Low Carbon London
Active Network Management (ANM) and Decentralised Energy

A Learning Event

The Riverside Room
IET Savoy Place
London
1 October 2012
Welcome

- Housekeeping and safety
- Introduction to the afternoon
Low Carbon London – a learning journey

*Learning how to create a smart, low carbon city*

A pioneering demonstration project, trialling new low carbon technologies, commercial innovation and design, operation and network management strategies...

- Smart Meters
- Residential ToU – demand flexibility to respond to availability of renewable generation
- Demand Response with Industrial & Commercial (I&C) customers
- Distributed Generation & Active Network Management (ANM)
- Electric Vehicles
- Heat Pumps and Small Scale Embedded Generation (SSEG)
- Engineering Instrumentation Zones
- New Tools, Operational and Investment Practices
- Learning Laboratory – learning dissemination
Enabling Distributed Generation

Challenge:
UK Low Carbon Transition Plan: 30% of UK electricity from renewable sources by 2020
Mayor of London’s renewable strategy target: 25% of electricity and heating from local generation by 2025

Our response:
Investigate the impact and enable the connection of distributed and local generation to the distribution network and trial Active Network Management (ANM) techniques to assess how they improve security of supply and reduce network investment costs

‘CONSTRAINING OFF’ – monitor and facilitate DG connections to the LV and HV distribution networks

‘CONSTRAINING ON’ – active management of DG to ensure security of supply and postpone network reinforcement

The best and most cost-effective way to adapt the electricity network to accommodate large amounts of distributed generation
Purpose of the day

• What is Active Network Management (ANM)?
• How ANM can be used to support the electricity network and to manage the increasing connections of low carbon technologies (CHP, PV etc.)
• Outline of the Low Carbon London trial proposition and recruitment process
• Lessons learnt and current barriers to recruitment
• Group discussions to suggest ways to overcome the barriers
• Smarter Grid Solutions ANM demonstration
Low Carbon London Learning Event

Growing grid capacity to power change

Colin Gault

October 2012
Contents

Introduction to Active Network Management (ANM)

Constraints on Network Capacity

Thermal

Voltage

Fault Level

Application of ANM
ANM increases capacity in the existing grid

- Maximise existing assets
- Avoid or defer network upgrades
- Cost effective and timely connections
ANM provides a new layer in grid management
Electricity Network Constraints

• Network constraints represent a barrier to increased penetration of distributed energy resources
• Network constraints are derived from the physical characteristics of the electricity network and the standards that govern electricity supply
• Three main network constraints are:
  – Thermal (Power Flow)
  – Voltage
  – Fault Level
• Other technical (e.g. power quality) and non-technical constraints can exist (e.g. commercial arrangements)
Thermal (Power Flow) Constraints

- The flow of current produces heat within electrical conductors ($I^2R$)
- Conductors are assigned a maximum operating temperature
- Exceeding this operating temperature can reduce the lifetime of equipment or result in overhead line conductors breaching safety clearances
- Assumptions are made about environmental conditions and conductor cooling to calculate a maximum current or power carrying capacity for every circuit section, known as the thermal rating
- Thermal ratings have traditionally been employed as a static variable with variations occurring between the different seasons of the year only
- Some components can tolerate an exceedence of thermal ratings for a defined period of time, known as the cyclic or short-term ratings
Thermal (Power Flow) Constraints – Network Design

• Traditional approach has been “fit and forget” for the connection of load customers
• Design of network for connection of load considers power flows during the maximum load scenario
• Estimates of future load growth are taken in to account to minimise network reinforcement
• Design of network for connection of generation considers minimum load maximum generation scenario (worst case)
• Generator connections dealt with individually with no consideration of expected growth or interactive nature of applications
• Planning standards, “Engineering Recommendation P2/6: Security of Supply”, sets out how much network you need to ensure security and reliability for demand customers
**Thermal (Power Flow) Constraints – Example 1**

Conductor Rating = 5 MW

Firm Generation
Rated Export = 6 MW

Minimum Load = 1 MW
Maximum Load = 5 MW

Acceptable Level of Firm Generation = Minimum Load + Conductor Rating
Acceptable Level of Firm Generation = 1 MW + 5 MW
Acceptable Level of Firm Generation = 6 MW
Thermal (Power Flow) Constraints – Example 2

Transformer Rating = 25 MW

Firm Generation
Rated Export = 30 MW

Non-Firm Generation
Rated Export = 25 MW

Minimum Load = 5 MW
Maximum Load = 25 MW

Acceptable Level of Firm Generation = Minimum Load + (1 X Transformer Rating)
Acceptable Level of Firm Generation = 30 MW

Acceptable Level of Non-Firm Generation = 1 X Transformer Rating
Acceptable Level of Non-Firm Generation = 25 MW
Voltage Constraint

• Voltages on the electricity network must be maintained within statutory limits
  – 230V +10% / -6%
• Ensures quality of supply and the correct operation of equipment
• Network operators penalised if voltage outside of statutory limits
• Sudden changes in voltages – step voltages – large enough to be noticeable to humans (e.g. light flicker) are undesirable and avoided wherever possible
• Sources of energy increase network voltages and consumers of energy decrease network voltages
Voltage Constraint – Network Design

• To minimise network losses electricity is transmitted across long distances at high voltage
• Network voltage tapers toward end users
• Traditional view of network is that power flows from high voltages to low voltages and this is reflected in network design and operating practices
• Voltage control is achieved in various ways:
  – Tapping of transformers
  – FACTS devices (mainly at transmission)
  – Reactive compensation devices, e.g. capacitors and inductors
  – Operating generators in PV mode (utilises reactive power capabilities to fix voltage)
Voltage Constraint – Example 1

Circuit 1

Automation Voltage Control (AVC) Relay

Primary Substation

Circuit 2

Feeder 1 – Max L

Feeder 2 – Max L

Upper Limit

Voltage

Lower Limit

Increasing Distance From Substation
Voltage Constraint – Example 2

Circuit 1

Circuit 2

Generator raises voltage profile

Generator masks load at primary substation and disrupts operation of AVC relay

AVC varies voltage at busbar

Upper Limit

Voltage

Lower Limit

Increasing Distance From Substation
Fault Level Constraint

• Fault levels relate to the magnitude of the current that will flow into a particular node on the electricity network if a short circuit fault were to occur at that node.
• Fault current is produced by both generation and load and is dependent on the impedance of the network between the location of the fault and sources of fault current.
• Circuit breakers and protection relays are installed and configured at strategic locations on the network to isolate and remove a fault quickly and safely.
• Fault Level as a constraint is concerned with the rating of circuit breakers, which are designed to operate for fault currents up to a specific magnitude.
Fault Level Constraint – Network Design

- Fault level is not readily measured in the same way as current and voltage
- Fault levels calculated using off-line analysis tools
- Effects of different network configuration considered with fault level analysis due to resultant change in network impedance
- Circuit breakers chosen with a design rating greater than the worst expected fault current – headroom allocated for future growth
- Fault levels re-assessed as new sources of fault current are connected to the network
- Fault current can be limited by increasing network impedances through splitting parallel paths or using high impedance equipment
  - Increases network losses and reduces network security
  - Fault current limiting devices are appearing on the market and being tested by DNOs
Fault Level Constraint – Example 1

- Circuit Breaker (CB)

I total = I1 + I2 + I3

CB3 Rating >= I1 + I2

Fault current contribution of short-term parallel generators also considered
Fault Level Constraint – Example 2

Standard running arrangement with 3 transformers run split

In the standard running arrangement total fault level contribution is split between 3 transformers

N-1 running arrangement with 2 transformers run split

In the N-1 running arrangement total fault level contribution is split between 2 transformers
Application of Active Network Management

- Identify network constraint(s) through power systems analysis
  - Thermal, Voltage or Fault Level
  - Locations
- Select appropriate Active Network Management application
- Perform feasibility assessment
  - Uses historical data and network topology as input
  - Provide estimates of energy production/consumption (MWh)
- Confirm commercial arrangements
  - Principles of access, e.g. Last In First Off, Shared, etc.
- Requirements gathering
- Detailed design
- Deployment
- Support
- Add further controlled devices or constraints
Application of Active Network Management

- **Thermal (power flow) constraint**
  - Measure power flow in real-time
  - Control generation or load when power flow exceeds limit
  - Exploit fluctuation in demand and generation
  - Utilise latent network capacity to maximise low carbon energy production

- **Voltage Constraint**
  - Measure voltage in real-time
  - Control generation, load or operating position of any voltage control devices installed on the network when voltage breaches limits
  - Exploit fluctuation in demand and generation
  - Fully co-ordinate load, generation and network devices to maximise utilisation of latent network capacity and voltage headroom
Application of Active Network Management

- Fault Level Constraint
  - Co-ordinate connection of generation to the network ensuring fault level contribution does not exceed fault level limits
  - Co-ordinate multiple generator intertrip schemes during network reconfiguration
  - Exploit difference between what generation could be connected to the network and what generation is connected to the network at any point in time
ANM – SECURITY OF SUPPLY

Paul Pretlove
UK Power Networks
Security of Supply - Requirements

• Requirements described within:
  – Distribution Code – DPC4
  – Engineering Recommendation P2/6
  – Engineering Technical Reports 130 and 131

• Distribution Price Control Settlement (DPCR)
  – Capital and Operational expenditure
  – Customer Interruption (CI) and Customer Minutes Lost (CML)
Security of Supply – Requirements Cont...

Diagram showing a main substation with transformers connected to load groups 1 and 2. FCO and SCO are marked with red crosses to indicate a specific requirement or condition.
Security of Supply – Calculation (Current)
Security of Supply – Calculation (Current)

Load
• Current
• Forecast

Contribution to security of supply
• Network Assets
  – Manufacturers information and engineering assumptions
• Transfer capacity
  – Network design and configuration
• Distributed Generation
  – Probability based analysis
Challenges associated with calculating the contribution from Distributed Generation:

• Information unavailable
• Resource intensive and time consuming

Consequences:

• Risk averse approach to under estimate the contribution from Distributed Generation
  – Over engineered network
• Inability for consideration in operational decisions
  – Increase in Customer Interruptions (CI) and Customer Minutes Lost (CML)
Security of Supply – Calculation (Proposed)
Security of Supply – Calculation (Proposed)

Challenges associated with calculating the contribution from Distributed Generation:
• Information unavailable
• Resource intensive and time consuming

Consequences:
• Risk of over/under estimating the contribution from Distributed Generation
  – Under/over engineered network
• Inability for consideration in operational decisions
  – Increase in Customer Interruptions (CI) and Customer Minutes Lost (CML)
Security of Supply – Calculation (Ambition)
Security of Supply – Calculation (Ambition)

Under contract with owners of Distributed Generation to contribute to the security of supply

• DNO benefits
  – Maximise use of existing assets
  – Greater interaction with customers

• Customer benefits
  – Additional revenue stream for the DG owners
  – Lower energy bills for all customers, as DNO’s use “smarter” use of their assets
LOW CARBON LONDON
Recruitment to Decentralised Energy ANM Trial

Chris Taylor
UK Power Networks
Customer Recruitment - Overview

- Engagement strategies (three approaches)
  - Approach One – tailored/targeted recruitment
  - Approach Two – higher level recruitment
  - Approach Three – mass targeted recruitment

- Accent Active Network Management Research

- Summary of current recruitment challenges
Approach One – Tailored/Targeted Recruitment

- Selection process prioritising existing customers (security of supply trials)
  - Hierarchy of selection criteria
    1. Type of connection
    2. Technology (low carbon technology)
    3. Location (near constrained main substation)
    4. Size
  - Customers meeting criteria 1 – 3 were contacted directly
    o 10 customer met this criteria
    o 1 successful contact
- Selection process for identifying new customers (enabling and security of supply)
  - No material leads
Approach One – Tailored/Targeted Recruitment

Learning and challenges identified:

- resource intensive
- difficult to obtain appropriate contact information
- technically unable to participate
- low uptake
Approach Two – High Level Recruitment

- Higher level contact with interested organisations
  - trade associations (CHPA, GLA, London First, UK District Energy Association etc)
  - CHP operators/providers
  - leverage internal customer relationships
- During this recruitment stage we contacted around 30 customers and CHP installers/operators
  - one firm lead
  - multiple other possible leads (in excess of 30)
Approach Two – High Level Recruitment

Learning /challenges identified:

• Occupancy arrangements being a barrier to implementation:
  – multiple decision makers
  – no financial benefits for party owning/managing the generator

• A significant number of people were technically unable to participate:
  – enabling – fault level issues
  – security of supply
    o no modulation of output
    o inability to “dump” heat
Why?

Findings:

- Financials /Incentives /Benefits
- Communications
  - Clients /Customer -> too complex
  - Consultants / Manufacturers -> too simplistic, lacking detail
- Requirement for full time recruitment resource in order to follow up leads effectively

The results of this research partly triggered Approach Three
Approach Three – Mass Targeted Recruitment

- Accent survey
- Introduction of monitoring only trial
  - existing customers selected based on meeting selection criteria 1 (type of connection)
- Increase in resource
  - dedicated customer liaison manager
  - ‘hot house’ sessions involving the whole LCL team.
  - all leads periodically followed up via email and phone
- Third party specialist engagement
Current Recruitment Challenges

- Unwilling to have third party equipment installed on premises
- Unable to obtain contact information for the customer or contact the decision maker within the organisation for programmes of this nature
- Unable to obtain correct level of management buy in
- No tangible benefits to participation
- Not enough time or resources available to consider the opportunity
- General unwillingness/negative response to ‘cold calling ‘ approach
- Lack of understanding of the concept of the trials and see the value they can add as a participant
- No response to any type of contact (email, phone, letter)
- Third party assistance difficult
Table Discussions to Support Approach Four
Closing Statements

• Questions

• Smarter Grid Solutions ANM demonstration

• Refreshments and networking