Programme Area: Smart Systems and Heat

Project: WP2 Manchester Local Area Energy Strategy

Title: Non-Domestic Decentralised Energy and District Heating Deployment, Bury

Abstract:

This study provides a desktop review of the EnergyPath Networks (EPN) Decentralised Energy and District Heating deployment in Bury, considering the connection of non-domestic buildings to heat networks. The EPN model develops heat network deployment across cluster area, with connections to both domestic and non-domestic buildings. This report provides general recommendations on nondomestic building connection to a heat network based on their use type and size.

Context:

The Spatial Energy Plan for Greater Manchester Combined Authority project was commissioned as part of the Energy Technologies Institute (ETI) Smart Systems and Heat Programme and undertaken through collaboration between the Greater Manchester Combined Authority and the Energy Systems Catapult. The study has consolidated the significant data and existing evidence relating to the local energy system to provide a platform for future energy planning in the region and the development of suitable policies within the emerging spatial planning framework for Greater Manchester.

Energy Systems Catapult

EPN District Energy & District Heating Deployment, Bury

Task 014 Report

FINAL | 5 September 2017

Job number 242342-00

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Contents

1 Executive summary

This study provides a desktop review of the EnergyPath Networks (EPN) Decentralised Energy and District Heating deployment in Bury. The study examines possible constraints and mitigations to the model outputs.

The study finds that all proposed pathways are considered viable at this stage. The feasibility of district heat pipework finds no significant barriers to deployment, however the energy centre placement for several clusters needs to be reviewed as there are conflicts with green belt land (cluster 2) and historic (listed) buildings (cluster 4).

The produced energy centre technologies are in general suitably sized and with operating strategies in line with industry best practice. There are minimal instances of erroneous capacity assumptions whereby optimising for plant lifecycles are not taken into account.

The deployment of heat pumps as a future low carbon generation is sound in principle, however relies on assumptions regarding the energy source availability which are considered optimistic given the information provided.

Proposed transmission links have been reviewed and no barriers have been found which would prevent the implementation between cluster 2 and 6. Additionally, a review of the generation capacity and demands has shown that two more transmission links could be investigated between clusters 3 and 4; and, 10 and 8. In the case of clusters 10 and 8, infrastructure boundaries (M60) may create more natural boundaries than those provided by the model, and it is suggested that the cluster boundaries in this case may benefit from reviewing.

2 Introduction

This report provides a desktop review of the EnergyPath Networks (EPN) Decentralised Energy and District Heating deployment in Bury.

The EPN model creates a heat network within a cluster area meeting the demands of local domestic and non-domestic buildings. Within each cluster, the model specifies a gas option and a low carbon technology option for an energy centre supplying the cluster. The model also determines if transmission links distributing heat between clusters are required.

This report assesses the selections made by the model in terms of:

- Energy centre technology suitability;
- Technical feasibility of installation and connection of proposed heat network;
- Implementation barriers and risks to the development of selected energy centres and heat networks in each cluster using a High/Medium/Low risk traffic light system;
- Key constraints including: highways, air quality, noise, visual impact;
- Indicative energy centre land take and flue height, and appropriateness of energy centre location;
- Values and risks of significant heat transmission between energy centres, and suitable additional transmission links not specified;
- The suitability and constraints to the use of large scale heat pumps to supply networks between 2020 and 2050.

The risk attributed to each barrier has been assessed based on the feasibility compared with an average/typical network. A low risk criteria is comparable to a typical heat network requirement and will not need any additional activity. A medium risk is one in which there are additional aspects which will need considering and which may hinder network development. A high risk indicated the network is not feasible and should not be progressed.

The energy centres have been placed according to the heat centre of gravity. This places the energy centre at the centre of the heat demand, which is the optimum location for supplying heat to all loads. It does not account for constraints such as visual impact, noise etc. which are assessed by this report.

The capacity of plant installed in each cluster has been inferred from the models output of the active capacity of each plant item over its lifetime. This report has relied on information supplied by others, and Arup accept no liability for any errors or omissions in this information. Databases of information for the constraints have been sourced and energy consultants have taken perceived major constraints into analysis. Our initial views from this high-level study are reported in each section. The study carried out was high-level and further detailed assessments may be required.

The scope excludes assessment of the financial viability of the proposed schemes.

3 Received information

Table 1: Received information

Name	Data format	Included	Arup notes
Clusters_v2	SHP	Cluster areas	Clusters 1 to 10 outlines. No cluster 9.
Bury_R2.1_CT90_Heat_Network_Data_for_Arup	XLSX	Network, connection and energy centre technology model outputs	Heat transmission, network demand, cluster centre X Y coordinates, domestic and non-domestic connections and timelines. Network lengths and energy centre technologies
Bury_R2.1_CT90_UPRNData_for Arup	XLSX	UPRN data on domestic connections	

4 Constraints considered

Table 2: Constraints considered

Item	Description	Source
Utilities	Major utilities in the area including gas distribution mains and electricity transmission infrastructure. Local utilities have not been assessed as this is too fine a resolution for the scope of this report.	National Grid through GMODIN, online mapping service, at mappinggm.org.uk
Roads	Major roads and the impact on them of local heat network/energy centre development.	Bing Maps
Railways	Railway lines in the local area, including local private railways and tramlines.	Bing Maps
Rivers and water bodies	Any water body within the local area.	Bing Maps
Flooding	Flood areas including, historic flood areas and risk of flooding from rivers and seas (rofras).	Data.gov.uk
Air quality	Air Quality Management Areas (AQMA)	Data.gov.uk
Noise	Noise Action Plan priority areas and local major road and rail noise pollution	Data.gov.uk
Planning	Listed buildings, historic landfill sites, common rights of way (CROW), rights of way, brownfield sites (pilot brownfield register)	Data.gov.uk
Conservation areas	Areas of outstanding natural beauty, Ramsar sites, Sites of Specific Scientific Interest, Special Areas of Conservation, Special Protection Areas, Local Nature Reserves, National Parks, Country Parks.	Data.gov.uk
Coal mining	Historic coal mining areas	http://mapapps2.bgs.ac.uk/coalauthority/

Utilities and other key planning layers can be found, and examined, at mappinggm.org.uk

5 Supporting maps

The following maps are included here to provide a visual reference and improve spatial understanding of the report content.

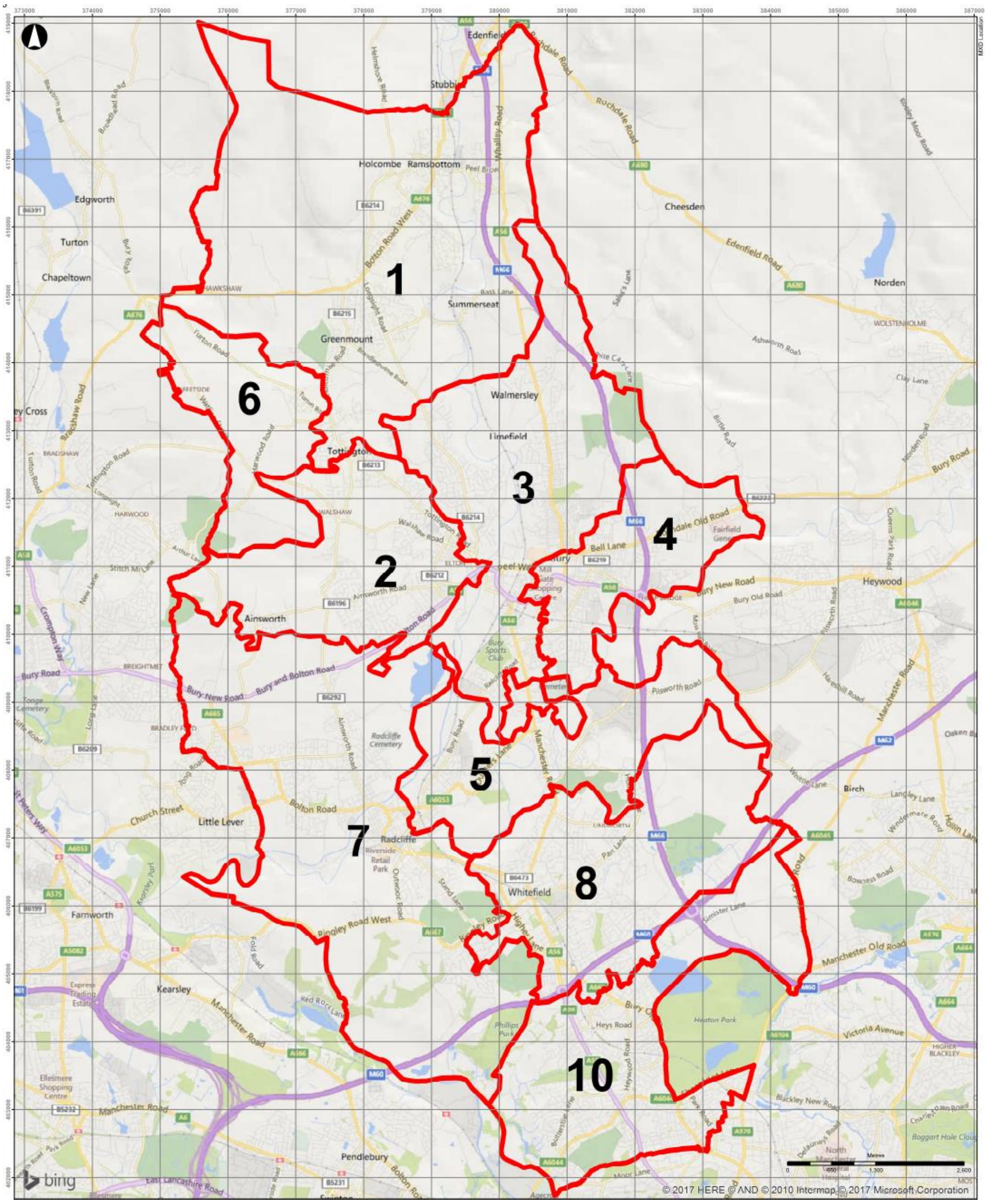

Figure 1 Cluster areas

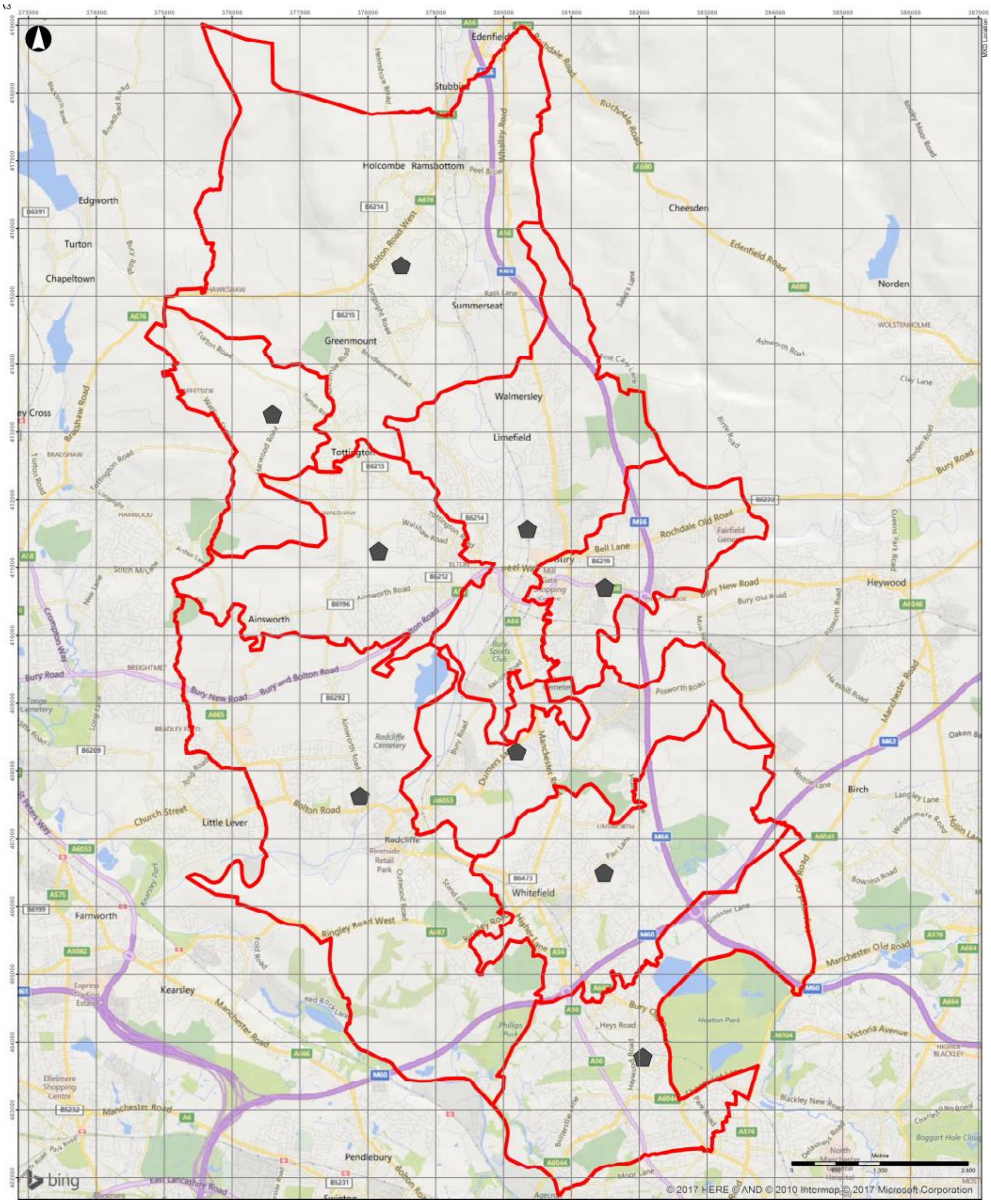

Figure 2 Energy centre locations

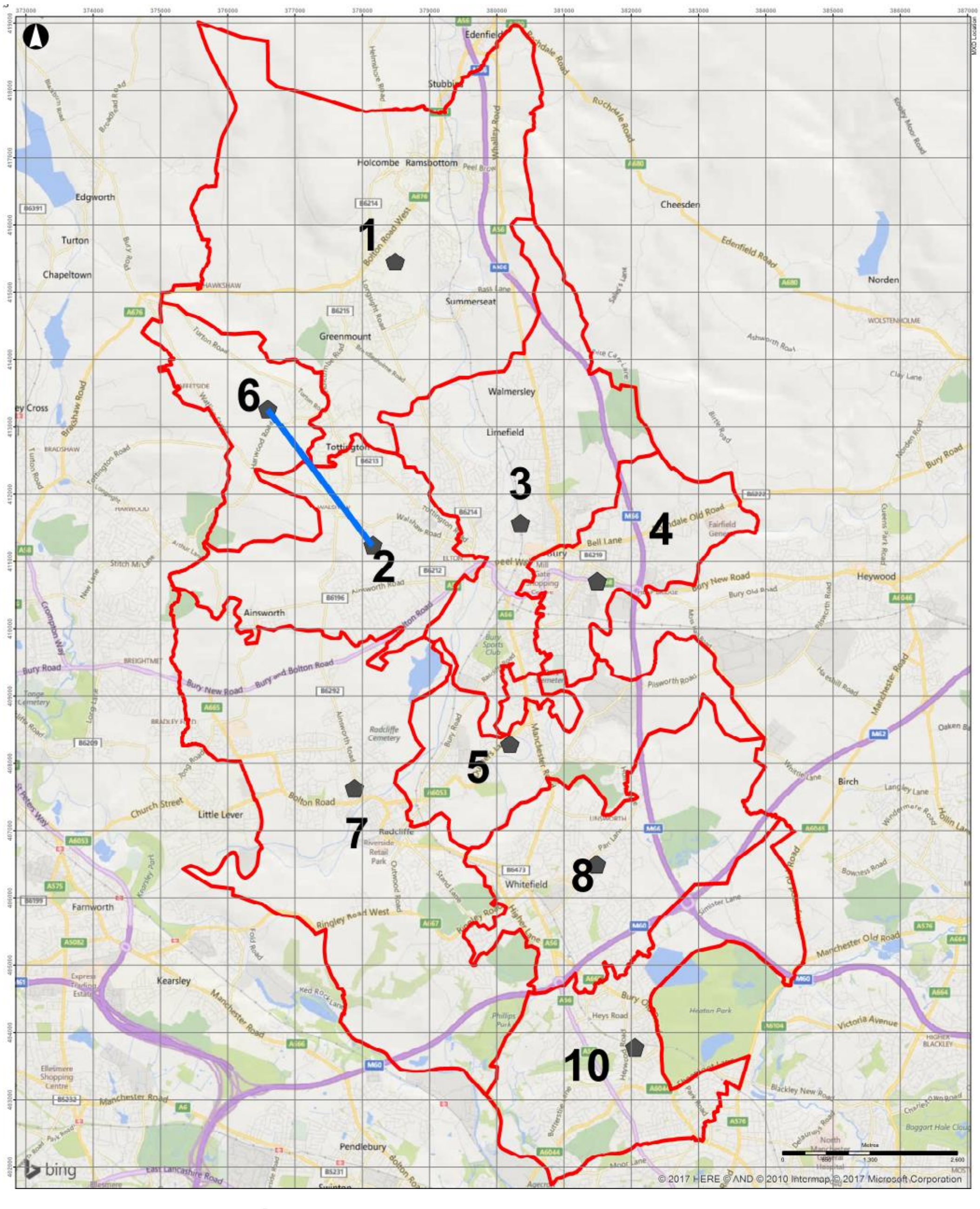

Figure 3 Transmission lines

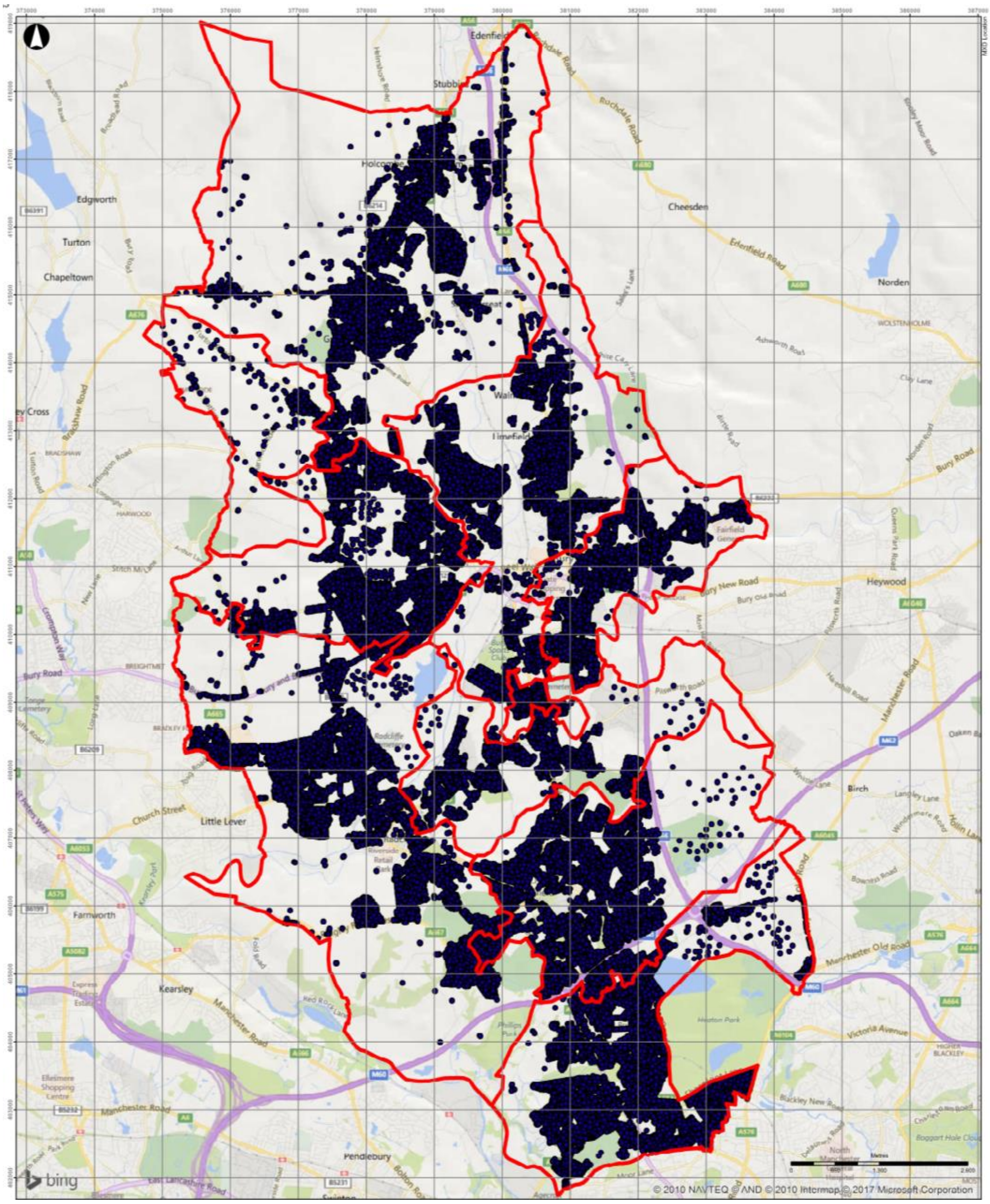

Figure 4 Domestic connections

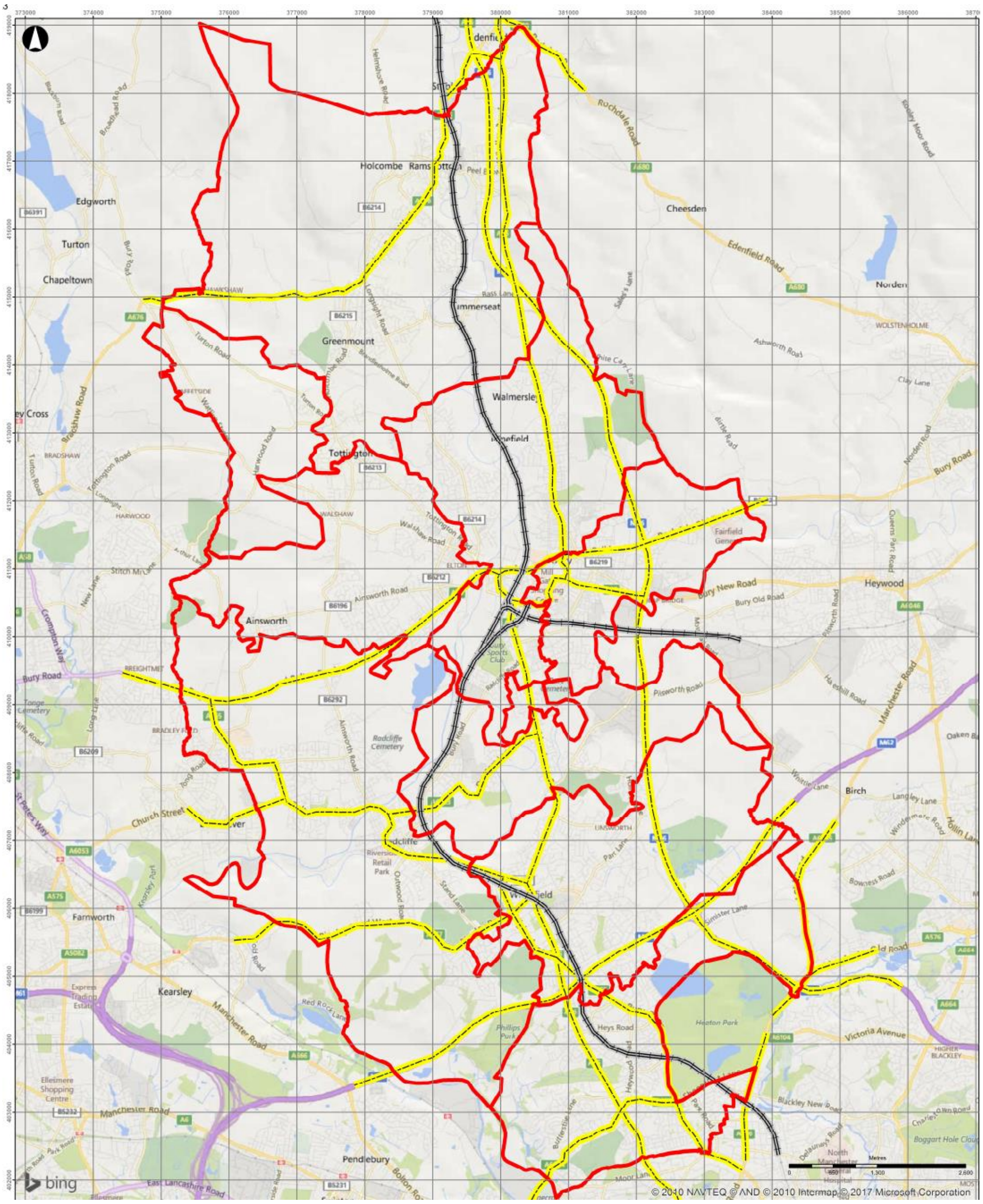

Figure 5 Major roads and railways

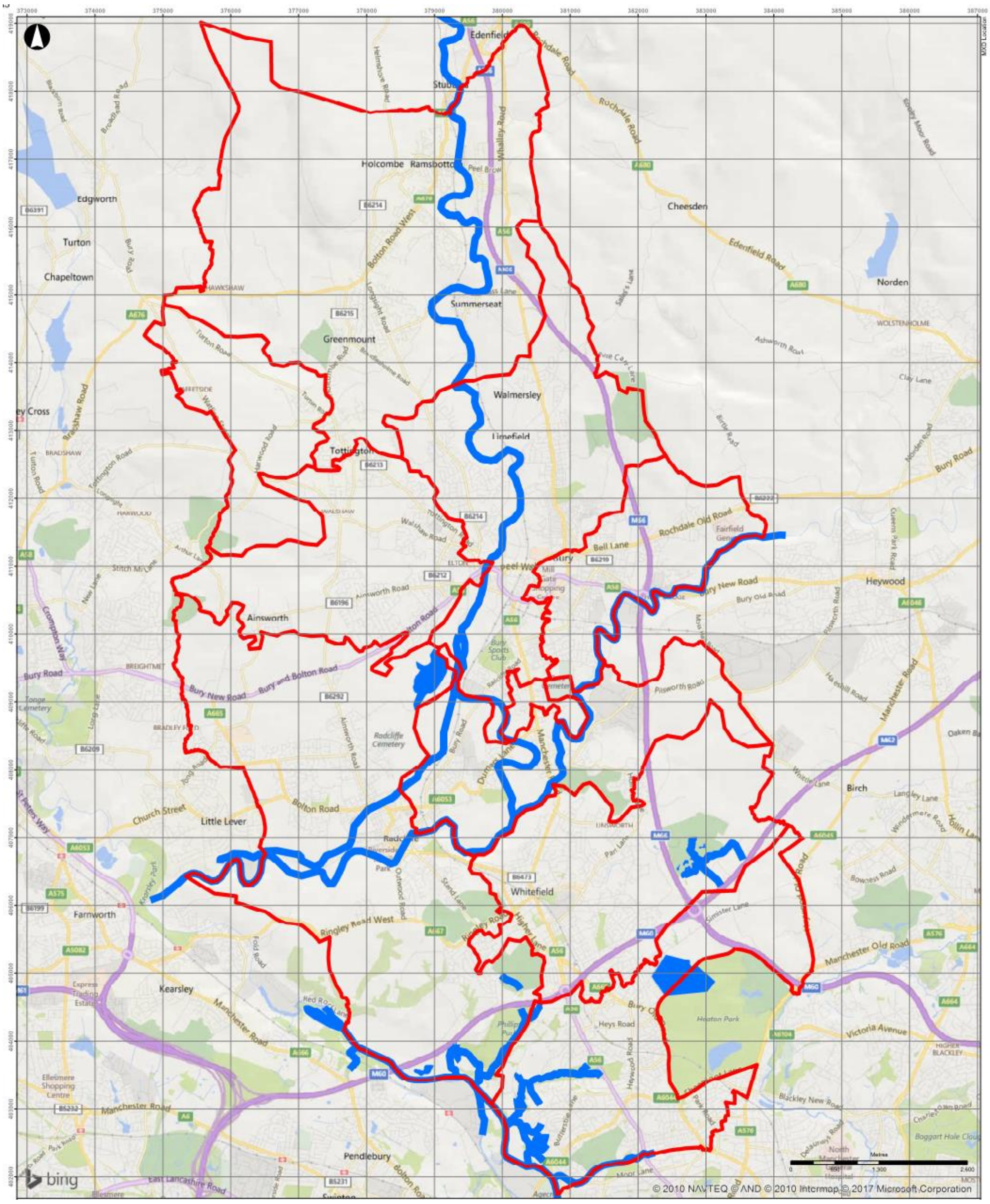

Figure 6 Rivers and water bodies

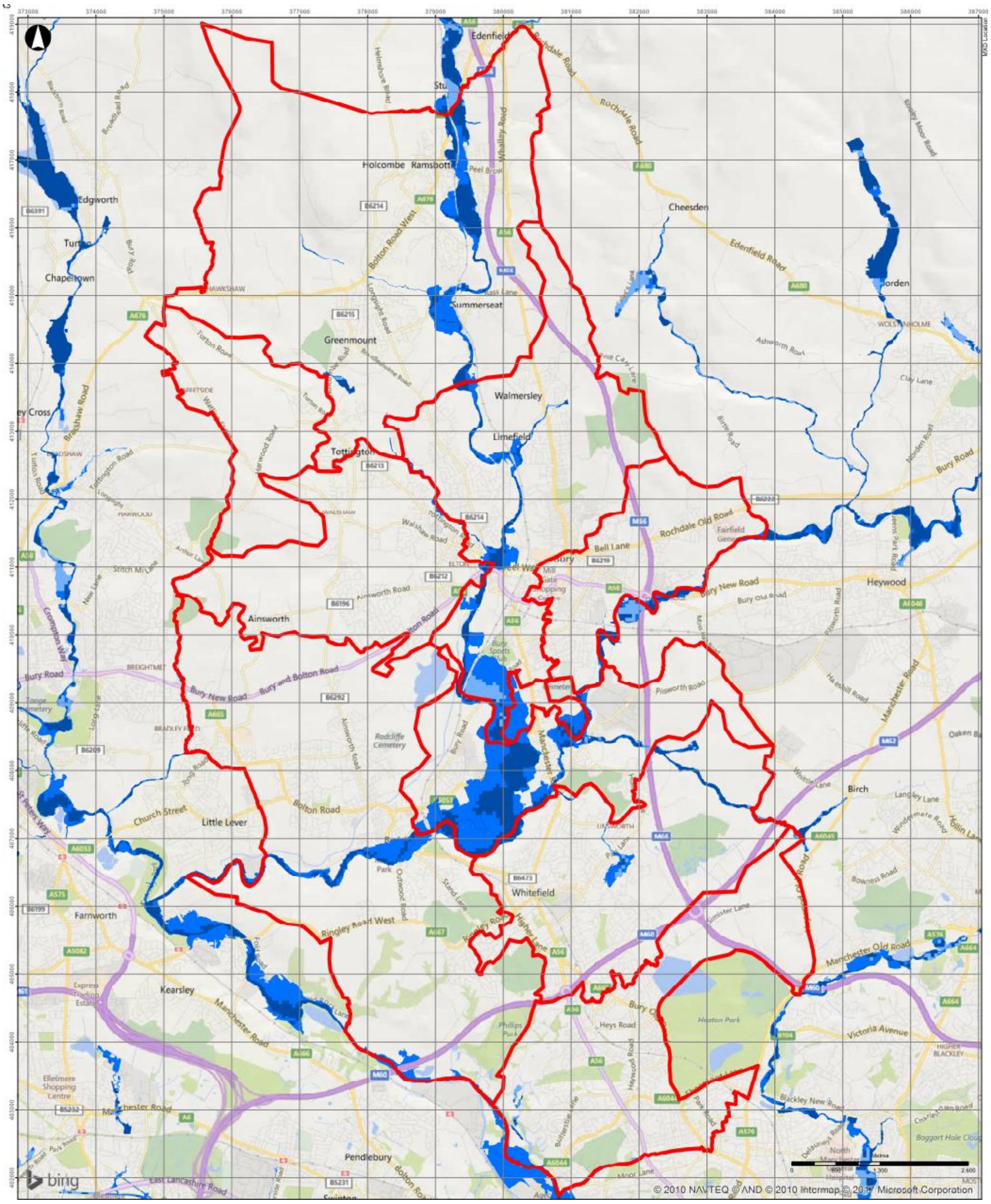

Figure 7 Flood risk map

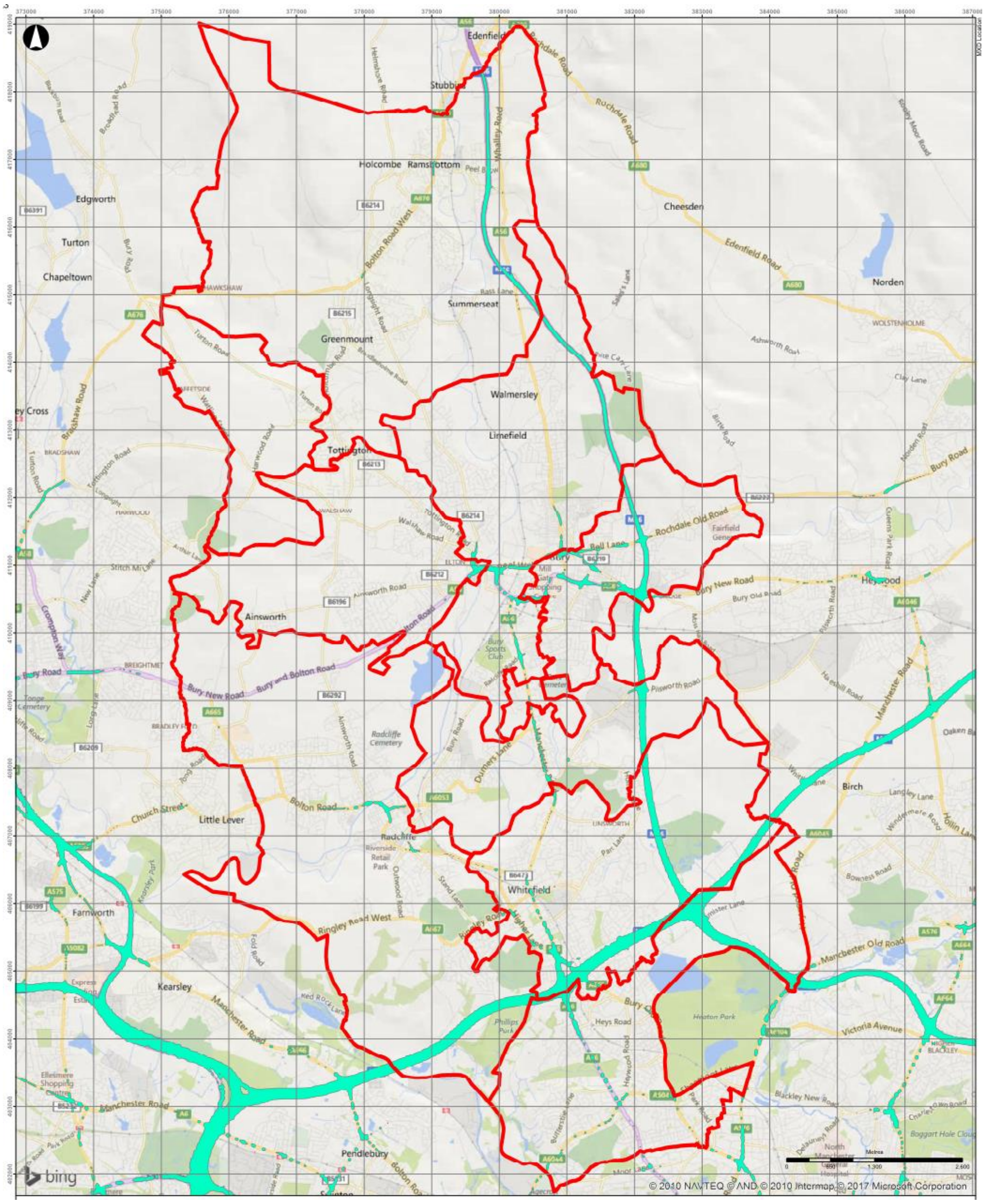

Figure 8 Air quality management areas (AQMAs)

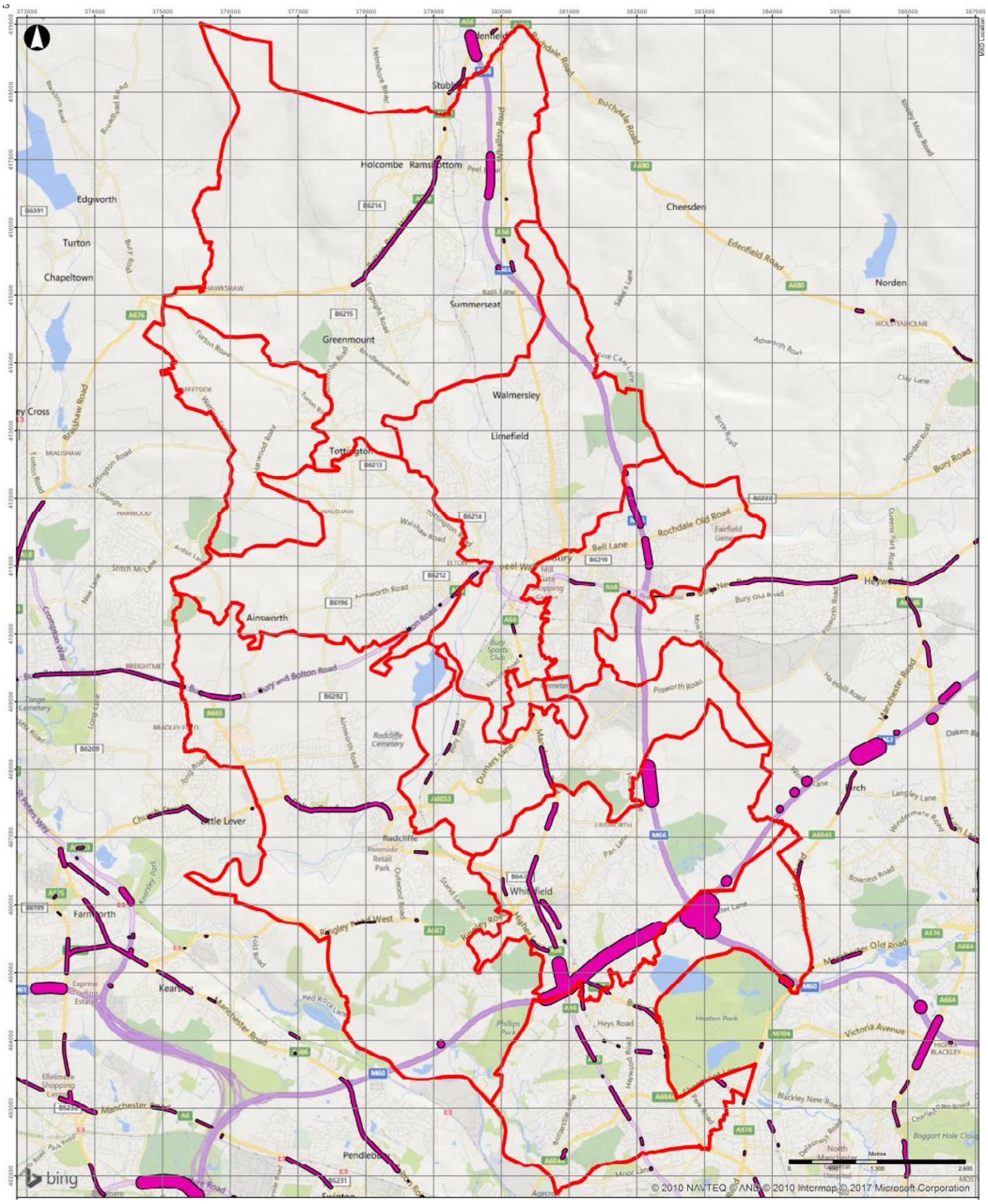

Figure 9 Noise action plan areas

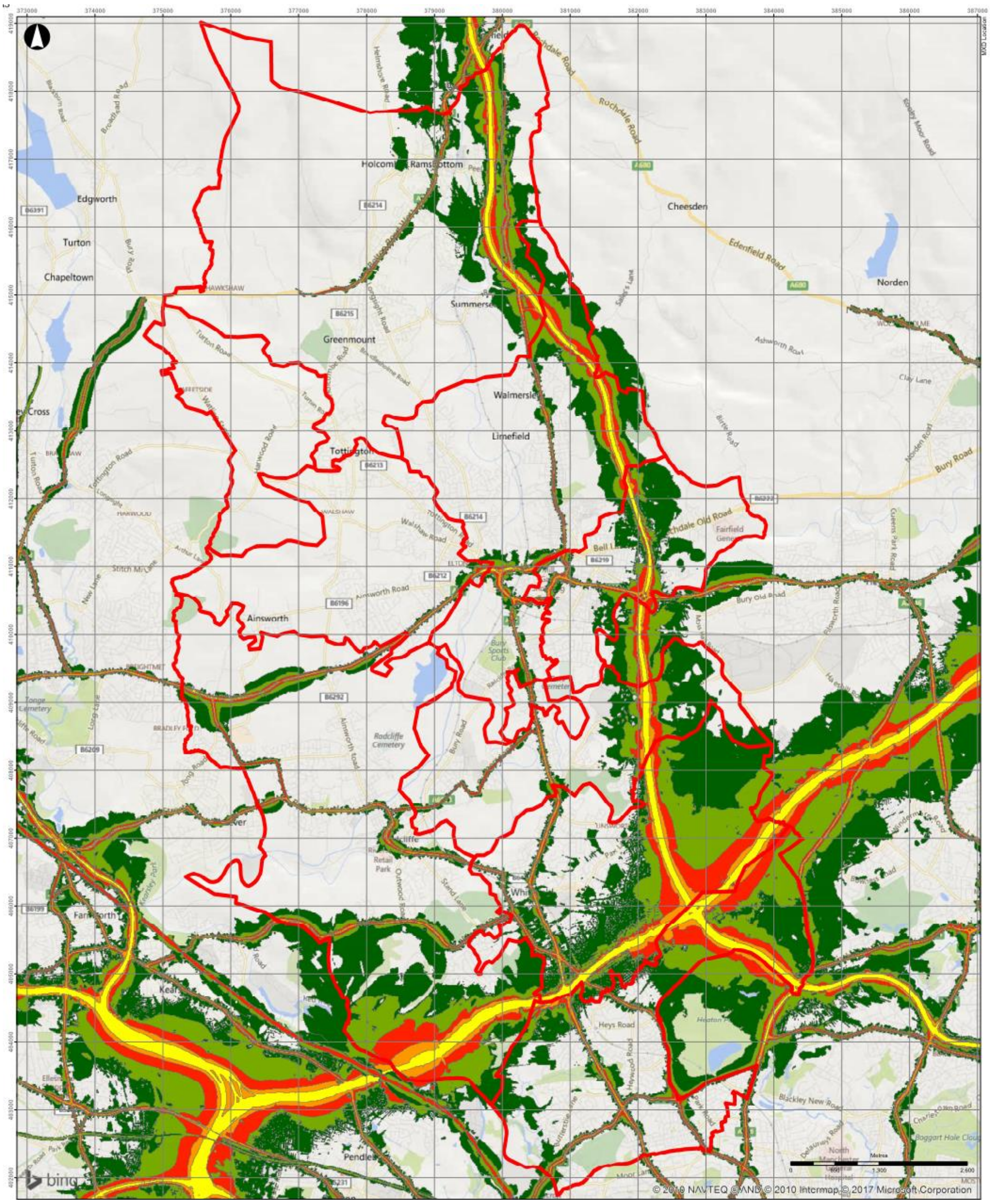

Figure 10 Noise pollution (roads and railways)

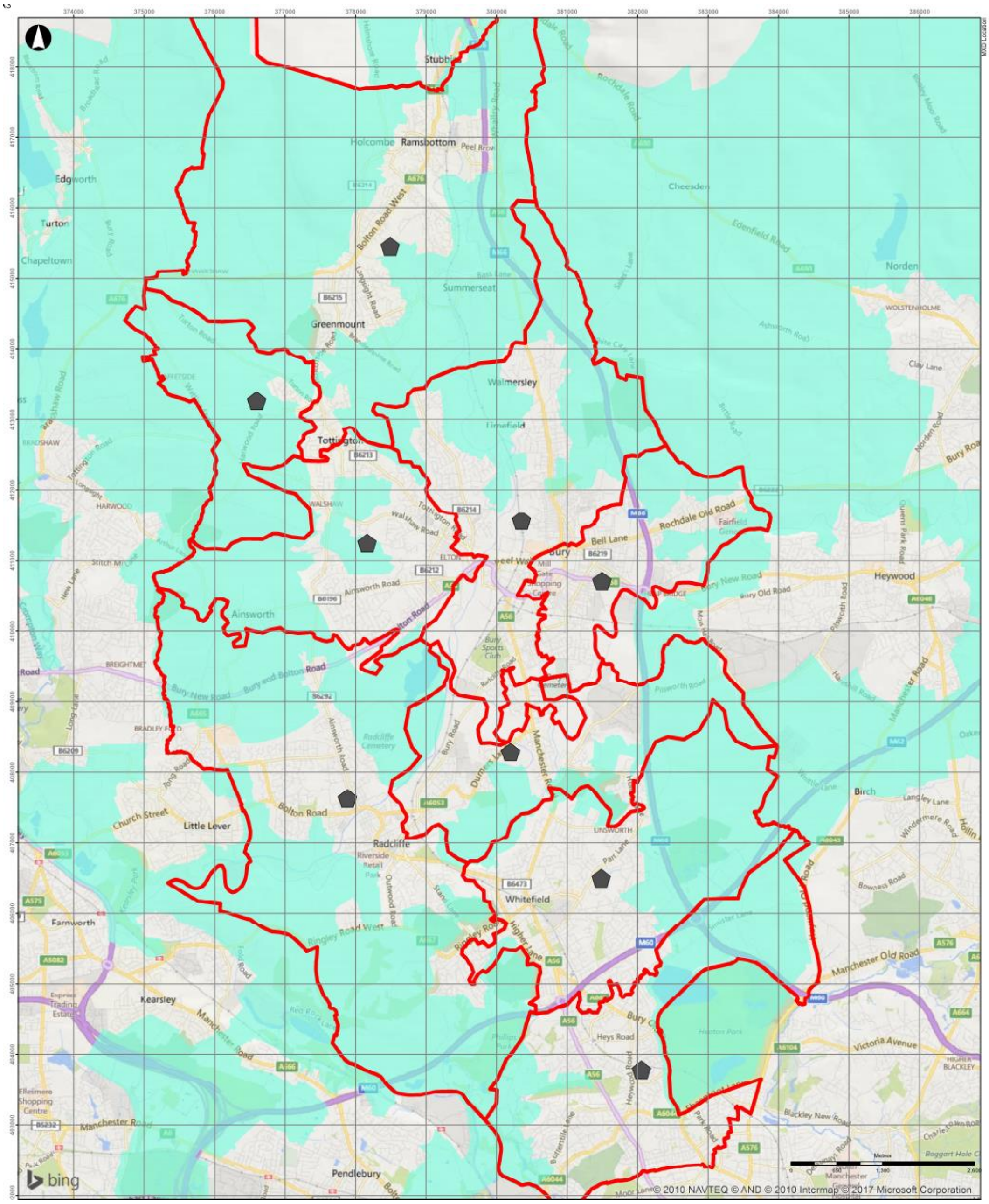

Figure 11 Green Belt land

6 Cluster overview

Table 3: Cluster overview and constraints risk

Cluster	1	2	3	4	5	6	7	8	9	10
Prime movers		Heat Pump Gas Boilers Gas Turbine CHP	Gas Boilers Heat Pump Gas Engine CHP Gas Turbine CHP	Heat Pump Gas Boilers Gas Turbine CHP	Heat Pump Gas Boilers Gas Engine CHP			Gas Boilers Heat Pump		Gas Boilers Heat Pump
Cluster area (km^2)	22	8	12	6	7	5	20	10		10
Network length (km)	141.7	96.7	124.6	86.4	62.6	19.6	146.7	117		124.2
Utilities		L	L	L	L	L		L		L
Roads		L	L	L	L	L		L		L
Railways		L	L	L	L	L		L		L
Rivers & water bodies		L	L	L	M	L		L		L
Flooding		L	M	L	M	L		L		L
Air quality		L	L	M	L	L		L		L
Noise		L	L	L	L	L		L		L
Planning & Conservation		M	L	M	L	L		L		L

7 Cluster reviews

7.1 Cluster 1

Cluster 1 is not required for analysis as part of this report. As such, there is no demand or energy centre specified for cluster 1. However there are a large number of domestic connections spread throughout cluster 1, and 141 km of heat pipe. This has not been analysed for Task 14.

7.2 Cluster 2

7.2.1 Technical feasibility and implementation barriers

Table 4: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	No gas distribution pipelines or electricity transmission lines (overhead) in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	The A58 runs across the south east boundary of the cluster. This is not a major constraint for development within cluster 2, as the majority of the domestic connections can be reached without crossing the A58. Should the A58 need to be crossed, closure of this road would cause local disruption and should be avoided/minimised if possible. Combining heat network installation with planned roadworks if available may reduce the impact on local traffic. Maintenance requirements should also be considered if installation in the area is required to minimise disruption over the long term.	The energy centre is not expected to have any impact on the roads in the local area. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L
Railways	No railways in the cluster.	No railways in the cluster.	L
Rivers & water bodies	There are four lakes to the south and west of the energy centre. These would require the heat network to be diverted around to reach connections however this would not be an extensive diversion.	There is a lake immediately south of the energy centre. This is not a constraint to the development of the energy centre and should the energy centre be placed here, a feasibility study should be commissioned to determine if the lake could be heat source for a water source heat pump.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Flooding	There is a low flood risk area in the centre of Bury (eastern edge of cluster) from the River Irwell. This is unlikely to affect the network development or operation. Any network infrastructure in this area (pumping stations, access points, valves etc.) should be water and weather proofed.	The energy centre is not in a flood risk zone.	L
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA in the centre of Bury (east of cluster) centred on the A58 junction with Crostons Rd. This is not close enough to the energy centre planned location to impact the development. The energy centre, and installed plant, should be managed to prevent any detrimental impacts to local air quality. The CHP may require flue gas treatment to reduce NOx emissions to acceptable levels The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area. This is not beyond the usual requirements of an energy centre design.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	The A58 (south/east edge of cluster) produces a high level of noise pollution, and is a noise planning action improvement area in several locations, including central Bury. This is not expected to impact the energy centre, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Planning & Conservation	Some listed buildings in the cluster (mainly in Ainsworth) which should have no effect on the distribution network, although may increase requirements at the point of connection, such as building entry.	The energy centre has been placed in Green Belt land and at the edge of a Site of Biological Importance (SBI). Locating a building within the Green Belt will increase planning requirements as national and local criteria must be met for the project to progress. This significantly increases the project risk. It is recommended that an alternate site be found if possible. In the immediate area, there is open green space (not designated), including a school playing field, which may be preferable as the energy centre site. The local buildings consist of low density residential, predominately semi-detached and detached houses, and a large school. A large energy centre with a high flue may cause local planning issues. The flue height would be minimal as there are no tall buildings in the area.	M

7.2.2 Energy centre

Table 5: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	13.78	17.31
	Annual [MWh]	47,700	59,900
Non Domestic	Peak [MW]	2.39	2.27
	Annual [MWh]	11,000	10,500

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

Table 6: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production
	MW	%	MWh	MW	%	MWh	MW	%	MWh	MW	%	MWh
Heat Pump (4x 4.2 MW)							5.0	29.13%	12,842	9.9	90.36%	78,192
Gas Boilers (20 MW)							11.7	2.96%	3,031	6.6	0.08%	46
Gas Turbine CHP (18 MW)							8.4	68.53%	50,281	6.1	0.04%	19

The energy centre will require approximately 700 m^2 footprint. The energy centre is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses at an estimated flue height of 10 m.

The energy centre plant appears to be well sized for the demand connected, with additional gas boiler capacity being included to meet peak demand and add resilience as backup plant. This is indicated by the low load factor on the boilers.

The load on the gas turbine is reduced in 2050 (load factor of 0.04%) allowing the heat pumps to provide low carbon heat to the network. Running the heat pumps off a low carbon source of electricity will therefore increase the carbon savings of the overall network.

It is not clear if thermal storage is included in the energy centre specification. If not, it is recommended that the thermal stores be investigated as they can significantly reduce the cost to produce heat by smoothing demand profiles and allow operational optimisation of generation. In most cases, this significantly outweighs the requirement for additional space and initial investment.

7.3 Cluster 3

7.3.1 Technical feasibility and implementation barriers

Table 7: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	No gas distribution pipelines or electricity transmission lines (overhead) in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	The M66 runs north-south along the east side of the cluster. There are minimal domestic connections across it from the energy centre, hence it is unlikely that a crossing will need to be found as the advantages of crossing (connection to buildings) are not expected to outweigh the disadvantages. There are however multiple underpasses in the area which could be utilised. The A56 runs parallel to the M66, and divides many of the domestic connections. It is highly likely that the pipework will have to cross this road at least once. Installation of this will disrupt traffic in the local area, as it is a major route to local towns. Maintenance requirements should also be considered if installation in the area is required to minimise disruption over the long term. The above is not in excess of standard network development.	The energy centre is not expected to have any impact on the roads in the local area which serve the adjacent industrial buildings. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Railways	East Lancashire railway runs north-south through the middle of the cluster. There are eight crossings: Baron St; A56; Bolton St; Peel Way; Tanpits Rd; Chamberhall St; Park Rd; and the Irwell footpath. These are all accessible crossing points which would not impact the railway. Of them, Park Rd appears preferable as it is immediately adjacent to the energy centre location. East Lancashire railway is a privately owned local railway, which does not have the same constraints and procedures as National Rail owned tracks. This means way leaves for construction and installation in the area and along the railway may be easier to obtain. The Metrolink tramline also enters the cluster in the south, ending in central Bury. This tramline has three bridges and one underpass so is not expected to provide a major constraint. Similarly, way leaves for the Metrolink are likely to be more accessible than for National Rail.	The railway line is immediately next to the energy centre location, but is not expected to impact the development in any way.	L
Rivers & water bodies	The river Irwell runs north-south parallel to the railway line. There are four road crossings in the cluster. There are multiple domestic connections across the river from the energy centre, so the river will need to be crossed. If a current crossing point cannot be used (e.g. not enough depth on the bridge), a bespoke pipe crossing could be designed.	The river is not in a position where it will affect the development or operation of the energy centre.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Flooding	There is a flood risk area in the centre and south of Bury from the River Irwell. Where possible, the trench routes should avoid high flood risk areas. Where they cannot, this is a minor risk during network installation, however unlikely to significantly affect the network development or operation. Any network infrastructure in this area (pumping stations, access points, valves etc) should be water and weather proofed. The trenches should be designed with adequate drainage.	The energy centre is not in a flood risk zone.	M
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA localised around Peel Way. This is not close enough to the energy centre planned location to impact the development. The energy centre, and installed plant, should be managed to prevent any detrimental impacts to local air quality. The CHP may require flue gas treatment to reduce NOx emissions to acceptable levels The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area. This is not beyond the usual requirements of an energy centre design.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	Peel Way, the A56 and M66 all produce a high level of noise pollution, and there are noise planning action improvement areas on both Peel Way and the M66. This is not expected to impact the energy centre, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Planning & Conservation	There are a group of listed buildings in the centre of Bury. While these may have only minimal effect on the distribution network if connected (increased requirements at the point of connection, such as building entry), they may indicated that the area is historic and there will be more congested and unknown utilities, making installation in the area more complex. There are several rights of way within the cluster. These will not impact the network development, as diversions can be put in place by the Council to mitigate any installation and trenching works required.	The energy centre is located in a low density industrial area north of Bury town centre. The local buildings consist of industrial units and warehouses. A large energy centre with a high flue is unlikely to cause local planning issues, and there would be minimal visual impact when situated with the surrounding buildings.	L

7.3.2 Energy Centre

Table 8: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	15.72	19.74
	Annual [MWh]	54,300	68,200
Non Domestic	Peak [MW]	4.58	4.36
	Annual [MWh]	21,150	20,200

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

Table 9: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production
	MW	%	MWh	MW	%	MWh	MW	%	MWh	MW	%	MWh
Gas Boilers (3x 10 MW)							11.3	0.09%	87	0.9	0.09%	7
Heat Pump (4x 4.2 MW)							1.1	29.13%	2,680	13.1	82.37%	94,625
Gas Boilers (1.4 MW)										1.2	0.09%	9
Gas Boilers (7 MW)										5.8	0.09%	45
Gas Engine CHP (2.3 MW)	1.8	95.00%	15,233	2.3	94.91%	19,022	2.3	95.00%	19,041	1.5	0.09%	12
Gas Turbine CHP (18 MW)				12.9	48.23%	54,396	11.1	68.68%	66,532	0.6	0.09%	5

The energy centre will require approximately 600 m2 footprint. The energy centre is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses. This would give an estimated total flue height of 10 m.

Although no heat load is indicated in 2020 and 2030, plant is installed during these time periods to generate electricity locally. No electrical load was provided for analysis so it is assumed that the electricity is exported to the local grid, as such it is not possible to comment on the sizing of the generation installed for this purpose.

The energy centre prime movers provide a large proportion of demand by CHP and the heat pump (2040) and the heat pump alone (2040). The load factor of 82% on the heat pump in 2050 shows the energy centre will be outputting lower carbon heat (assuming the heat pump is running off low carbon electricity). Total peak capacity in 2050 is 24.1 MW, the available peak capacity is 23.1 MW. This is an oversimplification as it assumes the peak domestic and non-domestic demand occur at the same point, however it highlights there may be a need to further investigate the capacity installed.

The low load factor on gas boilers (0.09%) shows they are being used as resilience/backup plant which is the recommended operational strategy. However installing 5.8 MW of gas boilers in 2050 which have a 0.09% load factor should be reviewed as this is capacity which could be absorbed by the boilers currently in situ. The 11.3 MW boiler installed in 2040 is removed despite boilers having a lifetime of 25 years. Keeping this boiler as the backup plant would minimising the requirement for new boilers, and extend the asset utilisation of the plant already installed.

It is considered uneconomical to install a 600 kW gas turbine, with such a low load factor in 2050. It is recommended that the gas engine CHP capacity available to the model is increased to allow the capacity allocated to the gas turbine to be absorbed into a larger sized gas engine.

CHP gas engine is equal to the upper limit set by the model in 2030 and 2040. It is recommended that this limit be increased to ensure this is the optimum size for the CHP. The gas engine CHP runs with very high load factor from 2020 to 2040 showing it is being well utilised.

It is not clear if thermal storage is included in the energy centre specification. If not, it is recommended that the thermal stores be investigated as they can significantly reduce the cost to produce heat by smoothing demand profiles and allow operational optimisation of generation, in particular when used alongside gas CHP. In most cases, this significantly outweighs the requirement for additional space and initial investment. Seasonal storage may also improve the annual performance of the energy centre depending on the type and availability of the heat pump energy source.

7.4 Cluster 4

7.4.1 Technical feasibility and implementation barriers

Table 10: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	No gas distribution pipelines or electricity transmission lines (overhead) in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	The M66 runs north-south though the middle of the cluster. There are some domestic connections, a retail/industrial area and Fairfield General Hospital across it from the energy centre, so a crossing will need to be found. There are underpasses from the A58 and B6222, and at Ferngrove in the north. Of these the B6222 is likely to be the most suitable as it is located in the middle of the cluster so provides an effective spine route. The underpass here is wide and construction is not expected to disrupt traffic. The B6222 and A58 run through the cluster east-west, installation in these areas may disrupt traffic as they are major routes into central Bury. Maintenance requirements should also be considered to minimise disruption over the long term. Other roads in the area are minor residential roads and installation will only cause minor local disruption.	The energy centre is not expected to have any impact on the roads in the local area. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Railways	East Lancashire railway runs east-west through the south of the cluster. There are two bridges crossing this railway at Alfred St and Market St. If neither are capable of supporting the heat network trenching, then a bespoke crossing may be required to reach connections in the south of the cluster. East Lancashire railway is a privately owned local railway, which does not have the same constraints and procedures as National Rail owned tracks. This means way leaves for construction and installation in the area and along the railway may be easier to obtain.	The railway line is not expected to impact the energy centre development in any way.	L
Rivers & water bodies	The River Roch runs along the south east boundary of the cluster. As such it does not need to be crossed to reach any connections.	The river is not in a position where it will affect the development or operation of the energy centre.	L
Flooding	The River Roch has a flood risk area, although this is on the opposite side of the bank to the connections so is not expected to affect the network.	The energy centre is not in a flood risk zone.	L
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA around junction 2 on the M66, and on the A58 at the location of the energy centre. This will increase the planning risk associated with the energy centre as although heat pumps are not likely to impact the air quality, a 12.9 MW gas turbine and 13.2 MW gas boiler will reduce air quality in the area. This may prevent development of the energy centre at this location. The energy centre, and installed plant, will need to be designed to prevent any detrimental impacts to local air quality and will require flue gas treatment to reduce NOx emissions to acceptable levels. The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area. With the	M

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
		AQMA this may be beyond the usual requirements of an energy centre design.	
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	The M66 and A58 produce a high level of noise pollution, and there are noise planning action improvement areas on both. This is not expected to impact the energy centre, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L
Planning & Conservation	No significant planning or conservation constraints could be found which would affect network development and installation.	The energy centre is located on/next to the Parish Church of Saint Thomas which is a listed building. The location of the energy centre should be adjusted as this will prevent the energy centre being developed. Adjacent to the site is Openshaw park with a bowls green, which may be more suitable. However, local brownfield land would be preferable as locating the energy centre on a local park may reduce public support of the scheme. The visual impact of the energy centre may be a planning constraint as the area is heavily residential. The design and location of the energy centre and it's flue will need to be managed carefully with local community groups being engaged with at every stage of the process.	M

7.4.2 Energy Centre

Table 11: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	14.55	18.27
	Annual [MWh]	50,200	63,000
Non Domestic	Peak [MW]	4.07	3.92
	Annual [MWh]	18,800	18,100

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

Table 12: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production
	MW	%	MWh	MW	%	MWh	MW	%	MWh	MW	%	MWh
Gas Boilers (3x 10 MW)							13.2	2.22%	2,562	8.5	0.14%	103
Heat Pump (4x 4.2 MW)							5.9	29.13%	15,078	10.6	91.20%	84,920
Gas Turbine CHP (18 MW)				12.9	68.64%	77,419	9.3	67.45%	54,802	5.2	0.03%	14

The energy centre will require approximately 500 m2 footprint. The church is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses. This would give an estimated total flue height of 13 m. This depends heavily on the proximity of the energy centre to the church, and as recommended above, an alternate energy centre location should be found. Hence the flue height may be less. If the energy centre were the tallest building in the immediate area, the flue height would be reduced to approximately 10 m. This may still cause local planning issues if the location is still in a heavily residential area.

The low load factor on the gas boilers (2.22% in 2040 and 0.14% in 2050) shows that they are being used as resilience/backup plant which is the recommended operational strategy. As the heat pump load increases in 2050, this reduces the load on the gas turbine, and therefore (assuming low carbon, sustainable electricity input) means the heat output of the energy centre will be more sustainable and have a lower carbon content.

The life expectancy of a gas turbine is ordinarily considered to be 15 years to 20 years. The turbine installed in 2030 is replaced in 2040, which is again replaced in 2050. With a high asset utilisation (as seen in through 2030 and 2040) it is expected that the turbine would require its major overhaul after 10 years at which point it may be economical to replace with a smaller capacity. Hence the regular replacement of the turbine specified by the model is considered a reasonable operational procedure.

It is not clear if thermal storage is included in the energy centre specification. If not, it is recommended that the thermal stores be investigated as they can significantly reduce the cost to produce heat by smoothing demand profiles and allow operational optimisation of generation, in particular when used alongside gas CHP. In most cases, this significantly outweighs the requirement for additional space and initial investment. Seasonal storage may also improve the annual performance of the energy centre depending on the type and availability of the heat pump energy source.

7.5 Cluster 5

Table 13: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	No gas distribution pipelines or electricity transmission lines (overhead) in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	Multiple roads bisect the cluster: The M66, however there is only a landfill site across the M66 from the energy centre, so heat pipe is not expected to be required. If needed, Pilsworth road underpass provides a convenient crossing, as does Aviation Rd underpass. The A56, which passes through the middle of the cluster. This is the main local road towards Manchester from central Bury. Installation of pipe along or across this road is likely to cause significant local disruption and diversions may need to be put in place. Maintenance requirements should also be considered to minimise disruption over the long term. The A6053, crossing the Irwell next to the energy centre location, is a relatively minor road and the heat network installation and maintenance is likely to only impact local businesses.	The energy centre is not expected to have any impact on the roads in the local area. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Railways	East Lancashire railway runs along the eastern edge of the cluster. This is unlikely to cause problems for the heat network development as the network is not expected to need to cross the railway. East Lancashire railway is a privately owned local railway, which does not have the same constraints and procedures as National Rail owned tracks. This means way leaves for construction and installation in the area and along the railway may be easier to obtain.	The railway line is not expected to impact the energy centre development in any way.	L
Rivers & water bodies	The River Irwell and the Roch both pass through the cluster centrally. The Irwell is a large river with the energy centre located on its eastern bank. The A6053 bridge is situated in an optimum location for connection to the domestic and non-domestic buildings on the opposite side and initially appears to be sufficient to allow for installation of buried pipes. The Roch is smaller, however there are only two crossing points in the cluster, The A56 at the southern edge, and a small footbridge in the centre which is not large enough to support large heat network pipes. Either a bespoke crossing will be required, or the network pipe will need to take a sub optimal route. Both options will increase the infrastructure requirements of the cluster network.	The river is next to the energy centre, but will not affect the development or operation of the energy centre.	M
Flooding	Much of the east of the cluster is a flood risk zone. The network trenching should be designed to allow for appropriate drainage. Any network infrastructure (pumping stations, access points, valves etc) should be water and weather proofed.	The energy centre is in a high flood risk zone so should be designed to be flood resistant. This could involve mounting plant on plinths or increasing the height of the Energy Centre base. Alternatively another location could be found which is less susceptible to flooding.	M

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA localised on the M66, and the A56. These are not near enough to the energy centre to constrain the development. The energy centre, and installed plant, will need to be designed to prevent any detrimental impacts to local air quality and will require flue gas treatment to reduce NOx emissions to acceptable levels. The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	The M66 and A56 produce a high level of noise pollution, and there is a noise planning action improvement area on the A56 in the cluster. However this is not expected to impact the energy centre, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L
Planning & Conservation	Local nature reserve (including a Site of Biological Importance) which the pipe route should avoid. However this is not expected to require a significant diversion as there are not connections on both sides of it and Croft Ln can be used as a route around the site. Large sections of the cluster are Green Belt areas, which may impact the planning requirements for any pumping stations or access points should they require external structures.	The energy centre is located in a new residential development, with terraced housing surrounding on all sides. A large energy centre with a high flue may cause local planning issues, and the visual impact of the energy centre will need to be managed to be in keeping with the area.	L

7.5.1 Energy Centre

Table 14: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	9.06	11.37
	Annual [MWh]	31,000	28,900
Non Domestic	Peak [MW]	2.40	2.32
	Annual [MWh]	11,100	10,700

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

Table 15: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity MW	Load Factor %	Annual Production MWh	Capacity MW	Load Factor %	Annual Production MWh	Capacity MW	Load Factor %	Annual Production MWh	Capacity MW	Load Factor %	Annual Production MWh
Heat Pump (4x 4.2 MW)										6.6	90.57%	52,722
Gas Boilers (10 MW)							7.2	0.06%	38	5.0	0.08%	35
Gas Engine CHP (7 MW)	5.6	95.00%	46,643	7.0	94.97%	58,288	5.9	88.11%	45,472	3.5	0.03%	10

The energy centre will require approximately 400 m2 footprint. The energy centre is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses. This would give an estimated total flue height of 10 m.

The plant installed is appropriate for the heat demand of the cluster. The heat pumps produce more heat in 2050 which indicates that the energy centre and network are moving to a lower carbon heat supply. The boilers low load factor show they are being used as resilience/backup plant which is the recommended operational strategy.

In 2030 the gas CHP engine capacity is at the boundary limit. In future model runs it is recommended that the boundary limit be increased to ensure that this is the optimum selection and not constrained by this assumption.

It is not clear if thermal storage is included in the energy centre specification. If not, it is recommended that the thermal stores be investigated as they can significantly reduce the cost to produce heat by smoothing demand profiles and allow operational optimisation of generation, in particular when used alongside gas CHP. In most cases, this significantly outweighs the requirement for additional space and initial investment. Seasonal storage may also improve the annual performance of the energy centre depending on the type and availability of the heat pump energy source.

7.6 Cluster 6

Table 16: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	An electricity transmission line crosses the cluster. This should not constrain the network development. No gas distribution pipelines are in the cluster.	No energy centre in the cluster.	L
Roads	There are no major roads in the cluster. Installation will only cause minor local disruption.	No energy centre in the cluster.	L
Railways	There are no railways in the cluster.	No energy centre in the cluster.	L
Rivers & water bodies	There are some small lakes/ponds in the area, which are not expected to cause any significant route diversions or planning constraints.	No energy centre in the cluster.	L
Flooding	No part of the cluster is at a risk from flooding.	No energy centre in the cluster.	L
Air quality	The network is not expected to have any impact on air quality in the area.	No energy centre in the cluster.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	No energy centre in the cluster.	L
Planning & Conservation	There are some Sites of Biological Importance in the cluster. These are not expected to cause problems to network development as they are centred on lakes/ponds and do not conflict with likely network routes to connections. No other significant planning or conservation constraints could be found which would affect network development and installation.	No energy centre in the cluster.	L

Table 17: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	0.58	0.72
	Annual [MWh]	1,800	2,200
Non Domestic	Peak [MW]	0.38	0.36
	Annual [MWh]	1,700	1,700

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

There is no energy centre in this cluster. The demand is met through a transmission line from cluster 2. This is assessed in a subsequent section.

7.7 Cluster 7

Cluster 7 is not required for analysis as part of this report. As such, there is no demand or energy centre specified for cluster 7. However there are a large number of domestic connections spread throughout cluster 7, and 146 km of heat pipe. This has not been analysed for Task 14.

7.8 Cluster 8

Table 18: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	An electricity transmission line runs along the southern border. This should not constrain the network development. No gas distribution pipelines are in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	The M60 runs east-west across the south of the cluster. In the south east of the cluster is the junction of the M66, M60 and M62. The A56 and the M66 cross the cluster north-south on the west and east sides respectively. The M62 is not a constraint to development as it is on the cluster boundary so does not need to be crossed. The M66 also has very few domestic connections across from the energy centre site. As the area is predominately a golf course, there are unlikely to be a significant number of non-domestic connections across the M66 either. Hence a small bore pipe is most likely to be required. There are two bridges over the M66. These would need further investigation to determine their capacity to carry district heating pipework. There are a large number of domestic connections across the M60 from the energy centre. There are currently six crossing points: a railway line; the A56 roundabout, a pedestrian footbridge and two minor road bridges. Any may be possible to utilise. It should be considered if the area to the south of the M60 could be absorbed within cluster 10 as there are no major barriers to prevent connection to this area from cluster 10. It is recommended that the cluster boundaries be reassessed.	The energy centre is not expected to have any impact on the roads in the local area. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
	The A56 is the main local road towards Manchester from central Bury. Installation of pipe along or across this road is likely to cause significant local disruption and diversions may need to be put in place. Maintenance requirements should also be considered to minimise disruption over the long term.		
Railways	East Lancashire railway runs north-south through the west of the cluster. There are two bridges crossing this railway at Alfred St and Market St. There are multiple underpasses which could be used to cross the railway at regular short intervals along its length. The railway is also raised above ground level, so the trench and pipe could be extended through the underpasses easily. East Lancashire railway is a privately owned local railway, which does not have the same constraints and procedures as National Rail owned tracks. This means way leaves for construction and installation in the area and along the railway may be easier to obtain.	The railway line is not expected to impact the energy centre development in any way.	L
Rivers & water bodies	Parr Brook meanders through the centre of the cluster. The brook is small and would not create any major issues for network installation.	The river is not in a position where it will affect the development or operation of the energy centre.	L
Flooding	Parr Brook has a flood risk area. Any district heat trenching should be designed to allow for appropriate drainage. Any network infrastructure in this area (pumping stations, access points, valves etc) should be water and weather proofed.	The energy centre is in a flood risk zone from Parr Brook so should be designed to be flood resistant. This could involve mounting plant on plinths or increasing the height of the Energy Centre base. Alternatively another location could be found which is less susceptible to flooding.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA over all areas of the motorways and along parts of the A56. The energy centre is not in a location where it will be affected by these. The energy centre, and installed plant, will need to be designed to prevent any detrimental impacts to local air quality and will require flue gas treatment to reduce NOx emissions to acceptable levels. The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	The major roads in the cluster produce a high level of noise pollution, and there are noise planning action improvement areas on large sections of all the roads. This is not expected to impact the energy centre, as the energy centre is located at the edge of the area of influence, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L
Planning & Conservation	A collection of listed buildings in Whitefield. These may have only minimal effect on the distribution network if connected (increased requirements at the point of connection, such as building entry), they may indicated that the area is historic and there will be more congested and unknown utilities, making installation in the area more complex. No other significant planning or conservation constraints could be found which would affect network development and installation.	The energy centre is placed in an area of residential housing, close to Heaton Park. A large energy centre with a high flue may create local planning issues, and the visual impact of the energy centre will need to be managed to be in keeping with the area. A more suitable location may be an area of brownfield and further along the railway line on Rectory Lane. .	L

7.8.1 Energy Centre

Table 19: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	0.74	0.92
	Annual [MWh]	2,500	3,100
Non Domestic	Peak [MW]	0.68	0.65
	Annual [MWh]	3,100	3,000

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

The annual demand is very small for such a large cluster area. This indicates that the heat density of the buildings may not be sufficient to be viable for a heat network.

Table 20: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production
	MW	%	MWh	MW	%	MWh	MW	%	MWh	MW	%	MWh
Gas Boilers (3x 10 MW)							1.0	51.86%	4,586	1.3	0.07%	8
Heat Pump (4x 4.2 MW)							0.6	29.13%	1,622	0.8	93.69%	6,712

The energy centre will require approximately 150 m2 footprint. The energy centre is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses. This would give an estimated total flue height of 10 m.

With a load factor of 0.07% it is not clear why the gas boilers have been increased in size, as a lower carbon source would be preferable, for example further increasing the size of the heat pumps.

7.9 Cluster 9

Cluster 9 does not exist and is not required for analysis as part of this report.

7.10 Cluster 10

Table 21: Constraints: Distribution network and energy centre

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Utilities	An electricity transmission line runs along the northern border. This should not constrain the network development. No gas distribution pipelines are in the cluster.	No impact. Utilities supply to the energy centre should be available from the local supply to the area.	L
Roads	A56, Bury Old Rd, A6044 and the M60 all bisect the cluster. Of these the M60 is the largest, but cuts relatively few connections off from the main cluster area, so is unlikely to be a significant barrier to implementation despite the size of the road. The A56 and Bury Old Rd are main local roads and installation of pipe along or across these roads are likely to cause significant local disruption and diversions may need to be put in place. Maintenance requirements should also be considered to minimise disruption over the long term. All other roads are minor, or only affect the cluster boundary, so would not be a cause for anything greater than localised disruption to traffic.	The energy centre is not expected to have any impact on the roads in the local area. There may be some minor disruption during construction and delivery of major plant, as would be usual for any energy centre development.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Railways	East Lancashire railway runs north-south through the west of the cluster. There are multiple bridges and underpasses, before the railway runs underneath Heaton Park, which could be used to cross the railway at regular short intervals along its length. On the other side of Heaton Park in the south-east of the cluster there are multiple crossing points which could be utilised. Therefore the network route is unlikely to need major diversions or significant additional infrastructure to reach both sides of the railway. East Lancashire railway is a privately owned local railway, which does not have the same constraints and procedures as National Rail owned tracks. This means way leaves for construction and installation in the area and along the railway may be easier to obtain.	The railway line is not expected to impact the energy centre development in any way.	L
Rivers & water bodies	There are some minor unnamed waterways in the west of the cluster. Not large enough to require significant infrastructure to cross. In the north, Heaton Park Reservoir cuts off the north-east of the cluster, and the network route will need to divert round this. However the connections in this area are along the side of the reservoir, so this is the most viable route for the trench regardless.	The waterways and reservoir are not positioned where they will affect the development or operation of the energy centre.	L
Flooding	There are no flood risk areas in the cluster.	There are no flood risk areas in the cluster.	L

Item	Comments/ Mitigation: Distribution Network	Comments/ Mitigation: Energy Centre	H/M/L risk
Air quality	The network is not expected to have any impact on air quality in the area.	There is an AQMA along all the motorways in the cluster. These are localised on the roads and so will not affect the energy centre development. The energy centre, and installed plant, will need to be designed to prevent any detrimental impacts to local air quality and will require flue gas treatment to reduce NOx emissions to acceptable levels. The flue will need to be designed following a dispersion modelling to emit at a height which will not impact the immediate area.	L
Noise	The network installation may cause some localised noise pollution during the trenching and pipe installation. This is not beyond the usual pipework installation and should be managed responsibly as any local infrastructure project.	The M66 and A58 produce a high level of noise pollution, and there are noise planning action improvement areas on both. This is not expected to impact the energy centre, nor should the energy centre installed plant cause noise which cannot be managed through usual procedures and insulation.	L
Planning & Conservation	Large sections of the cluster are Green Belt areas, which may impact the planning requirements for any pumping stations or access points should they require external structures. No other significant planning or conservation constraints could be found which would affect network development and installation.	The energy centre is located on/next to the Parish Church of Saint Thomas which is a listed building. The location of the energy centre should be adjusted as this will prevent the energy centre being developed. Adjacent to the site is Openshaw park with a bowls green, which may be more suitable. However, brownfield land would be preferable as locating the energy centre on a local park will reduce public buy in to the scheme.	L

7.10.1 Energy Centre

Table 22: Connected demand

Demand		2040	2050
Domestic	Peak [MW]	14.09	17.68
	Annual [MWh]	49,200	61,800
Non Domestic	Peak [MW]	1.53	1.45
	Annual [MWh]	7,100	6,700

All domestic buildings are connected in the 2040 time period. The change in annual and peak demand between 2040 and 2050 is a result of the year the domestic buildings switch to district heating within the 2040 time period. The 2040 time period runs from 2035 to 2044, with the switch over year being 2037. As this is two years into the time period, the average annual connected demand across the entire period is less than the 2050 time period, in which the demand is connected across the entire period (2045 to 2054).

Table 23: Energy centre installed plant, annual production and utilisation over time period (load factor). Note that the available boundaries of plant selection is in shown in brackets next to the plant name.

Plant	2020			2030			2040			2050		
	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production	Capacity	Load Factor	Annual Production
	MW	%	MWh	MW	%	MWh	MW	%	MWh	MW	%	MWh
Gas Boilers (3x 10 MW)							11.2	47.13%	46,240	12.4	0.07%	77
Heat Pump (4x 4.2 MW)							8.1	20.11%	14,213	9.3	90.26%	73,507

The energy centre will require approximately 300 m2 footprint. The energy centre is expected to be the tallest building in the immediate area, hence following best practice guidelines, the flue height will need to be 3 m above it to allow for adequate dispersion of flue gasses. This would give an estimated total flue height of 10 m.

There is high utilisation of the gas boilers in 2040, this could be revised to utilise a gas engine CHP as the load and annual production would allow a large CHP to be specified.

It is not clear if thermal storage is included in the energy centre specification. If not, it is recommended that the thermal stores be investigated as they can significantly reduce the cost to produce heat by smoothing demand profiles and allow operational optimisation of generation. In most cases, this significantly outweighs the requirement for additional space and initial investment. Seasonal storage may also improve the annual performance of the energy centre depending on the type and availability of the heat pump energy source. This may enable the energy centre operator to reduce the time spent running high carbon plant such as the gas boilers.

The increase in capacity of the gas boilers from 2040 to 2050 results from their installation date being partway through the 2040 time period. This gives a lower average annual installed capacity across the 2040 period than the 2050 period, in which the total capacity (12.4 MW) is installed across the entire period.

8 Heat transmission

This section investigates the installed generating capacity in each cluster, its annual available generation (MWh) compared to annual production and the connected demand, both peak and annual, to determine the utilisation of the energy centre assets in the clusters they are based, and therefore the availability for connection to another cluster via a transmission network.

The only transmission line specified by the model connects clusters 2 and 6. The transmission line is re-built/extended in time period 2050. This is not suitable as the pipework is only installed in 2040 and should have a lifetime of 50+ years if maintained properly. This should be checked in the model to ensure realistic assumptions and optimisation are being carried through. It has been assumed in this analysis that the pipework is all installed at 2040. The transmission line transfers 3,700 MWh/year in the 2040 time period and 4,100 MWh/year in the 2050 time period.

Table 24: Cluster heat demand and energy generation, showing available and used generation and capacity.

Cluster	Year	Annual production [MWh]	Installed capacity [MW]	Available annual generation [MWh]	% of available MWh utilised [%]	Annual demand (domestic and non-domestic) [MWh]	Peak demand (domestic and non-domestic) [MW]	Demand peak as % of installed generating capacity [%]	Annual demand as % of annual generation [%]	Annual demand as % of available annual generation [%]
2	2040	66,150	25.1	220,030	30%	58,720	16.2	64%	89%	27%
	2050	78,260	22.5	197,190	40%	70,400	19.6	87%	90%	36%
3	2020	15,230	1.8	16,030	95%					
	2030	73,420	15.2	132,830	55%					
	2040	88,340	25.7	224,820	39%	75,480	20.3	79%	85%	34%
	2050	94,700	23.1	202,720	47%	88,390	24.1	104%	93%	44%
4	2030	77,420	12.9	112,790	69%					
	2040	72,440	28.4	248,440	29%	69,030	18.6	66%	95%	28%

Cluster	Year	Annual production [MWh]	Installed capacity [MW]	Available annual generation [MWh]	% of available MWh utilised [%]	Annual demand (domestic and non-domestic) [MWh]	Peak demand (domestic and non-domestic) [MW]	Demand peak as % of installed generating capacity [%]	Annual demand as % of annual generation [%]	Annual demand as % of available annual generation [%]
	2050	85,040	24.4	213,860	40%	81,150	22.2	91%	95%	38%
5	2020	46,640	5.6	49,100	95%					
	2030	58,290	7.0	61,370	95%					
	2040	45,510	13.0	114,310	40%	42,060	11.5	88%	92%	37%
	2050	52,770	15.2	132,810	40%	49,620	13.7	90%	94%	37%
6	2040					3,520	1.0			
	2050					3,900	1.1			
8	2040	6,210	1.6	14,410	43%	5,630	1.4	86%	91%	39%
	2050	6,720	2.1	18,520	36%	6,100	1.6	74%	91%	33%
10	2040	60,450	19.3	168,760	36%	56,270	15.6	81%	93%	33%
	2050	73,580	21.7	190,440	39%	68,500	19.1	88%	93%	36%

Table 25: Cluster 2 to 6 transmission

Table 25 shows that all clusters have annual demand as a percentage of annual generation around 90%. The remainder of the generation is assumed to be distribution heat losses, making up 10% of annual generation. The demand for all clusters is only approximately 30-40% of available annual generation, however this is not unusual as the generation capacity needs to be sized for peak demand and resilience, and reviewing based on annual demand alone ignores the effect of demand profiles.

The peak demand of cluster 3 is greater than the installed capacity. This is a simplification as it assumes that domestic and non-domestic peaks occur at the same time, however highlights that additional available capacity may be required for this cluster. Adjacent clusters are 2, 4 and 5.

As cluster 4 energy centre is closest to the energy centre in cluster 3, and cluster 4 has available capacity, these clusters could be investigated to link via a transmission network.

Cluster 8 has a comparatively small annual and peak demand. This demand could be absorbed by cluster 10 or 5 via a transmission link.

A transmission link would provide:

- A reduction in overall capacity needed, as peak demand in the two connected networks is unlikely to occur at the same point;
- Reduced dependence in one energy source or fuel;
- Increased financial and operational resilience through shared generation assets;
- Optimisation of generation, allowing centralised control and decision making on prioritised generating plant from a wider set of assets.

However joining the clusters may: increase the pumping requirements and costs to transfer the heat; and increase heat losses through transmission pipes, which may in turn require heat top-up stations before the transmitted heat enters the receiving network so as to not reduce the flow temperatures.

For transmission between clusters 2 and 6, where cluster 6 does not have its own energy centre, this will reduce the resilience of the two clusters as both are relying on a single energy centre. It would be recommended, if possible, to have an additional energy centre for cluster 6. This would increase the resilience of both clusters and reduce the dependence on the transmission pipework. This energy centre could be used to house a proportion of back-up plant, as the demand of cluster 6 is comparatively small. This is considered similar for cluster 8, were it to be connected to another cluster.

Table 26: Constraints – Cluster 2 to 6 - Transmission network

Item	Comments/ Mitigation: Transmission network	H/M/L risk
Utilities	No major utilities preventing a transmission network.	L
Roads	There are only minor roads between the heat demand centres in cluster 2 and 6. These are unlikely to constrain the transmission network development or installation.	L
Railways	There are no railways in clusters 2 or 6.	L
Rivers & water bodies	There are no rivers or water bodies in either cluster which would affect a transmission pipe.	L
Flooding	There are no flood risk areas in either cluster.	L
Air quality	The transmission network is not expected to affect or be affected by air quality.	L
Noise	The transmission network is not expected to affect or be affected by noise.	L
Planning & Conservation	The area is Green Belt land. Whilst this is unlikely to affect pipe development and installation, if may increase planning requirements and project risk for any structures required, pumping stations etc	L

Table 27: Constraints – Cluster 4 to 3 - Transmission network

Item	Comments/ Mitigation: Transmission network	H/M/L risk
Utilities	No major utilities preventing a transmission network. However central Bury is likely to have congested utilities, especially when considering a large bore pipe of the type which would be required. This may increase the development requirements including trial pits and surveying in order to find a viable route.	L
Roads	The transmission line would need to navigate Bury town centre, including the A56 and A58. Installation and maintenance on large bore pipe through this area would cause significant disruption to local traffic.	L
Railways	No railways would be affected by a direct route between the two energy centres.	L
Rivers & water bodies	No water bodies would need to be crossed to create the transmission link.	L
Flooding	The transmission pipe route is not affected by any flood risk areas.	L

Item	Comments/ Mitigation: Transmission network	H/M/L risk
Air quality	The transmission network is not expected to affect or be affected by air quality.	L
Noise	The transmission network is not expected to affect or be affected by noise.	L
Planning & Conservation	No significant planning constraints could be found which are likely to affect the development of the transmission pipe.	L

Table 28: Constraints – Cluster 10 to 8 - Transmission network

Item	Comments/ Mitigation: Transmission network	H/M/L risk
Utilities	No major utilities preventing a transmission network.	L
Roads	The pipework would need to cross the M60. This is may be possible using existing infrastructure such as Sandgate Rd, the A665 or the tram crossing. However, for the large bore pipe required, these bridges may not be capable of supporting the large bore pipe required, and a bespoke crossing may need to be designed. This would significantly increase the risk associated with the project.	M
Railways	No railways would be affected by a direct route between the two energy centres.	L
Rivers & water bodies	No water bodies would need to be crossed to create the transmission link.	L
Flooding	The transmission pipe route is not affected by any flood risk areas.	L
Air quality	The transmission network is not expected to affect or be affected by air quality.	L
Noise	The transmission network is not expected to affect or be affected by noise.	L
Planning & Conservation	No significant planning constraints could be found which are likely to affect the development of the transmission pipe.	L

9 Heat pumps

The EnergyPath Networks tool utilises heat pumps as a key future low carbon heat generation technology. This section discusses the technology, future expected improvements and the assumption of large scale deployment.

Heat pumps utilises low grade waste heat occurring both naturally (in the air, ground or water bodies) and as a result of man-made processes including industrial processes and cooling. A heat pump captures this waste heat using a refrigerant. The temperature of the waste heat can be increased using a reverse Carnot cycle, making the heat useable in district heating networks.

The required energy input to raise the temperature to the desired value depends on:

1. The input temperature of the waste heat source;
2. The output temperature, in this case a district heating network;
3. The refrigerant used as the heat transfer medium.
4. The efficiency of the heat transfer cycle

As a result the coefficient of performance (CoP), the ratio of useful heat output to energy input, is highly sensitive these. Predictions on the future of heat pumps including likely efficiency and performance improvements can be made based on the predictions on changes to the individual criteria and corresponding impact on heat pumps.

9.1 Heat source temperature

The energy source is the most crucial part of the heat pump system, as it has the greatest impact on the coefficient of performance (CoP). The energy source and its availability is dependent on the location of the energy centre, and can be the deciding factor in the placement of the energy centre.

Common heat sources available are:

- Air
- Ground
- Water
- Industrial processes
- Cooling by-product

Of these, air source is unlikely to be viable of the scale required for a district heating network. The temperature of the air in the UK is low which, for a viable CoP heat pump, limits the available output flow temperature. Further to this, centralising air source heat pumps (ASHP) brings little benefits over distributing them and connecting individually to buildings heating systems.

Ground source heat pumps make use of the year round stable ground temperatures (approximately 9 °C – 13 °C). They require more initial investment in infrastructure in the form of boreholes which give access to deeper, more stable temperatures heat, or aquifers. The boreholes tend to be approximately 15 m deep for standard applications, or much deeper for geothermal energy with temperatures of 150 °C to 200 °C.

Ground source heat pumps operating at shallow depths can be implemented anywhere providing the local ground conditions permit, so may be viable in any of the clusters specified. Deep geothermal energy can only be accessed where the conditions are suitable. Both require geological surveys and boreholes to be drilled. However due to the depth of the borehole, deep geothermal has significantly higher project development costs, and comes with higher risks regarding unrealised heat capacity. Feasibility studies for the clusters should be undertaken before confirming the energy centre location as this may affect energy centre placement.

Water source heat pumps use the relatively stable temperatures of large bodies of water such as lakes, ponds, rivers, canals and the sea, or existing waterborne urban infrastructure such as sewage water. The source water can be circulated through the heat pump (open loop), or they can be kept separate (closed loop). For water source heat to be used, a suitable body of water must be locally available. For example, the adjacent lake in cluster 2, the River Irwell in cluster 5 or Heaton Park reservoir in cluster 10. The heat available from each water source would need to be investigated to determine the viability of using it to generate heat for the network.

Low grade waste heat from industrial process or as a by-product of commercial cooling can be captured and upgraded using heat pumps. This heat can be considered low carbon as it is otherwise rejected to the environment. The heat available is dependent on local businesses in the area, and the ability to collect and utilise the heat will depend on their appetite for supplying a low carbon heat network. This engagement can be a complex process, and as industrial heat offtake is a bespoke process involving thorough technical and economic optimisation. Additionally, future energy efficiency measures may be detrimental to the uptake of heat pumps on a large scale as the waste heat produced by industry is less available.

The availability of the sources is often governed by practical, environmental, technical or other barriers relevant to specific cases. This means in practice many potential sources may not be available. This highlights the risk of assuming large scale heat pump deployment without underlying knowledge of the sources themselves.

The temporal availability of sources affects how useful they are to a district heat network, as ambient sources are most beneficial during summer months when heat demand is normally lowest. This can be mitigated through the use of seasonal thermal storage, but may still affect the proportions of generating capacity assigned to heat pumps through the year.

One of the advantages of heat networks is that any combination of the above sources can be utilised to provide heat. As such the future energy supply is likely to come from a wide range of sources which will improve resilience of the network. Taking advantage of locally available sources will be crucial in supply the area with efficient, low carbon heat. However, the sources themselves are unlikely to change temperature significantly in the near future. This means that performance improvements cannot come as a result of source temperature.

9.2 Flow temperatures

The flow temperature of the network determines the temperature the heat pump needs to increase the temperature to. Therefore the lower the flow temperature, the less energy needs to be added by the heat pump and the higher its CoP.

Low temperature district heat networks with flow temperatures of 75 °C would increase the efficiency of the heat pumps providing the heat. Currently buildings with historic heating systems are incompatible with low temperature networks, but a popularity of low temperature networks is likely to increase as new builds with more efficient heating systems are added to networks, and as existing building stock is retrofitted or redeveloped. The drive towards these networks may also come from the resulting lower heat losses, improving technical and financial performance.

This increase in the performance of heat pumps does not come from the heat pumps themselves, but instead from a change in the systems in which they operate.

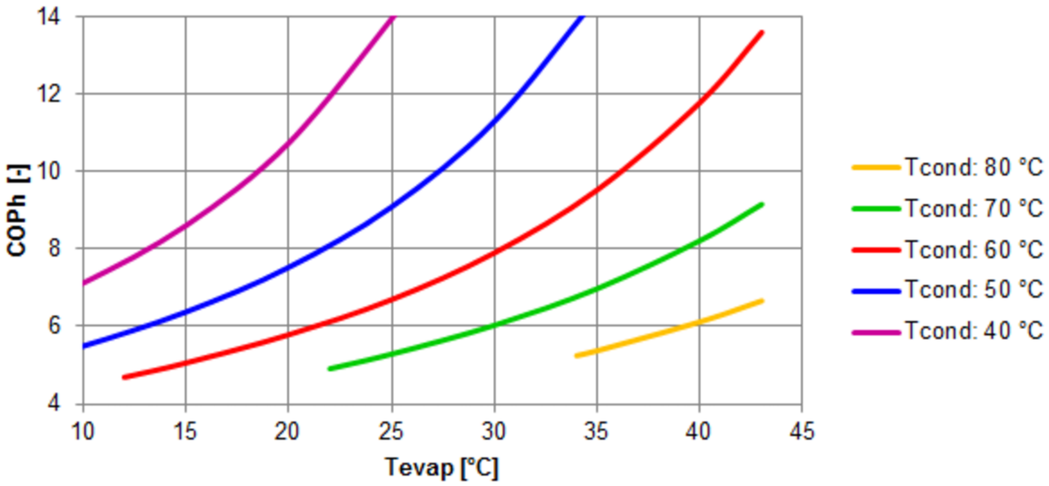

Figure 12: Effect of flow temperature (Tcond) and source temperature (Tevap) on CoP. *Source: industrialheatpumps.nl for Ammonia heat pump.*

9.3 Refrigerant used

A wide range of refrigerants are available for use in heat pumps, with selection depending on the end use and based on several criteria.

Condensation pressure is a crucial property as for some refrigerants at high temperatures, the pressures become too high and normal components cannot be safely used. Alternatively, too low a pressure and the volume required increases, increasing the size of components.

The global warming potential (GWP) is another criteria which is becoming more important, as the environmental impact of the refrigerants (in particular depleting the ozone) is a deciding factor in their selection. The global refrigerant market is phasing out hydrofluorocarbons (HFCs) and other ozone depleting refrigerants, moving towards low GWP refrigerants such as hydrofluoroolefins (HFO).

Across industry, ammonia continues to be the preferred refrigerant for large scale heat pumps as it has a high efficiency, while being a natural refrigerant which does not contribute to the greenhouse gas effect. Fourth generation refrigerants (HFOs), such as R-1234ze, are newer and show the market progression towards working fluids which are both environmentally friendly and efficient. Notwithstanding a technological breakthrough in refrigerants, the future trend does not appear to be one of significant improvement.

9.4 Electricity source

Heat pumps use electrical compressors to pressurise the refrigerant and increase its temperature. Compressor technology may improve in the future, with more efficient, lower cost compressors. This will reduce the electrical input for useful heat output improving the efficiency of the heat pump.

For a heat pump to be low carbon, the electricity source must be low carbon. The uptake of renewable electricity generation such as solar and wind means this electricity is more likely to be freely available. This will help to decarbonise heat networks powered by heat pumps. Similarly, as the national grid connects more renewable generation, the carbon intensity of grid electricity will reduce (see figure below), this will make grid electricity powered heat pumps lower carbon in turn. Connecting distributed electricity generation to electrical storage to power the heat network will also improve the resilience of the network by reducing transmission risk.

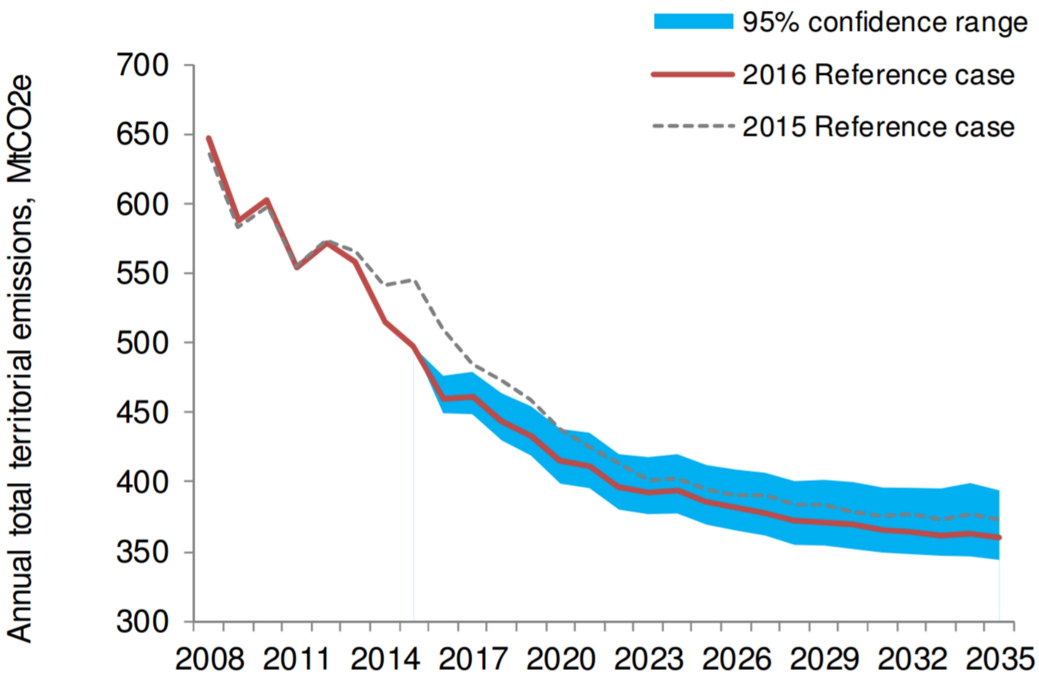

Figure 13 BEIS grid emissions forecast (including uncertainty)

9.5 Technology improvements

Heat pumps are limited by the theoretical CoP limit. In practice, even this limit is not achievable due to the working efficiencies of the heat pump such as heat transfer through the heat exchangers and compressor efficiency.

As heat pumps are a mature technology, the industry does not foresee significant improvements into the real world efficiencies of heat pumps, as they are close to (or may have already reached) a cost-effective efficiency peak. However, further improvements may still be achieved through the management and control of the heat pumps and ancillary plant items, and optimisation of temperatures and electricity uses/sources.

10 Conclusion

This report has assessed the outputs of the EnergyPath Networks modelling with respect to possible constraints and industry best practice. The report finds that none of the pathways proposed by the tool are considered no go options at this stage.

Without a network route defined, it is not possible to assess the selected route. However a review of the likely constraints to development found no significant areas which would constrain schemes in any cluster. In general, river and railway crossing were deemed possible where required in each cluster due to existing infrastructure. Installation along major roads is feasible, however would cause local disruption, the scale of which would be determined by the local traffic flows and extent of the road closures.

The energy centre location needs to be a reviewed holistically, with constraints such as local land categorisations (green belt), historic/listed buildings and high flood risk areas being avoided if possible. While placing the energy centre at the centre of the heat demand may be preferred operationally, additional constraints should be taken into account as they can significantly increase the project risk. In addition, sources of waste heat should be reviewed and if possible the energy centre should be placed in close proximity to provide a viable heat source for the transition to low carbon heat.

The plant located within the energy centres is in general in line with best practice. In some cases (clusters 8 and 10) utilising a lower carbon option would be preferable. Additionally, some cluster technologies could be optimised further and installation/disposal of plant be reviewed when considering optimisation of plant lifecycles and capacities. The assumption of the lifetime of gas turbines should be reviewed as it appears beyond industry norms where used.

Heat pumps have been used as the low carbon option for all energy centres. Expected future performance improvements for heat pumps has been discussed and no significant improvements are expected with respect to the technologies themselves. Improvements are expected to come as a result of improvements in the management and operation of whole systems and the connection to suitable low carbon energy sources. As heat pumps, and their efficiency, are so dependent on the energy source, it increases the project risk by assuming large scale heat pump deployment without underlying source availability information.

Transmission between clusters will improve resilience and reduce the overall installed capacity of plant across the region (assuming multiple energy centres). However the technical and financial aspects need to be established to determine the viability of the connection. The transmission link proposed (Clusters 2 and 6) appears to have no significant constraints to network development. Other transmission links have been proposed, and redefinition of the cluster boundaries (cluster 8) may be sensible in some cases where geographical constraints may be used to determine more appropriate boundaries.

There are a number of steps the local authority can put in place which can ease and assist the network development:

1. Take advantage of ongoing and future infrastructure projects in the local area by compiling survey data (desktop studies, GPR[1] scans, etc.) and detailed records of newly installed, replaced or maintenance on utilities, to develop a good understanding of the installed infrastructure along potential network routes.
2. Build relationships with large energy consumers in the local area and promote detailed record keeping of energy usage.
3. Closer to network build out, a local development order (LDO)[2] can help to progress the network at a more rapid pace, removing red-tape and unnecessary financial and time constraints.

Carrying out and maintaining these items will help de-risk network development by increasing the knowledge and available information on many of the high risk items during the feasibility and design stage.

[1] Ground penetrating radar
[2] Section 61, Town and Country Planning Act 1990