The Relevance of Smart Grids to the Wind Industry

Alan Gooding
Smarter Grid Solutions
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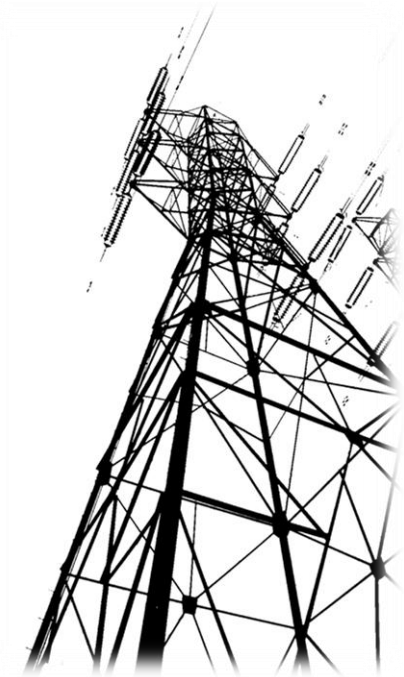
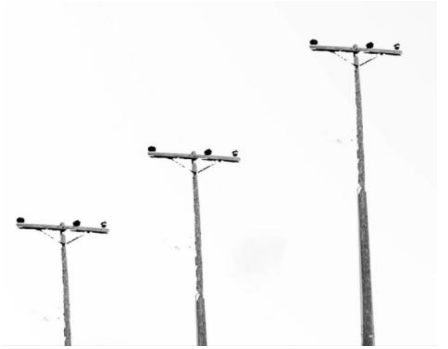
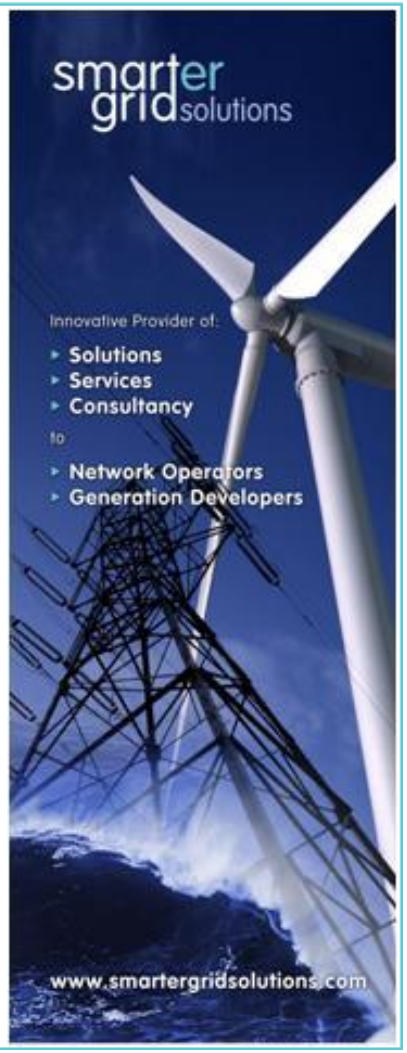




Smarter Grid Solutions Ltd

- Established Summer 2008
- 15 staff plus project contract staff
- Develop Active Network Management solutions to overcome grid constraints
- Consultancy – Power Systems Analysis, constraint modelling and system specification
- Products:
  - SGi - Power flow management, SGv - Voltage management
  - Real-time Thermal Ratings
  - Modules to integrate to other Smart Grid Technologies
- Systems Integration and Support
- “Best New Business” and “Best Renewable Innovation” awards at the Scottish Green Energy Awards, 2009

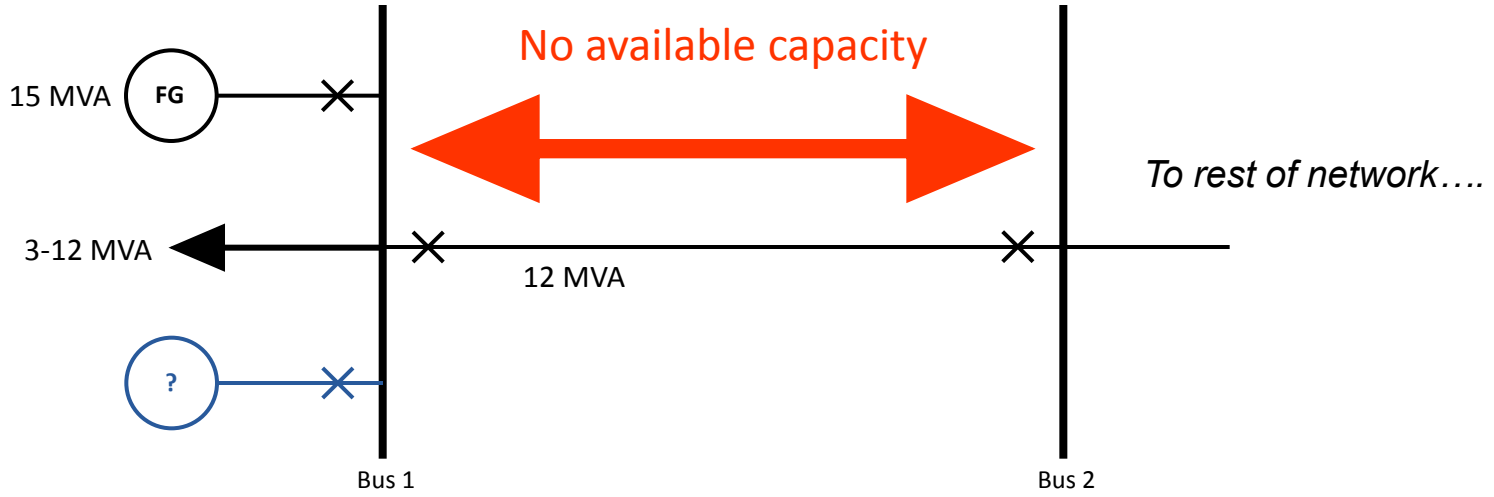


Active Network Management

Active Network Management

The Problem:

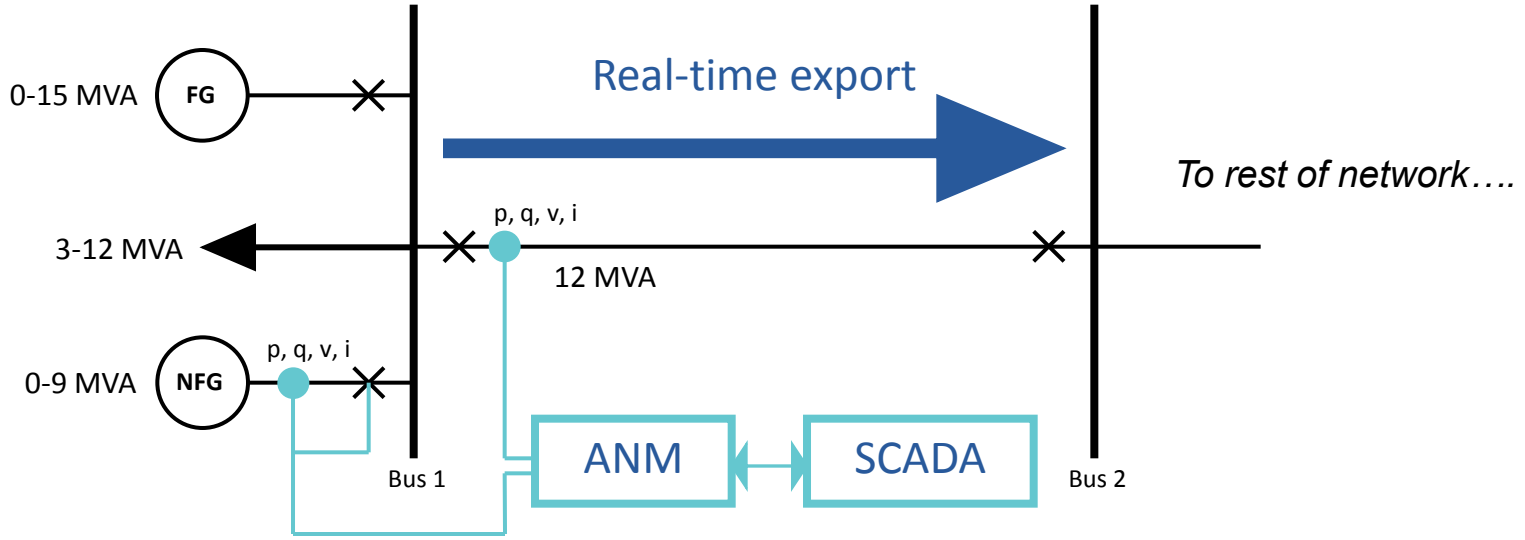
- Multiple generator applications but no capacity available due to network constraints
- Some diversity assumptions made regarding renewables
- Focus on conventional connection solutions including special protection schemes / intertripped non-firm generation (NFG)
- Lengthy timescales for network reinforcement



Active Network Management

Network perspective – tomorrow:

- ANM system measures real-time network export
- Pre-emptive action to stay within limits (regulate NFG MW in real-time)
- Takes corrective action if necessary (disconnect NFG)
- Voltage at bus 1 and bus 2 must be within statutory limits in all scenarios



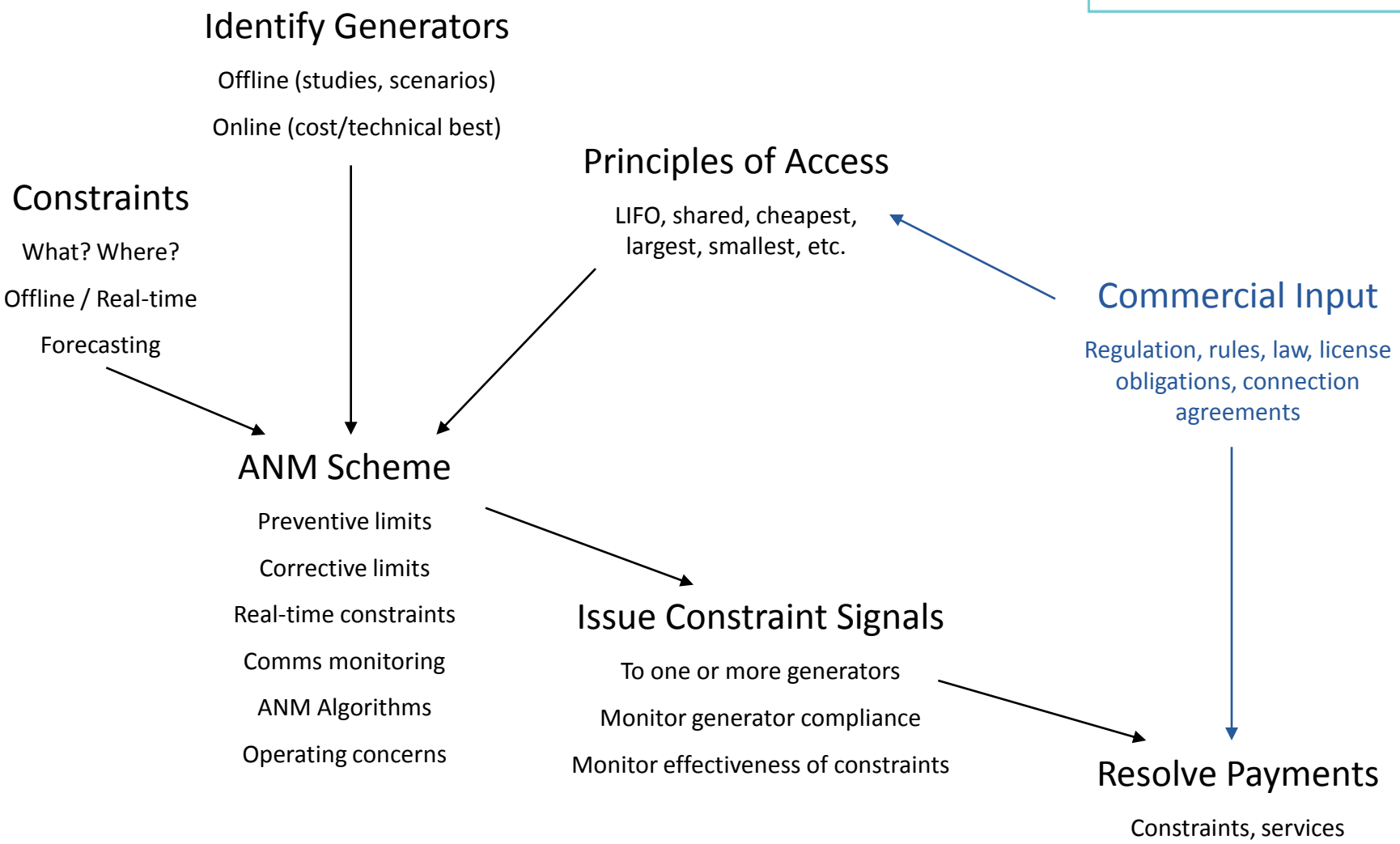
How to connect renewable energy sources to constrained networks?

- Uncertainty regarding grid connections is a problem
  - For both the developer and network operator
- Existing planning standards do not consider smart alternatives
- Cost and time associated with reinforcements
- Network operators have limited internal resources
- Existing skill-sets driven by regulatory environment
- Some smart grid technologies offer an alternative to reinforcement
- Cost-benefit of smart grid technologies is an issue
- How to manage risks associated with new technology adoption?

How to Connect Renewables Quickly and Economically to Constrained Networks?

- Need to reinforce **or** implement constraint management?
- Impacts on planning and operation
- Cost-benefit studies?
- Security standards?
- No real-time automatic constraint management systems available off-the-shelf?
- What about the commercial arrangements?
  - Recent developments in the UK - 'Connect and Manage'
- Active Network Management (ANM) can be deployed
- ANM forms one component of future smart grids

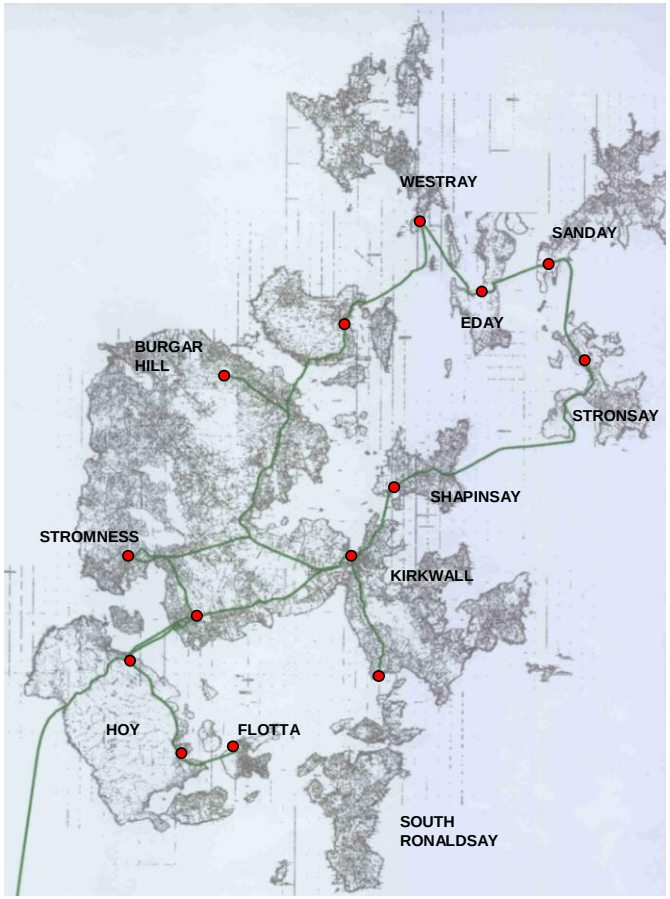
High-Level Constraint Management



Case Study – Orkney

The Orkney Situation

- 6 miles off North-Scotland
- 11,500 customers
- Min/Max demand: 8/31MW
- 33kV submarine cables: 2 x 20MW import/export
- Gas, wave, wind and tidal generator capacity allocated
- No capacity exists for further generator connections, according to established practice
- Long lead times for new capacity
- Multiple applications for grid connection from renewable developers



Scottish and Southern Energy plc

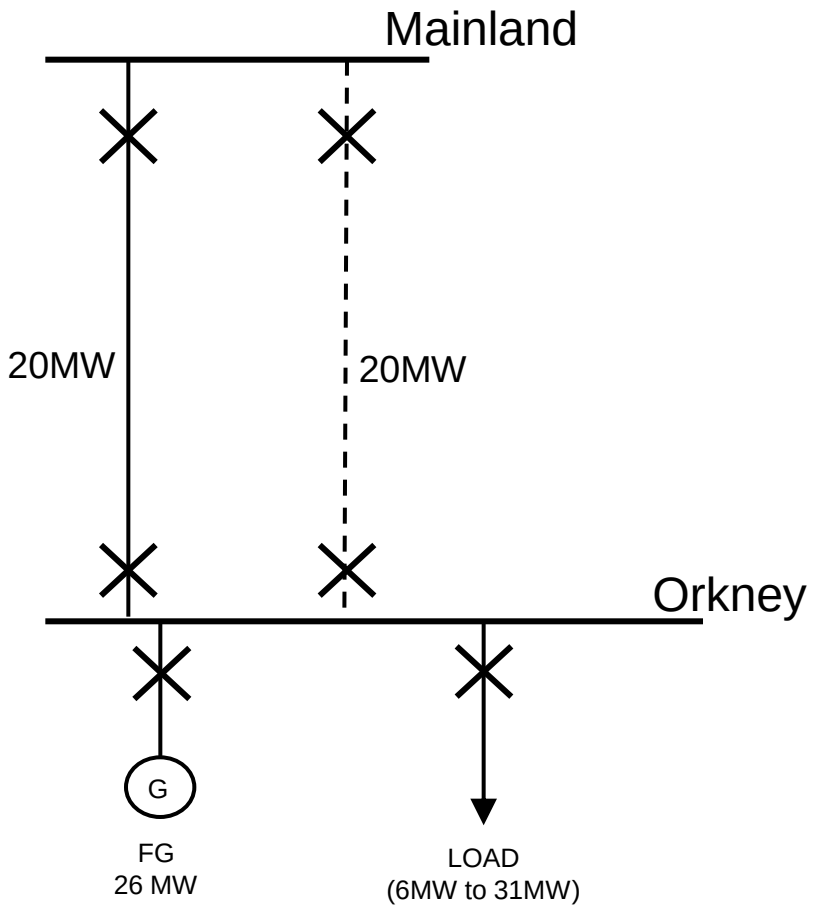
Renewable Energy on Orkney

Wind Farm at Burgar Hill, Orkney

Tidal device test facility at the Fall of Warness, Orkney

Wave Device test facility at Billia Croo, Orkney

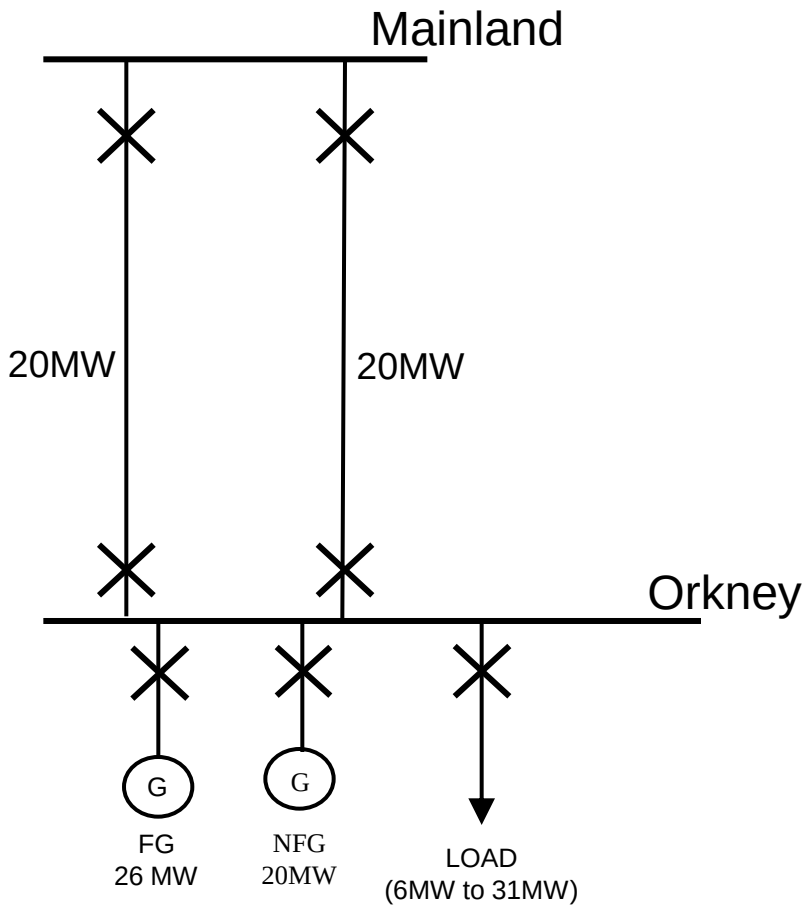
Existing Generator Capacity on Orkney



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

FG = 20+6 = 26MW

Post-Fault Intertrip to connect more DG

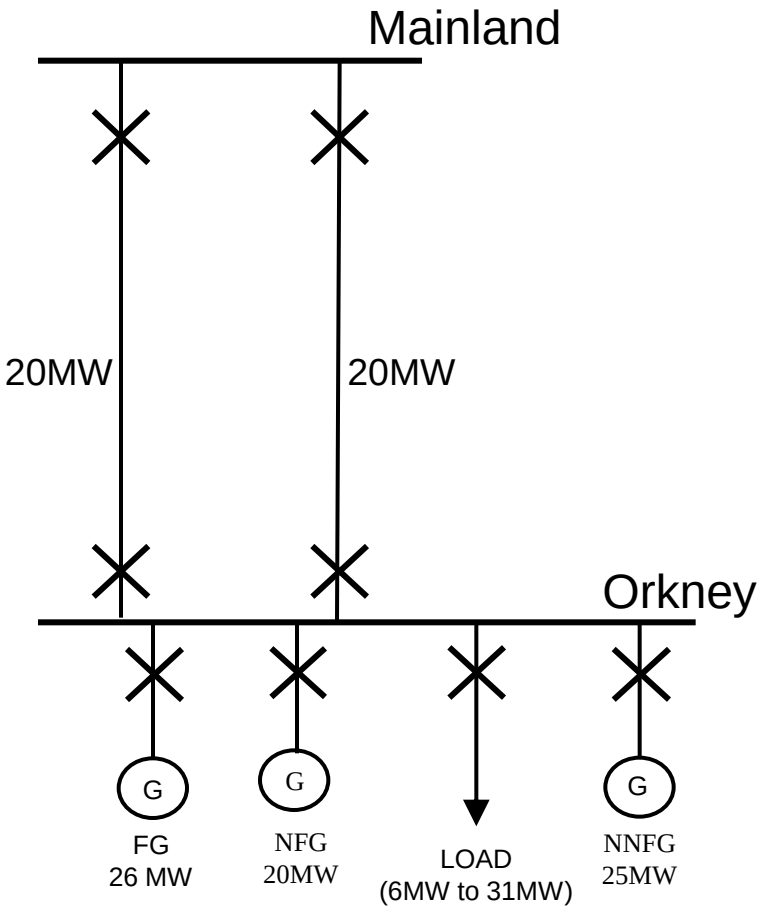


Intertrip NFG for N-1 contingency

NFG = Capacity of circuits + local minimum load - FG

NFG = 20+20+6–26 = 20MW

Real-time Control to Enable Further DG

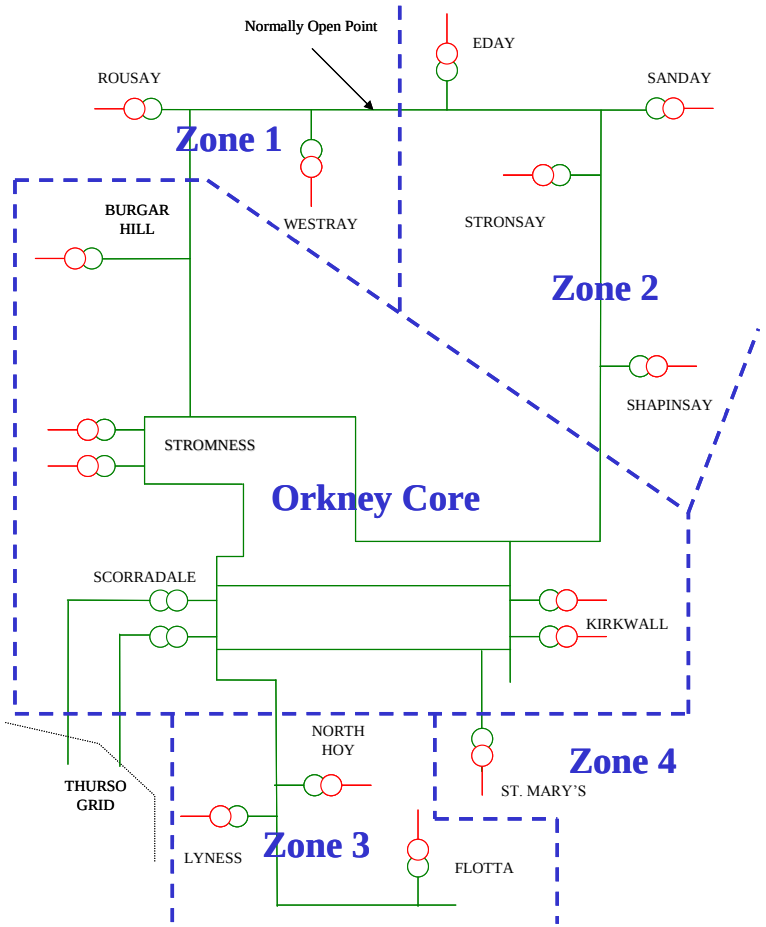


NNFG enabled by ANM scheme

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

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

The Orkney ANM Deployment



Picture Courtesy of SSEPD/University of Strathclyde

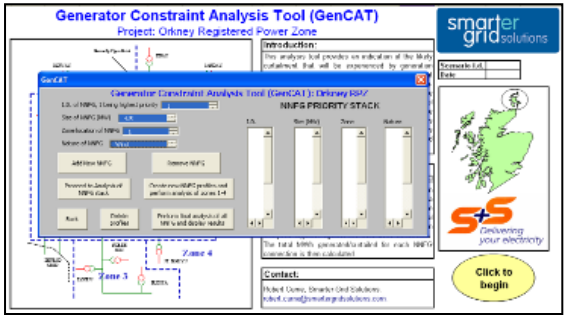
- Collaboration between University of Strathclyde and SSE
- SSE Planners and Control Room involved from beginning
- **NEW** connections only
- Multiple generators and constraints
- Real time ANM
- Nested control zones
- Existing connections unaffected
- Last In First Out (LIFO) approach
- Alternative to reinforcement

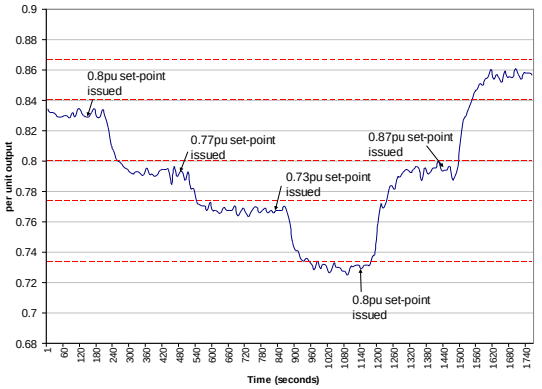
Commercial Arrangements

- Access to capacity
  - LIFO selected for implementation
  - Fits with existing practise
  - Sub-optimal but contractable
  - Curtailment estimates provided to generators to make viability decision
  - Provides a level of certainty to generators on likely access levels
- The connection agreement process
  - Generator place in the queue until planning permission
  - Priority stack position included within the connection agreement
  - Connection agreement contains no guarantees on levels of network access
- Pass through of on-going ANM scheme costs to generators

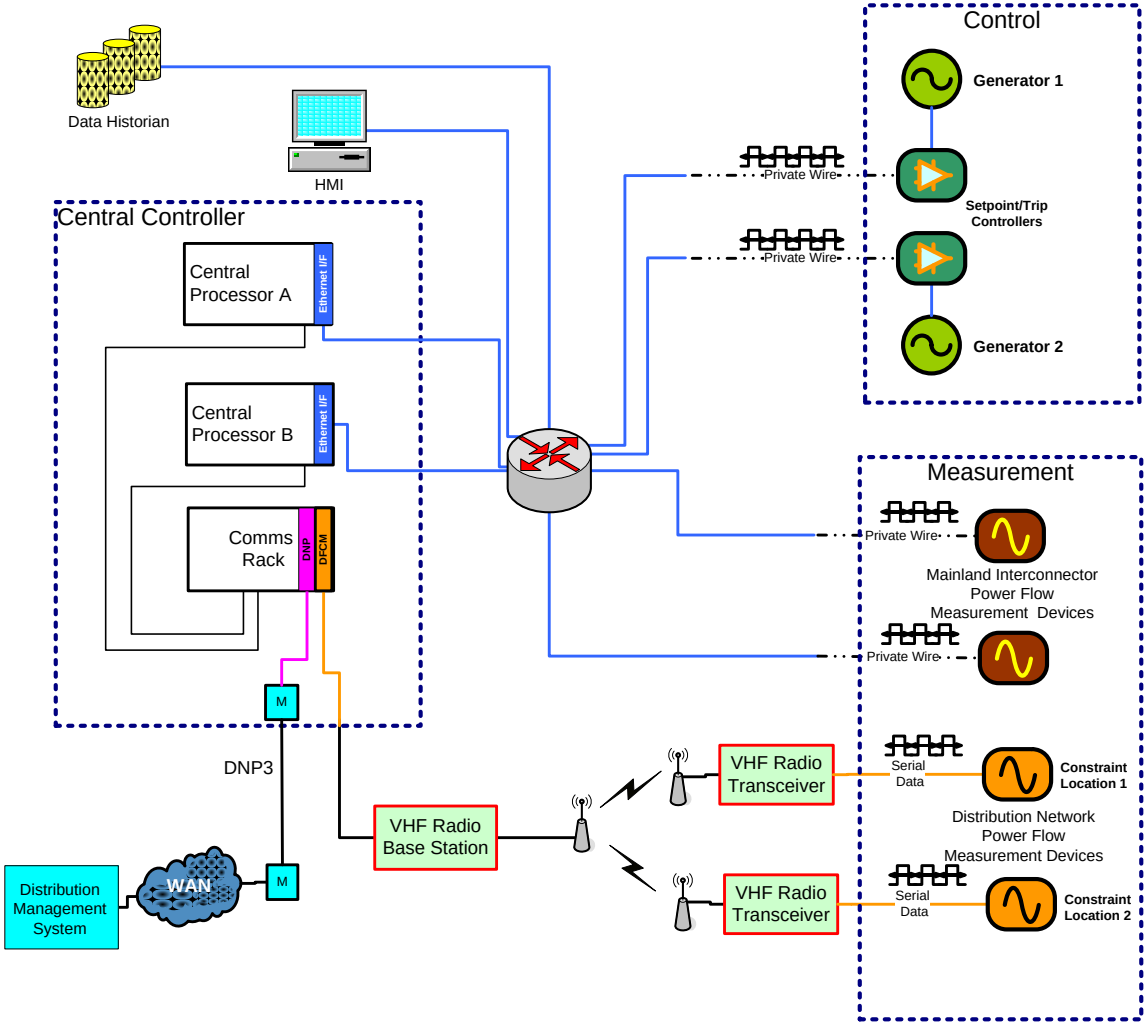
Summary of Orkney RPZ

- Around 15 MW of new capacity, made up of >12 generators
- Operational November 2009
- ‘Curtailment Assessments’ issued
- New commercial arrangements implemented
- Solution tailored to meet host DNO requirements
- SCADA interface
- Simulator, manuals and training seminars
- Flexible/Interoperable/Scalable





Overview of Deployed Orkney Smart Grid Architecture



- **Central ANM Controller**

  Receives all measurements, performs calculations, manages communications and interfaces to SCADA

- **Measurement Controller**

  Collects current, power flow, circuit breaker status, etc and passes to the Central ANM Controller

- **Generator Controller**

  Receives generator set-points from the Central ANM Controller and passes them to the generator control system, monitors generator compliance and communications links

Summary of Orkney RPZ

- 2 wind generators, 4 constraints installed late 2009
- Around 10 further generator connections in 2010/11 and beyond
- Radio and private wire communications implemented
- New and existing monitoring
- Platform for further smart grid developments
  - Dynamic Line Ratings
  - Real-time thermal ratings
  - Energy storage systems
  - Restoration & reconfiguration
  - Voltage management

Learning

- Commercial
  - Acceptance of new arrangements (DNO and Connection Customer)
- Technical
  - Took multiple years of research and development to identify the most appropriate approach to constraint management
- Customers less adverse to risk than perceived
  - One of many project risks
- No “ANM department”
  - Project co-ordination required across the organisation
- Communications
  - Cheapest not always best
- Complementary to centralised SCADA systems
  - Approach taken to control room integration
  - The role of decentralised intelligence

Client Feedback

Colin Hood, Chief Operating Officer at SSE:

"Smart Grid technology has the potential to significantly improve the efficiency of the electricity distribution and transmission network in the UK. This deployment provides a blueprint for how Smart Grids can be used to connect high penetrations of renewable generation in a cost effective way and resolve grid congestion as a result.

"The connection of similar levels of renewable generation on Orkney by the conventional means of network reinforcement would have cost around £30 million. The total cost of developing and delivering this innovative solution has been substantially less than this and taken far less time."

Relevance of Smart Grid to the Wind Industry

Active Network Management provides a means of connecting more renewables to congested grids to manage thermal or voltage constraints

Active Network Management can form the hub for integrating other Smart Grid technologies such as dynamic ratings or energy storage

Active Network Management and other Smart Grid technologies can be used to manage other network constraints

Active Network Management provides an alternative or intermediate solution to network reinforcement

Active Network Management and other Smart Grid technologies will have a significant impact on the wind industry