How Britain's distribution network operators are meeting the challenge of low carbon transition

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UK Power Networks
Delivering your energy

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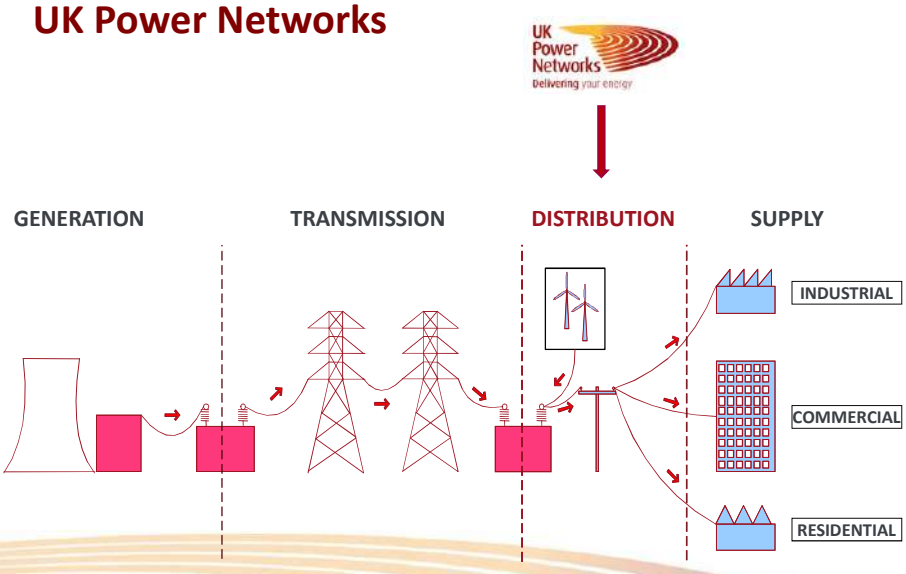

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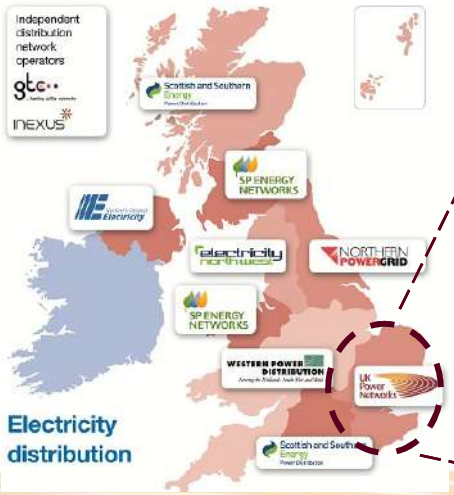
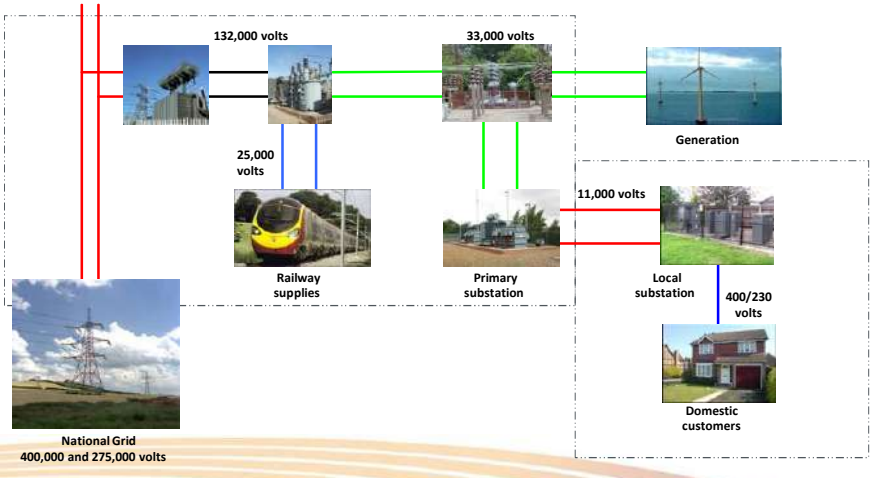
UK Power Networks



	Total	% of Industry
Consumers Million	8.1	28%
Service Area km²	29,250	12%
Underground Network km	139,024	29%
Overhead Network km	46,704	15%
Energy Distributed TWh	84.8	28%
Peak Demand GW	16.2	28%

GB network hierarchy



How Britain's DNOs are meeting the challenge of low carbon transition

- GB electricity scenarios and implications
- GB smart metering programme
- Innovation and smart grid initiatives
- Industry transition and governance implications

GB electricity scenarios and implications

- Low carbon energy policy objectives
- Emerging challenges for the British electricity system
- Implications for GB's distribution network operators

Low carbon energy policy objectives

Context: UK Energy Policy and 'The Carbon Plan'

- **Reduction of UK's green house gas emissions**
  - 80% reduction cf 1990 levels by 2050 – 50% reduction by 2030
  - Decarbonisation of electricity production
  - Electrification of heat and transport
- **Security of UK's energy supply**
  - Increasing electricity generation from low carbon and renewable sources
  - Reducing reliance on imported fossil fuels
  - Ensuring security and stability of energy resources
- **Strong UK Low Carbon Economy**
  - Becoming a low carbon technology world leader
  - Generating 'green' jobs
  - Exportable expertise
- **Affordability of UK Low Carbon Transition**
  - Depends critically on developing an efficient end-to-end electricity supply system
  - Optimising investment in new transmission and distribution network capacity
  - Minimising need for additional generation capacity (esp. low efficiency peaking plant)

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Emerging challenges for the British electricity system

Variable and decentralised low carbon electricity generation
Electrification of heat and transport

Variability of wind and solar generation output

Challenges

Increasing electricity usage to power electric vehicles and heat pumps

- Challenges for real-time system balancing and frequency control
- Increased electricity spot price volatility and commercial imbalance risk
- Reverse power flow voltage rise and fault level issues on distribution networks
- Potential for low carbon technologies to increase peak demand disproportionally to (higher) levels of electricity consumption
- Will consumers respond to ToU price signals (through smart meters) or permit some external control over their low carbon appliances in order to control peak demand and/or balance demand with low carbon generation availability?

We can no longer assume abundance of generation to meet demand spikes in real time
New paradigm of demand following generation (rather than vice versa)
Challenge of reducing system strength and loss of inertia

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Implications for GB's distribution network operators

Evolving role of Distribution Network Operators (DNOs)
Facilitating the move to a low carbon energy sector in a cost-effective way

Distribution networks will require significant adaptation to accommodate local renewable generation, heat pumps and electric vehicles

Challenges

DNOs will need to evolve from passive to active network managers – embracing new technologies and engaging with consumers and generators while playing a wider system balancing role

Smart grid technologies can enhance network performance whilst increasing capacity headroom

Combining technological and commercial innovation is the key to ensuring future cost-effective network capacity, capability and flexibility

A well developed and focused innovation strategy is a precursor to being able to develop and deploy the right solutions at the right time

DNOs will need to adapt and evolve their current practices in order to be able to respond to a range of credible low carbon scenarios in RIIO ED1 (to 2023) whilst preparing for even greater challenges in ED2 (to 2030)

Responding through innovation

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GB Smart Metering programme

- Why DNOs need smart meter data
- Network planning information
- Network operation functionality
- Idealised future smart metering data communications system

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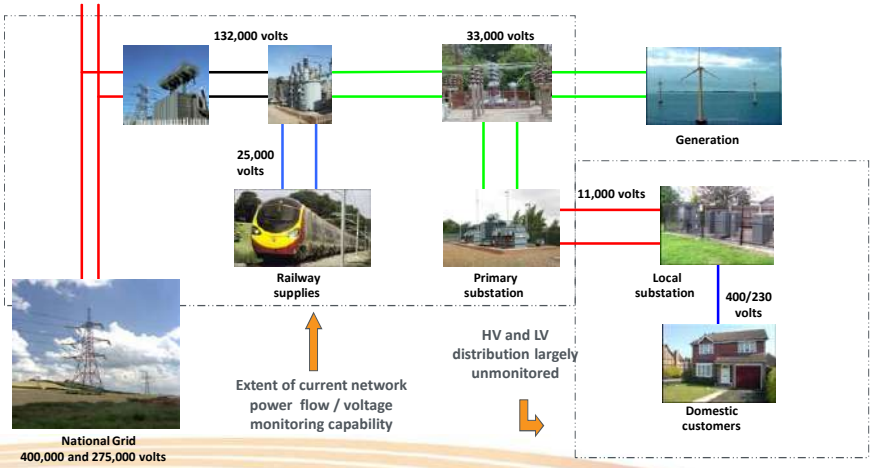
Why DNOs need smart meter data



Why DNOs need smart meter data

- Traditional HV / LV seasonal / daily load profiles well understood
  - means we have hitherto been able to reliably predict consumption, load shape (one-way power flows) and peak demands
- But going forward the distribution network will be impacted due to:
  - Distributed energy resources and feed-in tariffs
  - Electric vehicles
  - Heat pumps
- Implications for network demand and voltage control
  - can no longer manage without smart network intelligence
- Need for greater visibility of LV network supply interruptions
  - SCADA systems cover only HV and above
  - network storm performance has highlighted need for greater visibility of 'masked' faults (LV faults masked by upstream HV faults)
  - No longer acceptable to rely on consumers calling in

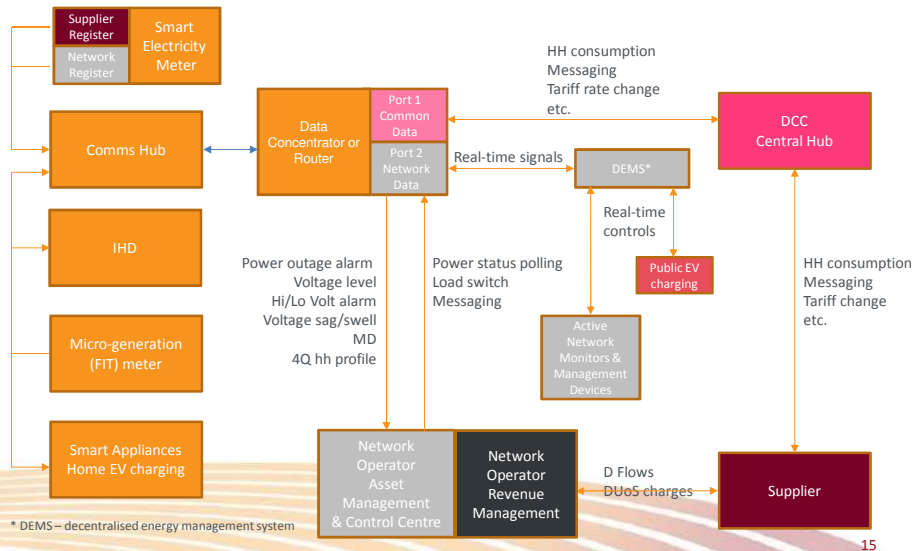
SMETS2 network planning information

- 4-quadrant metering (hh interval kWh & kVArh / import and export)
- Smart meter MD (hh avg. kW)
  - derivation of time-series demand profiles at individual LV circuit level (by aggregation of time-synchronised MD or hh demand profiles)
- Half-hourly average rms voltage
  - derivation of LV circuit voltage at individual nodes
- High / low voltage alerts (detection of non-statutory voltage conditions)
- Early identification of 'load creep' (due to un-notified load increases)
- Evaluation of capacity headroom for network planning and new connection enquiries
- Monitoring impact of increasing levels of distributed generation, heat pumps (on-line or soft start) and EV charging systems

SMETS2 network operation functionality

- Extreme high / low voltage alerts (detection of serious under-voltage and dangerous over-voltage conditions)
- Loss (and restoration) of supply alerts (last gasp / first breath function)
- Power status confirmation (pinging) - of particular value in managing system emergencies with 'masked' downstream faults
- Voltage sag and swell alerts (temporary voltage excursions)
- Voltage readings (rms hh avg.) for future voltage control of LV networks
- Time-stamped interruption / restoration information to validate Quality of Supply and Guaranteed Service Standard performance
- Consumer appliance load switching (basic level – access currently limited to Suppliers)
- Supports (Supplier) time-of-use tariff structures (to incentivise DSM/DSR)

Idealised future SM data communications system



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Innovation and smart grid initiatives

- Smart Grid Forum
- Ofgem network innovation stimuli
- UK Power Networks' innovation strategy
- Innovation case studies

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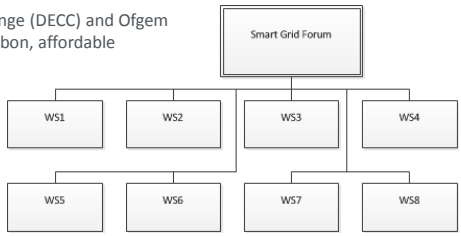
Smart Grid Forum

Created by the Department of Energy and Climate Change (DECC) and Ofgem to support the UK's transition to a secure, safe, low carbon, affordable energy system

- identify future challenges for electricity networks and system balancing including barriers to efficient deployment of smart grids
- guide the actions that Ofgem and DECC are taking to address future challenges, remove barriers and aid efficient deployment
- identify actions that Ofgem, DECC, the industry and other parties could be taking to facilitate the deployment of smart grids
- facilitate the exchange of information and knowledge between key parties, including those outside the energy sector
- help all stakeholders better understand future developments in the industry that they need to be preparing for
- track smart grid developments and their drivers
- track smart grid initiatives in Europe and elsewhere



WS1 - energy scenarios (led by DECC)
WS2 - smart grid evaluation framework (led by Ofgem)
WS3 - developing networks for low carbon (led by DNOs)
WS4 - closing doors (led by IET member of SGF)
WS5 - smart grid information portal (led by ENA)
WS6 - regulatory & commercial barriers (led by Ofgem)
WS7 - 2030 distribution network simulation (led by DNOs)
WS8 - smart grid vision & route map (led by DECC)

https://www.ofgem.gov.uk/electricity/distribution-networks/forums-seminars-and-working-groups/decc-and-ofgem-smart-grid-forum

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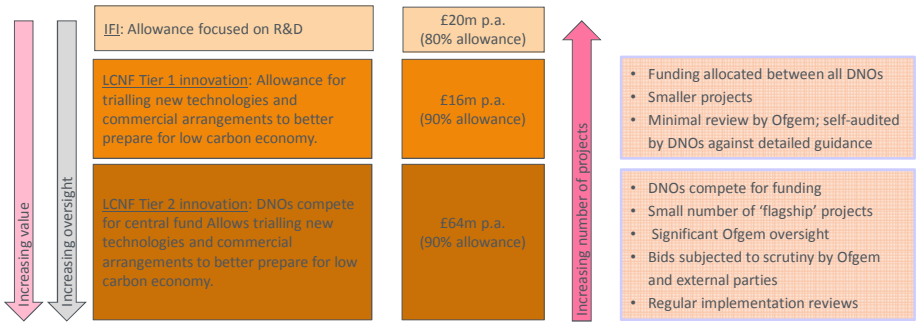
Ofgem network innovation stimuli

Innovation Funding Incentive (2005/06 – 2014/15)
Low Carbon Network Fund (2010/11 – 2014/15)



Network Innovation Allowance & Competition
(from 2013/14 TNOs / 2015/16 DNOs)

- NIA allows funding of up to 0.5% of base revenues
- Ofgem commitment to maintain £90m p.a. NIC funding from 2015/16 until 2016/17
- (from 2015/16, TNOs and DNOs will be in competition for NIC funds)

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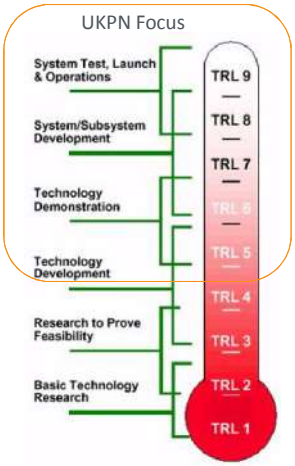
UK Power Networks' innovation strategy

Our 7 innovation themes and objectives

1. Managing asset risk and performance
2. Diagnosing the condition of our assets
3. Identifying network capacity limits and constraints
4. Smart options to release additional network capacity
5. Developing smart commercial solutions and products
6. Leveraging industrial and commercial consumer DSR capability
7. Managing residential and SME demand



UK Power Networks innovation case studies

- Low Carbon London DSR trials
- Smarter Network Storage
- Flexible Plug & Play Networks
- Flexible Urban LV Networks
- Short Circuit Management

For further information on our innovation strategy visit UK Power Networks' Innovation website:
http://innovation.ukpowernetworks.co.uk/innovation/en/

Low Carbon London

Residential dynamic time-of-use tariff trial

Trial purpose: to investigate the network demand impact of dynamic ToU Tariffs designed to maximise usage of zero carbon / marginal cost generation

Methodology:

- Install smart meters over the trial area (EDF Energy)
- Recruit 1100 trial domestic consumers plus a similar sized control group
- Appropriate demographic representation
- Offer a dynamic (day-ahead) priced tariff to residential consumers with smart meters
- Simulate a future where intermittent (wind and solar) generation will create new system balancing challenges and volatile spot prices
- Provide strong price signals to encourage effective demand response
- Curtailing demand when price is high, delaying or bringing forward consumption to periods when price is low
- 12 month trial period
- Study impact on daily demand profiles
- Identify possible new peaks and network constraints

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Low Carbon London

Residential dynamic time-of-use tariff trial

Tariff details:

- Emulating 'wind following' tariff
  - based on historic wind data
  - reflecting day-on-day and within day variation in generation output
- Strong price (per kWh) signals
  - 67.20p HIGH
  - 11.76p NORMAL
  - 3.99p LOW
- Min 24 hour notice
- Message delivered via IHD
- Option for additional SMS message to mobile phone

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ToU trial results 2013 summary

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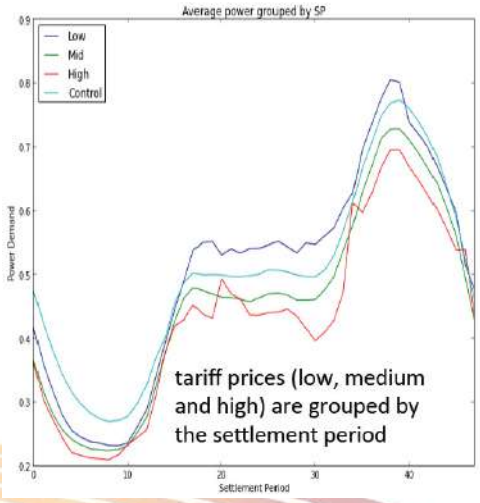
1100 ToU trial participants with smart meters
Similar sized control group with smart meters only

Dynamic ToU tariff trial observations:

- ToU trial participants tend to exhibit lower consumption generally
  - perhaps participation raises family awareness of energy efficiency opportunities?
- Clear response to high price signals
  - particularly daytime
  - less so evening peak but still significant
  - little response overnight
- Noticeable initial response to daytime low price signals
  - but unclear whether sustainable over consecutive days
  - and some fall off of response over trial period



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I&C demand response trial

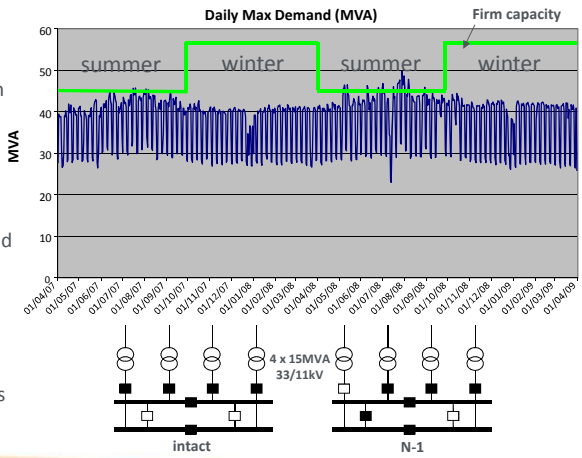
The challenge

- summer loaded substations
- reduced transformer emergency ratings under high ambient temp. conditions
- extremely expensive and disruptive grid reinforcement

The opportunity

I&C customers with flexible demand

- air cooling load
- industrial scale refrigeration
- supermarket lighting
- standby generation
- peak shifting when demand is above firm capacity (pre or post fault)
- potential to defer network reinforcement
- potential to leverage DSR capability to sell into STOR market



Delivering demand response

DNO utilisation of contracted DR

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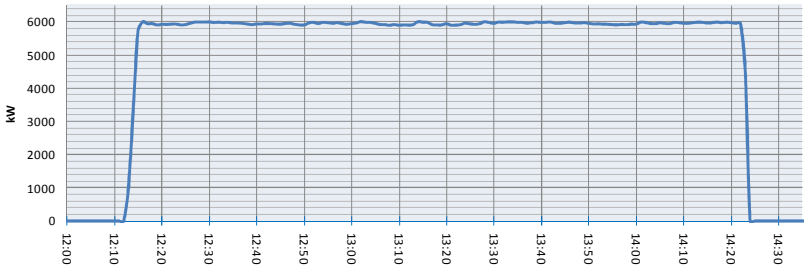
Our experience (successful response):

- Generation output curve for a successful DR intervention (6 MW requested, 2 hr duration, 12:18 – 14:18)



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Smarter Network Storage

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Trial Purpose: to investigate the technical and economic feasibility of electrical energy storage as a means of providing network support and upstream reserve services

Benefits:

- Removes need for major network reinforcement by providing network peak demand support
- Harmonic filtering (improved power quality)
- Power factor control (voltage management)
- Real power injection (improving system strength and stability)
- Capable of providing system reserve services: STOR, Fast Reserve and Frequency Response

Li Ion batteries

IGBT converter

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Business case

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The challenge: leveraging capability across the entire electricity supply chain

Use-Case	TSO	DNO	Supplier	Generator
Real-time management of power supply quality and harmonics Active and reactive power support	■	■		
Short-term and seasonal support of intermittency challenges – Frequency Response, Fast Reserve, STOR ancillary services Improving intermittent generation effective capacity factor	■			■
Peak shifting of daily demand-spikes Deferring or avoiding reinforcement Smoothing renewable generation export	■	■		
Reducing imbalance risk Energy arbitrage and trading opportunities			■	■

Individual business cases currently not viable

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Trial objectives

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Primary objectives of SNS:

- Demonstrate large-scale energy storage deployment - 6MW / 10MWh advanced lithium-ion storage system
- Demonstrate multi-purpose application of storage across full value chain and develop novel commercial arrangements
- Market opportunities
  - potential capacity market component
  - could enable a Supplier to reduce imbalance risk
- Potential ancillary service and market opportunities
  - STOR (alternative to DSR)
  - Fast Reserve and Frequency Response (not generally available through DSR)
  - Reducing Suppliers' balancing mechanism cash-out exposure
  - Capacity market

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Flexible Plug & Play Networks

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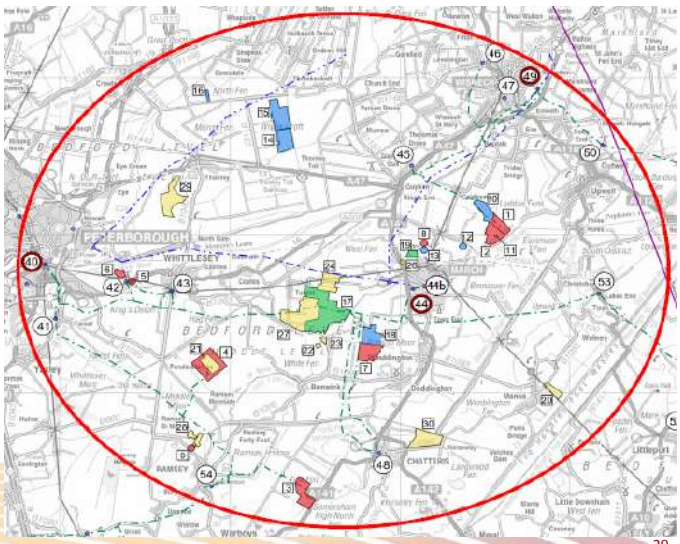
Peterborough - March generator dominated EHV network

The Challenge:

- 90MW generation already connected
- 188MW generation in planning
- Existing network constraints
- Conventional approach would involve major network reinforcement
- Potentially prohibitive connection charges and delays



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Flexible Plug & Play Networks

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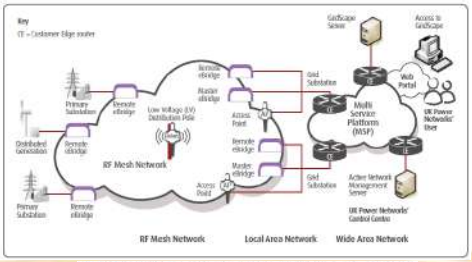
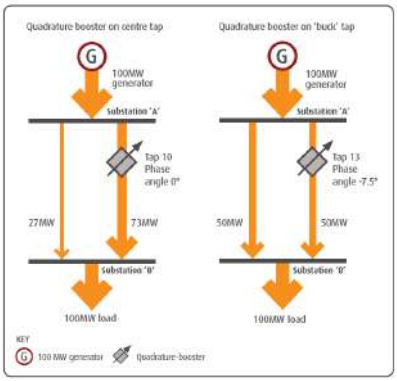
novel technology

The Solution:

- Smart applications: dynamic line ratings; active DG management; adaptive protection; frequent use switches; voltage management; quad booster
- IEC 61850 communications platform
- Innovative contractual arrangements



High-level end-to-end IP-based communications infrastructure



Phase shifting transformer

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Flexible Plug & Play Networks

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Connection offers and acceptances (as at March 2014)

8 ACCEPTED FLEXIBLE CONNECTIONS

31.75 MW will be connecting through FPP in 2014

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Flexible Urban LV Networks

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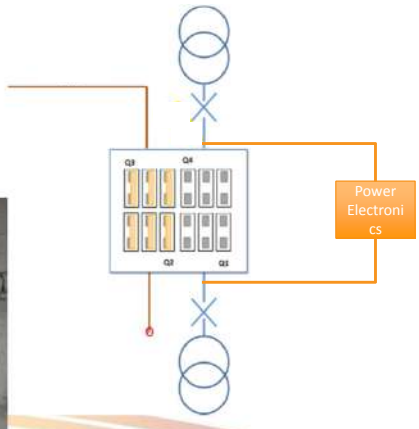
Features and Benefits:

- Replaces conventional link box
- Improved network utilisation through meshing
- Circuit load sharing (optimising voltage regulation)
- Harmonic filtering (cleaner supply voltage)
- Power factor control
- Reducing voltage dips
- Short-circuit current limiting

Power electronics based LV network 'soft normal open point'



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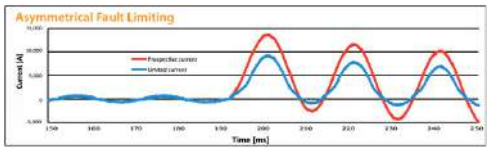
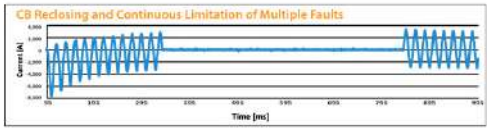
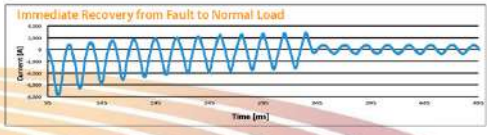
HV Network Short Circuit Level Management

Features and Benefits:

- Fault Current Limiter (pre-saturated core)
- HV fault current / voltage dip limiting
- Maintaining low source impedance
- Allowing greater penetration of DG







Industry transition and governance implications

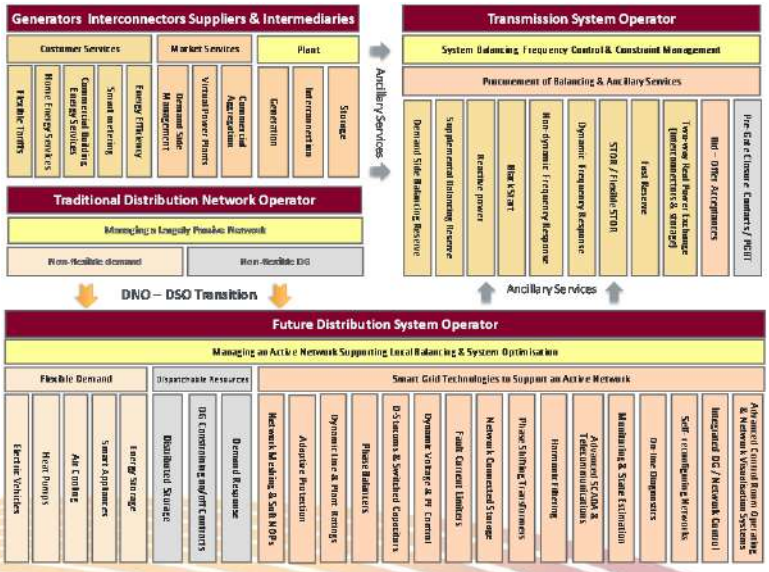
- New roles for DNOs (transitioning to DSOs)
- IET Power Networks Joint Vision

Whole system management - emerging role for DSOs

The traditional 'DNO' manages a largely passive network

The future 'DSO' will build and manage an active network:

- exploiting flexibility of demand
- contracting dispatchable energy resources
- deploying a wide range of smart grid technologies
- providing ancillary services to TSO



IET Power Networks Joint Vision

6 key recommendations arising from the 2013 IET study

1. DECC should work with industry to establish a **System Architect** role to achieve a **whole system** approach
2. Government/industry stakeholder groups should explore and address effective interactions between **engineering, market and regulatory** aspects to determine changes needed
3. DECC/Ofgem should develop the regulatory arrangements that will enable **demand response and distributed storage** to participate in **maximising whole system synergies** and the mitigation of risks
4. Network companies should together determine how to address the impact of a data rich environment, including the mechanisms for **improved internal and external data exchange**
5. Network companies' procurement arrangements should **facilitate greater access for specialist providers** to bring benefits in smart grids, demand management and new customer services
6. Network companies, the IET, and other interested parties should work out how to address the requirements for increasing engineering, commercial and business complexity, including **the means to access skills and research and test facilities**, and the sharing of knowledge

http://www.theiet.org/factfiles/energy/pnjv-page.cfm


Thank you
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