5. Existing energy networks

In this section we explore the existing gas and electricity networks that the City Region is embedded within, looking at where the energy comes from, the extent to which it is energy secure, and how robust our network infrastructure is, now and into the future.

5.1 Electricity and gas supplies

Approximately 93% of North West regions electricity is generated by a small number of large generating plants. Their fuel mix reflects the national electricity generation mix, being split three ways between natural gas, coal and nuclear generation:

- Natural gas: Rocksavage power station at Runcorn has a capacity of 784 MW. It was commissioned in 1998 and has a projected lifespan of at least 30 years [42];
- Coal: Fiddlers Ferry power station on Merseyside has a capacity of 1,989 MW and sources its fuel from Yorkshire and across the world, including Australia and South America. It was commissioned in 1971 and will remain operational until at least 2015 [43];
- Nuclear: Heysham 1 and 2 power station near Lancaster has a capacity of 2,400 MW and sources its fuel from across the world, including Canada, Africa, Australia and Russia. It was commissioned between 1970 and 1988 and with likely operation until 2014 (Heysham 1) and 2023 (Heysham 2) [44];

A small but growing proportion of the region, and the sub-region's, electricity is generated by renewable sources (7% in 2008) the majority of which is from on and offshore wind power. This is due to increase with a further 1,400 MW of offshore wind farm capacity consented or under construction [45].

Greater Manchester's electricity supply is based on the North West generating mix and can currently be seen to be diversified in its sources but highly dependant on imported fuels. There are a number of factors that may influence future energy planning and the ability to meet sub-regional and local CO_2 reduction targets [46]:

- Coal and nuclear generating capacity are both reliant on imported international fuel sources;
- Fiddlers Ferry and Heysham 1 and 2 stations are scheduled to be decommissioned by 2023;
- The Morecambe Bay gas field has a finite lifespan of between 10-20 years, based on current estimates;

[42] Power station operator Intergen, see www.intergen.com
[43] Power station operator Scottish & Southern Energy, see www.scottish-southern.co.uk
[44] Power station operator British Energy, see www.british-energy.com
[45] *See footnote 19*
[46] *See footnote 15*

- The position with regard to replacement capacity, including a decision on new nuclear capacity, is not yet clear although Sellafield in Cumbria has been put forward as a potential location.

A new 860 MWe Combined Cycle Gas Turbine (CCGT) power station has been granted permission at Carrington in Greater Manchester, creating a sub-regional drawdown of the Liverpool Bay gas resource. The potential to maximise the efficiency with which this gas resource is utilised by operating it as a Combined Heat and Power (CHP) plant – a condition of the Secretary of States consent – is explored as a case study by this study.

5.2 Electricity distribution network

The electricity transmission and distribution network in the UK consists of the National Grid which takes electricity from large power stations and transmits it though a high voltage network (400kV and 275kV) to grid supply points where it is transformed down to 132kV for distribution to customers over networks which are owned by 14 regulated distribution network operators (DNOs).

5.2.1 Regional electricity distribution

Electricity North West Limited (ENW) owns the electricity distribution network in North West England, distributing electricity to customers as the licensed network operator on behalf of the electricity supply companies. ENW currently has 13,127 km of overhead lines, 43,136 km of underground cables, and 33,822 transformers serving 2.3 million customers in the North West of England [47]. United Utilities operate, maintain, construct and repair these assets on behalf of ENW.

The price that ENW can charge for distributing electricity is regulated by the Gas and Electricity Markets Authority ('GEMA'), operating through the Office of Gas and Electricity Markets ('OFGEM') under a price regime that is reviewed every five years. The result of the most recent Distribution Price Control Review took effect on 1 April 2005. The next price control review is scheduled to take effect from 1 April 2010.

5.2.2 Greater Manchester's network

The network in Greater Manchester is fed through the main 132kV supply that is transformed down to 33kV at bulk supply points. It is then served through primary sub-stations which transform the voltage from 33kV to 11 and 6.6kV for distribution to local areas where smaller sub-stations step down the voltage to 230v or 400v for use by customers in factories, offices and homes.

An illustrative section of the 132 kV and 33kV networks, covering parts of Salford and Trafford, is shown Figure 5.2. The Barton Bulk Supply Point transforms the 132kV supply down to 33kV which then feeds the primary sub-stations in the area (e.g. at Lyons Rd, Barton Dock Road and

[47] Electricity North West (2008) *Strategic direction statement 2010-2035*, see www.enwltd.co.uk

Mount St). The Stretford BSP/Grid (middle bottom of Figure 5.2) feeds primary sub-stations such as Urmston, Chester Rd and Trafford. It should be noted that the 33kV networks are interlinked to provide network reliability and security e.g. the substation at Chester Rd is linked into the Barton and Longsight grids.

5.2.3 Connection of new demand

The connection of new demand to the network, especially large loads, can cause problems in terms of the available capacity at the sub-station to which the load will be connected. The network is designed with a degree of redundancy to ensure security of supply under fault conditions. The capacity or utilisation of a substation is specified as the capacity of the network after the most severe single fault.

An overview of utilisation of the primary 33kV sub-stations in GM is provided by Spatial Plan 5.1 which is based on assigning a polygon area to each sub-station. The plan highlights where the utilisation of each primary sub-station is high in terms of maximum load compared to sub-station capacity.

Figure 5.1

Greater Manchester 132kV Network

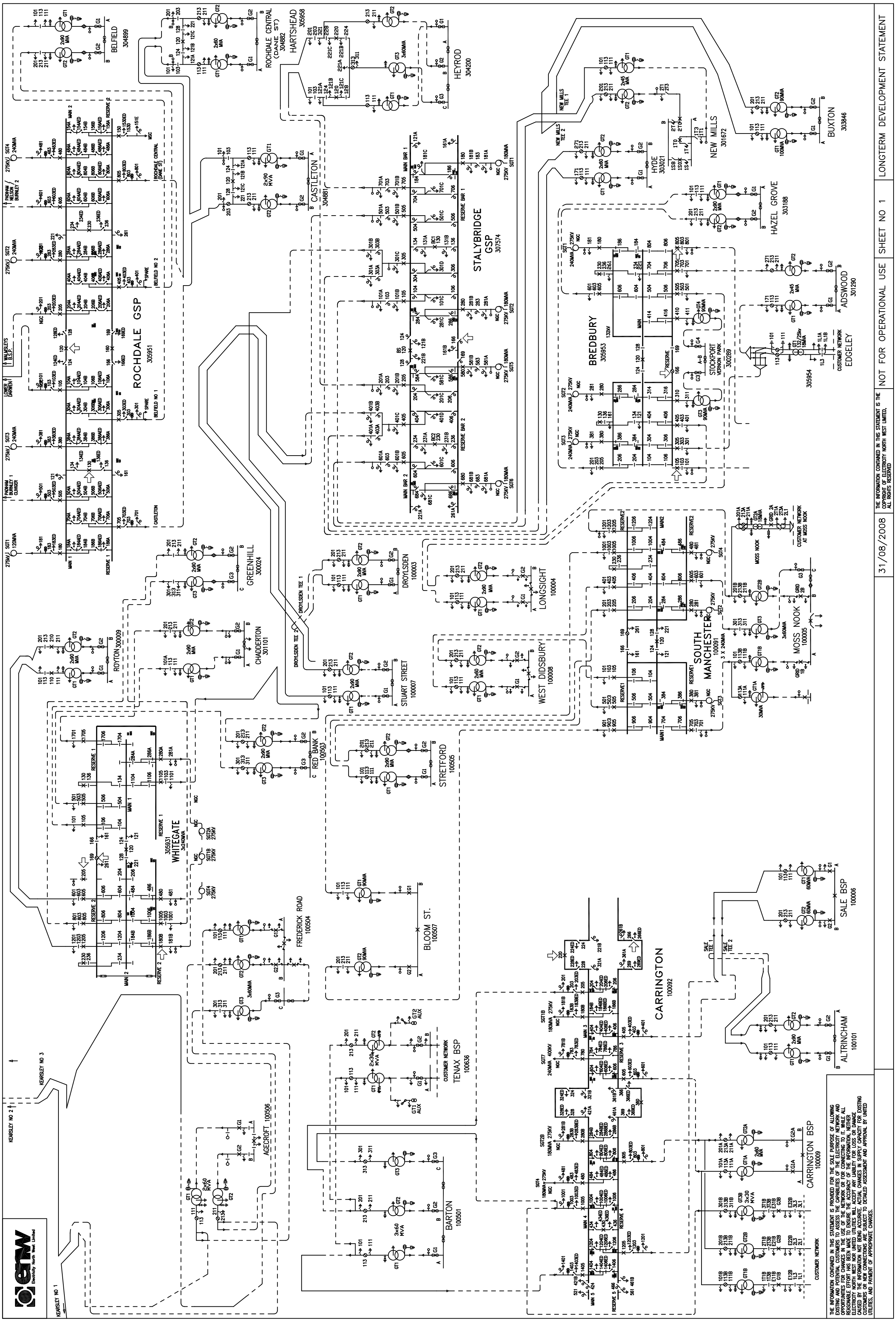
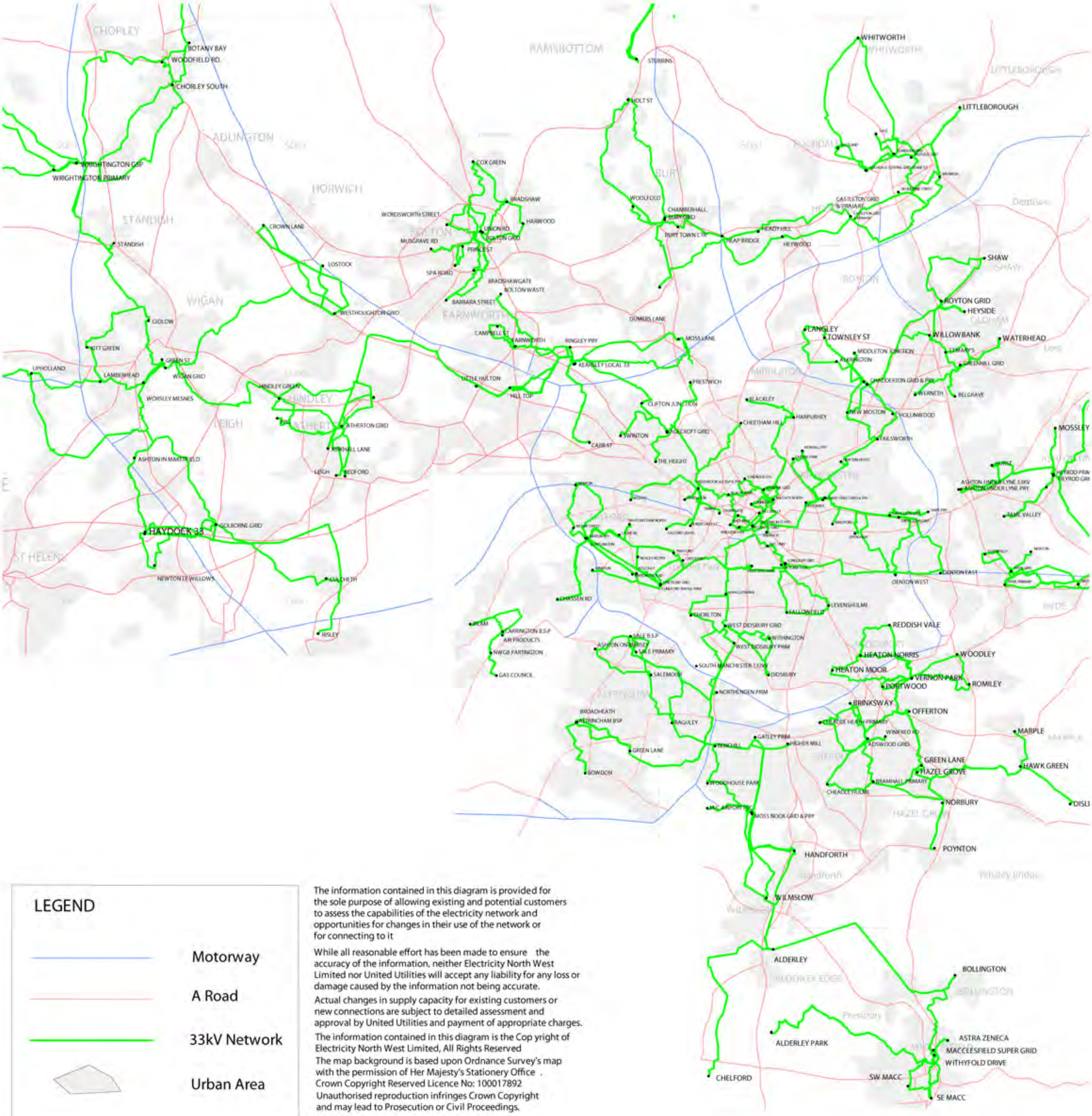


Figure 5.2

Greater Manchester 132kV and 33kV network



The information contained in this diagram is provided for the sole purpose of allowing existing and potential customers to assess the capabilities of the electricity network and opportunities for changes in their use of the network or for connecting to it

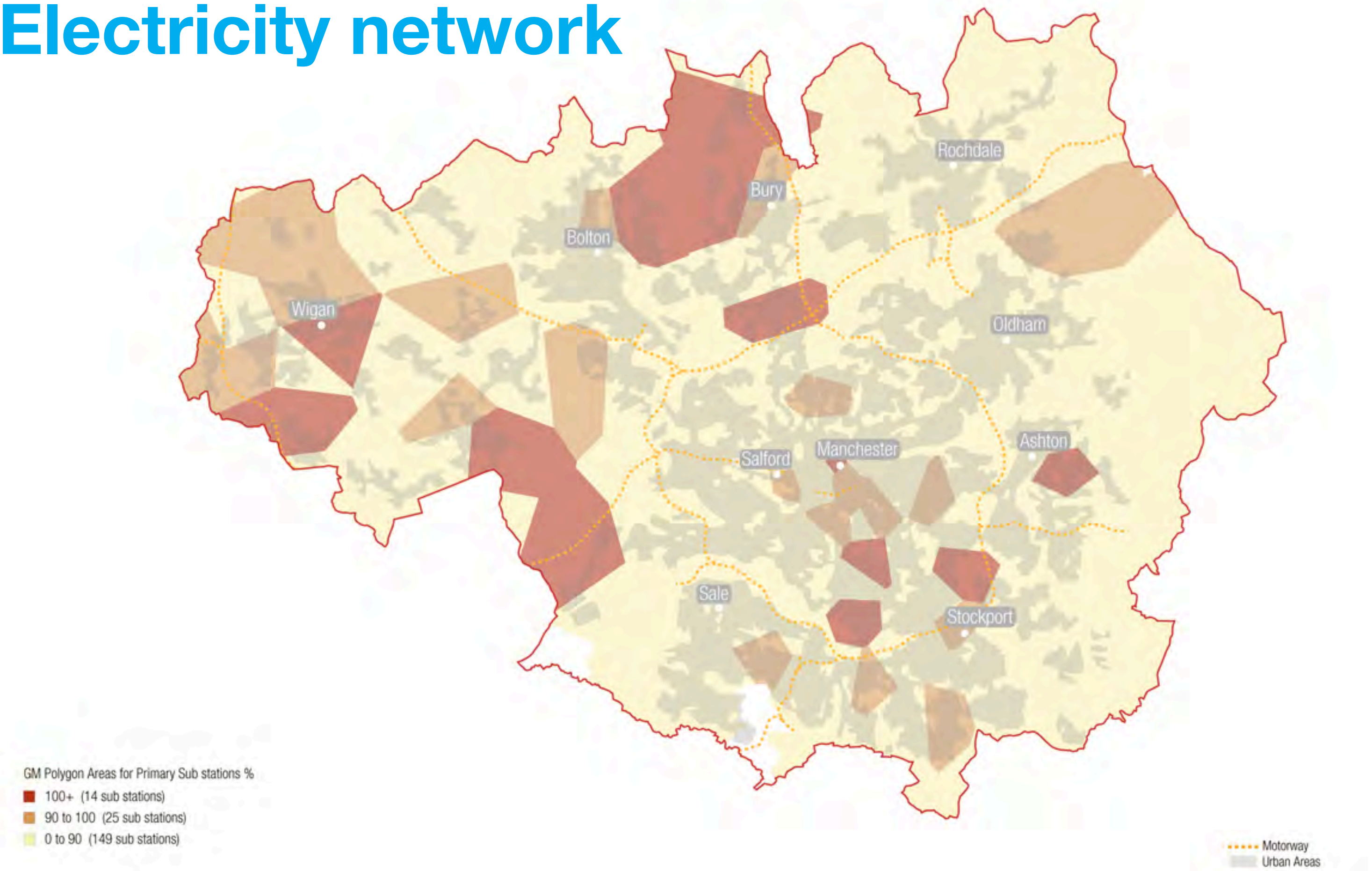
While all reasonable effort has been made to ensure the accuracy of the information, neither Electricity North West Limited nor United Utilities will accept any liability for any loss or damage caused by the information not being accurate.

Actual changes in supply capacity for existing customers or new connections are subject to detailed assessment and approval by United Utilities and payment of appropriate charges.

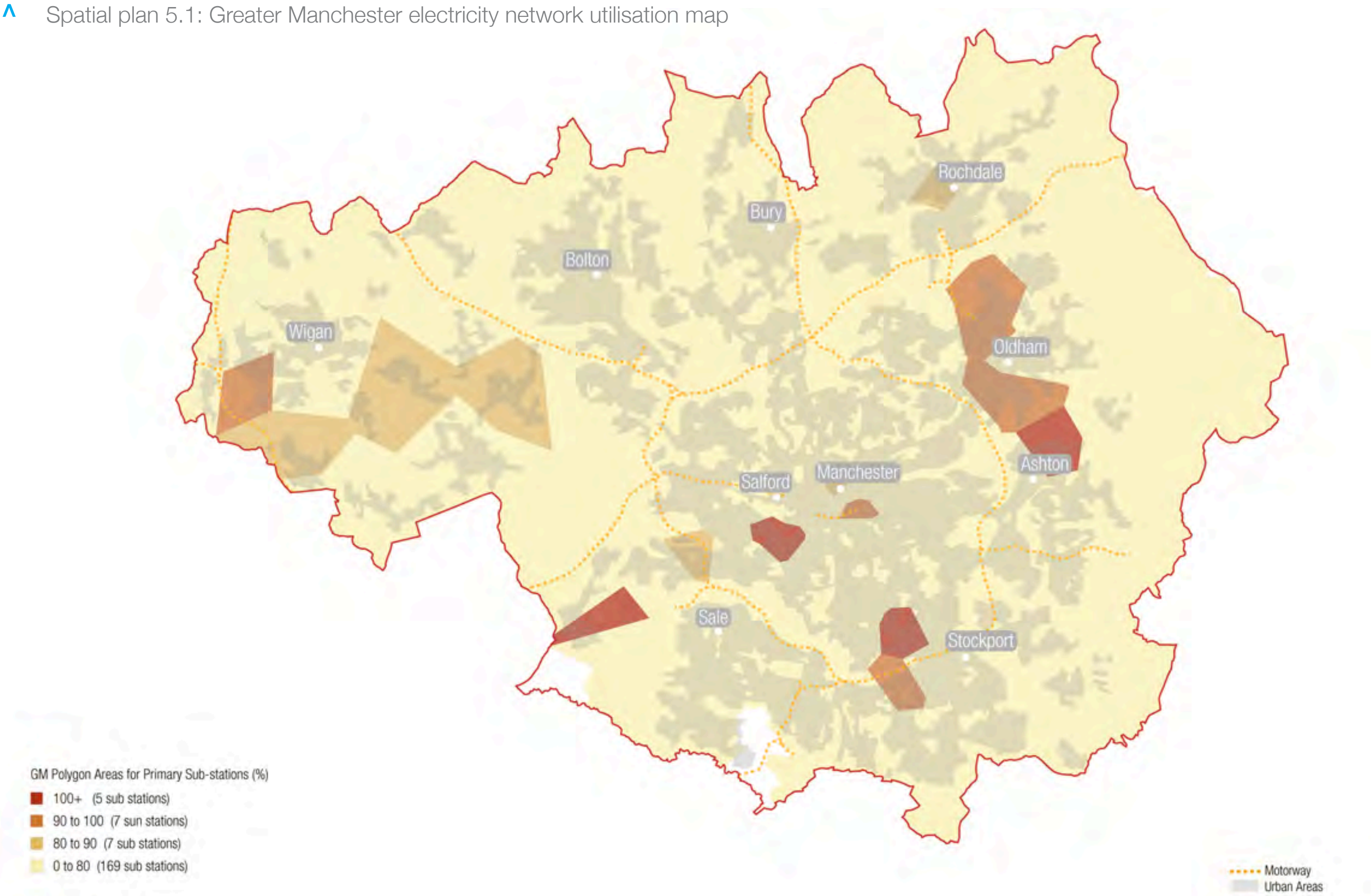
31/08/2008

Spatial plans

Electricity network



^ Spatial plan 5.1: Greater Manchester electricity network utilisation map



^ Spatial plan 5.2: Greater Manchester electricity network fault level thresholds

This illustrates that the majority of the Greater Manchester network is operating at utilisation levels below 90% but some broad areas in the sub-region have utilisation levels above this level and a few are at over 100%. It should be noted that loads can be switched from one sub-station to another in order to maintain supply at periods of high load. This usually coincides with the maximum domestic peak in the early evening.

The map does indicate areas where reinforcement of the network is more likely when significant new loads need to be connected. Conversely, the areas where the utilisation is below 90% should be able to accommodate the connection of new loads without reinforcement unless the loads are very high (e.g. 5 to 10MW maximum demand).

It should be noted in this context that a number of the larger developments covered by the case studies analysed for this study do exceed these levels of demand, especially in their later phases, hence some reinforcement of the network may be required even in areas which are not highlighted in the plan.

It should also be stressed that this map provides only a general indication of areas where there could be problems with the connection of new loads since there are a number of complex factors involved and a system study is needed to assess the situation for a specific development.

5.2.4 Connection of Distributed Generation

Connection of new generation plant to the distribution network, adopting existing standard connection solutions, can often be expensive and inefficient. The distribution network has not been designed to incorporate significant levels of generation, i.e. generation substantially in excess of local demand. Connection of generation can therefore lead to non-compliance with network design standards in respect of thermal rating, voltage and fault levels; the solution to which is reinforcement of the network.

An important factor in the connection of distributed generation is the fault level rating of the switchgear at the primary sub-stations especially for CHP. An overview of the fault levels of the primary sub-stations is provided by Spatial Plan 5.2. This indicates that the majority of Greater Manchester is currently operating at fault levels below the 80% and hence there should not be any problems with accommodation of DG capacity unless it is a very large plant. It should be noted that some of the areas are shown as having fault levels in excess of their rated capability and in those instances ENW is planning to undertake network reinforcement to remove that condition.

It should also be noted that the map does not indicate the fault level rating of switchgear at distribution sub-stations fed from the primary sub-stations. Therefore, although the primary sub-station may be operating well within its capability it may be that there is some switchgear embedded in the network that is highly stressed and this would not be reflected in the map.

5.2.5 Planned network investment

In its Long Term Distribution Statement (LTDS) [48], ENW identifies a number of areas within Greater Manchester where it is undertaking investment to improve the network through replacement of ageing assets and/or reinforcement to accommodate load growth (see Table 5.1).

Table 5.1

Network Investment Plans (current price control review period 2005 to 2010)

Location	Improvements	Completion
Ardwick	A new switchboard to improve fault level	July 2009
Cheadle Heath	A new switchboard to improve fault level	May 2009
Central Manchester	New primary substation in the Piccadilly area	March 2009
Heywood	Reinforcement of the 33kV network (new circuit breaker and cable between substations)	July 2009
Whitegate (Chadderton)	Substation replacement	November 2010
Chapel Wharf (Salford)	A new primary substation	July 2010

Further network developments are proposed in the Greater Manchester area but these are subject to the Regulatory settlement at the next Distribution Price Control Review (2010 to 2015) and they will be influenced by demand patterns in the city region.

5.2.6 Opportunities and constraints

Through discussion with Electricity North West we have been able to identify a number of key constraints in seeking to connect low and zero carbon distributed energy generation to the electricity distribution network. Opportunities can also be identified as workarounds to overcome these constraints and minimise connection costs.

Constraints

There are constraints with the connection of large developments and the integration of distributed generation that could lead to significant costs in reinforcing the electricity network. Specific problems include:

[48] Electricity North West (2008) *Long term distribution statement*

Fault levels

Distributed generation involves the connection of smaller generators (e.g. wind turbines, gas/biomass CHP etc) to the local distribution network. This can cause problems with fault levels depending on the size and type of generator involved. For example, a medium-sized CHP plant (3 to 5 MWe) would be connected to a local sub-station and there may be fault level issues particularly since much of the GM network is at 6.6kV rather than 11kV. A larger CHP plant (say 10 MWe) would probably have its own transformer and switchgear and hence there would not be such a problem.

Guaranteed supply

ENW has to guarantee supply when the distributed plant is not operating (e.g. due to maintenance, breakdown or intermittent operation), hence it needs to provide sufficient network capacity to back-up the supply even though this may only be needed occasionally. This can result in additional costs associated with reinforcing the network.

Speculative investment

OFGEM's price controls have placed constraints on the network operators which mean they are not able to invest speculatively in capacity for which there is uncertain demand. This can cause problems in a phased project since the network development is undertaken in stages and those involved in the later stages of the project may have to bear the full costs for any reinforcements rather than the costs being spread over the whole project.

Timing of investment

ENW is sometimes involved at a relatively late stage in the project cycle and this can lead to problems if there is insufficient capacity or a fault level issue with any DG plant in the development. In the past, this has resulted in projects being cancelled due to additional costs for which budget provision had not been made. Involvement of ENW at an early stage in a new development would help to address this problem and ENW might also be able to offer guidance on the network implications and how to avoid or minimise any reinforcement costs.

Substation locations

It is getting more difficult to site new electricity substations because of demands on visual appearance, and in-fill development pushing up values. Substations are having to be placed more remotely from development areas and designed to be more aesthetic (especially in city and town centres), all of which pushing up contributions from developers.

Opportunities

To address the possible constraints, a more strategic approach to the provision of electricity is required which addresses demand, generation and distribution issues. Key elements in this approach could include:

Distributed generation

DG needs to be local to the demand but also local to the prime source of energy (e.g. wind, biomass). It also need to be generating at a time when there is demand, otherwise reinforcement of the network may be required to enable the excess energy to be transported to other areas of demand.

Matching local generation to demand will also reduce the amount of electrical losses incurred. There may be scope in this context to address opportunities for energy storage particularly in CHP/district heating schemes where there is scope for heat storage to assist in matching supply and demand (also known as load following – see below).

Energy supply

Electricity suppliers will play key roles in changing customer behaviour through the introduction of feed-in tariffs for small-scale generation and installation of smart metering coupled with appropriate tariff incentive arrangements. There could also be scope for 'time of use' tariffs as seen in the USA.

Load following

Distributed generation plant could be used to contribute to security of supply and to avoid network reinforcement costs if it is appropriately sized and reliable. The network operator could contract with the generator to call on the plant (load following) when demand in a specific area and time of day is close to the maximum capacity of the network. OFGEM is encouraging the network operators to consider this as an option in the next price control review period.

Demand-side management

OFGEM is also encouraging the network operators to consider demand side management (DSM) options to avoid network reinforcement. DSM facilitates the reduction in the network maximum demand by consumers contracting with the DNO to reduce the demand requirements at the time of normal peak demand. This could be considered as one of the options for particular areas of GM e.g. where there are some large industrial and/or commercial loads.

Distribution losses

Distribution network losses account for approximately 5% of the total generated electricity. New network infrastructure can be designed to minimise these losses; this includes low loss assets and the intelligent application of distributed generation. Existing network loss performance can be improved by distributed generation but also by the application of new technologies currently being trialled.

'Smart grids'

The above techniques are just some of those available that can contribute to the delivery of a smarter decentralised network. A more ambitious vision is to bring together some or all of these techniques in a real time control environment facilitated by smart metering and standardised communications protocols i.e. a 'smart grid'.

The definition of a 'smart grid' is still the subject of much debate in the DNO community but should emerge as innovative ideas are transformed into real network solutions. This will require active participation of all parties: consumers, manufacturers of domestic appliances, developers, DNOs and energy suppliers.

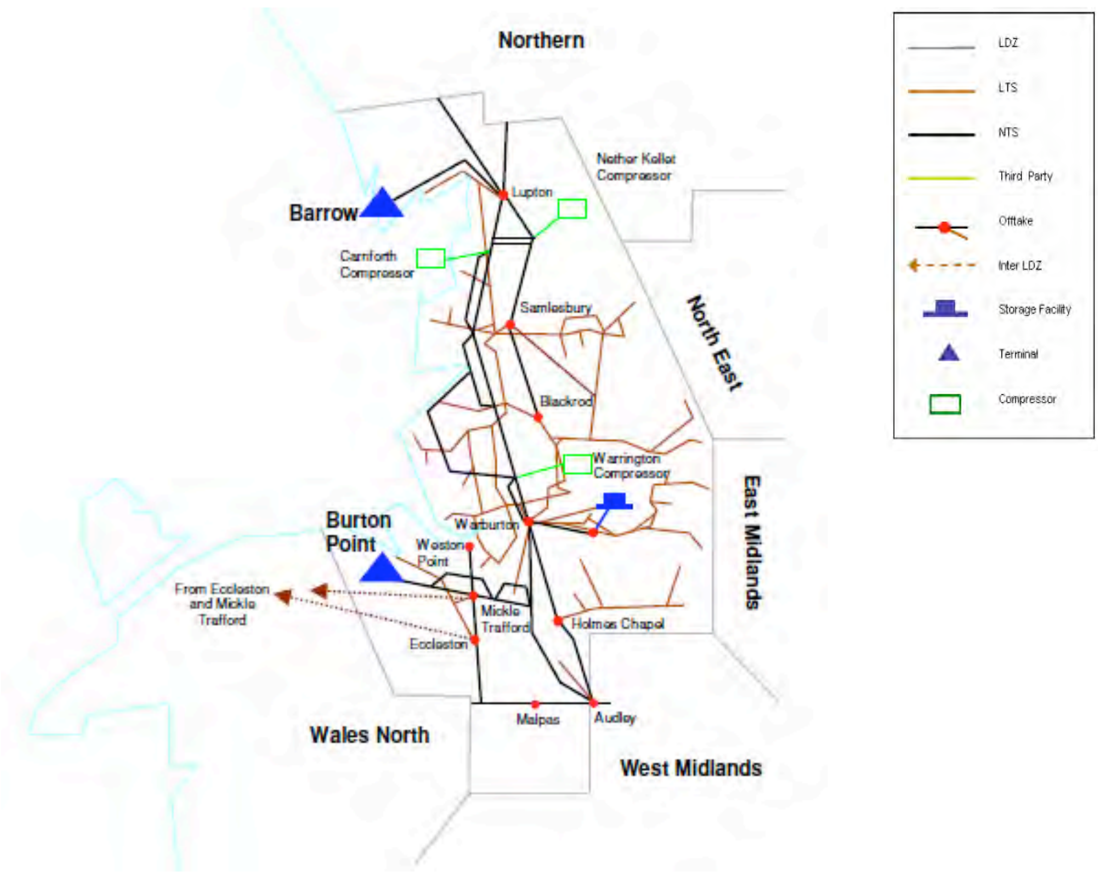
5.3 Gas distribution network

The gas transmission and distribution system in the UK is owned and operated by National Grid. Gas travels from the National Transmission System (NTS) to the Local Transmission System (LTS) and reaches most consumers via the distribution system that operates at three pressure levels [49].

5.3.1 Regional gas distribution

National Grid Gas Distribution (NGGD) is responsible for the operation of the region's distribution system and it operates under a similar OFGEM regulatory regime as for ENW. The price control period is 2008 to 2012/13.

Figure 5.3
The North West Gas Network



The NTS transports gas, at pressures up to 85 bar, from terminals at Barrow and Burton Point to NTS off takes. At the NTS off takes, gas travels into the High Pressure distribution system (HP), shown as LTS above. This tier transports gas to the lower pressure tiers and has gas

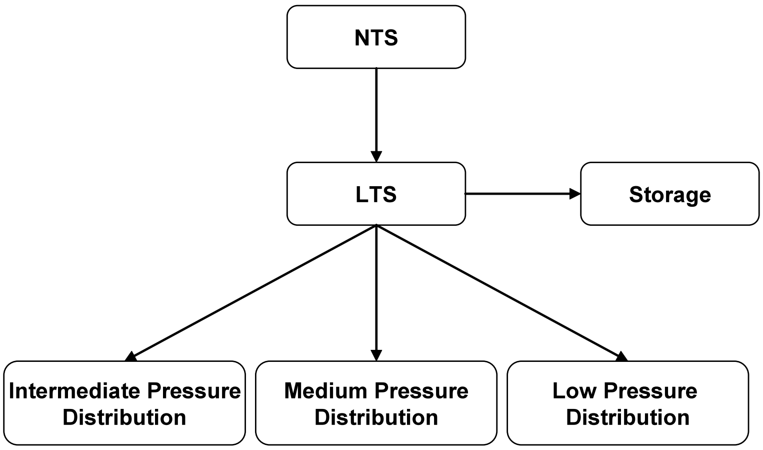
[49] National Grid Gas Distribution, www.nationalgrid.com/uk/Gas

storage facilities. The HP system operates at pressures mainly in the range 32 to 14 bar. Some very large users, including big CHP plants, will receive their gas directly from this tier.

The distribution system has three pressure tiers: Intermediate (2 to 7bar), Medium (75mbar to 2 bar) and Low (less than 75mbar). The majority of customers are supplied from the low pressure system. There are a variety of pressures within the low, medium and intermediate tiers for different purposes. The lowest pressure will supply small domestic size loads and the higher pressures are required for transporting gas between areas.

Figure 5.4

National Gas Grid tiers



The High Pressure (LTS) system does not enter city centre areas. Most developments will receive gas from the low pressure mains, if this causes constraints it may be possible to connect to medium pressure mains nearby dependent on location, cost and complexity (e.g. railways or other obstacles). Although the mains pressure can cause constraints for developments and CHP, the system is more flexible than the electricity network because it is possible to store gas to cope with the demand peaks.

5.3.2 Planned network investment

NGGD's Long Term Development Plan (LTDP) for the North West, which was published in October 2008 [50], states that NGGD will continue to develop the below 7bar distribution system to meet the needs of providing capacity to customers wishing to connect to the network. NGGD will also invest in the replacement of existing network assets, primarily the renewal of mains and services within the distribution system.

This includes replacement of cast iron and steel pipes with plastic pipes especially those which are within 30 metres of buildings. This is a long term (20/30 year) programme agreed with the Health & Safety Executive (HSE). The priorities are determined by a risk assessment of the gas

[50] National Grid Gas Distribution (2008) Long Term Development Plan

mains based on leakages and related issues such as change of use e.g. single occupancy building changing to multiple occupancy.

In addition, NGGD has identified some larger projects (greater than £0.5m) that have been approved or are under consideration in the period up to 2012/13. The only significant project listed for Greater Manchester is in Ashton in Makerfield – 2.1km x 250mm mains which is scheduled for 2009/10.

5.3.3 Opportunities and Constraints

Through discussion with National Grid Gas Distribution we have been able to identify a number of the key opportunities and constraints in seeking to increase investment in low and zero carbon distributed energy generation which require connection to the gas network:

Constraints

Location and proximity

There are connection issues related to the size of the load and the proximity to higher pressure systems. For example, a demand of over about 1,000 Standard Cubic Metres (SCM) would probably exceed the capacity of the LP system and hence it would be necessary to work back to find a larger main and the costs will be related to the distances involved. A typical house requirement is 1 to 2 scm (10 to 20 kWth) so this equates to a development of 500 to 1,000 homes.

Shock waves

Gas fired CHP can present a particular problem because of the demand requirements, particularly on start-up and shut down which can cause shock waves. It may be possible to connect small CHP units (below 1MW) to the LP network but bigger plants need to be connected to the MP or IP system and very large CHP plants may have to connect to the high pressure transmission system. Hence the reinforcement costs can be significant and, in the past, many CHP schemes have not gone ahead because of the gas infrastructure costs.

Phased development

There are issues if a number of developers are involved in the different phases of the project. For example, it may be feasible to connect the first phase of a development to the LP system but then it may be necessary to use the MP system for subsequent phases that would be more expensive. There is a procedure to work out who pays what under these circumstances but it suggests that there would be benefits from a more strategic approach as discussed in the section on the electricity network.

Lead-times

The lead times associated with reinforcing the gas network can be lengthy, especially if the connection needs to be made to the high pressure part of the network. Hence it is important that early notice is provided to NGGD of any large scale development plans.

Opportunities

Gas fired generation

Investment in gas fired CHP and district heating systems is considered by this study for a number of the case studies (see section 7). Despite a shift in focus towards biomass fuelled solutions gas-fired CHP is the most appropriate low carbon solution where biomass may be constrained e.g. due to location in Air Quality Management Areas.

Biogas injection

Biogas injection into the gas network e.g. based on the generation of biogas from sewage treatment and anaerobic digestion of organic waste. This raises important issues in relation to safety and quality standards that are currently under review by NGGD.

Thermal storage

The integration of thermal storage into gas-fired CHP and district heating networks allows for smoother generating profiles. This is because engines or turbines can then be run between 17 and 24 hours/day without the need for load following which can cause problems for the gas network such as shockwaves.

Fuel cells

The use of solid-state fuel cells creates the potential to use natural gas in a cleaner way. By using a steam reformer to strip out hydrogen from methane, which would then be fed to a fuel cell stack, electricity can be generated from gas with a carbon emissions rate approximately half that of the most efficient gas turbine generators. Fuel cells are also modular, creating a readily scalable solution.

5.4 Existing district heating networks

District heating networks supply medium temperature steam or low temperature hot water to buildings and industry. They consist of insulated pipes that can range in dimension from 20mm to 350mm. Networks can range in scale from those linking a small number of homes to major heat pipelines linking power stations and whole districts of cities. The technical application of district heating is explored in more detail in section 6.

Such networks are not currently the subject of formal regulation by OFGEM. There are examples of local regulation where networks have been developed by Local Authorities – for example, in Manchester where there is a citywide pricing structure. With the potential for significant future expansion of district heating the Government outlined proposals for greater regulation in its recent Heat and Energy Saving Strategy [51].

A brief scoping of existing networks in Greater Manchester was carried out. Only a small number of district heating networks were identified across the sub-region. For the most part

[51] *See footnote 19*

these are associated with Council housing estates built in the 1960-70's and large hospital and higher education sites where a number of buildings are served by one energy centre.

Local Authority district heating networks supplying housing can be found in Manchester (Plymouth Grove PFI and Alexandra Park), Oldham (St Mary's estate) and Stockport (five sites). Manchester is also notable for having invested in communal heating with CHP for 29 high-rise blocks at various sites across the city through a joint venture with Powerminster (Gleeson Group) in the 1990's. Networks did serve areas of Salford but have subsequently been removed as part of ongoing investment in the former Council housing stock, now transferred to the Salix ALMO.

There are approximately 12 major NHS sites across the sub-region, the majority of which are served by district heating networks. The University of Salford's main campus and UMIST are the largest education precincts that are currently served by District Heating networks, however both networks may be removed because of the high capital costs of upgrading them. Manchester's university precinct is for the most part made up of separate heating systems, but elements of Manchester Royal Infirmary, associated teaching facilities and the main precinct are supplied by communal plant.

5.5 What are the strategic implications for decentralised energy?

Whilst Greater Manchester is embedded within and is reliant on national and regional gas and electricity networks, it is still possible to identify where the city region's energy is supplied from, and to determine the extent to which it is energy secure, now and based on future projections.

The need for new forms of infrastructure is timely because the region as a whole is approaching key milestones in the planned replacement of ageing generating capacity and the rundown of fossil fuel resources. The North West's energy infrastructure mirrors the national picture – the gas fields in Morecombe Bay are projected to be depleted by 2020, and major coal and nuclear generating plant at Fiddlers Ferry and Heysham respectively are projected to close by 2015-2020.

This creates the impetus to develop new sources of renewable energy ensure and to ensure new generating capacity – including large new gas-fired plant such as at Carrington and smaller decentralised plant – operate as CHP plant supplying district heating networks. Carrington in particular is projected to drawdown at least a third of the remaining North West natural gas resource for a period of at least thirty years.

Engagement with the current gas and electricity distribution network operators has shown that the availability of gas and electricity supplies to meet Greater Manchester's requirements is not a current constraint. It is, however, their ability within market and regulatory constraints to:

- Match the needs of new development with timely and appropriately sized new connections;
- React to development projections which have varying degrees of certainty attached to them;
- Plan for localised upgrades to networks against which costs will need to be apportioned and underwritten;
- Accommodate decentralised generation within network tolerances and based on an acceptable apportionment of cost.

Moving towards new forms of decentralised infrastructure is likely to require an even greater level of certainty in order to underwrite investment, and will require the direct engagement of the existing network operators.

Investment may be required to re-enforce and re-configure existing networks. Decentralised energy generation could bring mutual benefits to both developers and network operators, but only if this was to form part of a co-ordinated approach to design and management.