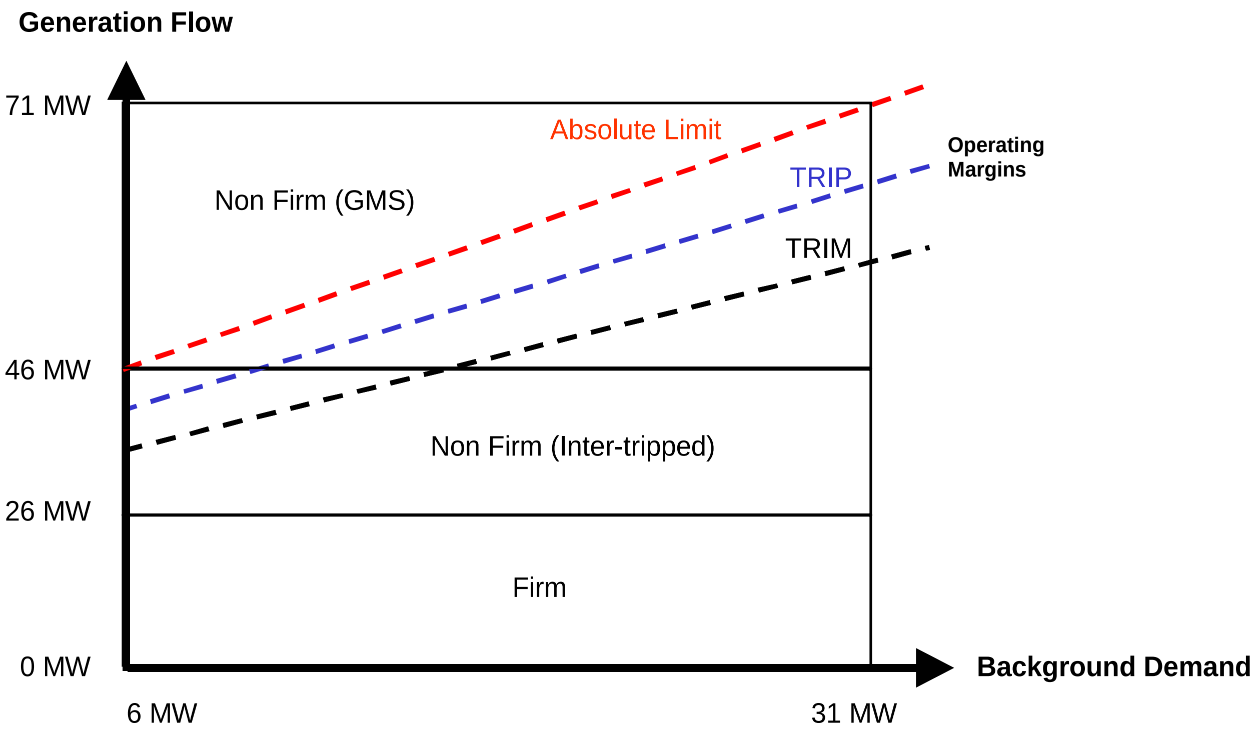
Zonal Approach to ANM

- Permits gradual implementation of ANM scheme

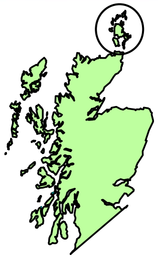


Operating Margins for ANM

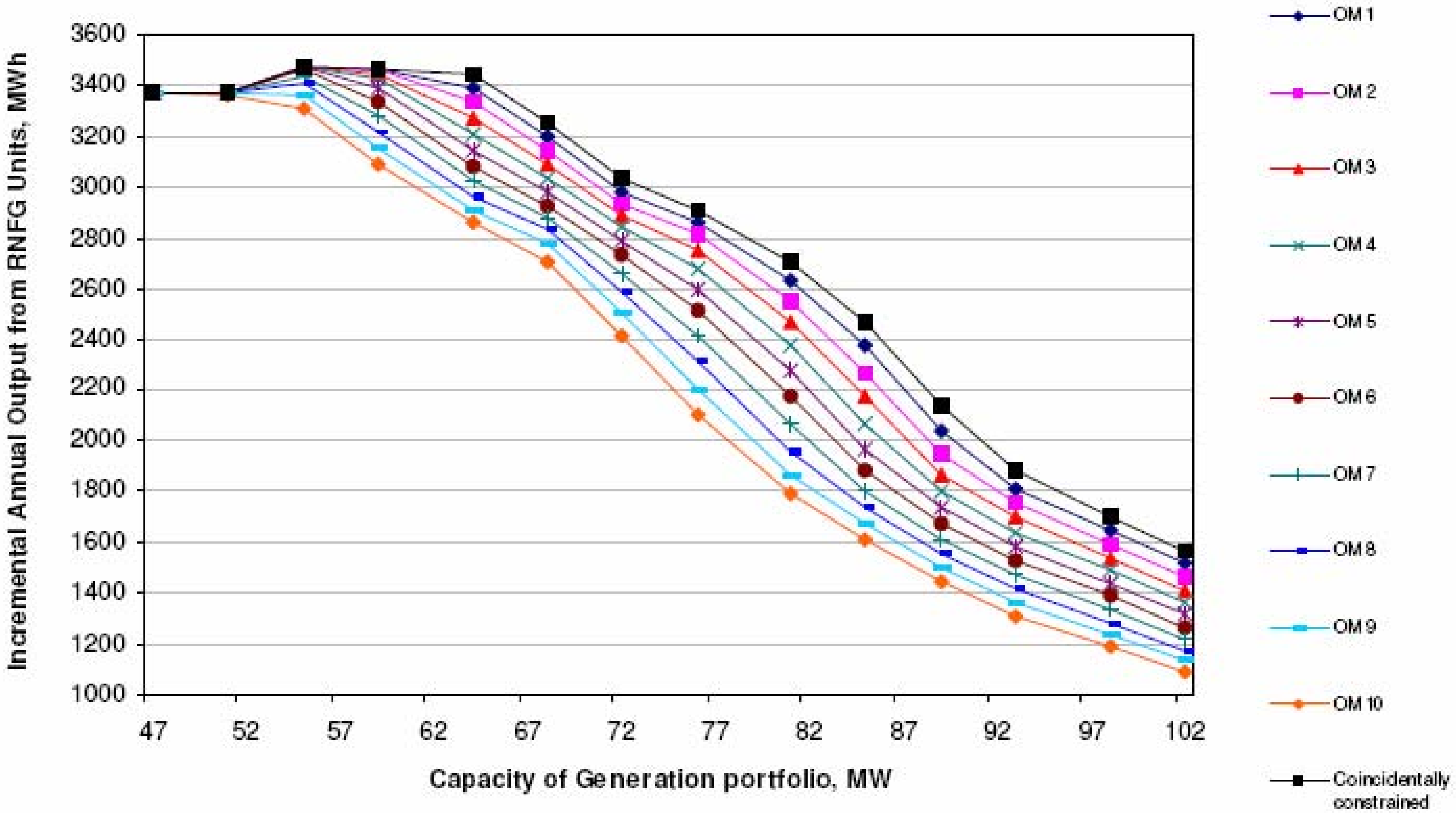
- Operating margins ensure network security
- Computational methods developed to calculate operating margins
- NFG intertrip export level included as reference point



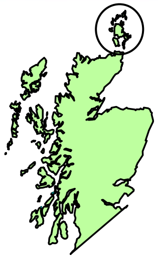
Economics of ANM on Orkney



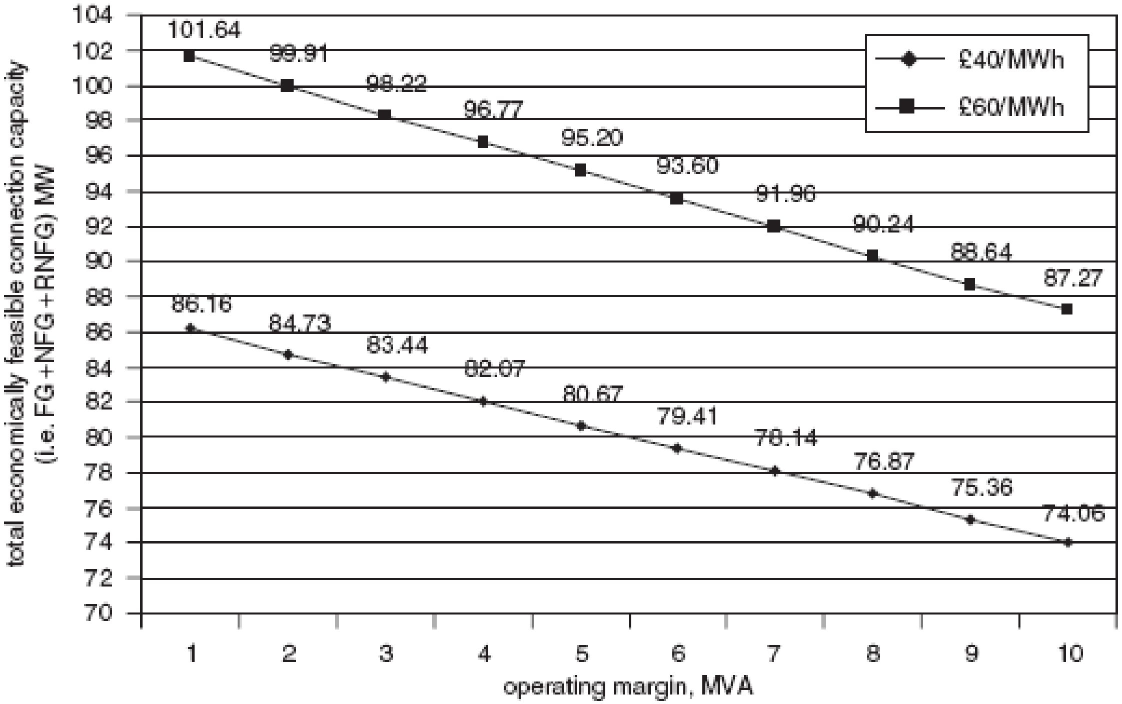
- MWh generated by incremental NNFG capacity

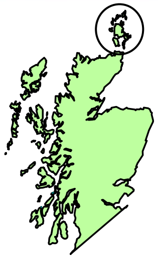


Economics of ANM on Orkney



- Economic limit for NNFG connections identified
- Impact of revenue level and size of operating margin investigated

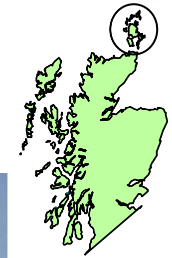


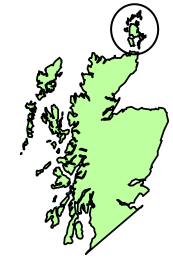


Orkney RPZ Trial

- Closed loop control trial conducted November 2006
- PLCs operational at Scorradale and existing Wind Farm
- Prospective trial outcomes:
  - Verification of logic control
  - Verification of communications solution
  - Integration of ANM scheme with WT/WF controllers
  - Verify PLC capability and interoperability
  - Measurement of communications and control system and generation response times

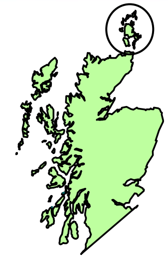
Just when we needed the wind!





Last minute drama…….

Orkney RPZ Trial Outcomes



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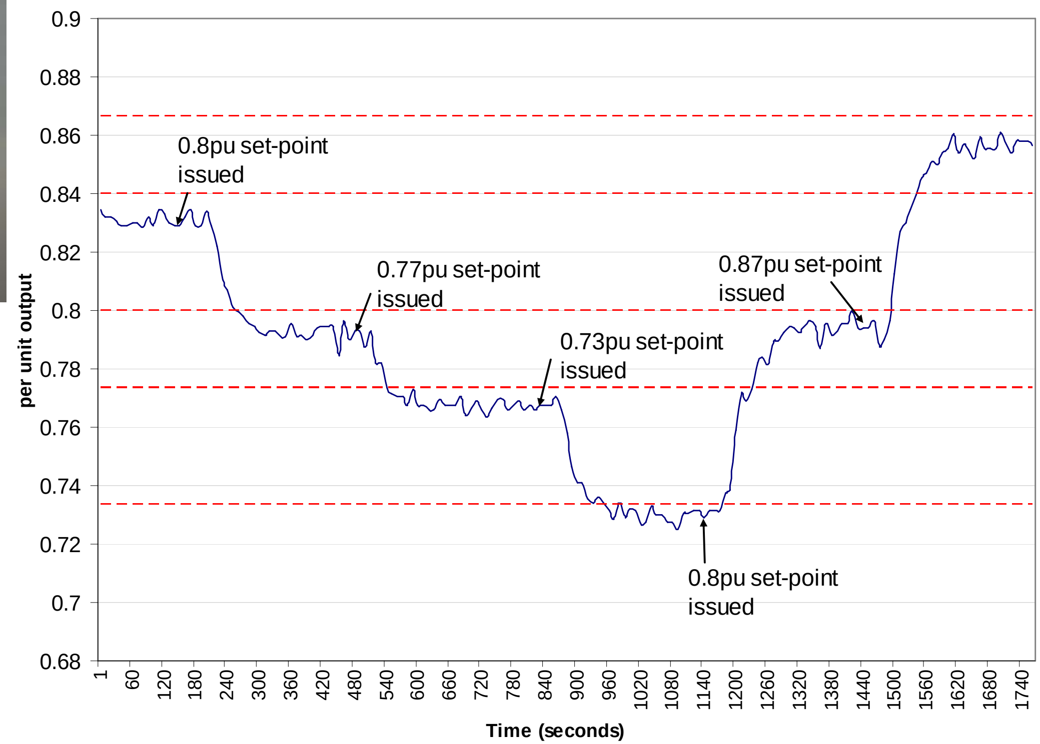
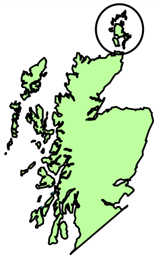
- Output of wind farm regulated below issued set-point
- Results of trial feeding directly into the design of the full ANM scheme



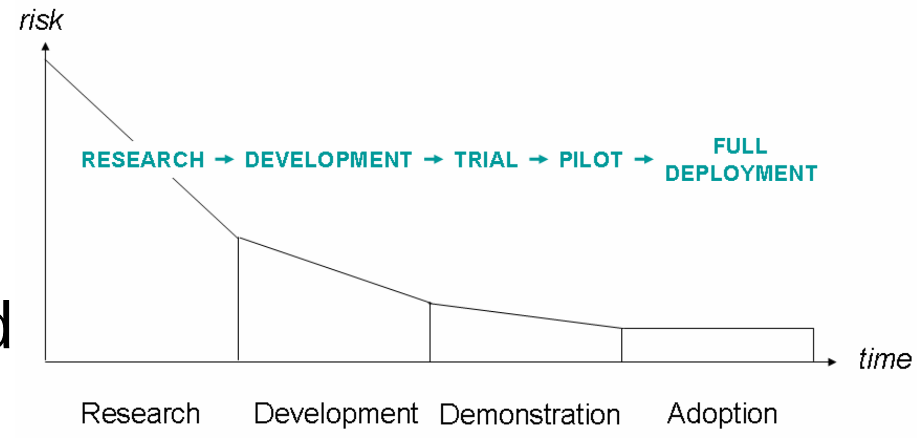
- Response of Wind Farm observed
- Closed-loop control achieved
- Communications and control logic proven

Summary of Orkney RPZ



- Greater access for renewable generation
- NNFG connections limited by economic rather than technical factors
- NNFG units benefit from diversity of DG output and load
- Communications and control approach proven in ANM trial
- Off-the-shelf ANM systems are not available (but ANM scheme components are off-the-shelf)
- UK’s first closed loop trial and multi-generator ANM scheme
- Applicable to other areas of UK, what about Europe?

Challenges to widespread ANM



- Maturity of ANM solutions
- Providing opportunity for R&D projects to achieve rapid maturation and market entry
- New analysis and economic appraisal techniques
- Integration of active network planning with existing system and maintenance planning
- Identifying and communicating suitable locations for ANM

Challenges to widespread ANM

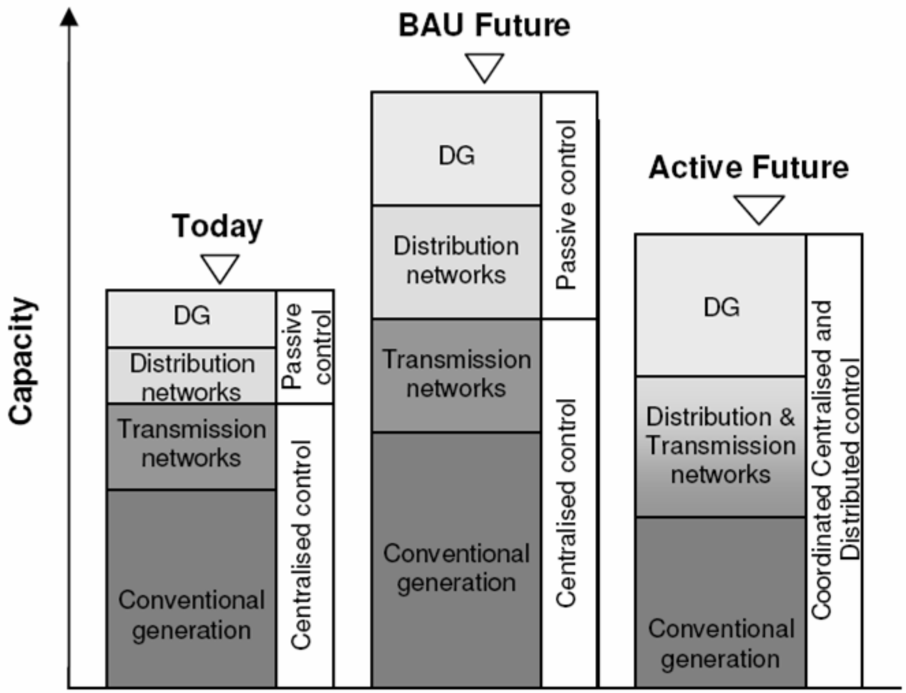
- Re-evaluation of incentives to greater recognise risks borne by DNOs and/or owners of ANM schemes
- Uncertainty regarding future incentives
- ANM becoming part of planner's toolkit
- Identifying the long term costs and benefits of ANM
- Maintaining/improving asset utilisation
- Incorporating new technologies (storage, DSM…..)
- Transfer best practice in commercial setting

Implications of widespread ANM

- Dispersed ANM ‘Pockets’
- Requirement for interoperability of different ANM solutions
- ANM technical standards
- Centralised Vs distributed control?
- Need to determine the visibility of ANM required
- Control room interactions and integration with existing systems
- ANM “enabled” SCADA?
- Staff training and awareness

Implications of widespread ANM

- Market interactions (what kind of participation for individual DG units? And for entire active networks or smart grids?)
- Effects on the transmission network (exporting BSPs…)
- Interactions with the transmission network (network control, services…)
- Reduced requirement for new capacity in some distribution networks and in system as a whole



Source: Strbac et al, 2007

Conclusions

- ANM schemes are emerging as solutions to the connection and operation of DG
- Mature ANM schemes tend to be bespoke
- Lessons learned and best practice need to be shared
- Orkney ANM scheme to be deployed in 2008, other applications identified
- Future scope of ANM is potentially very wide
- How the transition towards a more “active network” future will be facilitated is not clear
- Long term benefits and effects of ANM must be investigated

Questions?