

# 6. Future potential

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In this section we explore the future potential for a range of low and zero carbon energy sources as they apply to the City Region, and the infrastructure that would be required to realise the potential.

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To aid in understanding the different types of low and zero carbon energy technologies available we begin by identifying broad categories and grouping them based on their strategic planning implications. These include technologies that currently have sub regional targets for deployment in the North West RSS.

In the following sections we take each technology in turn, with a focus on those we have identified as having significant planning implications. For each technology we identify their broad characteristics, and discuss the opportunities and the constraints to their implementation across the City Region.

Where required spatial mapping has been carried out in order to explore the implications for land use planning and infrastructure. This includes City Region scale mapping of wind energy opportunities and analysis of site-specific opportunities relating to the use of waste heat from decentralised generators.

## 6.1 Technologies and their planning implications

The technologies identified have the potential to provide heat, power and cooling, with a number being distinctive to the City Region and/or representing newly discovered energy resources. They can be grouped into five broad categories:

- Networked heat and power generation: The use of decentralised Combined Heat and Power (CHP) generators and heat-only boilers using a range of different fuels to supply district heating and cooling networks linking together buildings;
- Networked heating and cooling: The use of different grades of renewable heat from surface and geothermal water resources to supply district heating and cooling networks linking together buildings;
- Standalone electricity generation: The use of renewable energy resources, such as the wind and hydro resources, to generate electricity;
- Renewable fuel supply chain: The production of a range of biofuels including chips, pellets and oils from sources including forestry, energy crops, industrial and municipal organic waste, biotechnology and carbon capture;
- Building integrated heating, power and cooling: The use of ‘micro-generation’ technologies including solar thermal, solar photovoltaics, bio fuelled boilers and heat pumps to supply individual buildings;

Our broad assessment for these technologies is intended to form an initial ‘top down’ evidence base for opportunities across the City Region – albeit in outline because of limitations on the scope of this study. We then make the link with their potential to deliver CO<sub>2</sub> reduction for new development is then explored in the ‘bottom up’ case study evidence base.

The scope of this section is by its nature broader than the sub regional allocations set out in the current North West RSS. This is because we have sought to identify and characterise the full range of technologies available to provide low and zero carbon energy supplies, reflecting the priorities in the UK’s Low carbon transition plan, the 2007 Energy White Paper and the draft Renewable Energy Strategy.

Figure 6.1

## **Technologies and their planning implications**

### **Significant implications relating to utility infrastructure and siting**

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#### **Networked heat and power generation**

- Combined Heat and Power (CHP): Small to medium-scale power generation (1-50 MWe) supplying district heating networks. These plant could run on natural gas or make use of a range of different renewable fuels (see below);
- Combined Heat and Power (CHP): National Grid-scale power generation (up to 800 MWe) supplying industrial steam and primary heat distribution pipelines. These plant would be more likely to be gas-fired.

#### **Networked heating and cooling**

- Biofuels: Dedicated boiler plant running on biofuels – both solid and liquid – in order to supply district heating networks;
- Geothermal: Heating and cooling loops drawing water from shallow boreholes, deep boreholes, or from mine water where the configuration of old workings supports heat transfer, supplying district heating;
- Wastewater: District and neighbourhood refrigerant loops routed through the sewer network or associated with treatment works, in order to supply district heating networks;

### **Significant implications relating to landscape character**

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#### **Standalone electricity generation**

- Wind: Large-scale farms or clusters of 1-3 MWe turbines located in areas with a strategic wind resource greater than 6.0-6.5 metres/second;
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## Specific implications relating to siting and transport

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### Standalone gas production

- Biogas: Medium to large-scale production of quality assured gas derived from biogas for injection into the gas network.

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### Standalone electricity generation

- Hydro: Small-scale 50-250 kWe turbines located in areas with a sufficient head of water.

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### Renewable fuel supply chain

- Mixed municipal waste: Use of mixed waste or Refuse Derived Fuel (RDF) in specified heat and power plant;
- Waste-derived biogas: Methane for gas production or CHP generation produced from landfill gas;
- Forestry-derived biomass fuel: Wood chips and pellets manufactured from managed forestry and municipal parks, gardens and tree surgery residue;
- Waste-wood derived biomass fuel: Wood chips and pellets manufactured from industry-derived waste wood;
- Industry derived biomass fuel: Pellets and fuel oils manufactured from waste oil and, potentially, algae from CO<sub>2</sub> capture
- Hydrogen: Gas produced by splitting water using renewable electricity, or by reforming natural gas or biogas.

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## Permitted Development or subject to local environmental regulation

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### Building integrated heating, power and cooling

- Solar: Heat and power generation from modules integrated into the roofs and facades of buildings.
  - Heat pumps: Upgrading of heat sources that including gardens, car parks, waste courses and wastewater in order to supply heating systems.
  - Biofuels: Heating supplied from boilers burning bio fuels that could include biomass and bio-oils.
  - Canal cooling: Small clusters of heating/cooling requirements located on the canal network (<1 MWth) supplying buildings.
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## 6.2 Networked heat and power generation

In this section we describe the strategic opportunities for the development of medium to large-scale Combined Heat and Power (CHP) generation supplying district heating networks, with the potential to make use of a range of fuels.

### 6.2.1 Combined Heat and Power (CHP) technology

CHP is a proven technology which has the greatest potential to reduce CO<sub>2</sub> emissions in mixed use, city centre locations. This is because of their high density of development and mix of uses, which create a diversified daytime heat demand profile.

This study considers the potential to utilise gas-fired, biomass, biogas and energy from waste-fired CHP – technologies that each have separate and very different implementation issues which are discussed in separate parts of this Section. What is common to all of them is the need for a district heating network to supply the heat to end-users.

#### Technology profile

The benefits of CHP are based on that fact that generating electricity using conventional coal, oil and nuclear power stations is inefficient, with over 60-70% of the energy being wasted. The most efficient modern CHP systems use engines, turbines and fuel cells to generate electricity, producing heat as a by-product that can then be distributed via a district heating system to local consumers.

By utilising the waste heat the fuel efficiency of power generation improves from, on average around 35%, to between 80% and 90%. Natural gas fired CHP supplying mixed use developments with a balanced energy load profile delivers corresponding reductions in CO<sub>2</sub> emissions of between 10% and 30% depending the scale of the CHP plant and the energy demand profile of the buildings.

Further emissions reductions can be achieved by using natural gas in fuel cell CHP units. Fuel cells are chemical engines with no moving parts, in which hydrogen gas is split in order to generate an electrical current and waste heat. Hydrogen can be extracted from natural gas, allowing the emissions from natural gas CHP to be halved.

Biofuelled CHP enables high levels of CO<sub>2</sub> reductions to be realised because it enables both heat and power to be generated using a carbon neutral fuel. There are a range of biofuel options that are relevant to this study:

- Biomass: Solid wood fuels derived from forestry, municipal parks and garden, and dedicated energy crops such as coppiced willow;
- Bio-oils: Crop-derived oils such as oil seed rape or food waste derived vegetable oils from food processing;
- Energy from Waste: Combustion of mixed waste or a Refuse Derived Fuel manufactured from processed waste;

- Biogas: Methane gas from the anaerobic digestion of organic waste from a range of different sources.
- Landfill gas: Methane gas from the decomposition of organic waste in landfill sites.

Under the Government's current definition many of these would qualify as being a 'zero carbon' source of energy. The majority of the solid and liquid biofuels are of a low grade and therefore tend to require larger plant to make them economic to burn.

### Track record in the UK

In the UK the image of CHP and district heating has suffered from the legacy of the 1960's and 70's when poor quality systems were installed on large new housing estates and mixed-use developments. The CHP industry has now matured and the technology has advanced significantly off the back of the experience and investment in mainland Europe.

There are a number of large CHP and district heating schemes in the UK. Most of these have grown from heating systems supplied by energy from waste incinerators. These were used to supply cheap base load heat to public buildings and large council housing estates – such as in Sheffield and Nottingham.

In the 1990's and 2000's gas engine and turbine CHP technology have been installed to supply large mixed use developments, with the most notable including Citigen in London (Eon), Southampton (Utilicom), Woking (Thamesway), Aberdeen (Aberdeen Heat and Power) and most recently Milton Keynes (Thamesway).

Biomass CHP technology is a newer technology for the UK which, to date, has only had limited application. Tried and tested steam generator (rankine cycle) technology is currently the preferred technology. However it requires economies of scale in order for it to be technically and financially viable, generally with a lower limit of around 5-10 MWe.

'Organic rankine cycle' biomass technology has now been demonstrated in Germany and Austria<sup>52</sup>. Whilst it is much less efficient, producing only one kWh of electricity for every three kWh of heat, it does allow smaller biomass CHP plant of <1 MWe to be installed.

### 6.2.2 District heating networks

Investment in district heating networks is a fundamental requirement to support the development of CHP as a means of reducing CO<sub>2</sub> emissions. In this section we briefly describe how district heating works, the opportunities and constraints for the development of networks, and the implications for planning such networks.

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<sup>52</sup> Duvia, A and Gaia, M. *ORC plant for power production from biomass: Technology, efficiency, practical experiences and economy*, Milano Polytechnic, October 2002 obtained from Econergy Ltd

## Technology profile

District Heating is a mature technology used across the world to enable the supply of heat to homes and buildings from a variety of heat sources including Combined Heat and Power (CHP) plant, as well as other sources such as industrial waste heat, geothermal aquifers, heat pumps and solar thermal collectors.

A district heating network consists of pre-insulated steel or plastic flow and return pipes which carry hot water to each building. The pipes are manufactured with a moulded layer of insulation to reduce heat loss, typically to less than 5-6% for a modern network. Modern 'secondary' distribution networks might typically have a design flow and return temperature of 80°C/55°C whilst 'primary' transmission networks – such as those supplying heat from larger power stations – might typically operate at 110-120°C/90°C.

The use of primary and secondary networks can be seen in cities such as Copenhagen and Berlin, where gas-fired power stations supply primary heat pipelines, which then step down to secondary heat networks supplying individual buildings. This approach forms the basis for proposals for Barking Power Station in London (see precedent study below).

The heat is supplied to each dwelling or building via a heat exchanger contained in a hydraulic interface unit, which replaces the role of individual boilers. Each new building, including apartment blocks, would be connected to the network via a large heat exchanger that would form an interface. Individual homes could be supplied either directly or indirectly via their own heat exchanger, which in each case would replace the role of a boiler for space heating and hot water.

## Precedent study

### Barking power station district heating pipeline study, London

A feasibility study was carried out in 2007 looking at the potential for heat off-take from Barking Power Station<sup>53</sup>. Based on the consultant teams experience with a network supplying Copenhagen, the heat would be distributed through a transmission district heating pipeline to a number of local district heating networks.

Eleven possible local district heating network developments were identified and a transmission network connecting these developments with Barking Power Station was proposed. The developments comprised a mix of:

- Existing district or community heating schemes;
- Public buildings including hospitals, universities and council office buildings;
- New developments that may consist of residential or mixed land used types.

Based on the total annual heat demand of these locations combined the transmission network was designed to supply 170 MWth (60% of the peak load). The total length of the proposed transmission network including branches to suggested supply points of would be 21.3 km.

## Opportunities and constraints

When district heating forms part of an energy strategy for a city, town or development site it can provide a number of strategic benefits:

- Ensuring fuel flexibility now and into the future, by preserving the ability to switch between natural gas, waste, biofuels and hydrogen;
- Balancing demand loads and providing continuity of heating supplies between different types of consumers and different low and zero carbon sources throughout the year;
- Supporting the development of Combined Heat and Power (CHP) up to 100 MWe in scale, by providing heat loads for medium and large scale power stations;

It is, however, a capital intensive infrastructure. Experience from countries such as Germany and Denmark suggests that in order to cost effectively develop district heating networks strategic heat planning is required<sup>54</sup>. This recognises the need for the same level of planning as for existing gas and electricity utilities, including the need for a combination of statutory powers, planning permissions and wayleaves to lay heating mains.

Heat planning requires the identification of locations with higher densities of development, a mix of uses and with layouts that will reduce pipe runs. Studies suggest that a heat density of at least 3 MWth/km<sup>2</sup> is required to give a minimum rate of return of 6% - accounting for 20% of the

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<sup>53</sup> London Development Agency (2008) *Barking Power Station heat offtake project*, Rambøll Denmark

<sup>54</sup> Danish Board of District Heating (2006) *The development of the Danish district heating sector*, [www.dbdh.dk/dkmap/development.html](http://www.dbdh.dk/dkmap/development.html)

UK's heat demand<sup>55</sup>. It also focuses on achieving a critical mass of heating connections based on 'least cost' connections to enable the installation of larger CHP plant. Southampton provides one of the best precedents for heat planning in the UK context<sup>56</sup> (see precedent study below).

### Precedent study

#### Southampton City Centre

Established in 1986, the city's district heating network has been delivered by a partnership between Southampton City Council and private sector partner Utilicom. The scheme consists of 11km of insulated district heating (and cooling) mains and a 5.7 MWe gas-fired CHP engine.

It supplies around 60 GWh of energy per annum with over 40 consumers including the Civic Centre, a hospital, four hotels, the Southampton Solent University, West Quay shopping complex, an ASDA supermarket, and over 400 flats (including two major new developments by Barratt Homes). Notably, over 95% of its revenue is from private consumers.

The scheme delivers annual CO<sub>2</sub> reductions of approximately 10,000 tonnes and it has received support from the local authority through the planning system - with new city centre developments now required to justify why they should not connect to the district energy supply. The City Council is using its new planning powers to expand the system elsewhere in the city, including the strategic planning of heating mains as a utility for regeneration masterplans.

### 6.2.3 Natural gas-fired CHP

Although still reliant on a fossil fuel natural gas-fired CHP is a mature low carbon technology with the potential to deliver substantial CO<sub>2</sub> reductions. It is an important technology to ensure that our remaining gas resources are used efficiently, with options including the potential for heat off take from large power stations.

#### Technology profile

Natural gas-fired CHP is a mature technology that is relatively flexible in terms of locating an energy centre. Projects such as Citigen in central London, Southampton Heat and Power and Woking's town centre scheme have demonstrated how the technology can be centrally located, and integrated into large public buildings such as car parks, old industrial buildings and leisure centres.

An energy centre housing a 5-10 MWe plant and associated boilers – sufficient to supply a large mixed use development - might typically have a typical footprint of between 200 and 450 m<sup>2</sup> - although if the availability or cost of a site is a constraint it is possible to stack plant on different floors, as demonstrated in by Thamesway in Woking. Utilicom's Comet Square project

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<sup>55</sup> DEFRA, *Analysis of the UK potential for combined heat and power*, Study by PB Power, October 2007

<sup>56</sup> Smith, M (2006) *Local authorities and delivery mechanisms*, Southampton City Council, CABA presentation

demonstrates how it can also be integrated into modern housing developments <sup>57</sup> (see precedent study below).

### Opportunities and constraints

Natural gas CHP has some specific locational and operational constraints. In terms of infrastructure they require access to a medium pressure gas main and, depending on localised fault levels, either a 6.6 or 11 kV electricity substation connection.. NO<sub>x</sub> emissions from CHP engines may require catalytic converters if a CHP plant is proposed to be located in an Air Quality Management Zone that is sensitive to elevated NO<sub>x</sub> levels eg. near major road junctions.

#### Precedent study

##### Comet Place, Hatfield

Comet Square is a new-build development, the first phase of which comprises 270 new apartments by Barratt Homes and a nursing home provided by Sanctuary Housing Association. A gas-fired Combined Heat and Power station and standby boilers will supply the heating and power requirements of the scheme. The scheme is being financed and delivered by district heating specialists Utilicom, and has been estimated to deliver annual carbon savings of approximately 1,500 tonnes.

### 6.2.4 Biomass-fired CHP

Whilst Biomass CHP has had limited application in the UK, at viable scales it is a mature technology which has the potential to deliver near zero carbon heat and power – although the fuel supply chain requires additional consideration.

#### Technology profile

A mature technology when deployed at a scale of greater than 4-5 MWe, biomass CHP has the potential to economically supply heat to larger district heating networks using wood chip or pellet fuel. The potential for mid-scale biomass CHP can be demonstrated by Danish plants such as Assens <sup>58</sup> (see precedent study below).

Larger plant currently tend to make use of wood chips rather than pellets because they allow for more flexible sourcing, greater variability in moisture content and because they are cheaper. They do, however, require large areas of storage for fuel, and associated lorry movements for fuel delivery.

### Opportunities and constraints

The availability of a secure supply of wood chip fuel is vital to the success of any biomass project, and we look in more detail at this in Section 6.5. The access requirements for a large

<sup>57</sup> Utilicom (2008) *Examples of major projects*, Case study brochure

<sup>58</sup> Skøtt, D (2000) *Wood fired CHP plant covers local energy demand* from Danish Centre for Biomass Technology (2000) *Danish bioenergy solutions*

number of lorry-based fuel deliveries, as well as the requirement for fuel handling and storage, create specific locational constraints.

For example, it is likely that a biomass CHP plant of a scale to supply a 5 MWe CHP plant would require 22,000 tonnes of fuel per annum, equating to between 3 and 8 lorry deliveries of upwards of 20 tonnes per day and storage requirements of 400-600 m<sup>3</sup><sup>59</sup>. This may require the plant to be located at a distance from a district heating network, incurring additional cost in connecting the plant to the network.

Air quality is also a potential locational and operational constraint. Biomass plants contribute to nitrogen dioxide and particulate emissions. Recent modelling by AEA Technology for the London Council's has suggested that biomass plant in Air Quality Management Areas may require closer regulation – particularly near major roads<sup>60</sup>. In particular the specification of combustion systems, pollution control equipment and stack height are likely to require specific attention.

### Precedent study

#### Assens biomass CHP plant, Denmark

Assens is a 4.7 MWe biomass CHP plant that supplies a small town. Assens District Heating, a consumer-owned ESCo in which the town council has a stake, owns the plant. It has operated successfully since 1999 using woodchips with a moisture content of up to 55%, and is based on traditional steam boiler and turbine technology and the electricity generating efficiency is 25%.

Delivery of woodchips from the 25 local suppliers takes place without the involvement of on-site staff, with lorries tipping the chips into one of the three large delivery bays. Each of these contains a different grade of chips, depending on the source and moisture content.

The chips are then mixed by fully automatic grab buckets into a fourth bay, which is used to create a consistent fuel feed. Suppliers include manufacturers of wood products, as well as sawmills. Storage levels are sufficient to cover 5 days fuel.

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<sup>59</sup> Data based on a study by URBED and Rambøll Denmark for Stoke on Trent City Council (2008)

<sup>60</sup> AEA Technology, *Review of the potential impact on air quality from increased wood fuelled biomass use in London*, Report to London Councils, December 2007

# Spatial plan 6.1 Air Quality



▲ Spatial plan 6.1: Greater Manchester's Air Quality Management Areas

## 6.2.5 Energy from Waste CHP

The opportunity to utilise waste heat from waste incineration plant currently exists at one strategic location in the sub-region, and this may expand in the future with proposals for the production of Refuse Derived Fuel (RDF).

### Technology profile

The most common form of Energy from Waste in the UK is the 'mass burn' of mixed municipal waste by incinerator plant. This technology typically requires large modern plant (>100-200,000 tonnes of waste per annum) in order to achieve economies of scale, and the installation of extensive pollution control equipment. A small number of older plants, including Raikes Lane in Bolton, were retrofitted in order to meet new EU standards introduced in 2000.

Smaller plant using processes that produce a gas from waste, and requiring a more consistent and pre-treated 'Refuse Derived Fuel', are at the pilot stage, creating the potential to locate plant and operate them in a way that the waste heat from electricity generation can more readily be used. The scope for this form of plant in Greater Manchester looks uncertain, as it appears much of the RDF that may be produced from new waste processing plant will be exported to Merseyside.

Only one mass burn incinerator remains operating in Greater Manchester. Electricity is currently generated by a 11.0 MWe Energy from Waste (EfW) plant at Raikes Lane in Bolton. The plant was constructed in 1972 and burns approximately 95,000 tonnes of mixed municipal waste per annum sourced from across Greater Manchester<sup>61</sup>. The plant has been transferred to management by Viridor, Greater Manchester Waste Disposal Authorities selected PFI partner.

The Raikes Lane EfW plant has the potential to supply at least 11.0 MWth of heat – which on the basis assumptions about the load factor of the plant has the potential to supply a base heat load for Bolton Town Centre, which is located 2.4 km to the north of the plant. However, whilst the plant was retrofitted in 2000 to allow heat off-take this resource is not currently utilised, with the waste heat rejected by adiabatic cooling towers.

By utilising the waste heat the plant's generating efficiency could be raised from an estimated 25-30% (electricity-only) to over 80% (electricity and useful heat). Examples of how this could work in practice include municipal CHP incinerators in the centre of Sheffield and Nottingham (see the Enviro-energy case study below<sup>62</sup>).

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<sup>61</sup> Data obtained by Aecom from the GMWDA

<sup>62</sup> Case study extract from working paper produced by URBED for the Barking Heat Power Station heat offtake project

## Precedent study

### Enviro-energy, Nottingham

Enviroenergy is a public-private company established and jointly controlled by Nottingham City Council. It exists to manage the sale of heat and power from the City's waste to energy plant. The waste to energy plant and heating network was extensively refurbished in the 1990's in order to respond to reliability concerns.

It was established as a 'public sector influenced company' following extensive consultation with heat consumers, particularly with regard to Council tenants and the delivery of affordable warmth. The intention was that as well as delivering affordable warmth and environmental benefits, that the project would generate revenue for the Council.

Council involvement and influence has enabled the expansion and maintenance of the network because of its statutory powers of undertaking to lay heat mains. Areas of new development are being brought forward under masterplans commissioned by the city's regeneration company. It is proposed that these are linked to an expanded district heating network.

### Opportunities and constraints

The distance of the plant from the town centre of Bolton will dictate the fixed cost of utilising the waste heat. The ability to invest in a pipeline to transport the heat will be dependent on there being firm end-users for the heat. This therefore places a strong emphasis on heat contracts and energy planning to create certainty. An indicative planned approach is explored in the related case study (see separate Case study document)

In order to utilise the plants waste heat medium pressure steam would need to be bled from the boilers or turbines, with an associated loss of electricity generating efficiency. A waste heat boiler would then be used to supply heat to a district heating pipeline. The exact technical requirement and associated investment would require further detailed verification.

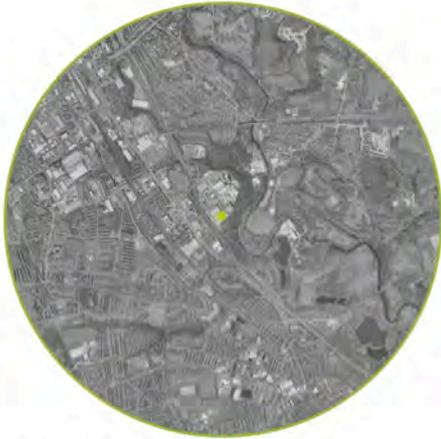
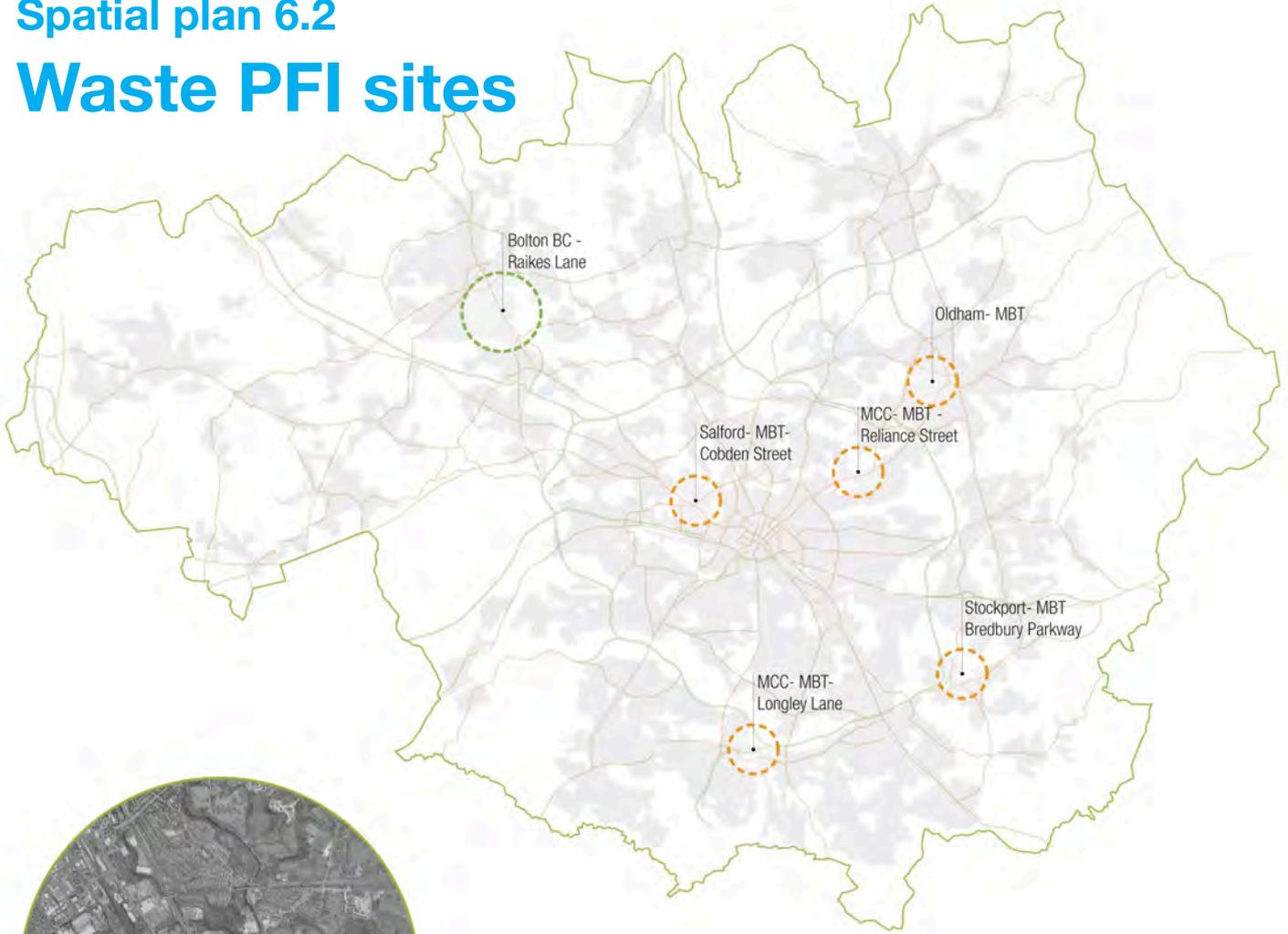
Discussions with the operators of the plant have indicated that the quantity of waste available to burn has steadily reduced as recycling rates have increased<sup>63</sup>. This suggests that over time co-firing with other fuels such as biomass or Refuse Derived Fuel (RDF) may be required.

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<sup>63</sup> See footnote 60

# Spatial plan 6.2

## Waste PFI sites



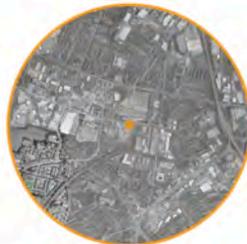
Bolton - Energy from Waste Plant  
Raikes Lane



Salford- MBT-  
Cobden Street



Manchester - MBT -  
Reliance Street



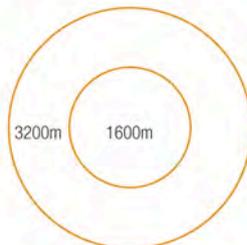
Oldham- MBT  
Arkwright Street



Stockport- MBT  
Bredbury Parkway



Manchester- MBT -  
Longley Lane



Mechanical Biological Treatment  
with Biogas Plant



Energy from Waste Plant

Installed Generating Capacity (MWe)

0 - 2

2 - 8

8 - 12

## 6.2.6 Biogas CHP

Electricity is currently generated using biogas produced from sewage at four locations, and is proposed using municipal and commercial waste at five locations<sup>64</sup>.

Waste heat is currently only utilised for operational purposes at the existing four sites.

### Technology profile

A range of organic wastes can be treated by anaerobic digestion, a fermentation process that generates methane gas. The gas can then be burnt in an engine to generate heat and power. Sources could include household food waste, farm organic waste such as slurry, food industry wastes and sewage sludge. A proportion of the heat is required to maintain the fermentation process. Waste authorities are increasingly specifying anaerobic digestion as part of their waste strategies in order to reduce the level of biodegradable waste going to landfill.

### Opportunities and constraints

As part of this study we have mapped the location of the existing plant, and the proposed sites for waste PFI plant associated with Mechanical Biological Treatment (MBT) plant, using radius of between 800m and 1,600m adjusted according to the plants power output to reflect the distance that waste heat might realistically be pipelined.

Heat off-take can readily be achieved from the type of gas engines used for biogas electricity generation. This requires the fitting of waste heat boilers to capture the heat from the jacket water and potentially also the exhaust gas from each engine – although the latter is technically more difficult. The availability of waste heat from sewage gas plant will be constrained by on-site requirements for heat to maintain biological processes in the anaerobic digestors.

Investment in order to facilitate any heat off-take would rely on there being a sufficient heat demand within a viable proximity, and a heat network to convey the heat.

### Sewage gas plant

United Utilities operate sewage gas plant at four locations. Davyhulme works (5.7 MWth potential) and Bury works (1.9 MWth potential) are within close proximity of local and commercial centres with comparable, or planned, heat loads<sup>65</sup>. In Bury the works is within close (0.5 km) proximity of the proposed development of the former East Lancashire Paper Mill site.

Davyhulme would be in a position to supply the nearby Trafford Centre, associated new residential development sites, and/or the redevelopment of Urmston Town Centre. United Utilities have recently announced that may also explore the potential to process biogas for use in its vehicle fleet and for injection into the gas network.

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<sup>64</sup> Identified following discussions with Urban Vision who are managing consultation on a joint waste DPD for Greater Manchester

<sup>65</sup> Taken from 2008 AGMA note on energy use and renewable energy generation capacity in Greater Manchester

### Waste PFI plant

The locations currently proposed for an anaerobic digestion plant under the waste PFI are less favourable in terms of utilising the potential waste heat<sup>66</sup>. This is primarily because of their relatively small size (1-2 MWth potential), with only one currently located within sufficient proximity of matching heat loads and two which may warrant further investigation. The three sites are as follows:

- Arkwright Street, Oldham: The plant is proposed for a site in close proximity to the town centre, and a major existing district heating network at St Mary's, for which an energy plan has been drawn up which forms part of a European Concerto funding bid;
- Longley Lane, Manchester: The plant is proposed for an existing Waste Transfer Station site at Sharston. The nearest major heat load is Wythenshawe Town Centre, which is approximately 1.6 km distance, and the subject of major regeneration investment.
- Reliance Street, Manchester: The plant is proposed for an existing Waste Transfer Station which is approximately 1 km via the highway network from One Central Park, a major new business park. The relatively low heat density of the park might, however, push up the cost of heat distribution to buildings;

Each plant would generate significant associated vehicle movements associated with deliveries of waste. Anaerobic digestion plant also requires effective abatement equipment to reduce odours from the process. Both of these issues have been addressed during the process of site selection associated with the waste Development Plan Document (DPD) for Greater Manchester<sup>67</sup>.

An alternative approach that has been demonstrated in Denmark is for the biogas to be piped to a location where the heat can be more readily utilised. The infrastructure required to transport gas would be less expensive than for heat, potentially improving the economics.

### Private biogas plant

There could be significant unspecified potential for further plant to be developed by private operators, including social enterprises, to process a range of organic wastes. For example, the Co-operative Group has for a number of years been investigating the potential to process food waste from its stores. The social enterprise Fairfield Composting was granted planning permission in early 2009 for a plant on the Bredbury industrial estate in Stockport.

#### 6.2.7 Landfill gas CHP

Electricity is currently generated using landfill gas at eight locations across the sub-region<sup>68</sup>. Waste heat is not currently utilised at these sites, but has the potential at some of the locations to be pipelined to nearby urban centres.

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<sup>66</sup> GMWDA, *Stage 2 issues and options report: Built facilities*, Report prepared by Urban Vision, October 2008

<sup>67</sup> See footnote 65

<sup>68</sup> See footnote 64

### **Technology profile**

Landfill gas (methane) is produced by decomposing organic waste in landfill sites.

Landfill gas CHP is broadly similar to natural gas CHP in that a gas is cleaned and then burnt in an engine to generate electricity. In the majority of cases the electricity is exported to the grid, and the waste heat from the exhaust gas and engine cooling jacket is rejected to the atmosphere via cooling towers. Each opportunity will be constrained by the lifespan of the landfill gas resource, which might typically be between ten and fifteen years.

### **Opportunities and constraints**

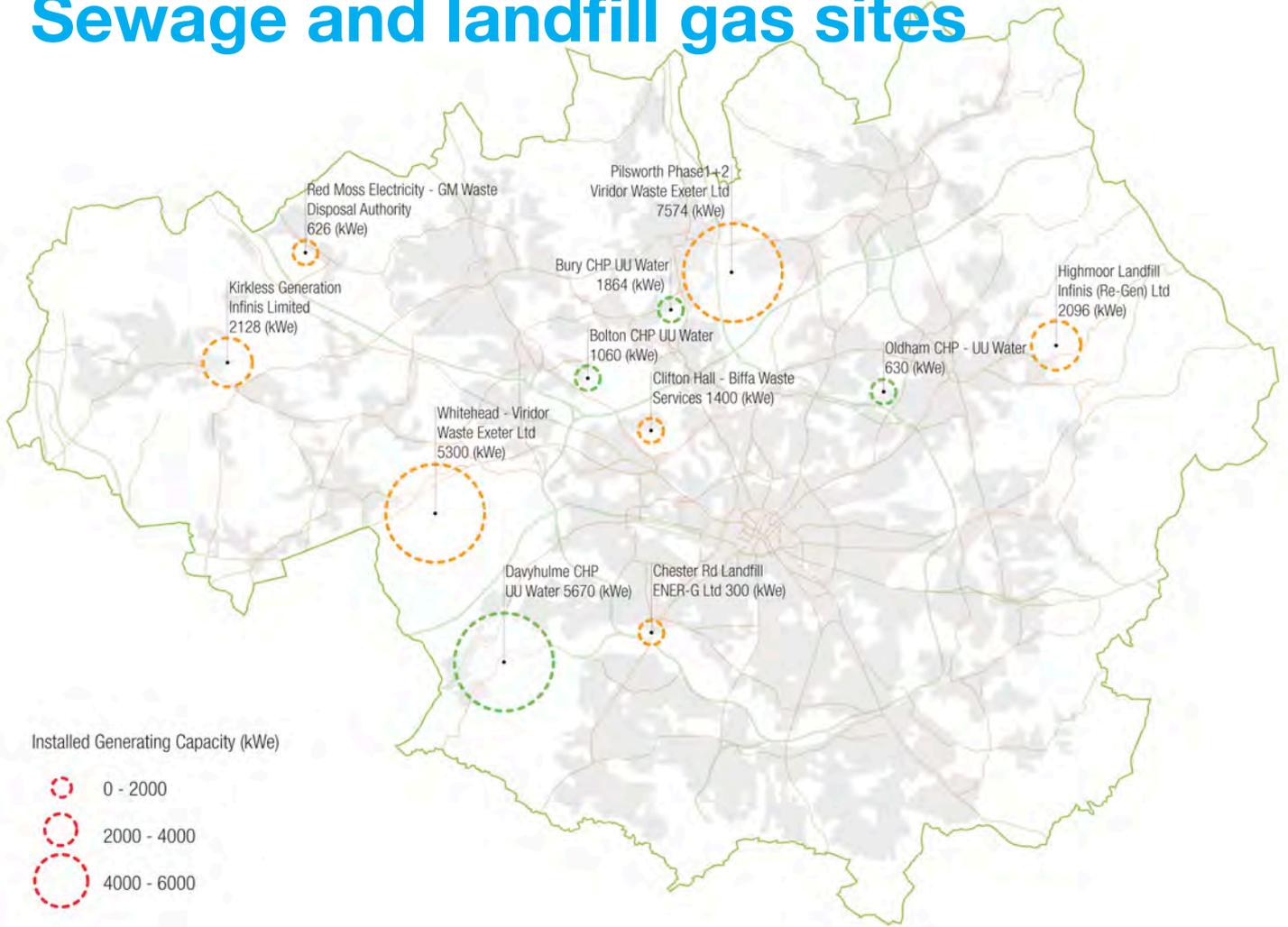
As part of this study we have mapped the location of landfill gas plant, using radius of between 400m, 800m and 1,600m adjusted according to the plants power generation to reflect the distance that waste heat might realistically be pipelined.

Heat off-take can readily be achieved from the type of gas engines used for landfill gas electricity generation. This requires the addition of waste heat boilers to capture the heat from the engine jacket cooling circuit and potentially also the exhaust gas from each engine – although the latter is technically more difficult. The investment would rely on there being a sufficient heat demand within a viable proximity, and a heat network to convey the heat. The opportunity would then be constrained by the remaining lifespan of the landfill gas.

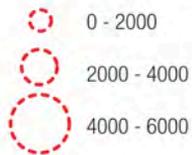
Two landfill gas sites have the potential for utilisation of the waste heat. Red Moss in Bolton (indicative potential of 626 kWth) is located adjacent to the proposed Growth Point development site on the Horwich Locomotive Works. Pilsworth 1 and 2 (Combined indicative potential of 7.5 MWth) are located approximately 2.6km from Bury Town Centre, with the potential to utilise a routing along a heritage railway line.

# Spatial plan 6.3

## Sewage and landfill gas sites



Installed Generating Capacity (kWe)



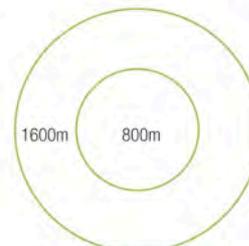
Bury CHP UU Water  
1864 (kWe)



Davyhulme CHP UU Water  
5670 (kWe)



Bolton CHP UU Water  
1060 (kWe)



Catchment Areas



Pilsworth Power Plant - Viridor  
Waste Phases 1+2 3450 (kWe)



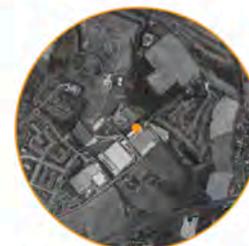
Whitehead - Viridor Waste Exeter Ltd  
5300 (kWe)



Clifton Hall - Biffa Waste Services  
1400 (kWe)



Highmoor Landfill Infinis (Re-Gen)  
2096 (kWe)



Kirkless Generation Infinis Limited  
2128 (kWe)

## 6.3 Networked heating and cooling

In this section we describe the strategic opportunities for the heating and cooling of clusters of buildings drawing on water sources above or below the ground, in water courses, aquifers and mine workings. Each solution would require district heating network planning.

### 6.3.1 Geothermal aquifers

Specific areas within the sub region have the potential to abstract geothermally heated water from shallow and, in a corridor extending from the city region's centre to the Cheshire plain, deep geothermal aquifers.

#### Technology profile

Groundwater flowing through aquifers is a potential source of heat, the temperature of which will depend on the depth. Shallow resources abstracted from wells of around 50-150 metres might typically be brought to surface at a temperature of 17-20 °C in winter if the aquifer has been charged with heat during summer, when the water can be used for cooling <sup>69</sup>.

Lower temperature resources have the potential to be upgraded for heating individual buildings, or clusters of buildings, using heat pumps. These work in a similar way to a refrigerator, using an electric compressor to raise the temperature so that it is suitable for space heating and hot water.

In summer the cycle can be reversed for buildings requiring cooling, with cooler groundwater circulated and then re-injected. In this way the aquifer can be used as an inter-seasonal heat store, the potential of which has been demonstrated by a number of large commercial and public building projects in the Netherlands, and a number of pioneering UK projects. This system might typically achieve between 20% and 30% reductions in CO<sub>2</sub> emissions for office buildings specified with cooling <sup>70</sup>.

The average temperature gradient in the UK of 25°C/kilometre so in deeper wells, such as those utilised by Southampton's geothermal system, the temperature might be more than 30-40°C – sufficient to supply low temperature space heating for homes and offices. The ability to utilise the resource will be influenced by the permeability and porosity of the aquifer.

These higher temperature geothermal resources have the potential to supply heating directly to buildings without requiring any upgrading by heat pumps. Directional drilling based on oil technology can now be used to locate abstraction and re-injection points, with a typical spacing of 2 km, and reduces the constraints on where energy centres can be located <sup>71</sup>.

Baseload geothermal heating formed the basis for Southampton city centres geothermal heating network (1.6 km depth/80°C resource) that was developed as a pilot project in the late 1980's

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<sup>69</sup> Clarke, P *Beyond ground source heat pumps*, Building Magazine, October 2007

<sup>70</sup> Kennett, S *Aquifer thermal storage: Dig! A Dutch method of sorting out energy*, Building Magazine, August 2008

<sup>71</sup> Based on discussions with Geothermal Energy, an Irish geothermal specialist

<sup>72</sup>. In the EU major deep geothermal projects have recently been developed in Bavaria, Southern Germany including the Messestadt Reim in Munich <sup>73</sup> (see precedent study below). At a sub-regional scale the Paris Basin demonstrates how geothermal resources can be developed in a planned way across a broad area <sup>74</sup>.

### Precedent study

#### Messestadt Reim geothermal heating network, Munich (Germany)

A deep geothermal heating network has been developed to supply the 550 hectare 'Trade Fair City' site. Upon completion in 2016 the development will provide homes for 16,000 residents. Around 515,000 m<sup>2</sup> commercial space is proposed including a conference centre for up to 7,000 people and a shopping mall with 120 stores.

It is planned that by 2016 around 50% of the heating demand of the new quarter will be provided by geothermal energy, supplying 45,000 MWh per annum and providing a base thermal load 6 MWth. Although the system has incurred high upfront capital investment the operational costs are relatively low, enabling heating costs to be independent of fossil fuel prices.

The geothermal well is located east of the site. It has been drilled to a depth of 2,700 to 2,900 metres from which water at a temperature of 80° C is abstracted. The water, which is drawn from a vast subterranean lake located underneath much of southern Bavaria, is conveyed via a new district heating network. The water is then returned to avoid any depletion of the ground water levels. Pumping energy to bring water from such depths reduces the CO<sub>2</sub> emissions savings by around 10%.

### Opportunities and constraints

The British Geological Survey carried out geothermal studies in the 1980's which highlighted the geothermal potential of the 'Cheshire Basin' – a combination of Triassic and Permian sandstone and limestone aquifers that underlay areas of the sub region, stretching from the centre of Manchester in the form of a corridor out into the Cheshire plain. The Cheshire Basin was estimated to have a maximum potential temperature of between 80 and 100 °C at the extent of its depth of 3-4 km <sup>75</sup>.

Recent survey work by the Irish company Geothermal Energy with support from Manchester Enterprises suggests that faulting at key locations in the centre of Manchester may allow hot water to be brought to the surface at a temperature of 107 °C from a depth of between 3.3 and

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<sup>72</sup> See footnote 55

<sup>73</sup> SWM (2003) *Geothermie-Anlage für die Messestadt Reim*, München – translation by Sebastian Von Gosen, URBED

<sup>74</sup> Ungemach, P. *Insight into geothermal reservoir management district heating in the Paris Basin*, Paper for the IEA Geothermal Heat Centre, June 2001

<sup>75</sup> Rollin, K. *Low temperature geothermal energy – modelling the potential resource in the UK*, British Geological Survey and discussion with Jonathan Busby and the BGS

4.5 km<sup>76</sup>. At present without further survey work and test drilling this resource is unproven, and the extent to which a corridor of further potential may exist is unclear.

The geothermal resource would provide the benefit of providing a stable baseload supply of heat all the year round, with standby boilers then used to meet winter peak loads. The additional capital cost of sinking deep wells would, however, generally only be justified if district heating is used to supply hot water to a larger number of buildings.

Using broad classifications of aquifer types proposed by Urban Vision to inform waste planning, it is possible to identify broad areas of potential for geothermal across the City Region. This highlights an area of highly permeable geology extending north from Cheshire and encompassing most of the southern portion of the City Region, including Manchester, Trafford and Salford.

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<sup>76</sup> Geothermal Energy, Potential for geothermal energy in Manchester City Centre, Draft report, February 2009

## Spatial plan 6.4

# Shallow geothermal resource



▲ Spatial plan 6.4: Shallow geothermal opportunity areas

### 6.3.2 Mine water

The sub-region has a history of coal mining dating from the industrial revolution. All of these colliery sites are now closed. However, depending on their depth and extent they could have the potential to supply geothermally heated water.

#### Technology profile

The use of mine water as a heating and cooling source to supply district heating is a relatively new concept, and is the focus for a network of pilot projects across seven EU countries – the ‘minewater heating’ project <sup>77</sup>. Whilst minewater geothermal is a new concept, the technologies required– including well drilling, heat pumps, district heating - are mostly tried and tested.

Mine water heating and cooling projects utilise the ‘standing’ temperature change between shallow mine galleries and deep galleries, with a typical temperature increase of 3°C for every 100 metres increase in depth <sup>78</sup>. Abstracted water can be raised to a higher temperature by a heat pump. Cooler water from nearer the surface can be used directly for cooling, or chilled by a heat pump. In this way the body of water can be charged with heat during the cooling season, which can then be drawn out during the heating season.

In the UK Shettleston Housing Association’s 16 unit scheme in Glasgow has demonstrated the potential for heating apartment blocks <sup>79</sup>. At a large scale the town of Heerlen in the Netherlands has demonstrated the potential to supply larger scale district heating and cooling projects <sup>80</sup> (see precedent study below).

#### Precedent case study

##### Mine water heating and cooling, Heerlen (Netherlands)

Since 2005 the City of Heerlen has been leading a team of 7 European partners exploring whether it is technically possible, economically viable and environmentally beneficial to extract geothermal energy from the water in former mine workings on a large scale.

The City Council has invested in drilling five wells to extract minewater from galleries up to 700 metres below the surface. A pilot project has now been taken forward by the City Council and the Housing Association to supply heating and cooling to 200 homes, several large floor plate commercial offices, shops and a library.

Development of the project required the surveying of the mine galleries in order to determine how to balance the flow and return of water extracted from the workings. The solution was therefore bespoke to the specific conditions created by the workings.

<sup>77</sup> Minewater project (2008) *Minewater as a potential renewable energy source*, Information guide funded by EU Interreg

<sup>78</sup> Heerlen Council, *Minewater project Heerlen – realisation and results*, September 2008

<sup>79</sup> UK Coal Authority and Holymoore Consultancy, *Existing open-loop minewater sourced heat pump schemes in Scotland*, Presentation to EU Minewater 2008 conference

<sup>80</sup> See footnotes 77 and 78

## Opportunities and constraints

The sub region has an extensive legacy of coal workings dating back to the turn of the 19th Century, with around 33 major sites operational during the late 19th Century and 20th Century<sup>81</sup>. All of these workings are now closed, with many of the less productive workings ceasing to be mined in the inter war and immediate post war period. The majority of these mines are located in Salford and Wigan, although there are notable workings in Manchester, Tameside, Bury and Bolton.

Whilst the experience from completed projects such as Heerlen in the Netherlands suggest the thermal potential for a mine is generally site specific, it is possible to make a broad-brush estimate of the baseload thermal potential across sub-region. The BRE has developed a methodology for estimating the thermal potential of mines based on the workforce of the mine at its peak capacity which we have then applied to opportunities in the city region<sup>82</sup>.

It is likely that deeper collieries modernised as ‘super pits’ in the post war period, including Bradford (Manchester), Agecroft (Salford) and Astley Common (Wigan), could offer the greatest site specific potential. However, there are a significant number of medium size collieries that, although tending to have a smaller thermal potential, are in general located close to the towns and villages that originally provided their workforce.

**Table 6.1**  
**Colliery site thermal potential: High-level estimate**

Colliery size	Workforce	Sites	Thermal potential (MWth)
Very large	>2,000	1	11.34
Large	1,350 - 2,000	3	28.35
	700 - 1,349	3	22.68
Medium	350 - 699	8	45.36
	125 - 349	18	68.04

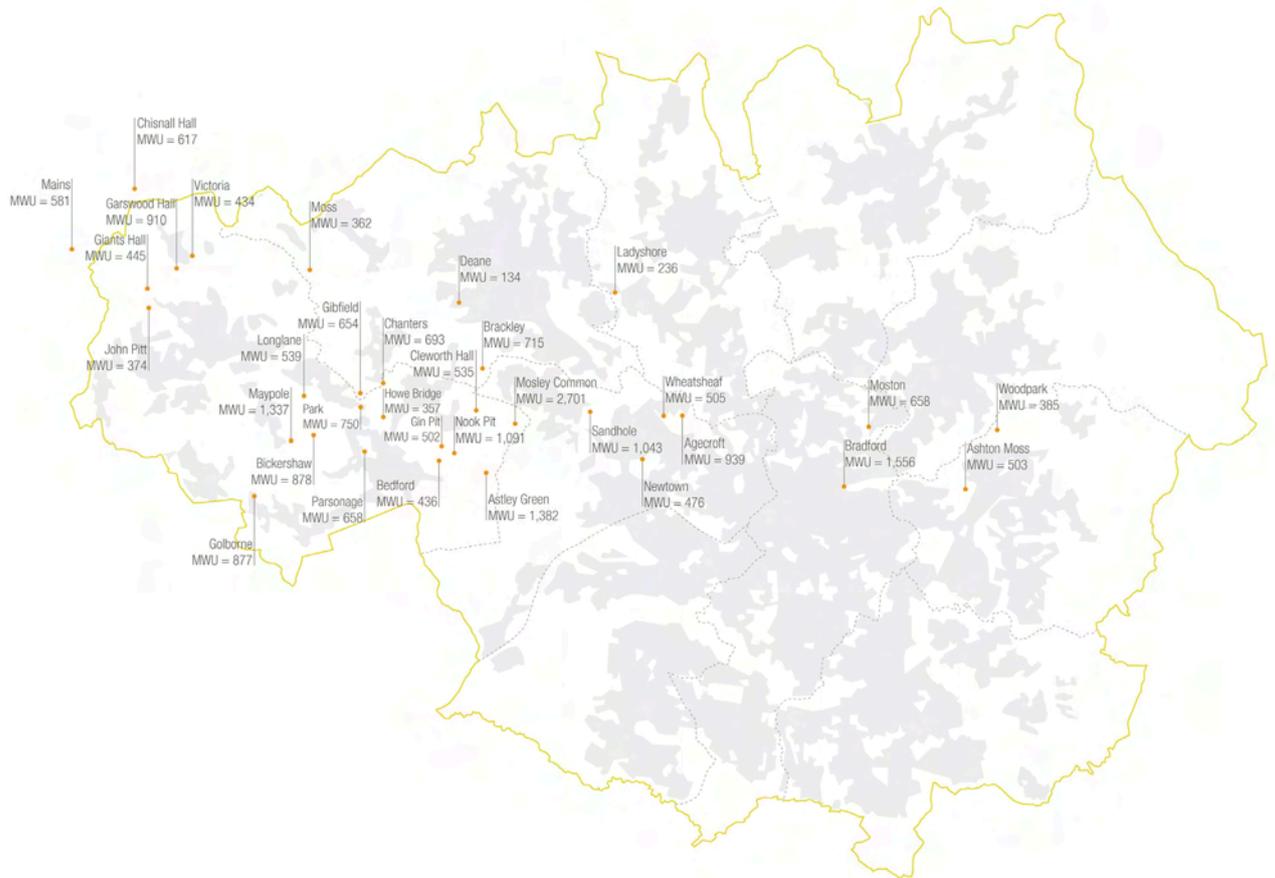
In order to validate the potential resource associated with each colliery further investigation would be required in conjunction with the Coal Authority who, under the remit of the Coal Mines Regulation Act, monitor mine workings closed after 1872. Any project would also be likely to require consent from the Environment Agency.

<sup>81</sup> Platt, B (2009) *The Lancashire coalfield – collieries operating on 1<sup>st</sup> January 1947 (vesting day) and since closed*, Statistics compiled from the National Coal Board

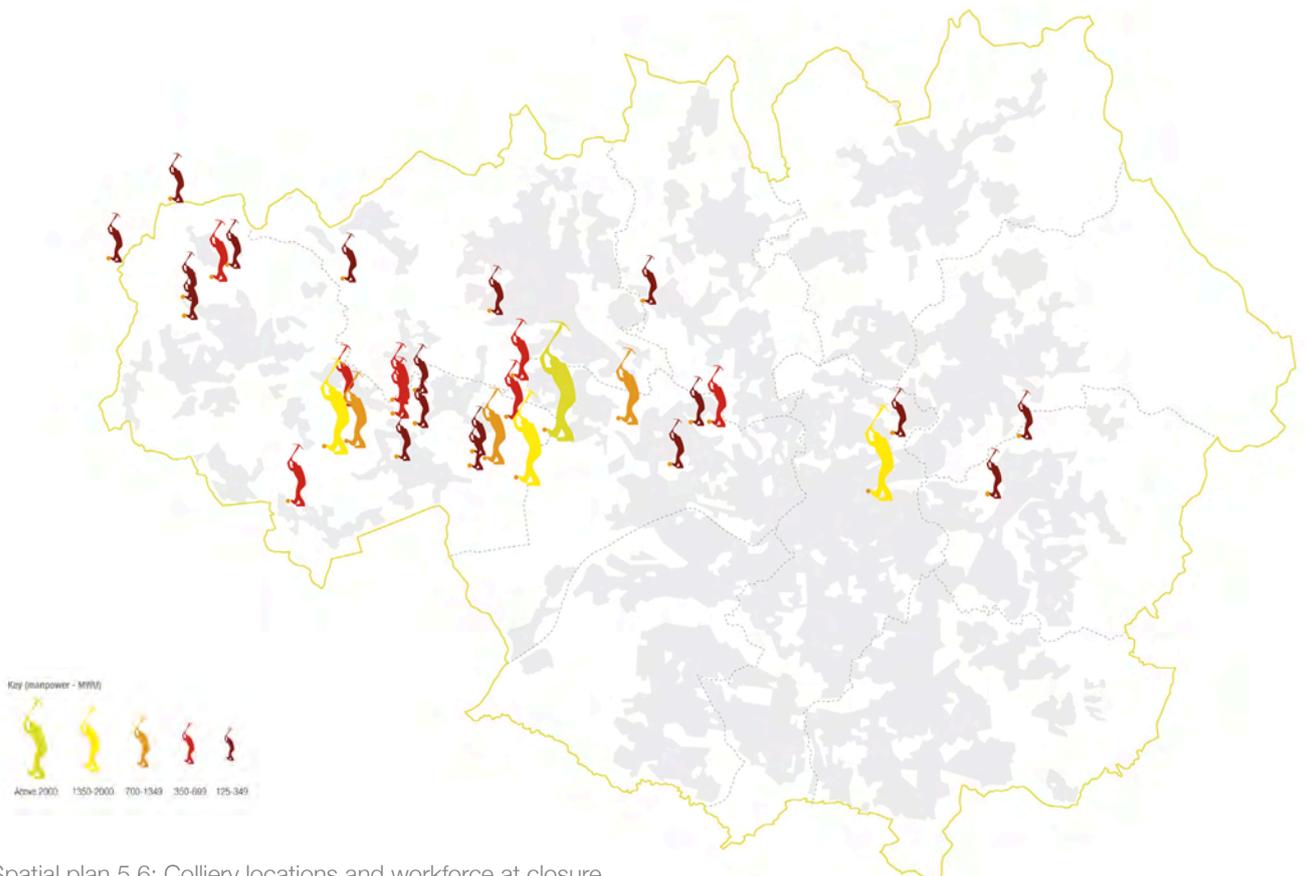
<sup>82</sup> Wiltshire, R (2008) *A high-level study into minewater potential*, BRE presentation to EU Minewater Project conference

## Spatial plans

# Minewater geothermal resource



▲ Spatial plan 5.5: Colliery locations and output at closure



▲ Spatial plan 5.6: Colliery locations and workforce at closure

## 6.4 Standalone electricity generation

In this section we explore the potential for standalone electricity generation based on harnessing wind and hydroelectric energy across the City Region, exploring how opportunity areas could be identified in order to regulate development.

### 6.4.1 Wind power

The sub-region has the potential to support clusters of medium to large-scale wind turbines located in areas with a commercially viable wind speed. While there would not usually be a direct physical connection between the electricity generated and that used by developments, under proposals by the government a link could be made between investment and associated CO<sub>2</sub> reductions.

#### Technology profile

Electricity can be generated from a suitable wind resource by modern wind turbines. These can range in scale from small micro-wind turbines of a few kWe with a hub height of 10-15 metres and a blade diameter of several metres, to large turbines with a rating of between 2 and 5 MWe, a hub height of over 60 metres and a blade diameter of over 80 metres – as demonstrated by Scout Moor in Rochdale.

Wind power is a mature technology, with the industry having a track record of nearly 30 years. Reduction in cost and increases in turbine size and efficiency, together with market mechanisms such as the Renewables Obligation mean that even medium-scale (1-10 MWe) projects can now achieve a simple payback of between five and ten years based on a modest rate of return.

The amount of energy that can be extracted from a given wind resource is subject to the cube rule, so a turbine in a location with an average wind speed of 7 metres per second will be able to generate nearly 60% more power than a turbine in a location with an average wind speed of 6 metres per second.

#### Opportunities and constraints

In order to carry out a high level assessment of the opportunities and constraints in Greater Manchester we have used as a starting point the targets stout in the North West RSS and constraints plans drawn up for 4NW<sup>83</sup>. A series of high-level spatial constraints have been applied to wind speed maps of the sub-region derived from the UK Wind Speed database.

The North West RSS provides indicative targets to 2020 for onshore wind energy, which it predicts as contributing 21.7% of the regions renewable electricity generation capacity. The RSS works on the assumption that the majority of the potential in Greater Manchester would be installed by 2015, and that this would account for around 15% of the regions onshore wind energy capacity.

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<sup>83</sup> See footnote 30

Table 6.2

**North West RSS indicative wind energy targets 2010-2020**

Deployment	Sites and cumulative installed capacity (MWe)		
	2010	2015	2020
Onshore farms and clusters	5-7 (90)	6-8 (97.5)	6-8 (97.5)
Single large turbines	8 (12)	14 (21)	14 (21)

These targets are based on a target of 20% of electricity from renewables by 2020. With the revision upwards of this target to more than 30% there will be the need to find additional wind capacity and to utilise larger turbines to maximise electricity generation. Whilst this does not preclude the potential for smaller installations associated with development sites or discrete buildings, it does highlight the importance of maximising the utilisation of a given wind resource.

Scout Moor in Rochdale has an installed capacity of 65 MWe, and there are currently applications for over 36 MWe of further capacity in the Rochdale area. This would meet the majority of the existing RSS onshore target, but revision upwards of the 2020 targets would mean that at least 80 MWe of capacity would be required to be brought forward.

In order to relate these overall figures to the possible spatial location of new wind energy sites a series of constraints agreed with statutory stakeholders by Arup for 4NW can be applied in order to begin identifying broad areas for development. These include areas that are:

- ‘Constrained’ by protected landscapes, nature conservation areas and related functional areas, including a buffer zone of 500m for residential areas;
- ‘Variably constrained’ by heritage features, less sensitive nature conservation areas, aviation flight path and radar areas, and deep peat sites;
- ‘Less constrained’ by the features and designations listed above, but which may be subject to local designations and/or impact on greenbelt landscape character.

The 500m residential buffer is the most significant constraint, eliminating a significant proportion of Greater Manchester. This constraint layer warrants further refining as it currently includes non-residential locations where siting may be possible. Additional network constraints relate to the need for electricity connections at either 33 kV or 132 kV to the distribution network.

4NW’s application of these constraints suggests an ‘absolute’ potential for the sub-region of 118 MWe (excluding constraints and variable constraints) and 244 MWe (excluding only constraints). This suggests that development may need to be permitted in variably constrained locations, for example in the greenbelt, in order to deliver the higher renewable electricity targets.

In order to test the assumptions made by the North West RSS and by 4NW we have explored the spatial implications of opportunity areas related to different wind speeds by producing a series of indicative wind maps:

### **6.5 metres/second opportunity areas**

The 4NW study assumes the exclusion of sites with a wind speed of less than 6.5 metres/second at a hub height of 80 metres. In order to ensure consistency with the RSS targets we have used a 45 metres hub height as a starting point. The majority of the opportunity areas identified can be seen to fall within statutory green belt.

Applications in these areas would currently be determined based on the impact on landscape character and whether wind energy is 'appropriate' green belt development. There is emerging legal precedent that while wind energy might be deemed inappropriate development the need to tackle climate change can override this as a consideration <sup>84</sup>.

### **6.0 metres/second opportunity areas**

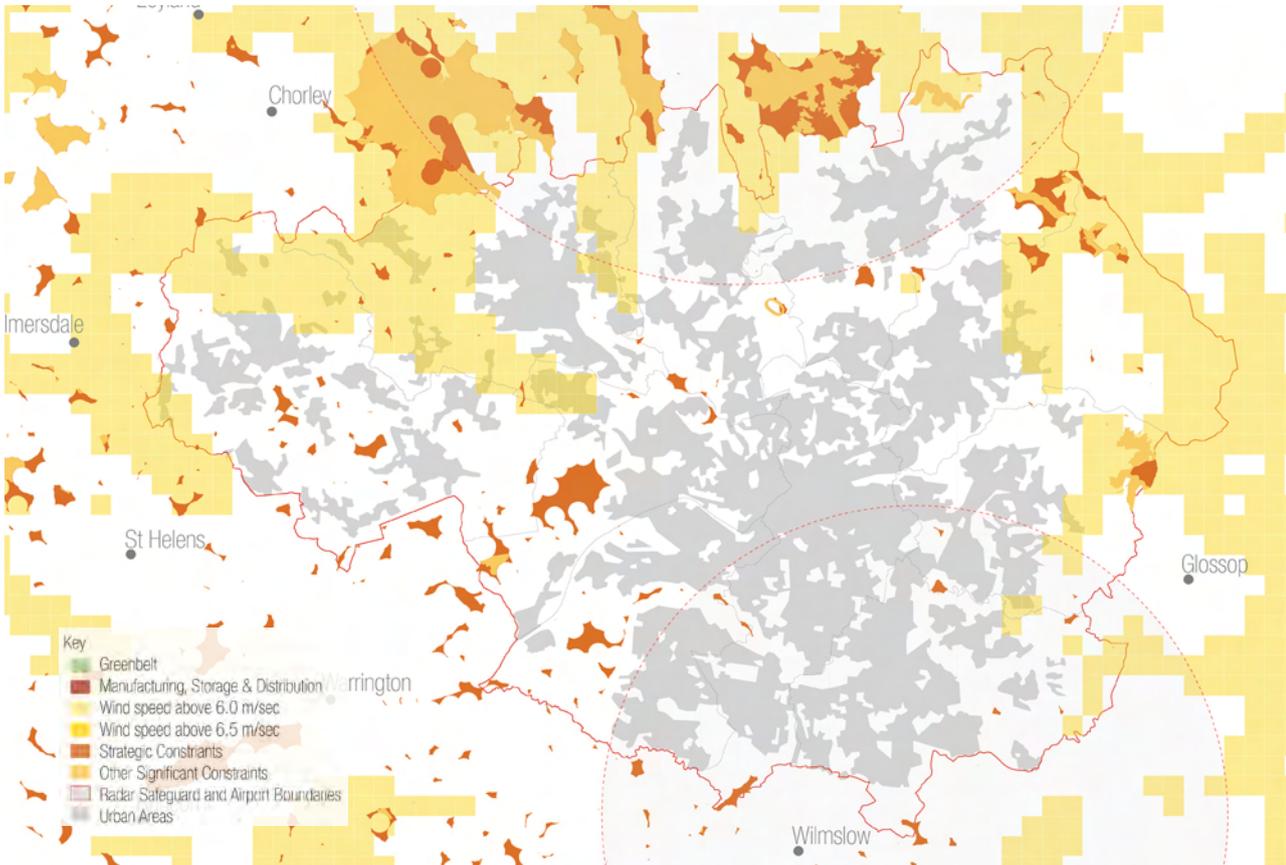
Reducing the wind speed to 6.0 metres/second at 45 metres yields a significant increase in opportunity areas. This wind speed accords with the commercial threshold for 'merchant wind' type investments in 1-2 large turbines associated with industrial sites, commercial development and Local Authority supported investment proposed by the Carbon Trust's Partnerships for Renewables scheme. These areas extend beyond the green belt and encompass a broad range of land uses, including industrial sites where the impact of wind energy on landscape character might be considered to be less acute.

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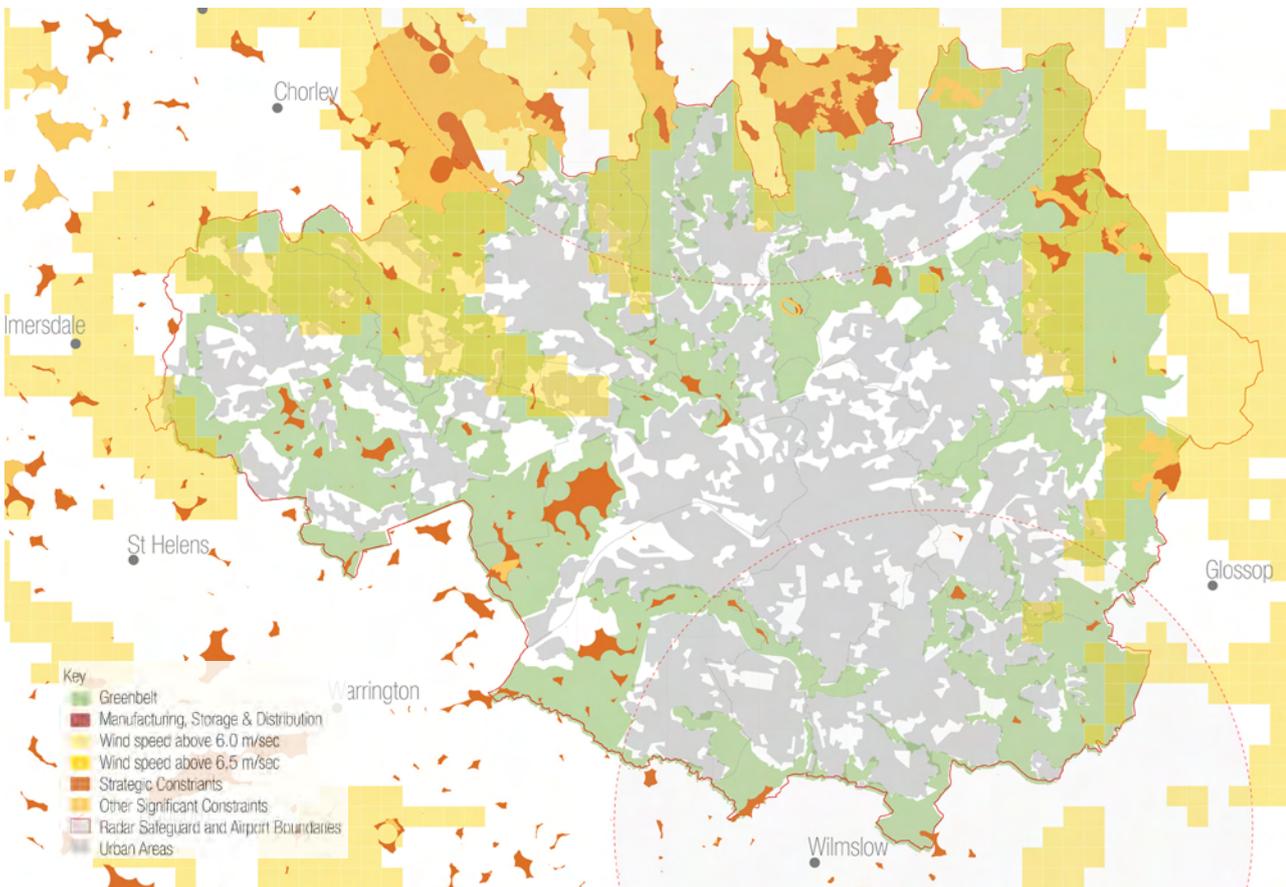
<sup>84</sup> Secretary of State's response to an appeal made by Coronation Power Ltd, [www.communities.gov.uk/documents/planning-callins/pdf/1355954.pdf](http://www.communities.gov.uk/documents/planning-callins/pdf/1355954.pdf)

## Spatial plans

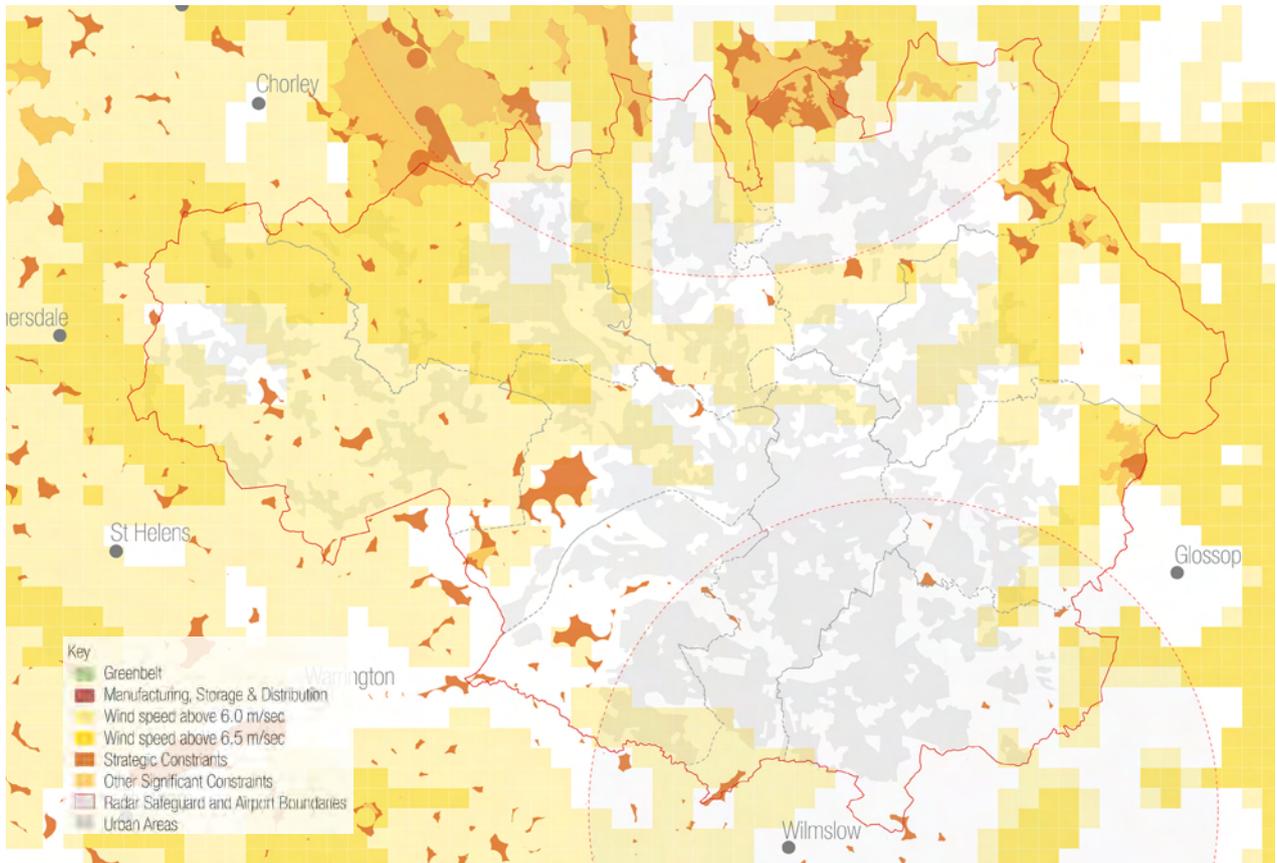
# Wind energy resource



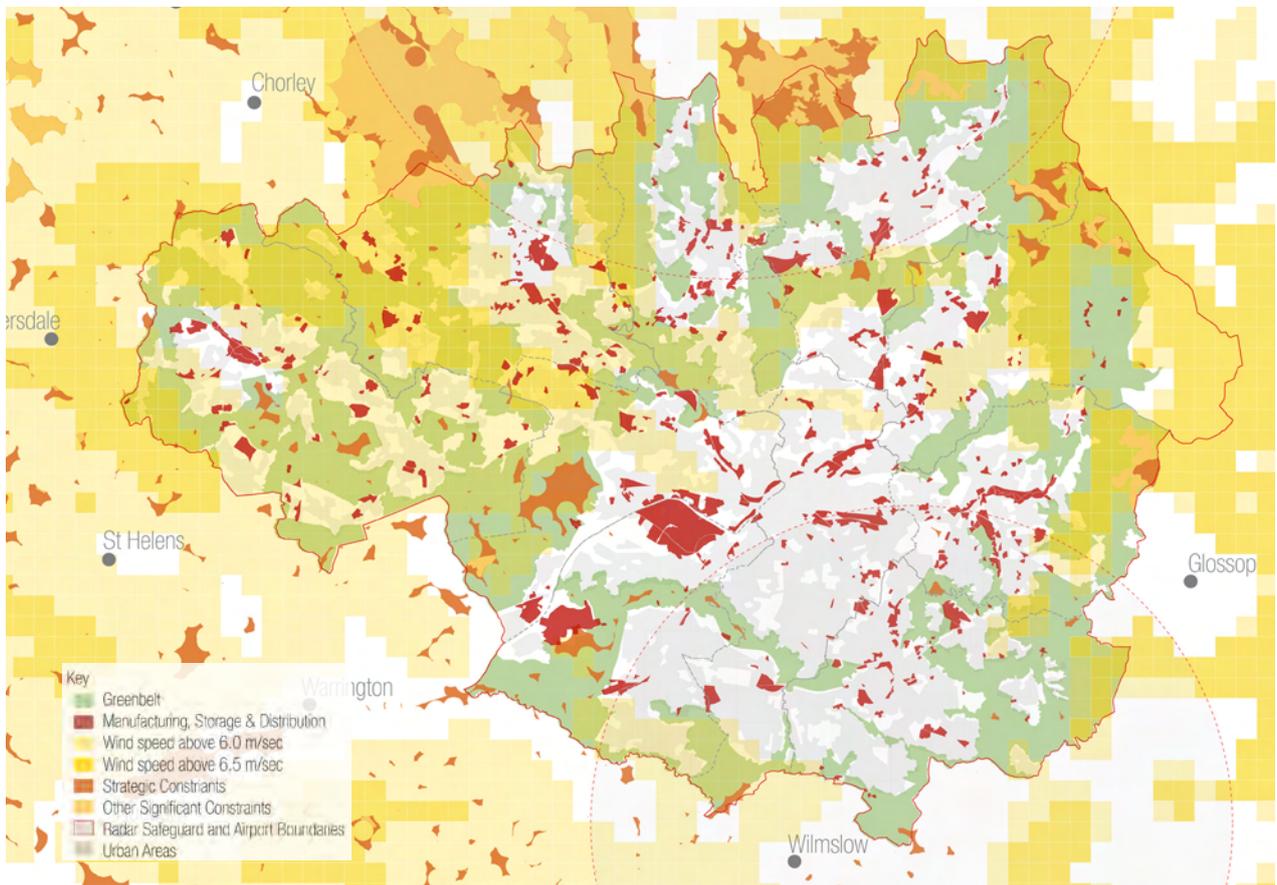
▲ Spatial plan 5.7: 6.5 metres/second at 45 metres with constraints applied



▲ Spatial plan 5.8: 6.5 metres/second at 45 metres, constraints applied and greenbelt overlaid



^ Spatial plan 5.9: 6.0 metres/second at 45 metres with constraints applied



^ Spatial plan 5.10: 6.0 metres/second at 45 metres, constraints applied, greenbelt and industrial sites overlaid

## Using planning to regulate development

Whilst some of the ten districts have carried out their own wind constraint mapping exercises, to date the ten districts have not designated broad areas of opportunity for wind power in their local plans. This has meant that planning applications have had to be dealt with on a more ad hoc basis. Planning policies on wind may also require updating in line with the more 'positive' criteria-based approach in PPS1 and the likely need to bring forward more capacity than the RSS sub-regional targets.

Our indicative wind mapping exercise has highlighted Wigan and Bolton as having the most significant broad areas of potential, followed by Oldham and Rochdale, and, to a lesser extent, Stockport and Bury. A refined constraints exercise would need to be guided by an agreed methodology for assessment of impact on landscape character (including cumulative impacts) – including limited siting within the greenbelt.

With the need for further significant site allocations having been highlighted there is the opportunity to pre-empt further ad hoc planning applications. One approach could be to emulate the approach taken in Germany, which has already seen the development of near to its 'absolute' potential in many areas<sup>85</sup> (see precedent study below). This would require consultation on the designation of 'suitable sites' for wind power in each district, with reference to the strategic need to bring forward sufficient capacity, to be informed by a criteria for cumulative impact assessment.

Experience in Denmark and Northern Germany has also shown that an element of community ownership can also increase acceptance of wind power – the opportunities for which we discuss further in Section 8.

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## Precedent study

### Sub-regional spatial planning to regulate wind energy, Germany

National and regional programmes to support renewable energy led to a 'dash for wind' in the late 1990's and 2000's. The result is that Germany has one of the highest installed wind energy capacities in the world, with 23,903 MWe.

This has led to a huge amount of development pressure, as private investors have sought out the best sites and obtain planning permission, often in the face of local opposition and a lack of clarity over conflicting policy objectives such as nature conservation.

At a sub-regional and district level planners sought to respond by consulting on, and identifying in local plans, 'suitable areas' where wind energy would be encouraged. These areas are illustrated spatially in local plans and have helped to regulate the impact of wind energy on the landscape, and to balance different policy objectives by applying constraints and buffer areas.

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<sup>85</sup> Bruns, E. *The role of spatial planning and environmental planning in the innovation biography of wind energy in Germany*, Berlin University of Technology, November 2006

## 6.4.2 Hydroelectric power

The sub-region has the potential to exploit a small hydroelectric resource. While there would not usually be a direct physical connection between the electricity generated and that used by developments, under proposals by the government a link could be made between the investment and associated CO<sub>2</sub> reductions from buildings.

### Technology profile

Electricity can be generated from hydro resources where there is sufficient head of water to create the force needed to drive an alternator. Turbines, Pelton wheels or archimedean screws can be used to generate electricity from low head resources as small as 2-3 metres. These would generally include weirs and locks, of which many can be found across the sub-region.

The potential can be illustrated by two distinct local examples. Barton Lock hydroelectric scheme was installed in 1994 and has a capacity of 660 kWe<sup>86</sup>. A single turbine was installed in a lock forming part of Manchester Ship Canal. Torr Mill Hydro installed a 70 kWe archimedean screw on a weir just over the border in High Peak, making use of a low head resource<sup>87</sup>.

### Opportunities and constraints

There are no definitive assessments of the extent of the sub-region's hydroelectric resource. ERM carried out a broad assessment as part of the regional renewables assessment in 2001 and updated in 2004 but this did not identify any new 'viable' sites of more than 65 kWe<sup>88</sup>. The North West RSS established a sub-regional target for 1 MWe of capacity by 2020, reflecting a limited potential over and above the Barton Lock scheme and a small low head potential.

The most recent assessments include a study commissioned by Stockport MBC, which identified five potential sites with a combined capacity of 256 KWe<sup>89</sup>, and a study commissioned by Groundwork Bury from the University of Lancaster, which identified two potential sites with a combined capacity of 366 kWe<sup>90</sup>. In each case the potential, whilst small, could be linked to investment in discrete development sites within a close proximity.

Identification of further low head sites would require modelling of the sub-region's catchment areas, and a comprehensive survey of weirs and locks. This could be facilitated by the University of Lancaster's modelling capabilities, which have been applied to Cumbria and Lancashire in order to identify potential.

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<sup>86</sup> CADDET (1998) *Hydroelectric generating station built within a canal lock system*, Technical brochure 81, [www.caddet-re.org](http://www.caddet-re.org)

<sup>87</sup> Torr hydro New Mills (2009) [www.torrshydro.co.uk](http://www.torrshydro.co.uk)

<sup>88</sup> ERM, *Investigating renewable energy in the North West of England: Investigating the potential and developing the targets*, January 2001

<sup>89</sup> Water Power Enterprise and H2OPE, *Hydro feasibility study*, Prepared for Stockport MBC, November 2008

<sup>90</sup> Lancashire University Engineering Department (2006) *Presentation to Groundwork (Bury) on renewable energy in the Bury area*

## 6.5 Biomass supply chain

In this section we explore the implications for development of a biomass supply chain to supply CHP and heating plant, drawing on a range of different wood fuel resources, including those available within the City Region.

Early indications are that, in addition to wind power and solar photovoltaics, biomass heat and power generation is likely to be one of the most cost effective and widely applied means of achieving Code for Sustainable Homes levels 5 and 6. The ability to source biomass fuel on a firm contracted basis and to the appropriate specification will therefore be vital to support any growth in demand stimulated by planning and regulation.

### 6.5.1 Planning for growth in demand

In order to understand how the sub-region might plan for this growth sub-region it is important to understand the nature of the supply chain. Biomass fuel comes in broadly two main forms:

- Pellets are manufactured from wood wastes such as from sawmills and are more suitable for smaller installations because they have a high energy density and therefore require less transport and storage;
- Wood chips are a raw wood product, and can be produced from a range of sources including commercial wood waste, forestry residue, municipal tree waste and energy crops. Chips often have a higher and variable moisture content.

Larger biomass CHP and boiler plant tend to make use of wood chips because they allow for more flexible sourcing and because they are, at present, on balance cheaper.

An increasing number of local authorities are turning to biomass as a relatively cheap and efficient way of switching over the heating supply for public buildings and housing schemes with district or communal heating. Barnsley Council is leading the way with its 'biomass fuel heating policy', which has been complemented by investment in their supply chain based on the districts arborological waste and managed forestry resources<sup>91</sup> (see case study below).

### 6.5.2 The North West supply chain

The supply chain for biomass fuel in the North West region, and within the city-region is at an early stage of development. There are broadly three potential sources that we have considered at a strategic level:

#### Existing producers

We have mapped the existing biomass chip and pellet producers in and around the city-region based up to date information from Envirolink North West's biomass directory<sup>92</sup>. This suggests

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<sup>91</sup> Bradford, D, *Wood – today's heating fuel*, presentation by Principal Building Services Engineer, Barnsley Metropolitan Borough Council, November 2006

<sup>92</sup> Envirolink North West, *Biomass fuel supply in England's North West*, April 2007

that although there are a number of large producers in the sub-region, such as Hadfields in Tameside, much of their output is currently contracted to biomass power stations elsewhere in the region or in southern Scotland. There are also concerns about the suitability of biomass produced from commercial waste streams, which may include contaminants, potentially making it unsuitable for smaller boilers or CHP plant.

### **Local authority arboricultural waste**

Survey work by Red Rose Forest has produced estimates for wood chips that might be available from at least eight of the districts from street tree and park tree waste. This suggests that around 4,267 Oven Dried (OD) tonnes/annum of wood chip might be available in the sub-region – although this figure may fluctuate year on year<sup>93</sup>. There are indications that much of this wood chip is currently sold on by Councils and contractors and very little is landfilled<sup>94</sup>.

### **Managed forestry**

In recent years the establishment of Community Forest programmes across the sub-region, pioneered by Red Rose Forest and Pennine Edge Forest, has led to the promotion of managed forestry that could generate economic value from by-products such as wood chip. The Newlands Programme has aimed to establish woodland-based regeneration projects.

Estimates of the biomass fuel potential of this programme are not readily available, however, DEFRA's agricultural and horticultural survey (2007) suggests that there are 580 hectares of woodland in the sub-region which if managed could yield, based on Forestry Commission estimates, approximately 1,160 OD tonnes/annum of wood chip.

### **Energy crops**

Fast growing woody crops such as Short Rotation Coppice willow can be grown on lower grade agricultural land. DEFRA's agricultural and horticultural survey (2007) suggests that there are 479 hectares of setaside land that could be used for energy crops. This could create an absolute potential yield approximately 4,790 OD tonnes/annum. It is likely that a wider approach, encompassing rural areas across the region would be needed to contract supply.

Overall these estimates suggests that with co-ordination of the sub-region's supply chain there could be access to 10,217 tonnes/annum, supplemented by access to a wider regional supply chain from which a proportion of an estimated 325,000 tonnes/annum could be contracted<sup>95</sup>.

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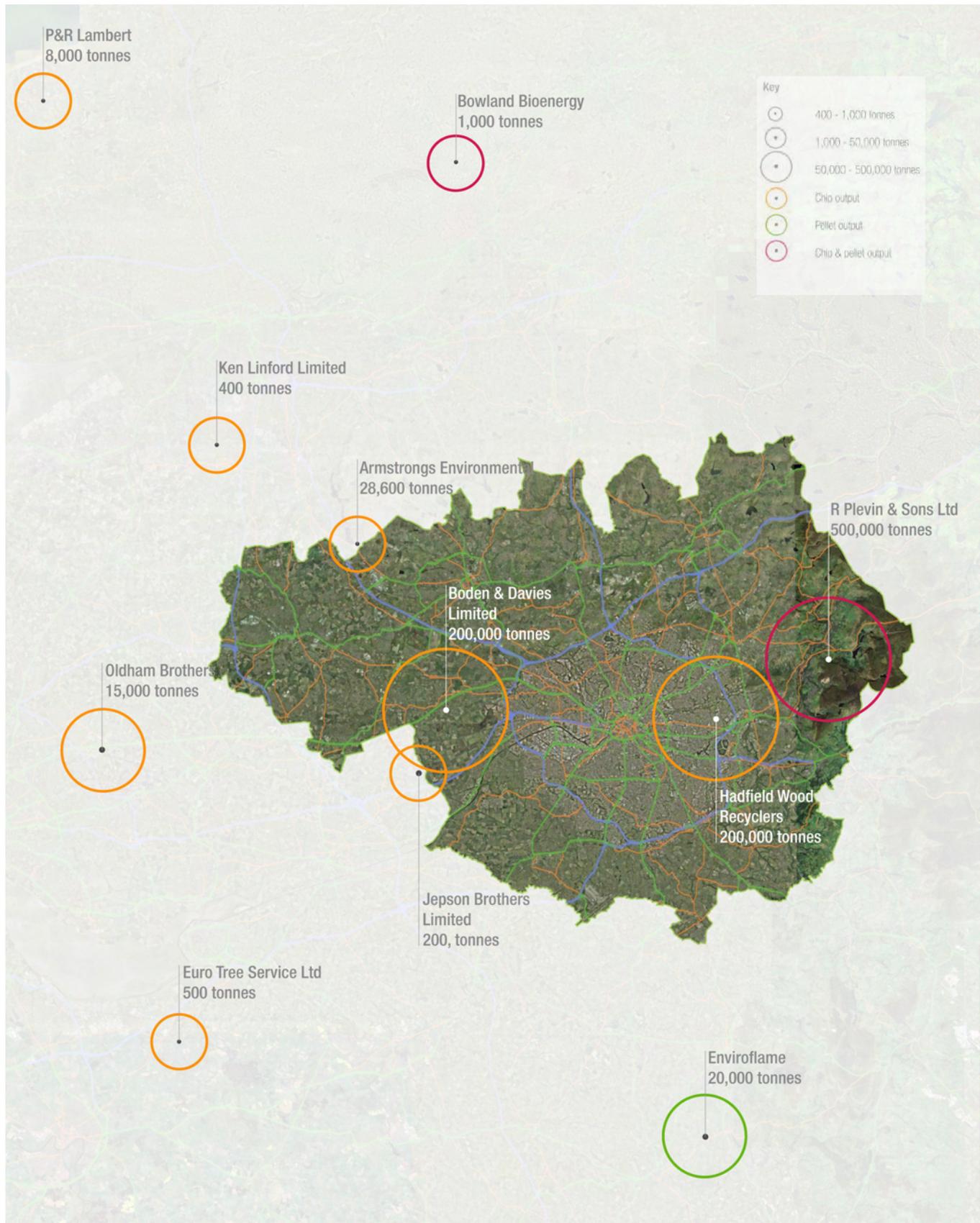
<sup>93</sup> Red Rose Forest and Mersey Forest, *Of chips and logs...making the most of arboricultural arisings in the Mersey Belt*, July 2006

<sup>94</sup> Discussions with Phil Benn, Manchester Tree Station, contractor to Red Rose Forest

<sup>95</sup> North West Regional Forestry Framework (2009) *Biomass woodfuel strategy*

## Spatial plan 6.11

# Biomass producers



^ Spatial plan 6.11: Large-scale producers of biomass fuel in the North West

### 6.5.3 The logistics of increased demand

Larger demands for fuel could at present only be met on a firm basis by importing fuel from other parts of the region such as Cumbria, other regions, such as Yorkshire and Scotland or from other EU countries via ports on Liverpool or Humberside. For example, Renewable Fuels (part of the Swedish Lantmännen agricultural co-operative) based in Yorkshire currently supply large tonnages of wood chip to power stations such as Drax.

The import of biomass fuel raises two major concerns that require addressing. The first is fuel price. Biomass is generally transported by lorry, and its cultivation (in the case of energy crops), harvesting (energy crops and forestry residue) and production is also reliant on fossil fuels. This means that the price is strongly influenced by oil prices, at a time when energy customers are looking to fuels such as biomass in order to decouple renewable energy and fossil energy prices.

As far as possible fuel supply chains should therefore be developed as near as possible to the sub-region, and based on by-products, suggesting that the area of search should firstly focus on other areas of Lancashire and Cheshire, as well as by-products available from North Wales industries such as sawmills. Barnsley MBC's development of a district supply chain to serve its biomass heating programme provides precedent for this approach<sup>96</sup>, and this approach could be taken further in the City Region with the potential to invest in wood pellet production plant(s).

The second issue are CO<sub>2</sub> emissions relating to harvesting, processing and transport of the fuel. There is conflicting evidence as to the emissions arising from producing and transporting biomass. A recent report by the Environment Agency provides the most definitive data, suggesting a reduction in CO<sub>2</sub> savings of between -5% (wood chip) and -18% (wood pellets) for European imports, but the data is not clear for transport within the UK<sup>97</sup>.

If biomass fuel were to be imported from discrete other sub-regions, or other countries, there could be the potential to utilise rail infrastructure to transport the fuel in a way that minimises lorry movements. Reverse logistics could be used in certain instances. For example, municipal waste is currently transported to landfill sites on Humberside in iso-freight containers that return empty. Humberside is a major point of arrival for biomass imports from Scandinavia and Russia and has been a focus for investment by Yorkshire Forward.

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<sup>96</sup> See footnote 95

<sup>97</sup> Environment Agency, *Minimising greenhouse gases from biomass energy generation*, April 2009

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## Precedent study

### **Barnsley biomass heating and fuel supply**

Barnsley Council has set an ambitious target to reduce its emissions 60% by 2015 primarily by switching to biomass heating. This has been adopted at member level as the 'biomass fuel heating policy'. Working with biomass heating specialists Econergy the council have initiated a switch over programme. To date this included the new civic centre, the central library, all schools, council blocks of flats, and a new digital media centre.

In support of its corporate biomass fuel heating policy Barnsley Council has sought to develop a stable and cost effective supply of wood fuel. The council has carried out a survey of the available biomass resources in the district, and has established wood fuel handling centres to supply its boiler switchover programme. The centres will handle and process a range of wood including tree surgery waste and forestry residue.

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## 6.6 Building integrated heat and power

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In this section we explore the potential for building integrated 'micro-generation' technologies, including solar thermal, solar photovoltaics, biofuelled boilers and heat pumps, to provide on-site heat and power.

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Micro-generation technologies have a smaller but still significant role to play in delivering low and zero carbon energy supplies. This is because the majority of new homes projected for the sub-region are likely to be developed at a lower density, requiring solutions for small clusters of homes, or on individual homes.

Achieving greater deployment of micro-generation creates a different challenge from networks and standalone technologies. They will require installation on many thousands of individual properties. At this scale the unit costs are at their highest and so achieving economies of scale and greater repetition by contractors will be essential.

Micro-generation technologies are also notable in planning terms because, for the most part, they are now permitted development. Rules were relaxed following the Government's 2006 micro-generation strategy, but the main barrier to their widespread deployment remains their higher upfront capital cost compared to a number of the networked and standalone technologies reviewed by this study.

### 6.6.1 Solar thermal

Solar thermal collectors are a mature technology that can be installed on buildings in order to supplement their hot water supply. Carbon emissions savings are achieved because it displaces hot water provided by gas or electric heating systems. The technology has a track record of over 30 years in the UK, and was one of the most commonly installed technologies supported under the Government's Low Carbon Building Programme.

Solar thermal technology takes two main forms - flat plate panels or evacuated tubes installed on the roof of a building. Water is circulated through the panels and tubes, and is warmed by the sun and then provides hot water for building occupiers. Installed on a typical home it can typically provide between 50% and 60% of the annual hot water requirements, equating to a 15% gross CO<sub>2</sub> reduction for a home built to 2006 Building Regulations, enabling homes to achieve Code levels 3 and 4.

### 6.6.2 Solar photovoltaics

Solar photovoltaics are a mature technology that can be installed on buildings in order to generate electricity from sunlight. Photovoltaics are a form of semi-conductor that generates Direct Current (DC) power from sunlight. The DC electricity generated is then rectified to AC current by an inverter. The most common form are polycrystalline cells arranged to form standardised modules or panels, which can be fixed to, or integrated into roofs and facades.

The power output from photovoltaics closely matches the peak demand for comfort cooling in summer, but they can also assist in meeting daytime power demands from spring through to autumn. This makes them particularly suitable for meeting the power needs of commercial office blocks and public buildings. This power output will also help to reduce load on the local distribution grid, and it can be exported in order to obtain Renewables Obligation Certificates (ROC's) and in 2010 a higher value 'Feed-in Tariff'.

Photovoltaics are receiving attention as a technology because they can assist new homes to reach Code for Sustainable Homes level 6. This is because, despite their high capital costs, they are one of the few low carbon technologies that can supply electricity in sufficient quantities to meet the needs of detached or semi-detached homes, which in many cases may not be suitable for energy networks. With the introduction of Feed-in Tariffs in April 2010 it will become viable to offset the high capital costs against the revenue from electricity sales.

### **6.6.3 Biomass boilers**

Biomass boilers are a mature technology and they are available in a range of sizes, from those that can supply district heating networks and large buildings to those designed for a single home. Simpler biomass stoves supplying hot water via a back boiler can also be specified for homes with a very low heating demand.

As we discussed in section 6.5 biomass fuel comes in two main forms – wood chips and pellets. Pellets are manufactured from wood waste and are more suitable for smaller installations because they have a high energy density and require less storage. A larger boiler plant would tend to make use of wood chips because they allow for more flexible sourcing and because they are cheaper.

Biomass boilers, like biomass CHP, are receiving significant attention because they can provide developments with zero carbon heating, enabling them to achieve Code levels 4 or 5 – as demonstrated by Rocks Green in Shropshire<sup>98</sup> (see precedent below). All demonstration homes meeting Code level 6 have had to incorporate biomass heating – albeit at a much higher unit cost than for schemes with district heating networks.

In London higher on-site renewable targets have led biomass boilers to be the favoured technology. Whilst modern plant are very clean the cumulative impact of unconstrained biomass use does, however, create a potential risk to air quality – directly from boilers and indirectly via associated fuel deliveries. This issue was discussed in Section 6.2.4.

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<sup>98</sup> Sustainable Housing Action Programme (SHAP) (2008) *Case studies of low carbon housing*, [www.shap.uk.com](http://www.shap.uk.com)

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## Precedent case study

### Rocks Green housing scheme, Shropshire

Rocks Green is a development of 91 new semi-detached homes by South Shropshire Housing Association in Ludlow, South Shropshire. All of the homes are supplied with their space heating and hot water from communal wood chip boilers, with heat distributed to each property via 1,200 metres of pre-insulated district heating mains.

The boiler house contains two 150 kW Austrian KWB boilers together with a 200 kW oil-fired standby boiler and a thermal storage tank. The storage tank is required in order to match the supply and demand for heating. The development has been estimated to require 200 tonnes of wood chips per year. The fuel is to be supplied under a contract with Midlands Wood Fuel, which was established by Marches Energy Agency. The contract is based on the heat output delivered by the fuel.

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#### 6.6.4 Heat pumps

Heat pumps are a mature technology that can provide heating and cooling using the same technology as a refrigerator or air conditioning system, with electricity or heat being used to raise or lower the temperature of air or water.

Typically a heat pump can deliver three units of heat for every unit of electricity or heat, but this will vary depending on the 'Co-efficient of Performance', which in turn is dependant on the temperature of the heat source. Sources in increasing order of efficiency could include:

- Air (ambient or from an industrial process),
- Surface water (canal, river or lake),
- Geothermal (soil or groundwater),
- Wastewater (sewage or industrial effluent).

The heat can either be extracted using a 'closed loop' network of pipes through which refrigerant is circulated, or a 'direct loop' with water pumped from a watercourse or borehole and then through a heat exchanger.

Heat pumps can be used to provide heating and cooling to individual buildings and homes. However, in built up areas constraints on land may limit the potential for a closed loop system. In these locations a direct loop system based on a resource such as an aquifer would represent a better heat source. The latter has been show to be an economical solution for large offices and apartment blocks.

It is important to note that heat pumps require an input of energy, and their carbon reduction potential is limited by CO<sub>2</sub> emissions from this input, which is usually grid electricity. BRE trials have shown that a modern house with gas-fired heating can make a 15% reduction in CO<sub>2</sub>

emissions by using a heat pump <sup>99</sup>. This performance will improve over time as carbon emissions from the electricity supply reduce.

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<sup>99</sup> Energy Saving Trust, *Heat pumps in the UK: A monitoring report*, GIR 72, November 2005

## 6.7 What are the opportunities and constraints for the City Region?

This study has explored the ‘top down’ spatial planning implications for a range of low and zero carbon technologies. Each creates distinct opportunities for the sub-region, but also have specific constraints which will need to be overcome in order to increase deployment in-line with the UK renewable energy strategy and the need for low and zero carbon infrastructure for new development.

In order to make progress the targets set out in the North West RSS and refined further by 4NW need to be given a greater spatial context – bringing them down to sub-regional, district and site-specific level in order to understand the implications. The range of technologies will also need to expand in order to cover heat, and to exploit the full range of low and zero carbon technologies that will be needed to meet overarching carbon reduction targets.

An outline framework of ‘top down’ deployment targets for the City Region is set out in table 6.3. The implications for deployment of these technologies to achieve carbon reductions are then explored by the ‘bottom up’ case study evidence base.

### 6.7.1 Networked technologies

A series of networked technologies are likely to create the most significant medium term scope for CO<sub>2</sub> reduction. Each creates strategic opportunities whose contribution would be over and above those identified by targets in the North West RSS and the recent study for 4NW. In particular the role of natural gas fired CHP as an interim low carbon technology to deliver CO<sub>2</sub> reductions is not currently accounted for, and could play a significant role – particularly if waste heat was to be utilised from the proposed Carrington CCGT Power Station.

This suggests that clear deployment targets for low carbon technologies will be required for the sub-region, alongside existing renewable energy targets. The opportunities for deployment of these technologies are fundamentally linked to the built environment because of the need to supply district heating. Targets should only therefore be set in conjunction with a spatial plan that gives them context.

### 6.7.2 Standalone power generation

Challenging regional targets for the deployment of wind power at a sub-regional scale raise important issues as to how planning could be used to bring forward new capacity. Large-scale onshore wind power will be needed to supply electricity to the major centres where demand is located and in order to offset unregulated emissions from lower density housing developments which are likely to make up the majority of the projected housing numbers.

In order to avoid a continued ‘dash for wind’ on viable sites by prospective developers the districts should look to identify and allocate suitable sites so that they can exercise more control over the process and, more importantly, its cumulative impact on landscape character. This is likely to include the need for some development in the greenbelt. Sites are also likely to be required for wind turbines financed in part from developer contributions.

### **6.7.3 Fuel supply chains**

Fuel supply chains will be required for heat and power generation, requiring the development of resources and logistics in order to provide security of supply. At present the position is entirely market-led. However, a large increase in demand for biofuels could have significant implications, and unintended consequences, if not planned for at a strategic level. This should include consideration of options such as transport by rail and site allocation for fuel storage depots.

Biomass wood fuel has been identified as important by a range of strategies, but the development of a wood fuel supply chain that decouples biomass energy prices from oil prices (for transport of the fuel) is likely to be constrained. The City Region is therefore likely to be reliant for biomass on the region's rural areas, or even further afield, in order to respond to market-led growth in demand.

### **6.7.4 Micro-generation technologies**

Micro-generation will have an increasingly important role to play in relation to lower density and smaller clusters of housing, particularly if the cost of technologies such as solar photovoltaics can be brought down over the next decade. Given the granting of Permitted Development rights for most technologies, market development programmes to achieve economies of scale are likely to be more important than planning at this scale. Investment vehicles that are geared up to finance technologies such as solar photovoltaic's using FIT revenue – thereby reducing the capital costs for developers - may also be needed.

Table 6.3

**City Region strategic energy infrastructure**

Technology	Description	Scale of potential (MW electricity or thermal)	Technical requirements
Combined Heat and Power (CHP)	Small to medium-scale gas or biomass power generation (1-50 MWe) supplying district heating.	Regional Centre (at least 50 MWe), 8 sub-regional centres (5-10 MWe), 34 local centres (1-2 MWe), major regeneration areas (at least ten 1-2 MWe)	<ul style="list-style-type: none"> <li>• District heating networks supplying mixed use areas with a high heat density;</li> <li>• Allocation of sites for energy centres and/or integration into development;</li> </ul>
	Small-scale biogas power generation or energy from waste (1-10 MWe) supplying district heating.	At least three waste PFI sites (3-6 MWth), two sewage gas sites (7 MWth) and one landfill gas site (7 MWth)	<ul style="list-style-type: none"> <li>• Alignment of investment strategies to support heat offtake to supply development;</li> <li>• Agreements governing operational arrangements and pricing for heat off take.</li> </ul>
	Power stations (up to 800 MWe) supplying industrial steam and district heating.	Carrington Power Station (300 MWth in two phases)	<ul style="list-style-type: none"> <li>• Heat pipeline routed to supply Growth Point sites and Regional Centre;</li> <li>• Operational agreement for heat off take with Carrington Power;</li> </ul>
Geothermal heating	Deep boreholes (~25 MWth each) supplying district heating	Initial 25 MWth site, South Manchester and Trafford (unconfirmed potential)	<ul style="list-style-type: none"> <li>• Further seismic studies to validate potential across broad area;</li> <li>• District heating network(s) to utilise thermal resource.</li> </ul>

	Minewater from old workings (5.3 MWth per site) supplying district heating	33 sites (176 MWth) in Manchester, Salford, Wigan, Bolton and Tameside.	<ul style="list-style-type: none"> <li>• Technical studies of selected workings to validate potential;</li> <li>• District heating networks to utilised thermal resource;</li> </ul>
Wind power	Small farms or clusters of turbines (3-10 MWe) and single turbine sites (1-2 MWe) utilising wind resource greater than 6.0-6.5 m/s	53 – 179 MWe (variable by constraints). Farms in Oldham, Rochdale, Bolton, Wigan and Tameside. Clusters in Bury, Salford and Stockport. Single turbine sites in all districts.	<ul style="list-style-type: none"> <li>• Refinement and application of constraints in order to identify opportunity sites;</li> <li>• Agreed methodology for assessing landscape impact and cumulative impacts;</li> </ul>
Hydroelectric	Small head hydro sites (60-250kWe) utilising weirs and mill races with a head of more than 2 metres	622 kWe new capacity in Bury and Stockport, with additional unconfirmed potential in Bolton, Rochdale and Oldham and Ashton.	<ul style="list-style-type: none"> <li>• Detailed modelling and design of existing potential sites;</li> <li>• Scoping of watercourses for new sites in other districts.</li> </ul>