Renewable Generation and its Impact on Networks

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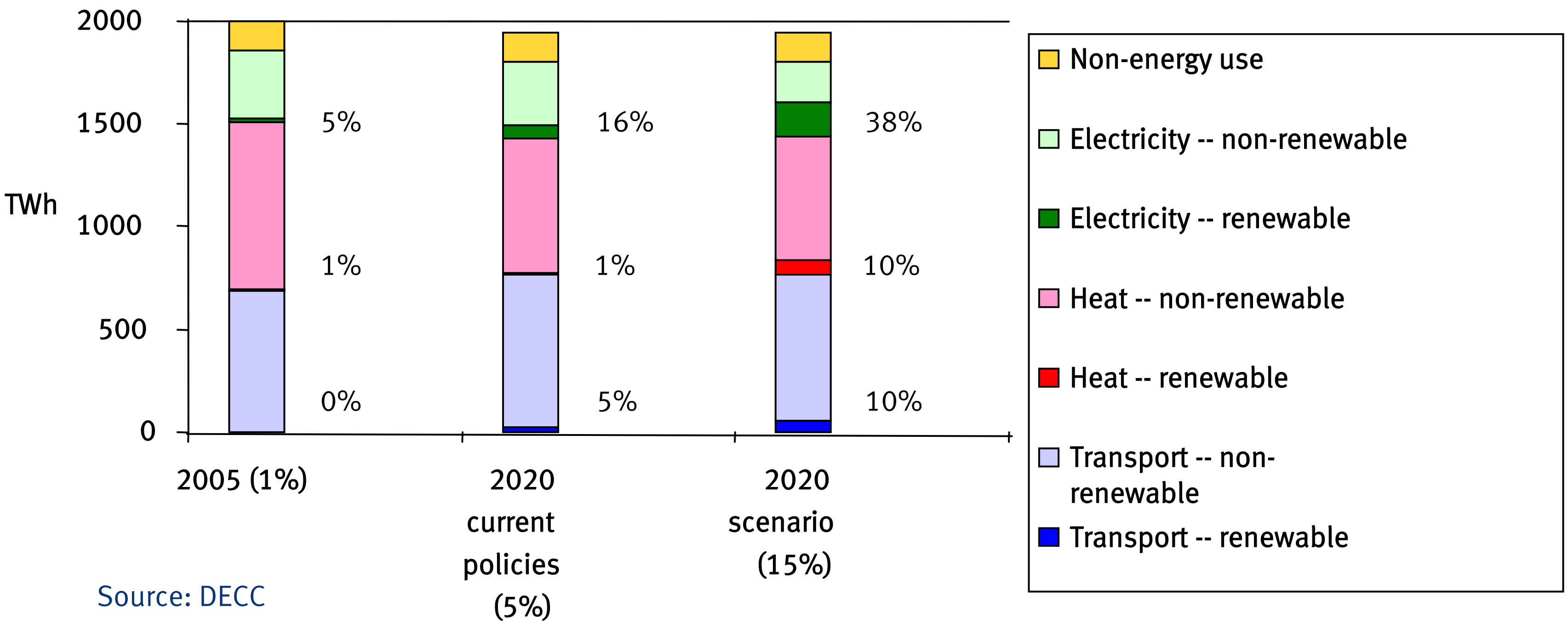
UK Distribution Network Operators

Renewable Generation and its Impact on Networks

- Background to the UK Government's Targets
  - EU '20/20/20' and UK renewable targets
  - Required contribution from electricity production
- Implications for Electricity Generation
  - Wind, tidal, hydro, wave technologies
  - Gas pressure reduction sites
  - Impact of feed-in tariffs
- Implications for Electricity Networks
  - Transmission Network Architecture
  - Distribution Network Architecture
- Active Power Flow Management
  - Active Generation Constraint
  - Demand Side Management and Smart Metering
  - Distribution System Balancing
- Future Role of DNOs

EU '20/20/20' and UK Renewable Targets

- The European Council Climate and Energy Package (March 2007) contains three key targets (to be achieved by 2020):
  - to reduce emissions of greenhouse gases by at least 20%
  - to increase energy efficiency by 20%
  - a 20% contribution from renewables across EU member states (UK target is 15%)



Source: DECC

Implications for Electricity Generation

Anticipated 2020 GB Generation Portfolio (by production)

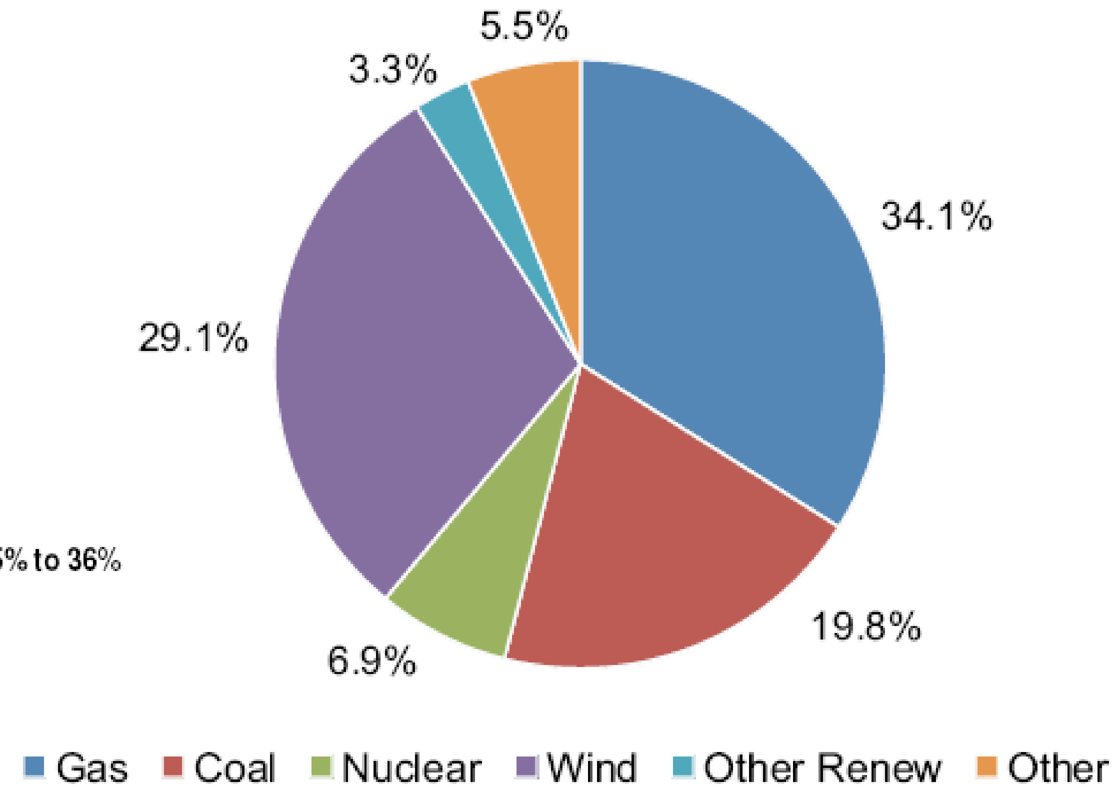
- **Plant closures**
- 12GW Coal & oil LCPD
- 7.5GW nuclear
- Some gas & additional coal

- **Significant new renewable**
- 30 GW wind (19GW offshore & 11GW onshore)
- Some tidal, wave, biomass & solar PV

- **Significant new non renewable build**
- 3GW of new nuclear
- 3GW of new supercritical coal (some with CCS)
- 11GW of new gas

- **Renewable share of generation grows from 5% to 36%**

- **Electricity demand remains flat**
- Reductions from energy efficiency measures
- Increases from heat pumps & cars

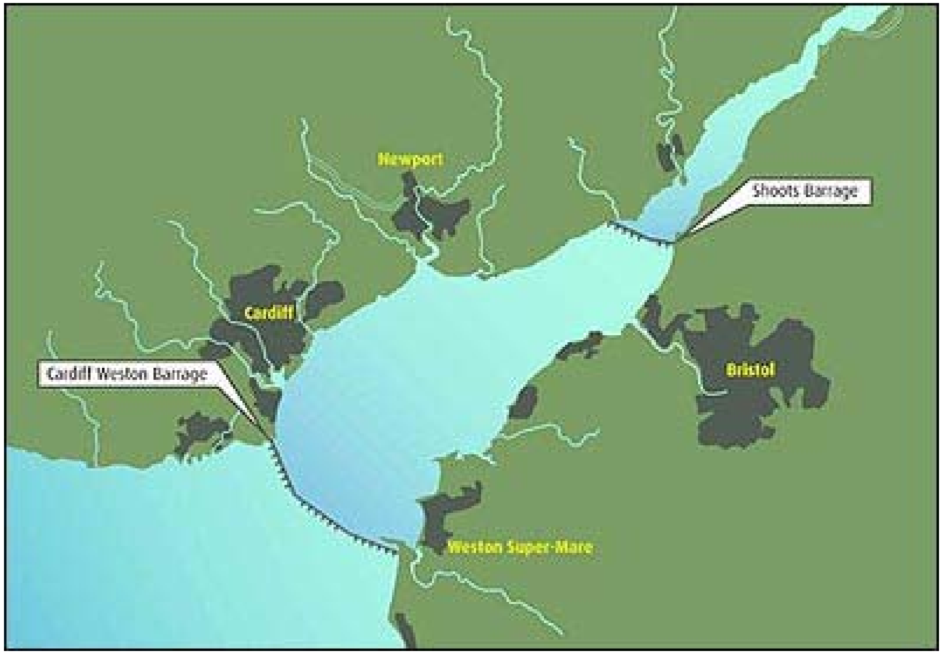


Wind ~ 98TWh annual production

Hydro, Wave and Tidal

Severn Barrage Project

- 8.6GW peak output
- 2GW average
- 17TWh annual production
- 16M tonnes carbon emission saving



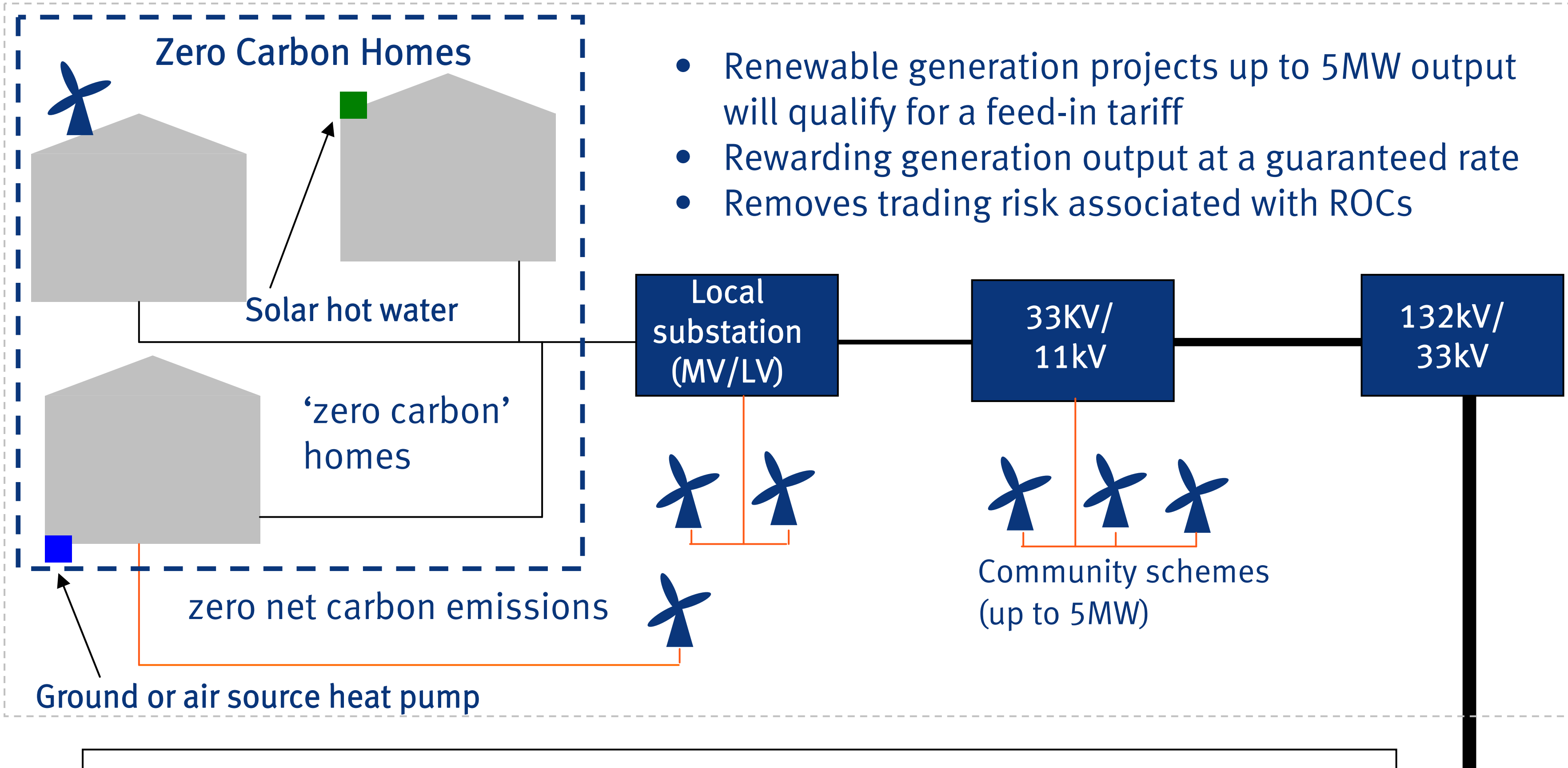
Proposed Severn Barrage

Other hydro / marine opportunities

- Glendoe (Loch Ness) - potential 100MW hydroelectric station
- West coast of Scotland potentially a rich source of wave power generation (theoretically up to 70MW per km wave front)
  - example: proposed Isle of Lewis scheme - 3.6MW

Impact of Feed-in Tariffs

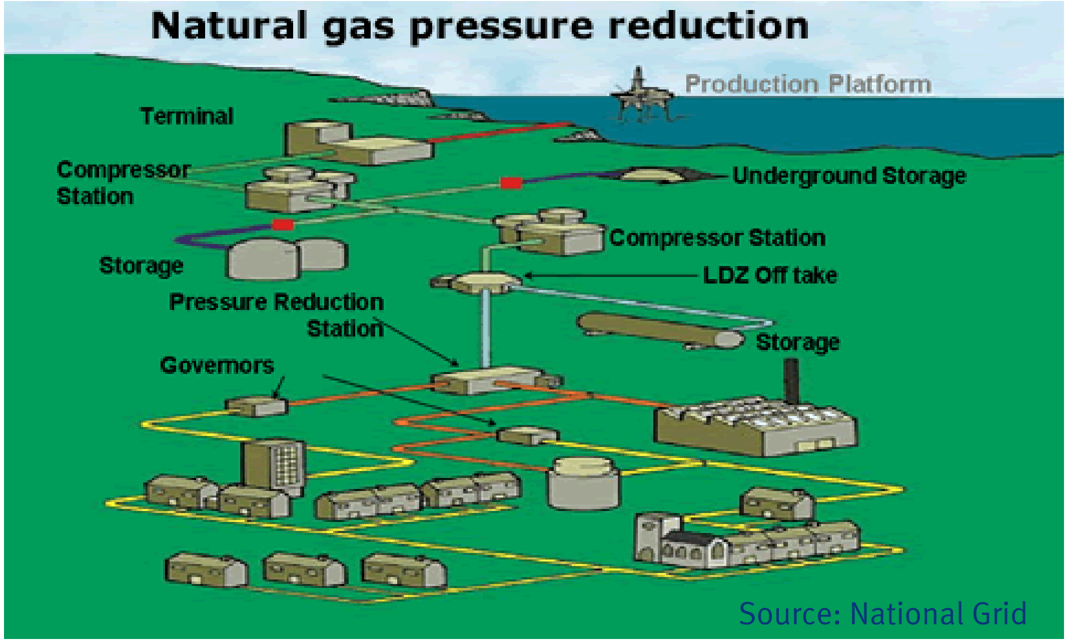
- Renewable generation projects up to 5MW output will qualify for a feed-in tariff
- Rewarding generation output at a guaranteed rate
- Removes trading risk associated with ROCs



- Target = 200,000 new zero carbon homes p.a. from 2016
- ~ 1M zero carbon homes by 2020
- ~ 1GWe generating capacity by 2020
- ~ 2TWh p.a. (assuming 25% load factor from local / on-site wind turbines)

Gas Pressure Reduction Sites

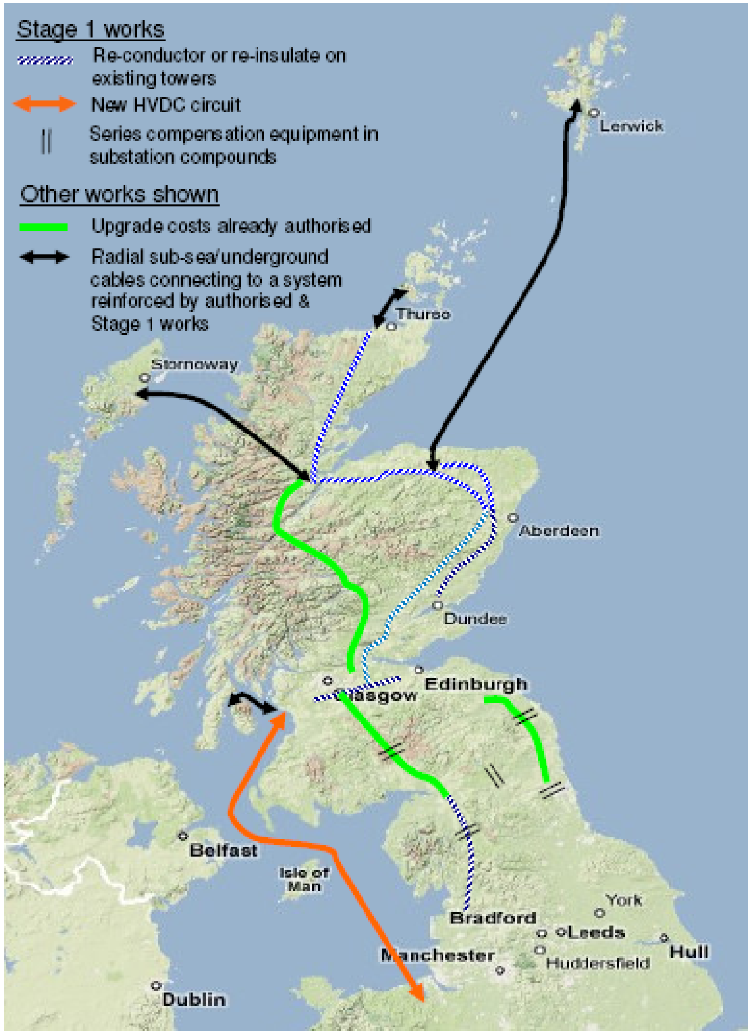
- Potential to harness energy created by gas pressure reduction to produce electricity
- Combined Cycle Bio Generator comprising:
  - turbo-expander
  - biomass pre-heater
- Initial trial of 8 sites
  - 5 - 13MW per site
- Potential to apply to 200 (10%) PR stations

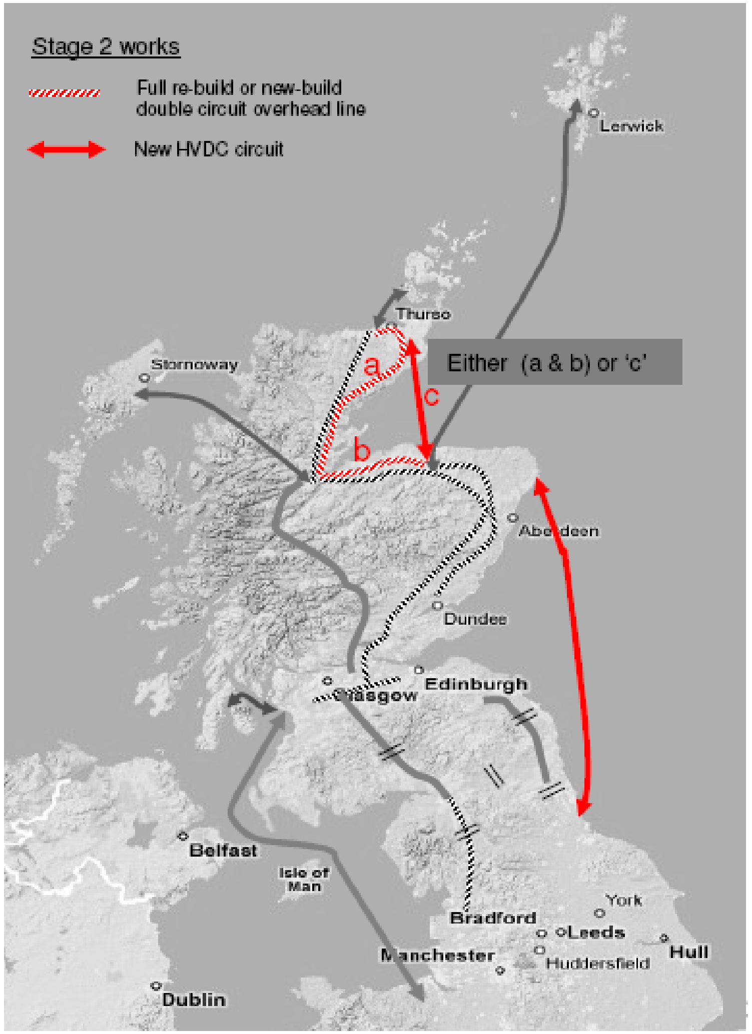


Source: National Grid

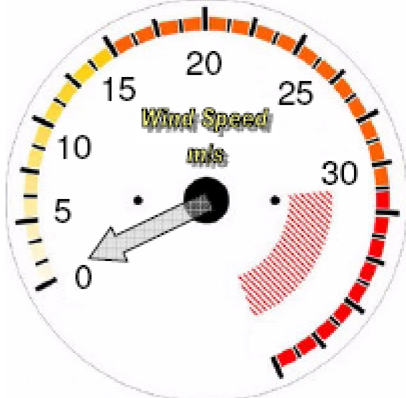
- Overall potential for 1GW of renewable electricity generation
  - ~ 9TWh p.a. (good correlation of availability and system maximum demand)

Implications for Transmission Network Architecture

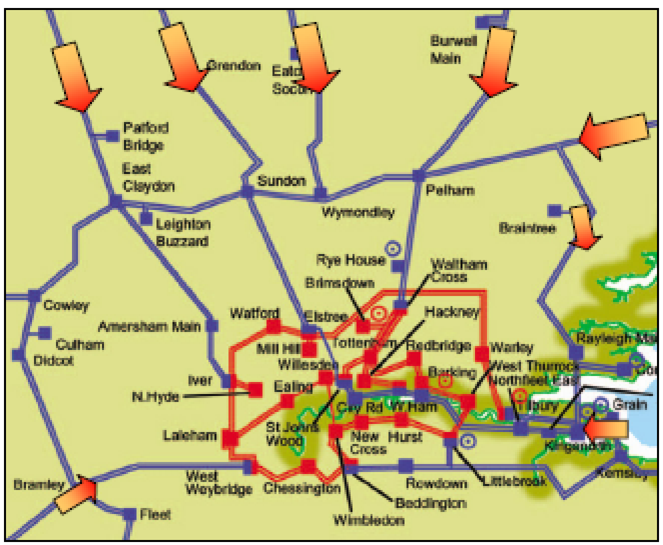




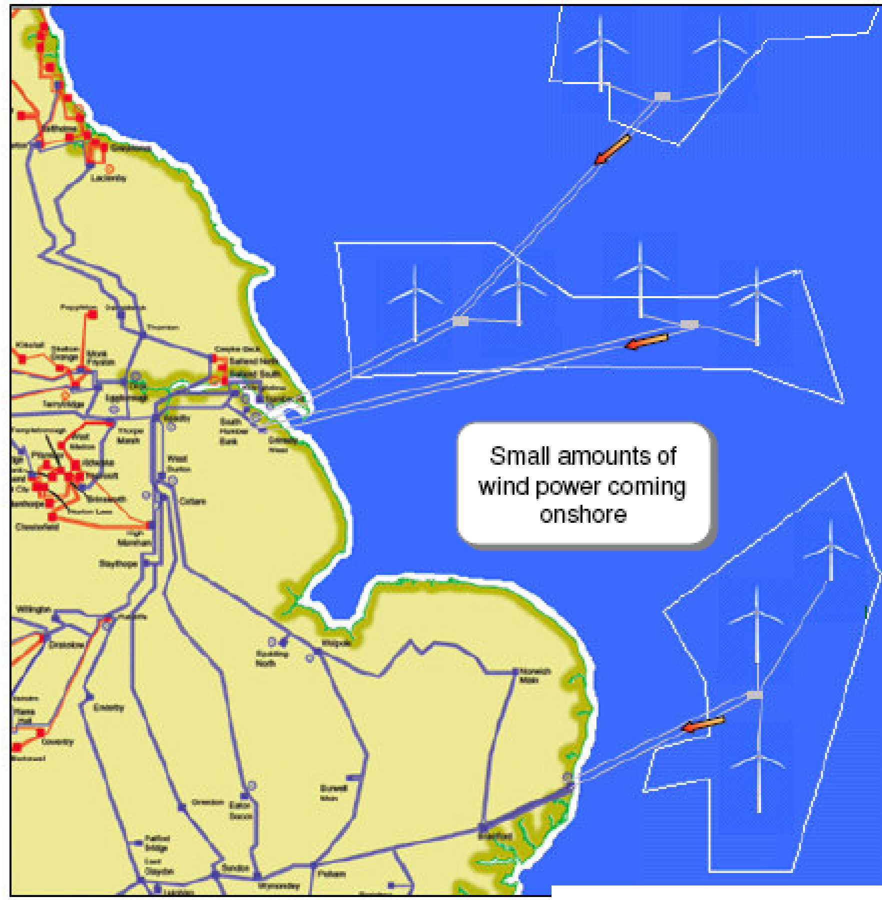
Implications for Transmission Network Architecture
Offshore Wind Intermittency



Conventional power flows into London



Calm weather over the North Sea



The power of action:

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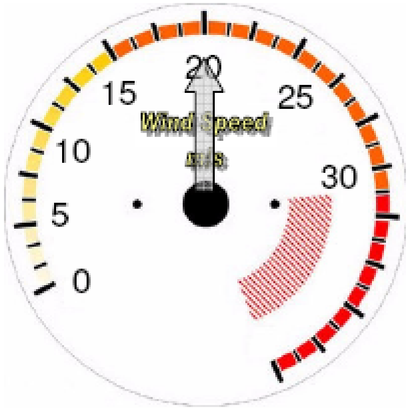
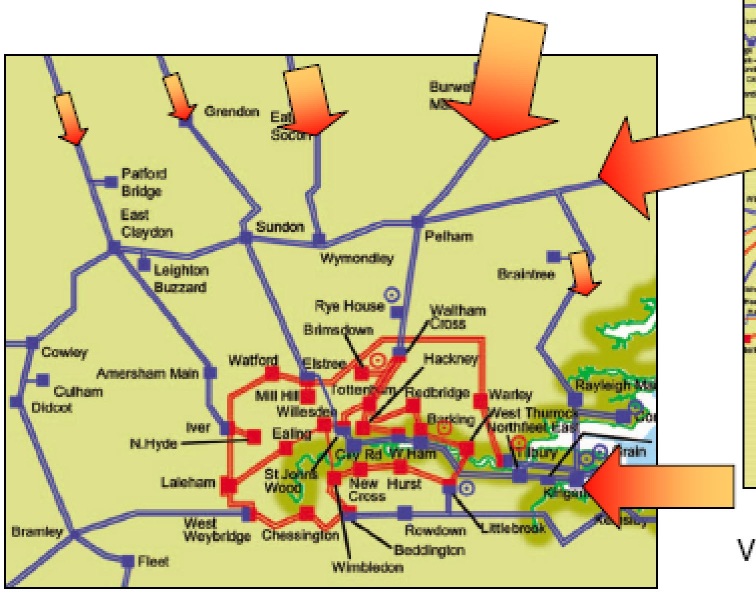
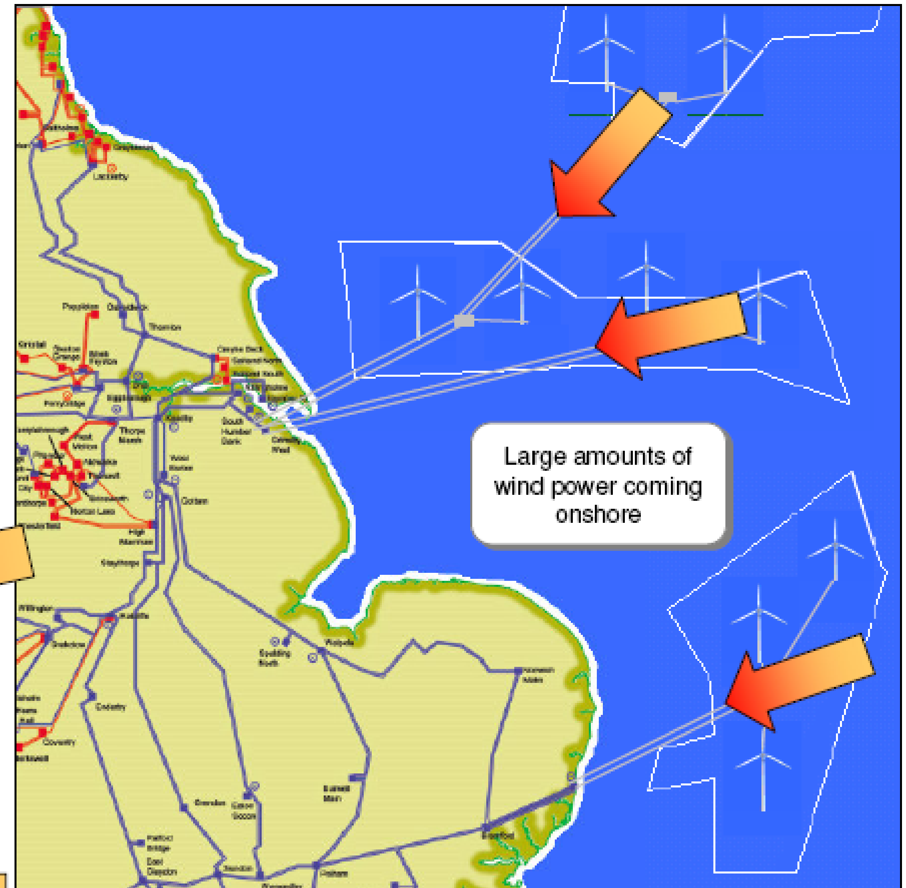
Implications for Transmission Network Architecture
Offshore Wind Intermittency



Flows heavy from east due to wind



Windy weather over the North Sea



Variable power flow issues exacerbated for large exports to continent

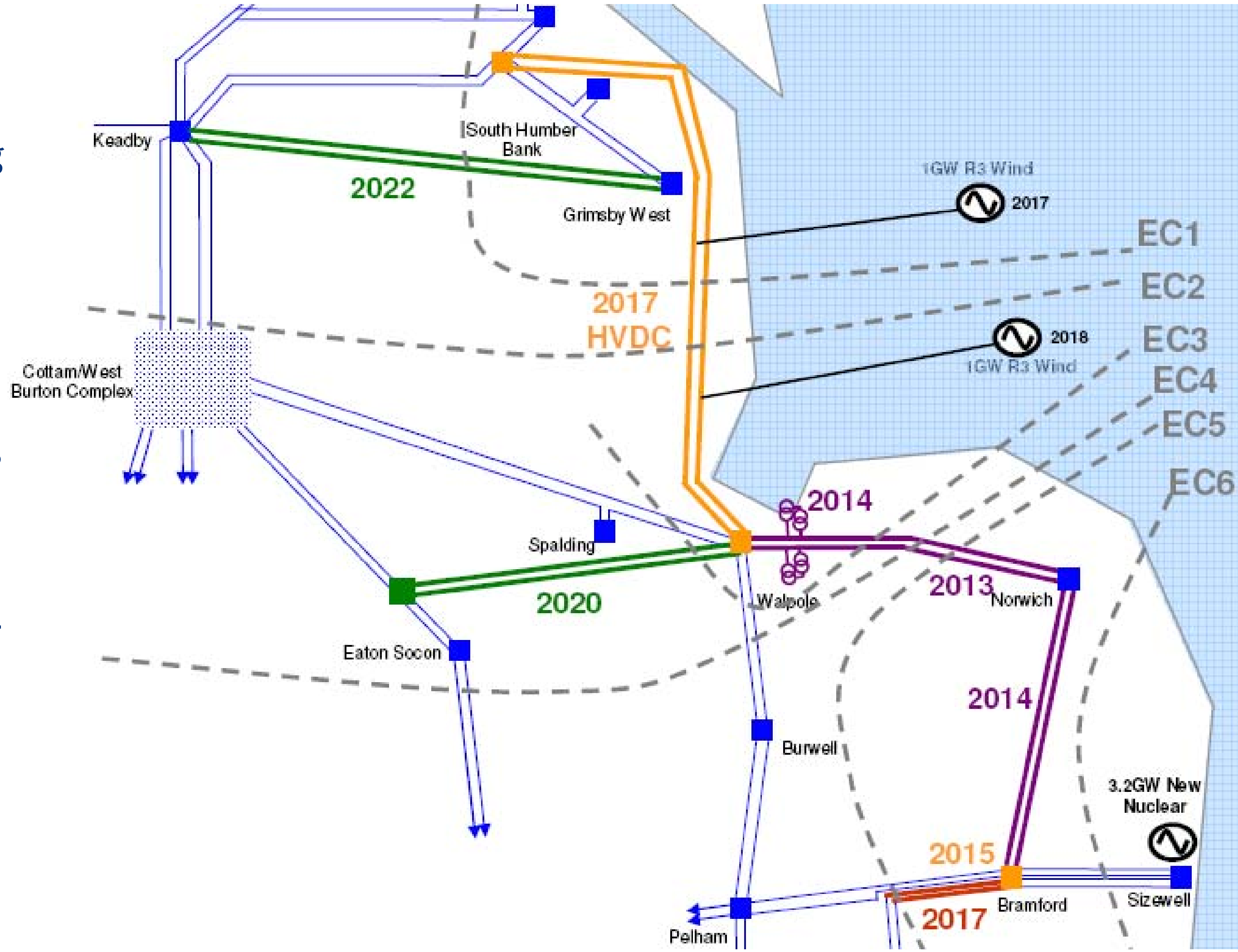
Implications for Transmission Network Architecture

By 2020 - 5GW offshore wind flowing into East Anglia

Plus additional nuclear plant at Sizewell

Substantial upgrades to East Anglia transmission system

New East coast multi-terminal HVDC link allowing direct connection of some offshore generation



Implications for Distribution Network Architecture
(1) Active Dynamic Rating

- 2 x 97MW North Sea offshore wind farms (Lynn & Inner Dowsing) connecting to 132kV distribution network
- Applying conventional ratings would require reinforcement of 132kV overhead line
- Real-time dynamic rating takes account of ambient temperature and wind speed
- Power Donut’ (see inset) continuously monitors conductor current and temperature
- Enables maximum wind farm export to be accommodated under most circumstances
- Registered as an RPZ

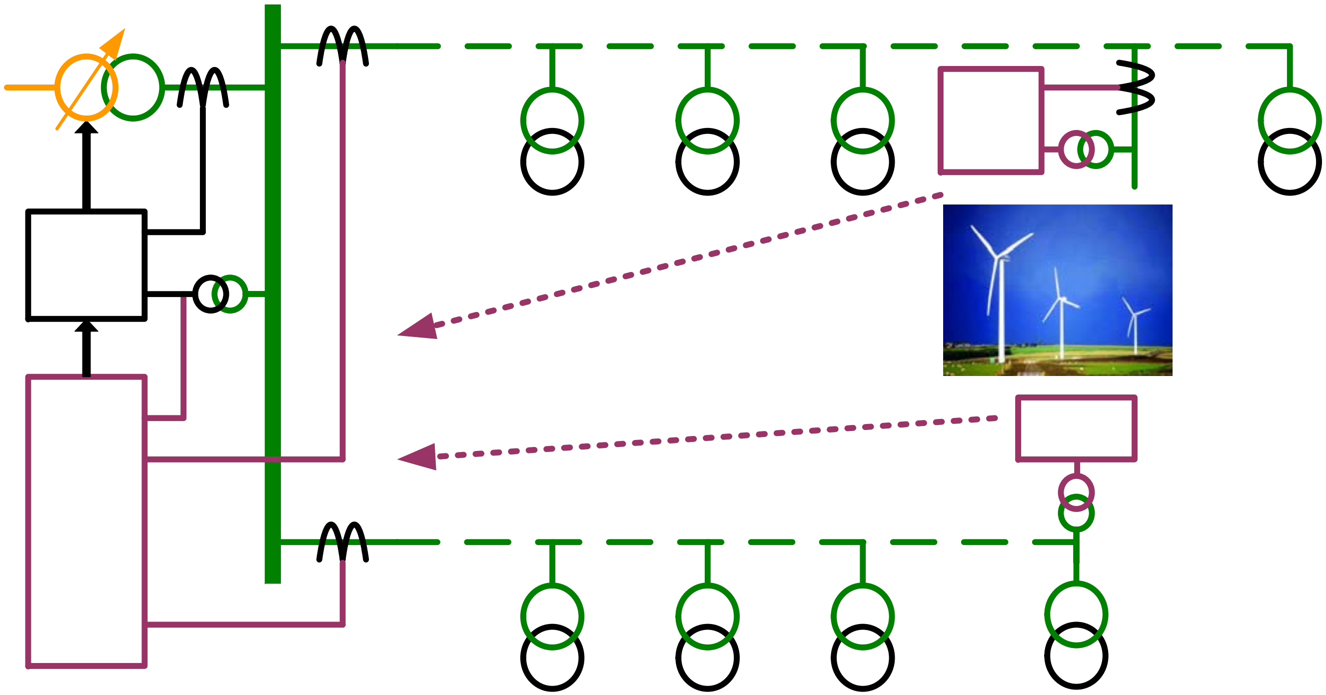
Power Donut fitted to 132kV conductor – measures conductor current and temperature

Local ambient temperature and wind speed continuously monitored

Permits real-time dynamic rating of conductor

Implications for Distribution Network Architecture
(2) Active Voltage Control

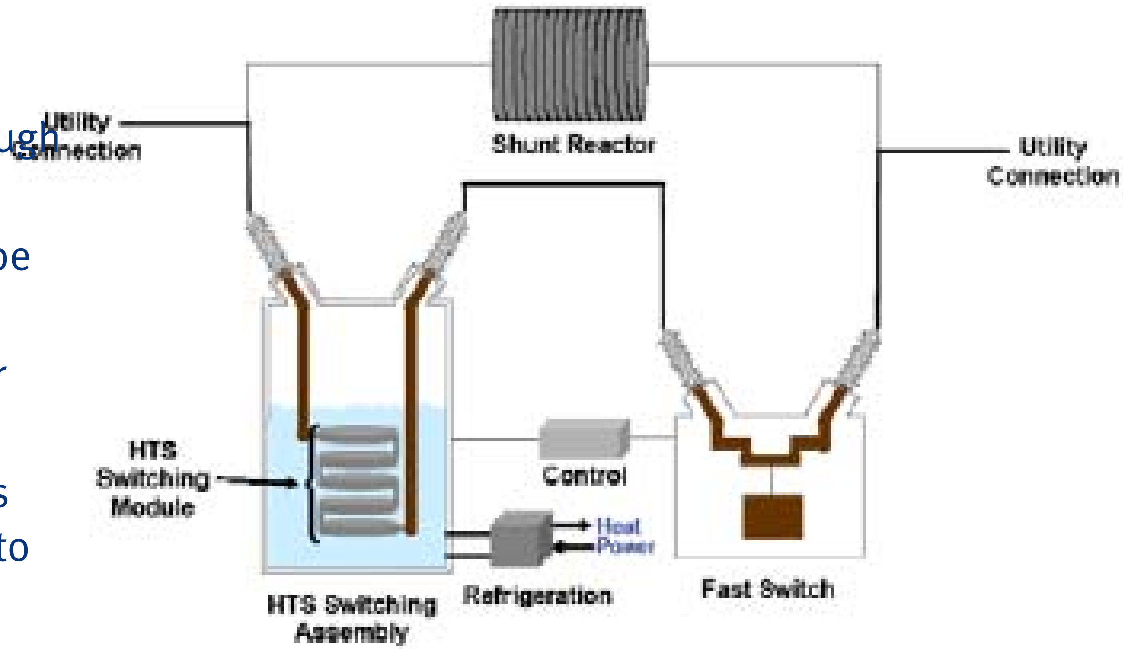
Martham 33/11kV substation Norfolk UK



- Monitoring and state estimation optimises 11kV busbar voltage to maximise generator export – interacts with traditional LDC scheme
- Developed in collaboration with Econnect – registered as an RPZ

Implications for Distribution Network Architecture
(3) Active Short Circuit Current Management

- Fault level management through fault current limiting devices
  - maintaining the benefits of high fault levels (improved power quality) …
  - … but limiting energy let-through in the event of a fault
  - Is limiters considered not to be fail-safe
  - HTS and magnetic FCLs under development
  - LPN network already operates with split 11kV bus-sections to limit fault level …
  - … plus inter-tripping of generation under outage conditions



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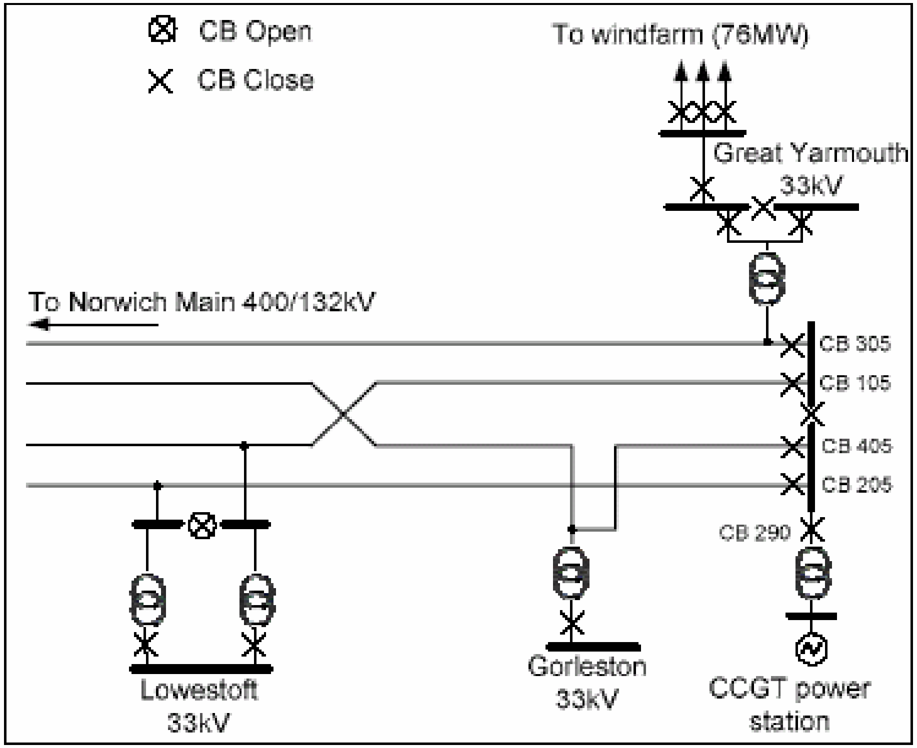
Active Power Flow Management

- Active Generation Constraint
  - curtailing intermittent generation to optimise network capacity
- Demand Side Management
  - to avoid excessive peak demands
  - maximising new demand side storage opportunities arising from:
    - electrically heated hot water storage
    - electric vehicle batteries
  - to improve network utilisation and load factor (load-shaping)
    - minimising network reinforcement and losses
  - enabled through Smart Metering
- Distribution System Balancing
  - 'despatching' storage to balance local network
  - providing an ancillary balancing service to GBSO at the T&D interface

Active Demand Management
(1) Active Generation Constraint

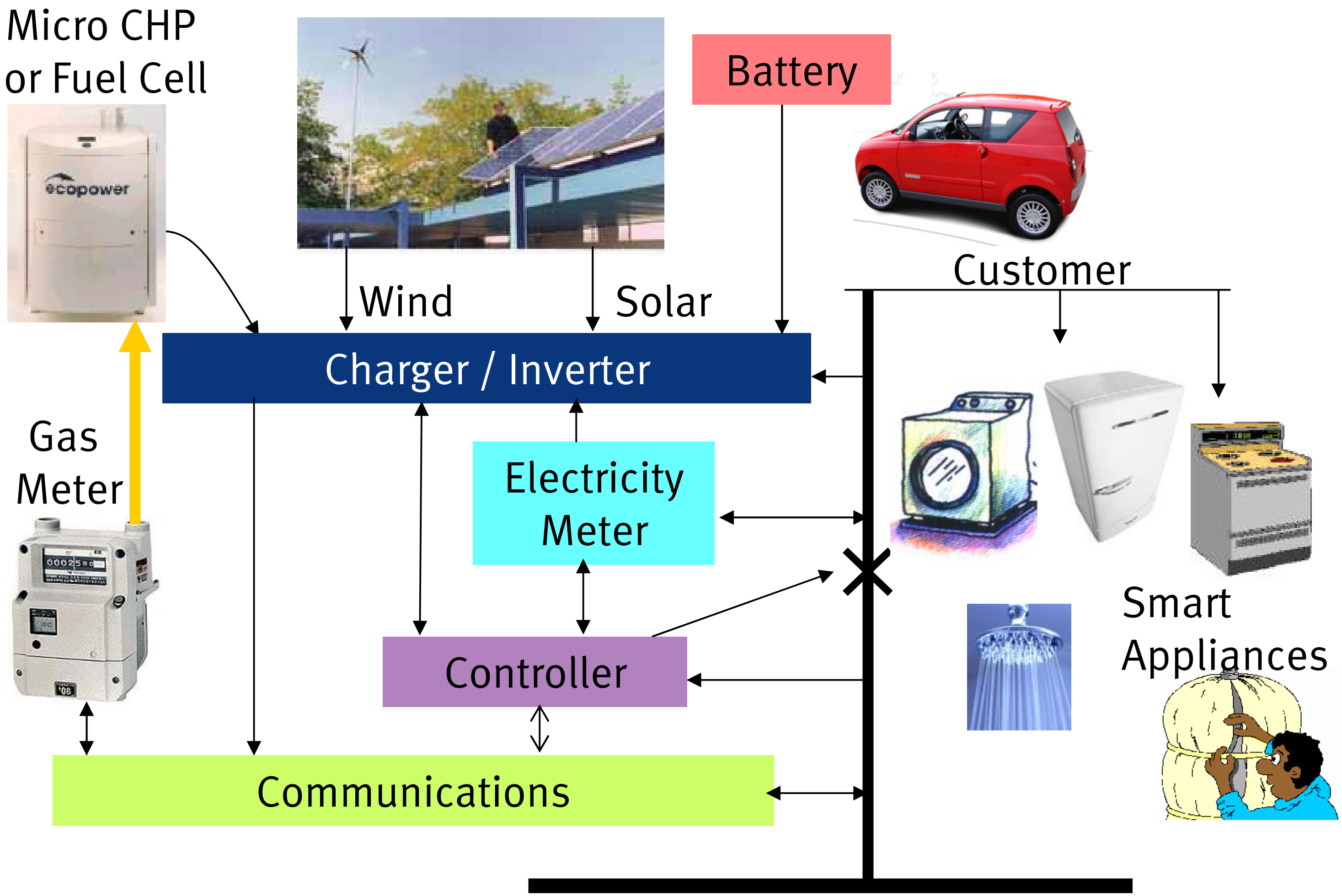
Scroby Sands Wind Farm



wind-farm constraint signal initiated only during circuit outage conditions if combined CCGT / wind-farm export (net of local demand) exceeds line rating

Active Demand Management

(2) Demand Side Management and Smart Metering



Active Demand Management
(3) Distribution System Balancing

- ‘Proof of Concept’ SVC-Light demonstration project
- Connected to the 11kV distribution system - close to 2 existing wind farms
- Rating: 600kVA (short-time) 200kW (1 hour)

Network Interface

Lithium-ion Battery

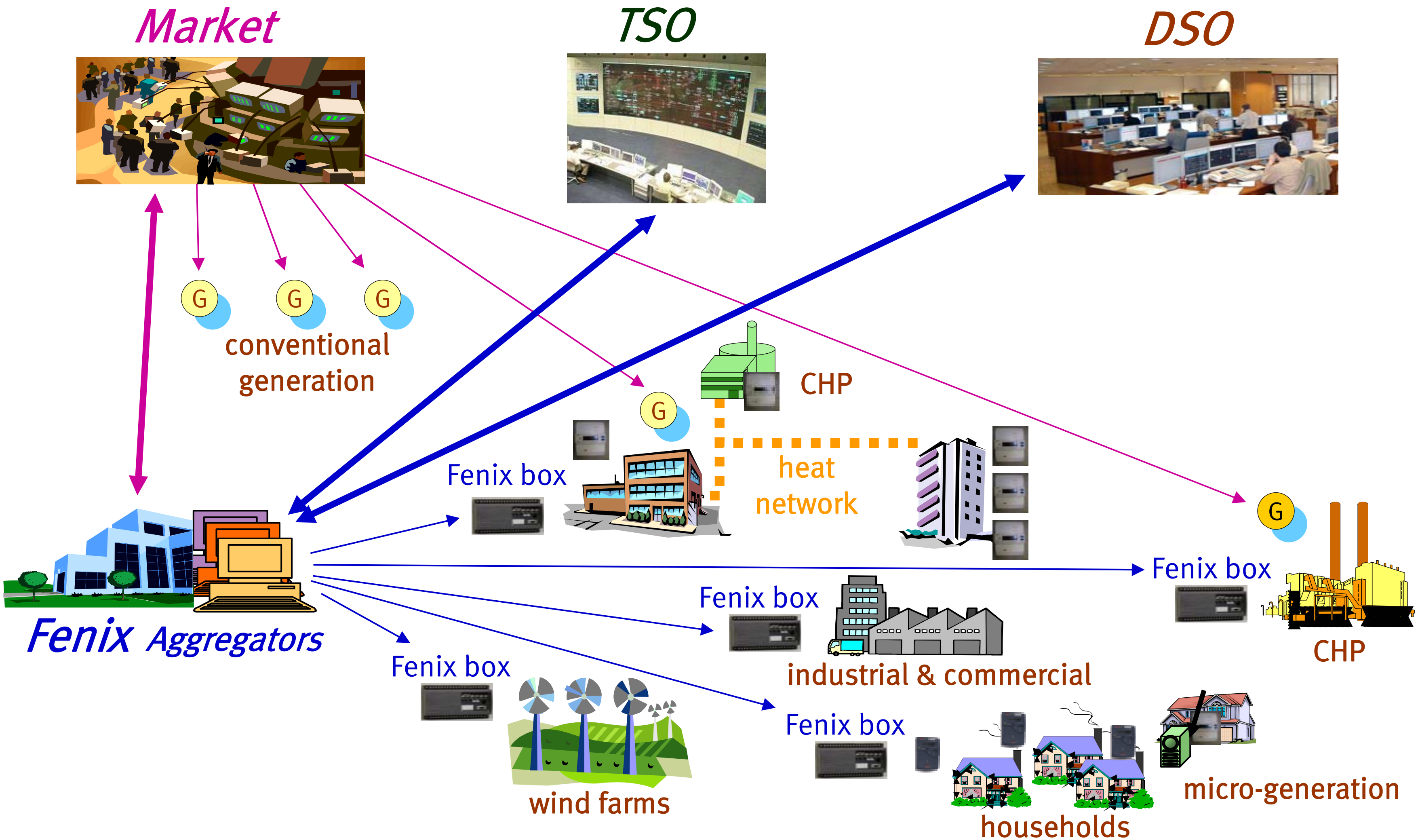
SVC-Light Power Conversion System

Control System

Future Role of DNOs

- Significant challenges for DNOs
  - arising both from Grid and Distribution connected renewable generation
  - and from increasing electricity consumption due to electrification of heat and transport
- DNOs may need to evolve to become distribution ‘system’ operators (DSOs)
  - near-to-real time system balancing / optimisation
  - using Smart Metering to provide highly granular network loading information
  - load shaping to manage local distribution and upstream transmission network constraints (avoiding need for extensive network reinforcement)
  - active management of DG, storage and DSM – facilitated by Smart Metering
  - providing an essential ancillary service to GBSO

Future Role of DNOs



Thank You

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