Programme Area: Smart Systems and Heat

Project: WP2 Bridgend Area Energy Strategy

Title: Bridgend Local Area Energy Strategy – Review of Near Term Transformation Projects – Detached

Abstract:

This report is one of two reports reviewing the commercial and technical viability of a predominately domestic heat network across two clusters in Bridgend. This report assesses detached houses in the area connected to a network including 13 specified non-domestic buildings.

Context:

Bridgend County Borough Council has been working with a group of stakeholders consisting of Welsh Government, Western Power Distribution, Wales and West Utilities and the Energy Systems Catapult, to pilot an advanced whole system approach to local area energy planning. Bridgend is one of three areas including Newcastle and Bury in Greater Manchester participating in the pilot project as part of the Energy Technologies Institute (ETI) Smart Systems and Heat (SSH) Programme.

Energy Systems Catapult

Support for EnergyPath Networks

Task 016: Review of Near Term Transformation Projects

ESC0000050376

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Contents

1 Executive Summary

This report is one of two reports reviewing the commercial and technical viability of a predominately domestic heat network across two clusters in Bridgend. This report assesses detached houses in the area connected to a network including 13 specified non-domestic buildings.

This report finds that the dwellings connected are generally clustered which benefits the heat network due to the increased heat density. However, connection to outlying properties should be reviewed, as they require extensive lengths of pipe to connect comparably small heat offtake. This can be mitigated by connecting the (semi-detached) dwellings specified in the parallel report, which in most circumstances would increase the heat density of outlying areas.

The commercial viability of the scheme could be improved by connecting key non-domestic buildings throughout both clusters in addition to those specified. Several buildings are not considered for connection despite adjacent residential connections.

There were no significant barriers found to energy centre development. Although the placement of both energy centres should be reviewed as neither appear optimum due to their surroundings (railways in cluster 9 and residential in cluster 8).

A network and transmission spine route has been developed avoiding key constraints where possible. It is estimated that 50 km of trench is required to connect the specified connections.

This report estimates total costs for the entire development across both clusters and including the interconnection pipe to be £155 m. Key market barriers to the development will be meeting this capital costs along with uncertainties regarding long term demand and securing energy supply agreements.

A high level assessment of outlying connections has shown that the removal of 2 dwellings from the network could reduce the overall costs by £4 m.

The key risk associated with the energy centre development is anticipated to be the heat pump source, as this is currently unclear, and it is not known if this source is available or can provide the required temperatures while meeting current or future industry standards.

2 Introduction

Arup has been appointed to carry out a desktop review of the Energy Systems Catapult’s EnergyPath Network (EPN) tool in regards to decentralised energy and heat network deployment in Bridgend.

The report develops a proposed heat network across two specified areas, referred to as clusters, in Bridgend based on connections to 13 non-domestic buildings (including schools, nursing homes and shops), and 2,205 selected detached dwellings in the area. The connected heat demand and proposed energy centre plant has been reviewed for suitability. This is alongside the technical and commercial deliverability of the scheme.

2.1 Scope of review

The review focuses on the commercial and technical viability of the scheme installation. As such operational costs and annual revenues have not been assessed. This means there is no calculation of the financial viability of heat networks in either cluster.

3 Heat Demand Assessment

3.1 Domestic connections

EPN specified the domestic connections included in the analysis. These are detached properties built after 1980. The following table summarises the key aggregate information for these buildings.

Table 1: Domestic connections

	Number of connections	Aggregate annual heat consumption (MWh/annum)	Aggregate peak heat demand (MW)
Cluster 8	1,886	16,067	5.5
Cluster 9	319	2,068	0.9
TOTAL	2,205	18,133	7.6

Note that the above table has assumed inclusion of all domestic connections meeting the typology criteria within clusters 8 and 9.

The EPN tool determines preferred low carbon technologies for buildings to transition to. For the typology criteria, the data supplied showed a heat network as the chosen technology for the majority properties, with some properties shown as supplied via an individual ground source heat pump. The data provided a consumption and demand in heat for those connected to the heat network, and electricity for those using to a heat pump.

For connections with a ground source heat pump, a coefficient of performance of 2.38 (as used within the EPN model) has been used to convert the provided electrical units to corresponding heat units. This allows this report to consider all buildings as connections to the heat network.

3.1.1 Heat density

There is a large number of properties in the centre-south of cluster 8, and at the far north of the cluster. These make a viable connection group for the heat network development due to the heat demand density. Other outlying domestic connections are recommended to be removed from the network unless close to, or en route to, a large heat offtake. These will otherwise significantly decrease the overall linear heat density of the pipe reducing the effectiveness of the network. The viability of connecting the outlying properties may change as a result of connecting dwellings outside of the scope of this report, for example semi-detached housing built between 1945 and 1979, as addressed in a separate report.

There are three small groups of clustered domestic connections in cluster 9. The group to the east of the cluster provide the more viable area for connection due to the number and density of the domestic connections in conjunction with the adjacent non-domestic connections. Connecting the outlying domestic connections is not recommended as this will significantly decrease the overall linear heat density of the pipe reducing the effectiveness of the network, again unless other commercial or domestic connections are available in the vicinity which would affect the linear heat density of the pipe.

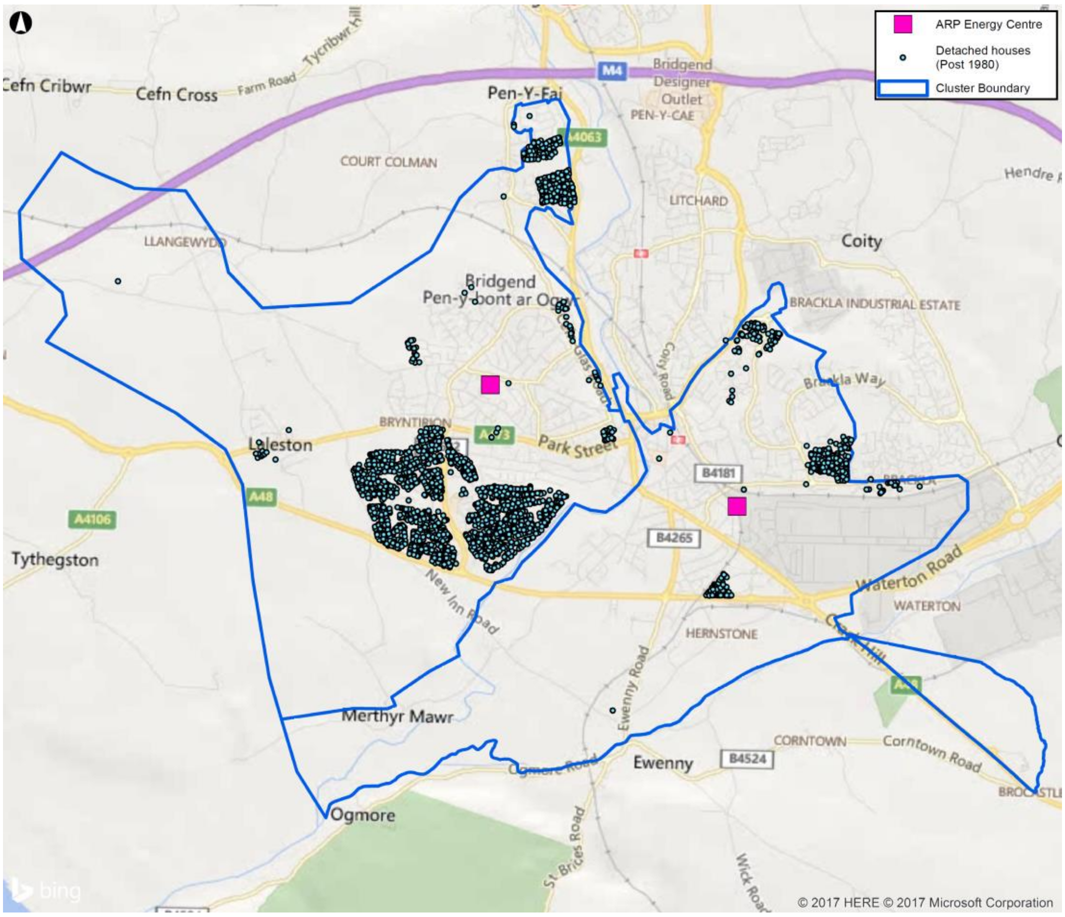

Figure 1: Domestic connections

3.1.2 Domestic demand assessment

The peak demand provided by EPN for the domestic connections in general appears to be low.

For houses of a similar typology as those considered here, a typical space heating demand would vary between 4 kW to 10 kW peak. This is a result of the building, its age and therefore typical building standards achieved, and its heat loss due to type of house.

This demand needs to be added to a diversified domestic hot water demand, which would typically vary between 1 kW to 3 kW (depending on the number of houses and size of HIU). This gives estimated heat demand boundaries of 5 kW to 13 kW.

The average peak demand (including both diversified hot water and space heating) provided by EPN is 3 kW, hence this is considered to be quite low compared to the expected peak demand estimation.

3.2 Non-domestic connections

The non-domestic connections included in the analysis were provided by ESC. These consist of 13 buildings, a mix of schools, nursing homes (with floor area greater than 350 m^2) and shops (with floor area greater than 1,000 m^2). The following table shows the key information for these buildings.

Table 2: Non-domestic connections

	Cluster	Floor area (m^2)	Annual heat consumption (kWh/annum)	Peak heat demand (kW)
Penybont Primary School	9	2,450	288,000	62
Archbishop McGrath RC Comprehensive School	9	16,400	1,933,000	418
Brackla Primary School	9	1,450	168,000	36
Ysgol Gymraeg Bro Ogwr	9	1,650	197,000	43
Oldcastle Primary School	9	4,050	476,000	103
Brynteg Comprehensive Upper School	9	3,000	351,000	76
Brynteg Comprehensive Lower School	9	1,450	174,000	38
Pen Y Bont Court	9	2,050	615,000	133
Bryn-y-Cae Nursing Home	9	1,750	519,000	112
Co-op + other stores Brackla	9	1,150	175,000	38
Wilko, Nolton House	9	5,650	863,000	187
Rhiw Shopping Centre	9	3,500	532,000	115
Wyndham House	9	1,150	174,000	38
TOTAL (rounded)		**45,700 m^2**	**6,465 MWh**	**1.4 MW**

3.2.1 Heat density

The non-domestic connections are all located in cluster 9 (see Figure 2). The majority are grouped in small clusters of connections which will benefit the network, in particular the north-east and the town centre group. Ysgol Gymraeg Bro Ogwr in the north and Pan Y Bont Court in the south are far more remote than the other connections and less likely to provide a viable heat network connection due to the length of pipe required to connect them.

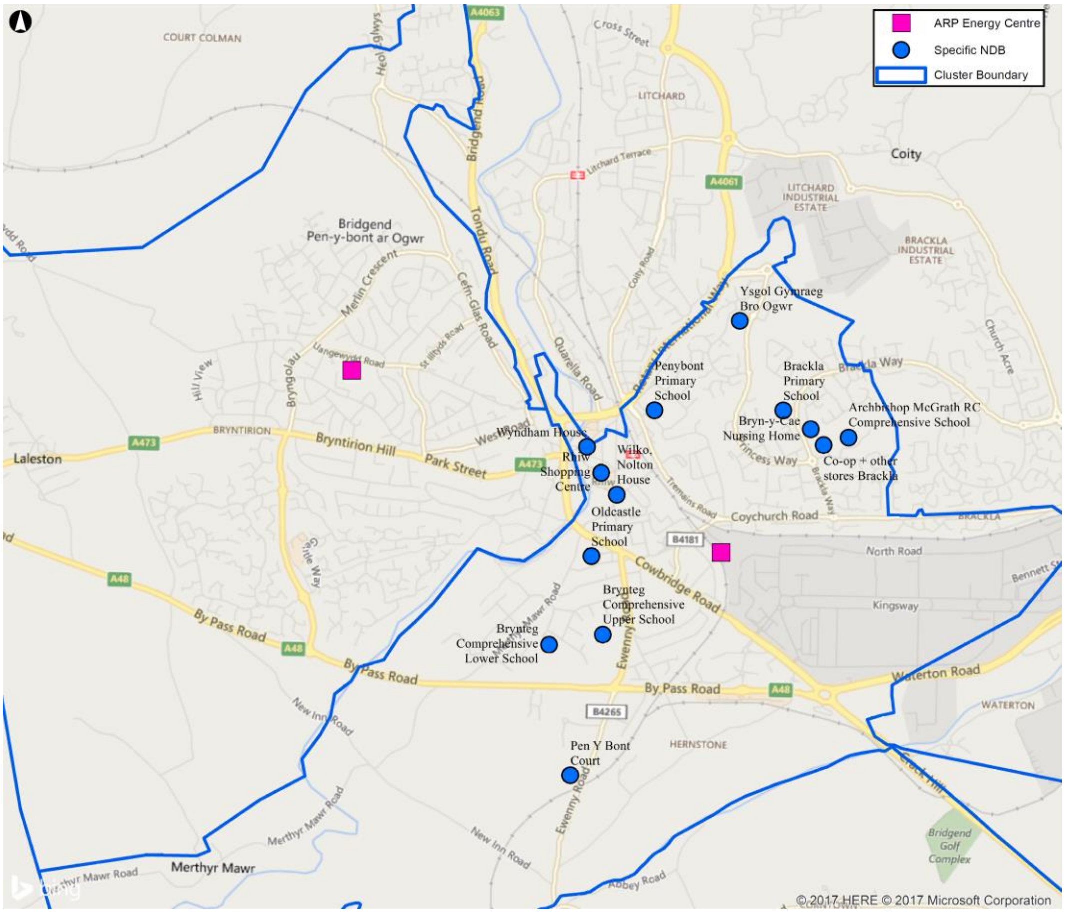

Figure 2: Non domestic connection locations

3.3 Total heat demand

The total heat demand for each cluster is presented in the table below.

Table 3: Combined heat demand

	Annual heat demand (MWh)	Peak heat demand (MW)
Cluster 8	16,067	5.5
Cluster 9	8,533	2.3
TOTAL	**24,600**	**7.8**

4 Energy Centre Assessment

4.1 Cluster 8

Table 4: Cluster 8 energy centre prime movers

Plant installation date:	2020	2030	2040	2050
Gas Boilers	18.0 MW	18.0 MW		1.9 MW
Gas Engine CHP	7.0 MW	7.0 MW	7.0 MW	0.5 MW
TOTAL (Installed capacity)	**25.0 MW**	**25.0 MW**	**7.0 MW**	**2.4 MW**

Note, blanks in the table above indicate no technology specified for those years.

4.1.1 Local impacts

The energy centre is located in the playing fields of Llangewydd Junior School. The school grounds are surrounded by semi-detached residential houses. It is expected that visual impact will be the largest risk to planning consent. The development will repurpose some of the school land. This may cause strained relations between the development and stakeholders in the school, namely parents and governors. This can be mitigated through a stakeholder engagement programme aimed to increase understanding of the project benefits and long term aims.

The publically available database MagicMap[1] has been searched for statutory land based constraints and known habitats and species. This has shown no statutory environmental constraints; however, more detailed environmental investigation would be required. This poses a risk to development until carried out.

The energy centre may increase emissions in the local area if not managed correctly. An emissions impact assessment will need to be performed during the design stage and any negative impacts mitigated through the design where possible. It is expected that the CHP plant will required flue gas treatment and cleaning to maintain acceptable local NO_X levels. The energy centre is not located in, or near, a current air quality management area so the development should not encounter adverse planning regulations. The development will still be required to meet national and local air quality standards. The visual impact of the flue and perceived reduction in air quality in the area are expected to cause significant planning issues.

The energy centre should be designed to reduce noise levels from the plant and ancillaries to acceptable levels. This is not considered to be high risk item as sound attenuation from a CHP energy centre is standard practice.

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[1] http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx

4.1.2 Footprint & flue

The estimated footprint for the energy centre is 300 m^2. The flue height has been calculated as 3 m above the tallest building in the immediate area. This gives an estimated flue height of 8 m. However detailed dispersion modelling and more detailed information on the current and any planned buildings in the immediate area are needed to provide more accuracy on this estimation. The flue height may cause planning permission issues in the area as it is heavily residential and is likely to be deemed as unsightly.

4.2 Cluster 9

Table 5: Cluster 9 energy centre prime movers

Plant installation date:	2020	2030	2040	2050
Gas Boilers			1.4 MW	13.1 MW
Biomass CHP			1.9 MW	2.7 MW
Gas Turbine CHP			0.7 MW	4.3 MW
Large Scale Heat Pump			11.2 MW	16.9 MW
TOTAL (Installed capacity)	**0 MW**	**0 MW**	**15.2 MW**	**37.0 MW**

Note, blanks in the table above indicate no technology specified for those years.

4.2.1 Local impacts

The energy centre is located at the western end of the Bridgend Industrial Estate. The site is bordered by the railway, and does not appear to have a direct road link with the rest of the industrial estate. The area is industrial made up predominately of warehouses, as such the energy centre is not expected to cause any undesirable local impacts.

Local roads may see increased traffic due to biomass deliveries. Considering the size of the biomass CHP units installed, the deliveries required are not expected to negatively affect the local area as the area is industrialised. If access could be routed through the industrial park (not currently available), this would keep traffic away from the town centre and make better use of existing infrastructure.

The energy centre should be designed to reduce noise levels from the plant and ancillaries to acceptable levels. This is not considered to be high risk item as sound attenuation from a typical energy centre, is standard practice.

It is not clear what the heat source or method of extraction of the heat pumps is. This report assumes ground source heat as there are no water bodies in the immediate area, and air source is not considered a viable technology over the scale and capacity shown. There is unlikely to be the area required for horizontal (surface) pipe loops, and hence drilling of boreholes is expected to be required. This may cause some local disruption and noise pollution during drilling and construction, but long term is likely to have minimal effect on the local area. Given the capacity of the heat pumps there may be environmental impacts associated with drawing such significant amounts of heat from the ground. The extent of this, and if the amount of energy is available over a long period, is not possible to know without further information on the technology selected.

The energy centre may increase emissions in the local area if not managed correctly. An emissions impact assessment will need to be performed during the design stage and any negative impacts mitigated through the design where possible. It is expected that the plant will required flue gas treatment and cleaning to maintain acceptable local NO_X and particulate matter (PM_{10} and $PM_{2.5}$) levels. The energy centre is not located in, or near, a current air quality management areas so the development should not encounter adverse planning regulations, however this does not exempt the development from meeting national and local air quality standards.

4.2.2 Footprint & flue

The estimated energy centre footprint is 1,000 m^2. The flue height has been estimated as 12 m. This is 3 m above the tallest building in the immediate area, (in this case the Energy Centre itself). However detailed dispersion modelling and more detailed information on the current and any planned buildings in the immediate area are needed to provide more accuracy on this estimation. The flue height is unlikely to cause planning problems as the area is industrial.

5 District Heating Routing Assessment

5.1 Routing methodology

The heat network route proposed was developed using functionality within ESRI's ArcMap. The energy centres, non-domestic connections and domestic connections were loaded into the software alongside an analysis network of local roads. ArcMap Network Analyst tools were used to compute the shortest distance to reach all connections from the energy centres using the road network. This provided a heat network spine.

This spine was then reviewed to avoid local constraints (e.g. main roads, bridges), and to take advantage of local opportunities (e.g. soft dig areas, shorter non-road routes) which were not available to the network solver when determining the optimum route. No allowance has been made for alignment with other highways and utilities works. This should be included when more detailed knowledge of the route and construction timeframes are known. It is recommended that the heat network construction programme take advantage of other infrastructure projects where possible to minimise disruption and costs where possible.

5.1.1 Constraints

Constraints considered when assessing the heat network routing are listed in the following table.

Table 6: Constraints to network development

Constraint	Description
Utilities	Areas of congested utilities add risk to the installation of the network pipes. A greater number or surveys and trial pits will be required, and the pipe route may require diverting increasing cost and causing project delays.
Roads	Major roads and bridges may constrain network development, increase costs of installation and significantly increase local disruption. Smaller bridges may not be capable of carrying large bore distribution pipes.
Railways	Railway lines increase time and cost to cross or gain wayleaves for, requiring a high degree of engagement with Network Rail and a risk that the network route may not be viable.
Rivers	Rivers require bridges or tunnels to cross. The impact of this can be mitigated via bespoke pipe bridges or drilling methods such as horizontal directional drilling. Where rivers flood regularly and for long periods of time this may change the trenching requirements in the surrounding area, and can affect the lifetime of the pipework.

Note that a more detailed assessment of the above constraints should be carried out. The assessment performed here is a desktop study based on publicly available information, not suitable for detailed design. In particular, the local utilities company should be informed of the network development and be engaged at the earliest possible opportunity.

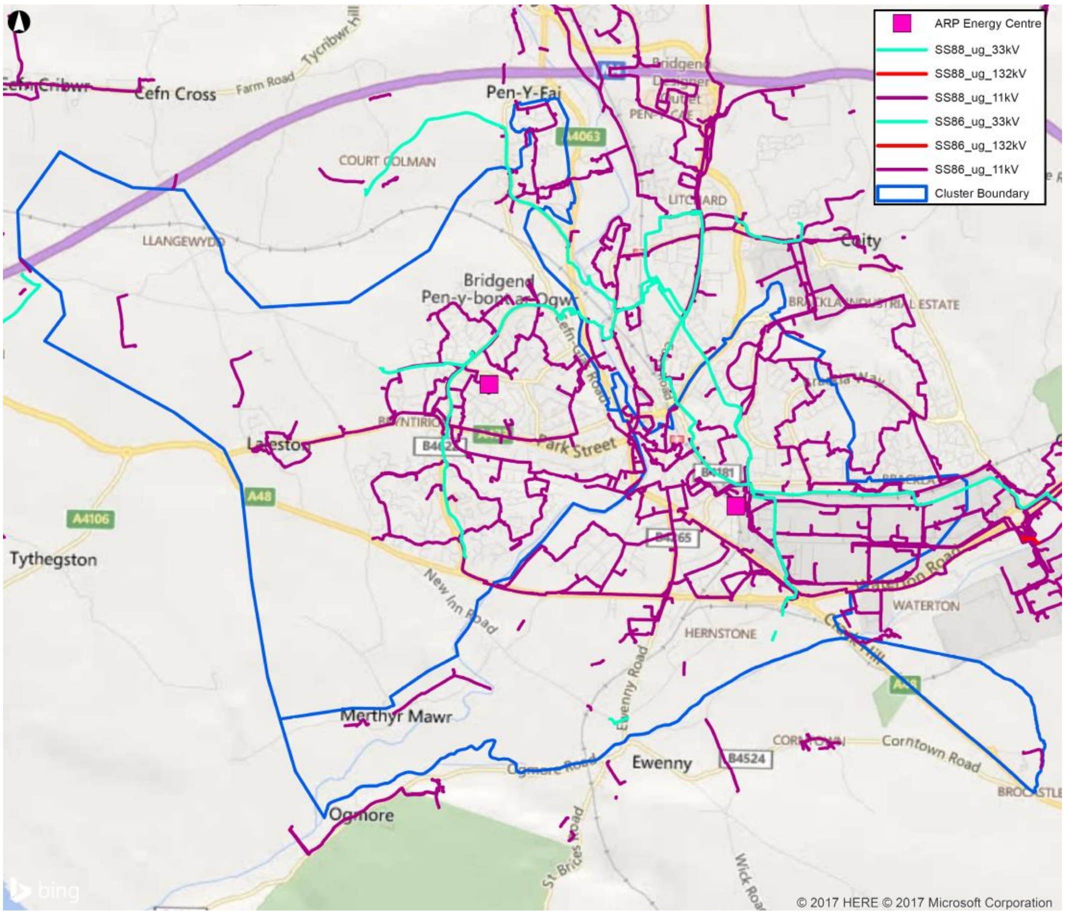

Figure 3: Publicly available underground electricity distribution network (Western Power Distribution, 2017)

The electricity distribution map, **Error! Reference source not found.**, shows the extent of the 33 kV and 11 kV underground distribution networks throughout the clusters. This indicates the congestion of utilities across the heat network installation area in the centre of the town.

It should be noted that this is publicly available information and may not be up to date, complete or accurate to the degree required. It is important that the project team contact the local utilities companies as soon as possible to gain access to more accurate, recent information. Additionally, this map does not show the gas and water supply pipes, wastewater pipes, broadband and other cabling that may be in the area (not publicly available information) which must also be considered when designing and installing the network.

Some utilities (including gas pipes) may have easements associated with them, which restrict certain types of activity directly above. This may add additional constraints to routing and construction.

5.2 Cluster network results

Figure 4 shows the cluster networks developed using the methodology described in the previous section.

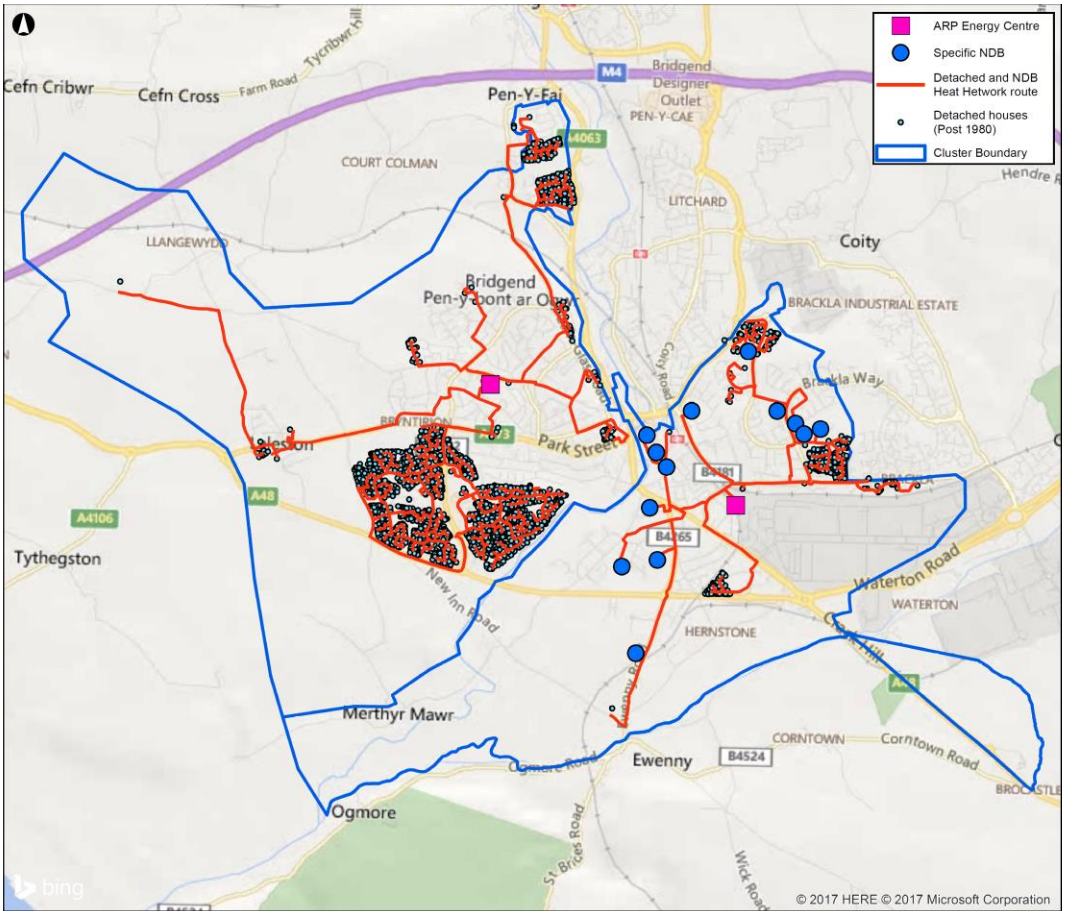

Figure 4: Indicative heat network, clusters 8 and 9, connecting specific non-domestic buildings, detached post 1980 homes and energy centres.

The network spine has a total trench length of 50 km across both clusters. This could be decreased by 2 km if the single domestic connection in the north-western corner of cluster 8 was removed. A further recommended reduction is the removal of the single domestic connection to the south of cluster 9, which would reduce the trench length by 1 km.

5.2.1 Constraints

The network route has been proposed around mitigating major obstacles to development where possible. The following sections of pipe have been noted as being higher risk in terms of technical feasibility and deliverability and were not possible to mitigate through network routing.

As can be seen there is a high degree of electricity utilities congestion in the area immediately north of the energy centre in cluster 9. It is not possible to easily mitigate this area via a route change due to the existing road and rail infrastructure. Nonetheless, the pipe in this area is required to serve all the connections in the north of cluster 9, hence a large bore pipe is expected to be required, which will make route finding through congested utilities more difficult.

Central Bridgend is likely to also be congested with utilities, however again this is difficult to mitigate due to the requirement to serve the buildings in this area. These areas should be considered high risk.

The network route runs down Ewenny Road, Cowbridge Road, Coychurch Road and Tremains Road in cluster 9 and Bryntirion Hill in cluster 8. These roads are all major carriers of traffic and installation of heat network pipe along them will cause local disruption. The overall effect of the local disruption on the town centre should be mitigated where possible through the construction programme.

The railway is crossed using the bridge on Coychurch Road north of the energy centre in cluster 9. This is unavoidable due to the energy centre location. This bridge may need reinforcing to be able to support the size of heat network pipe required.

5.3 Interconnection network results

The transmission pipe route connecting the two clusters was developed using the same methodology as described in Section 5.1. Figure 5**Error! Reference source not found.** shows the proposed route. The route requires 3 km of trench.

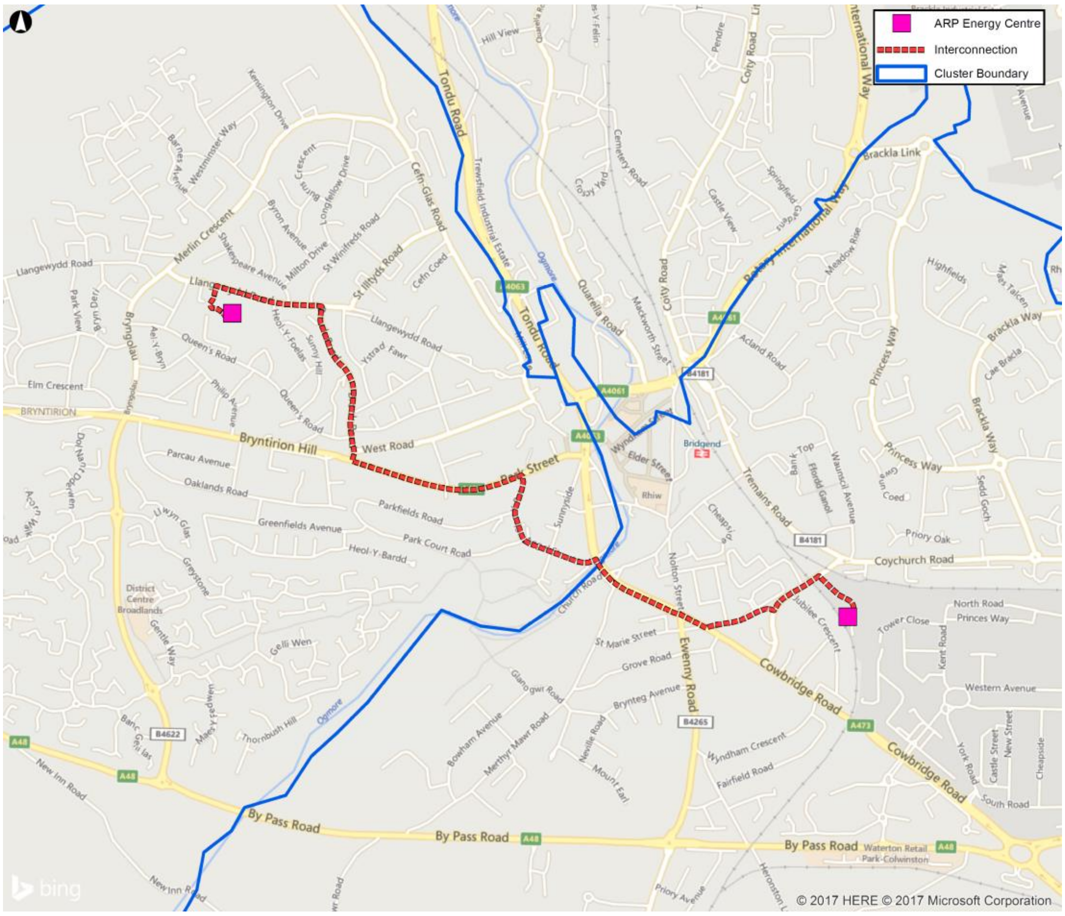

Figure 5: Clusters 8 and 9 interconnection network route.

This route aims to avoid the centre of Bridgend, where utilities are likely to be congested and where installation could cause more disruption. The route makes use of Cowbridge Road Bridge to cross the River Ogmore. Whilst installation will cause local disruption, the bridge is assumed to be large enough to support the pipe diameters required. This pipe would be large bore preinsulated pipe similar to that used throughout the rest of the network.

To connect the two networks there are two options. One option is to connect the distribution pipes from each network together. The other option is to install a separate transmission pipe which directly connected the two energy centres and serves no other connections.

This analysis has assumed a separate pipe acting as a transmission line between the two energy centres. This is considered a suitable strategy for the Bridgend clusters as it is a low risk option which does not require the installation of oversized pipes for long periods ahead of use. This in turn improves the network performance while they are unconnected. In addition, as the heat enters the other network at the energy centre no separate heat top up station is necessary to ensure temperatures are maintained. Should an energy centre go offline, the heat from the other could be used to maintain reduced supply to both networks, depending on the installed generation and pipe.

The other option of transmission, connecting the two pipe networks at their closest point, requires oversized pipes on the shortest energy centre to energy centre path in the overall network. This method would reduce the overall length of pipe, but requires foresight and long term planning of connection, increasing the risk should the interconnection not go ahead.

5.3.1 Suitability

Interconnecting heat networks may benefit both networks through:

- Increased resilience, from shared generation and the potential to diversify the fuels used.
- Reduction in overall capacity required as a result of increased demand diversity and shared peak capacity.
- Supply optimisation from centralised control of a wider number of generational assets used to meet the demand.
- Wider ability to meet strategic targets (e.g. carbon, financial, etc.) through optimisation of energy centre control strategy.

In typical circumstances, a single large energy centre would be chosen as the prime supplier of heat, with smaller heat ‘top up’ stations being utilised to add heat to the network when required (i.e. winter months). This operational strategy allows one energy centre to operate for longer at maximum (most efficient) output.

From a commercial viewpoint it is considered best practice to minimise the number of energy centres. This improves the economies of scale of the plant capacity, and the maintenance of the system. From technical point of view, multiple heat generation centres and top up stations is preferable in order to optimise the operation of a large network.

A hydraulic break can be used to protect either network. This is often implemented where a new network is to be connected to an older network and refurbishing the old network to the required standard/operating conditions is not feasible. A hydraulic break will incur losses across the connection point.

Considering interconnection of two networks against their standalone operation, a major disadvantage is the pumping required to transmit large amounts of heat from one energy centre to another. Additional pumping stations may be required at key locations. These will increase both the capital and operational costs of the network. High heat losses will occur due to large bore pipes used to transfer the heat. This will increase the operational costs of both networks due to additional heat losses incurred to serve the same consumers. None of this would be incurred if the networks were kept separate.

More complex control methodologies will be needed to manage heat supply across both networks.

5.3.2 Constraints

The interconnection pipe needs to cross the River Ogmore. This has been achieved using Cowbridge Road. There is a small footbridge which could be used at this location but would likely need to be reinforced.

Similar to the heat network route, the interconnection pipe may encounter congested utilities and requires routing along two major roads, Park Street and Cowbridge Road. This is unavoidable due to the heavily built up area needing to be crossed to connect the two energy centres.

The railway needs to be crossed once on Coychurch Road. This bridge may need reinforcing to accommodate the interconnection pipe. This is unavoidable due to the energy centre location and should be considered as a high risk item with potential to increase the initial infrastructure costs.

6 Network Installation Considerations

6.1 Typical routing details

6.1.1 Trench dimensions

Manufacturer's indicative minimum trench dimensions are shown in figure 6. Best practice dictates that there should be a minimum soil cover of 400 mm between the pipes and the bottom of the road layer. Final trench specifications are contingent on local constraints and a protective cover may need to be installed if only the minimum cover can be reasonably achieved.

The minimum dimensions shown in figure 6 display how the trench should be sufficiently large for installation. Warning tape must be applied above trenched areas in order to prevent accidental pipe damage by works. In areas of high traffic or where the minimum soil cover cannot be achieved, pipes must be protected against weight overload.

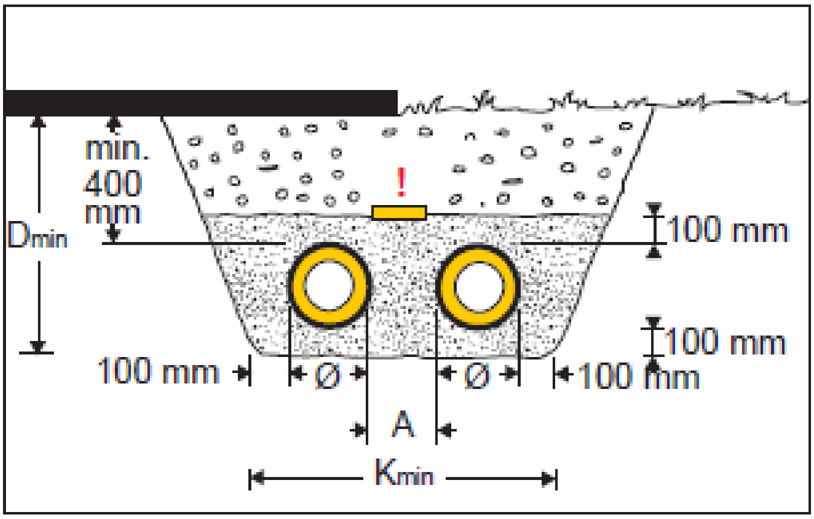

Figure 6: Manufacturer's indicative minimum trench dimensions (source: Logstor Handling & Installation, Version 2015.06)

6.1.2 Utilities avoidance

It is expected that areas within the assessed clusters will be congested with utilities. The implementation of the heat network may require diversion around the utilities. Historic (and in some cases recent) utilities are often poorly mapped with the very limited knowledge of exact locations. This presents potentially a high risk to both local disruption (due to utilities interruption and longer installation times) and health and safety of workers during construction. Heat network pipes may need to be routed around the utilities, and in worst case scenarios, a new route may need to be found. Utility avoidance represents a costly and time-consuming risk to the project. Thus, the development of an effective mitigation strategy is necessary to minimise disruption.

All available information should be reviewed during the design stage to mitigate potential high risk areas. Desk based surveys covering service drawings and communications with utilities providers are non-intrusive and offer a higher-level approach. The Council can further increase the information available by compiling survey data (desktop studies, GPR scans, etc.) and detailed records of newly installed, replaced or maintenance on utilities during ongoing and future infrastructure projects in the local area. This can be used to help to develop a good understanding of the installed infrastructure along potential network routes.

During detailed design and construction, trial pits and GPR scans should be performed to highlight potential areas of concern at the earliest possible opportunity. This is should be focused on areas expected to be heavily congested. Trial pits are a more costly and intrusive approach but can facilitate the gathering of geotechnical data as well as exact utility locations.

6.1.3 Ground conditions

Ground conditions may present constraints in terms of network routing with unsuitable or contaminated ground influencing route development. Ground surveys and risk of contaminates should be included for. Where the ground is found to be unsuitable relevant measures should be taken to divert the network route to suitable land. The implementation of the network could be aided greatly if the Council collated data on historic ground surveying within defined areas of land.

The detached properties in Cluster 8 and 9 are located in low risk areas away from existing coal mine openings and there are therefore minimal constraints with respect to routing details.

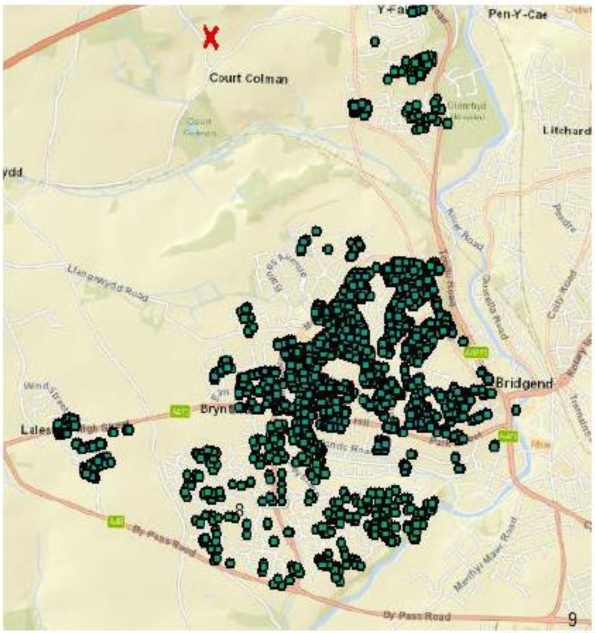

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Figure 7: Cluster 8; Development high risk areas and mine openings.

6.2 Domestic connection

A heat network connection to the dwellings can be provided at the front of the house. Pipework may enter the house at the front, access to which is readily available, providing visual impact is minimised. Configuring the connection in such a way reduces the need for additional trenching (more expensive) or boxing in (more visual impact) to the side or back of the house. Generally, the detached houses within the assessed clusters appear to have sufficient space to carry out the connection works. There may be some congestion with utilities at a domestic scale, however this is dependent on local conditions affecting the placement and depth of those existing utilities. Inside the house, the heat network would terminate at the HIU.

6.2.1 HIU placement

Domestic HIUs are generally of a similar size to the gas boilers found in homes. Consequently, it is possible for the HIU to occupy the same space as the gas boiler with no additional space requirements. Where direct replacement is not possible due to accessibility constraints for maintenance, it is possible to locate the HIU at the outside wall of the house in a suitable enclosure. This may be preferred depending on the ownership demarcation point of the installed assets.

A review of the detached houses from the relevant period (post 1980) reveals that the majority of these houses have a boiler flue on the ground floor (indicating boiler location). However, as the variety of house structures is extensive the location of the HIU will be dictated by the local constraints of the building and therefore usually determined by the contractor and home owner upon retrofitting.

6.2.2 Land ownership

The heat network proposed for the assessed clusters may overlap with existing land ownership structures. In such cases, early engagement and discussions with the landowners in conjunction with the planning team is necessary to facilitate the development of the agreements and planning permissions necessary for the implementation of the heat network. The adoption of a Local Development Order covering the installation of pipework, cables and engineering work related to heat network would assist greatly in the implementation of the heat network and energy centre.

6.3 Network and installation sequence

Based on transition date it is anticipated that the network would be installed over a period of years between 2021 and 2037. The phasing of domestic connection is shown in Figure 8**Error! Reference source not found.**. This shows that much of cluster 9 is to be connected in the first transition period (2022), and hence it is recommended that the non-domestic buildings are connected at this time too, as this will improve the commercial viability of the network.

The domestic connections in cluster 8 are predominately converted in 2037. Therefore it is recommended that, without other connections, all buildings are connected in 2037. Should the heat network pipes be installed in 2022 to serve the few domestic buildings connected at that time, they will be hugely oversized for purpose for 15 years. This will lead to inefficient operation and poor financial performance.

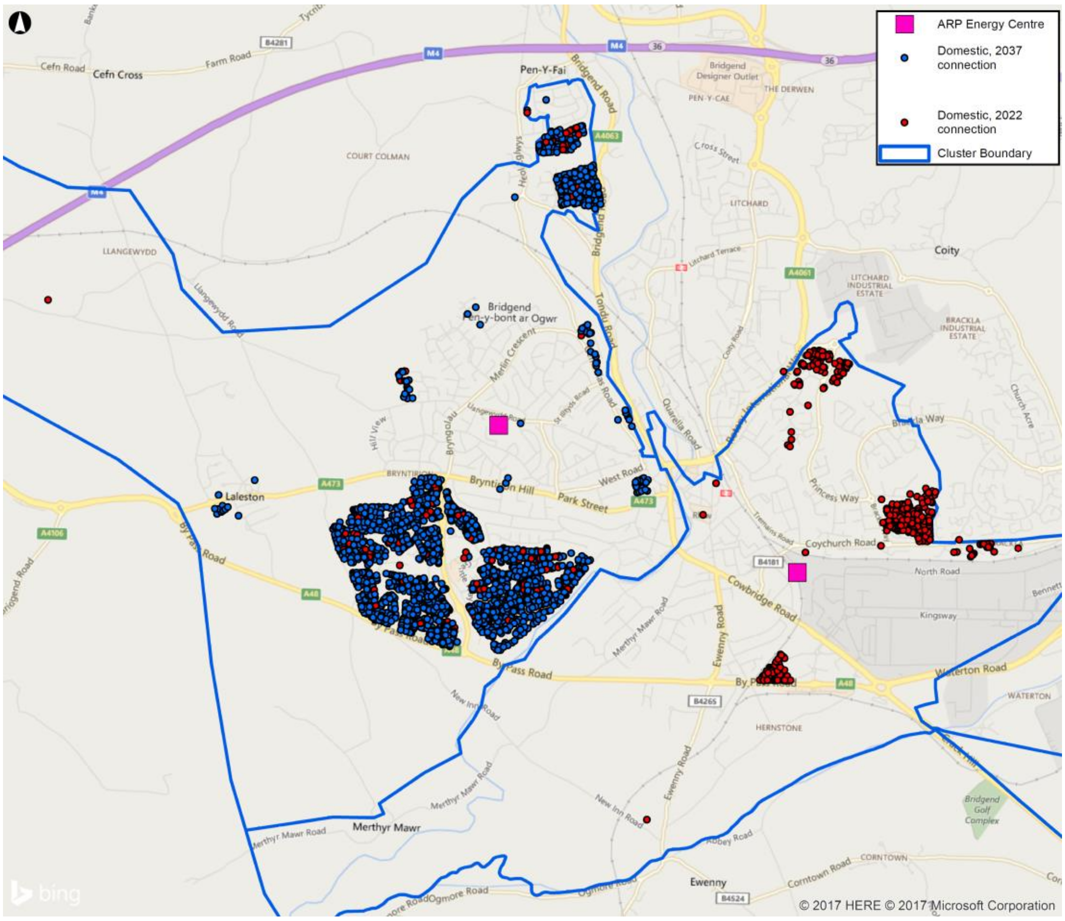

Figure 8: Domestic connection phasing

The networks are recommended to be installed with cluster 9 in 2022, aiming to connect the largest heat users as soon as possible to maximise commercial performance, and with cluster 8 in 2037.

6.4 Network efficiency

Network losses should aim to be a maximum of 10% of the total heat supplied to consumers. This is in line with CP1 guidance (UK Heat Networks Code of Practice) and is the responsibility of the operator and designer to achieve through pipe sizing, insulation selection, seasonal optimisation of operating temperatures and efficient operation of the system.

This may not be achievable if particularly long runs of pipe serving few dwellings are installed. Whilst these sections may reduce the overall network efficiency, they may still result in the lowest carbon equivalent emissions.

7 Cost Assessment

7.1 Cluster 8

7.1.1 Energy centre costs

Table 7: Cluster 8 energy centre costs

	2020	2030	2040	2050
Gas Boilers	£540,000	£0	£0	£60,000
Gas Engine CHP	£4,910,000	£0	£0	£0
Energy Centre building and ancillaries	£1,460,000	£0	£0	£10,000
TOTAL	**£6,910,000**	**£0**	**£0**	**£70,000**

Note that this build up does not include allowance for the purchase of land. It is assumed that the nearest gas connection would be within 100 m of the development.

7.1.2 Pipework and connection costs

Table 8: Cluster 8 pipework and distribution costs

	Cost (£)
Distribution (spine network)	£61,480,000
Connection pipework (domestic)	£6,060,000
Domestic connection costs	£2,660,000
Non-Domestic connection costs (Heat exchanger etc.)	£0
TOTAL	**£70,200,000**

Note that connection pipework to the non-domestic buildings is considered under the distribution spine due to the assumptions and method of calculating the spine length. The connection length from the spine to each residential house is assumed to be 5 m, using DN25 mm diameter heat network pipe.

7.1.3 Cluster 8 costs

The combination of energy centre costs as well as pipework and connection costs gives a cluster cost of approximately £77 m.

7.2 Cluster 9

7.2.1 Energy centre costs

Table 9: Cluster 9 energy centre costs

	2020	2030	2040	2050
Gas Boilers	£0	£0	£40,000	£350,000
Biomass CHP	£0	£0	£9,550,000	£3,950,000
Gas Engine CHP	£0	£0	£550,000	£2,700,000
Large Scale Heat Pump	£0	£0	£11,180,000	£5,670,000
Energy Centre building and ancillaries	£0	£0	£5,340,000	£2,500,000
TOTAL	**£0**	**£0**	**£26,660,000**	**£15,170,000**

Note that this build up does not include allowance for the purchase of land. It is assumed that the nearest utility connection (i.e. gas, electricity and water) would be within 100 m of the development.

7.2.2 Pipework and connection costs

Table 10: Cluster 9 pipework and distribution costs

	Cost (£)
Distribution (spine network)	£27,900,000
Connection pipework (domestic)	£1,030,000
Domestic connection costs	£450,000
Non-Domestic connection costs (Heat exchanger etc.)	£160,000
TOTAL	**£29,540,000**

Note that connection pipework to the non-domestic buildings is considered under the distribution spine due to the assumptions and method of calculating the spine length. The connection length from the spine to each residential house is assumed to be 5 m, using DN25 mm diameter heat network pipe.

7.2.3 Cluster 9 cost

The combination of energy centre costs as well as pipework and connection costs gives a cluster cost of approximately £71 m.

7.3 Interconnection

Table 11: Interconnection pipe costs

	Cost (£)
Interconnection pipe (assumed to be DN400 mm)	**£6,500,000**

The interconnection costs are approximately £7 m.

7.4 Total costs

Combining the cluster 8 costs with the cluster 9 costs with the interconnector costs gives an approximate total cost. This is approximately £155 m for the entire development.

7.4.1 Outlying costs reduction

As discussed previously, a reduction of 3 km in the network length could be made if the most remote connections (2 dwellings) were not included. This would reduce the capex by approximately £4 m. This does not include removal of buildings in the area of those assessed in Part 1 of this commission.

8 Commercial Assessment

8.1 Cost and commercial viability

Heat network project viability is predominately judged on metrics such as Internal Rate of Return and Net Present Value. These indicate the long term commercial viability and are used as a decision making tool by stakeholders.

Additional key performance indicators depend heavily on the project drivers and goals. For example, carbon savings or reduction in fuel poverty may be the main focus of the scheme, in which case they may take precedent over the purely financial metrics.

Part of the masterplanning, feasibility and design stages of the project are to ensure that decisions have been made to maximise the benefits of the project in line with the key performance indicators. The following section highlights key items that should be further investigated to improve commercial viability.

8.1.1 Connection strategy

All heat offtake connections should be connected to the network as soon as possible. This will maximise the revenues gained, improving the financial returns of the project and in doing so improve the commercial viability. Investing in infrastructure (pipework) without achieving the corresponding planned heat offtake revenue will reduce the projects commercial viability.

8.1.2 Heat density

Heat density is crucial in developing a commercially viable network. Long stretches of pipe are expensive to install, hence the heat sales from the pipe must be sufficient to offset its costs. As a rule of thumb, a linear heat density of 2 MWh/m would be expected to produce a commercially viable network.

The heat density of a scheme can be improved by connecting smaller loads between anchor loads, or by extending the pipe to serve larger heat demands in close proximity to current connections.

8.1.3 Additional connections

A brief analysis of clusters 8 and 9 has highlighted the following buildings as being potential connections which may benefit the heat network, either due to their location or anticipated annual heat demand.

Cluster 8:

- Llangewydd Junior School (also energy centre location);
- Bryntirion Comprehensive School;
- Maes Yr Haul Primary School;

- Bridgend Life Centre;
- Bridgend County Council Offices.

Cluster 9:

- Bridgend College;
- Bridgend Industrial Estate – multiple buildings;
- Central Bridgend – multiple buildings.

Connection of these additional buildings will depend on balancing their individual long term pathways against improving the heat networks commercial viability. This could involve immediate connection to the heat network, and following successful network initiation the buildings revert back to their optimum technology pathway.

8.2 Potential delivery vehicles/mechanisms

Delivery vehicles might involve formal corporate entities or existing organisational structures. Corporate entities created for the purpose of heat network delivery may be a Joint Venture body or Special Purpose Vehicle. The delivery vehicle chosen will result from the delivery model chosen.

Delivery models are typically conceived as ranging from “public” to “private”. In reality there are many potential combinations of parties fulfilling the various roles. Thus the choice of delivery model is more of a continuum of solutions rather than a defined set of solutions. To help simplify this, four main types of delivery model can be identified, depending on the parties undertaking the different roles:

1. Private sector led;
2. Public-private shared leadership;
3. Public sector led;
4. Community Company (CoCo).

The delivery model chosen is likely to depend on the commercial viability of the scheme. The following Internal Rate of Return boundaries[2] are generally accepted to indicate the commercial viability of the project and the resultant interest by commercial partners.

- **> 12%** indicates commercially viability. Likely to attract private sector interest.
- **6 – 12%** indicates economically viable. The public sector is likely to need to play a role in investment in the scheme.

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[2] Making Heat Networks Work, Energy World, (July/August 2016)

- **< 6%** indicates a sub-economic network. Grant funding would be required to deliver this network, often for strategically or socially beneficial reasons. Alternatively the community could provide some funding.

8.3 Market barriers

The following are market barriers to heat network development across the UK[3] anticipated to be issues which may need addressing/overcoming.

1. Difficulties with meeting development and capital costs
2. Uncertainty regarding longevity and reliability of customer demand
3. Uncertainty regarding reliable heat sources
4. Lack of regulation and inconsistent pricing of heat
5. Lack of generally accepted contract mechanisms
6. Lack of a generally accepted and established role for local authorities
7. Choice of heating system
8. Skills gaps
9. Access to land
10. Tax and business rates
11. Air quality approval.

Many of these barriers are a result of large scale heat networks being relatively new to the UK heat market. Their impact may reduce as more regulation and best practice guidelines are set in place over time. This is significant for Bridgend due to the timeframes associated with the development.

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[3] Research into barriers to deployment of district heating networks, DECC (2013)

9 Risk Assessment

This section presents the anticipated key risks associated with the energy centre and network deliverability. The risks have been graded based on their impact on the technical and commercial viability of the project.

9.1 Energy centre deliverability

Table 12: Energy centre deliverability

Item	Explanation	Risk
Proximity of energy centre to domestic housing	The energy centre in cluster 8 is in a residential area. The local residents may not be accepting of a large energy centre with a tall flue if as it is not in keeping with the local area. This may make the planning permissions more stringent, impact the design of the energy centre, and increase the stakeholder and community engagement required.	M
Planning permissions for energy centre	Without a local development order the energy centre development will need to progress through the standard planning approval process. This could delay the project programme.	L
Heat pump source technology	There is no heat source specified for the large scale heat pumps. This adds inherent risk as the source may not be available or it may not be technically feasible to generate the heat required whilst maintaining acceptable coefficients of performance.	H
Air quality requirements	The energy centres may need additional exhaust gas cleaning and flue treatment above the standard requirements to meet more stringent air quality regulations. This will increase the costs associated with the development. However, the energy centre is not inside a current air quality management area, which reduces the risk of deliverability.	L

9.2 Heat network deliverability

Table 13: Heat network and interconnection deliverability

Item	Explanation	Risk
Disruption to traffic during installation	The network route requires installation of heat network pipe down many major roads throughout Bridgend. This will disrupt local businesses and residents as roads are closed. Disruption management plans alongside diversions will need to be put in place. This may affect public opinion of the heat network and harm its long term credibility. The optimum network route may not be available due to unacceptable levels of disruption, in which case sub optimum routes may increase costs and impact long term operational performance.	M
Cost increases due to river and railway crossings (bridge reinforcement, route diversion etc.)	The network route requires installation of heat network pipe across several key railway and river crossings. Should the chosen bridges not be able to support the pipe, this may lead to cost increases to reinforce the bridges, construction of	M

Item	Explanation	Risk
	bespoke crossing points, or an alternate sub-optimum route being taken.	
Cost increases due to diversions as a result of congested utilities	Areas of congested utilities may require sub optimal heat network route to be taken, increase in surveying and route planning requirements.	H
Land ownership and development rights not granted	Without a local development order and/or required land ownership the network route may need to be diverted to a less optimum route or costs and programme delays may be a result of negotiations and route disagreements between stakeholders.	M
Nonstandard connections to non-domestic properties	Nonstandard connections will increase the costs of installation and connection and may dissuade the developer (or consumer) from connecting.	L
Cost increases due to building side conversions	No building side conversion costs have been included in the cost assessment. Should the building side systems require extensive retrofitting or refurbishment, and this fall under the responsibility of the network developer, this will increase the costs of the development.	M
Unable to secure energy supply agreements with key anchor loads	The review and EPN model assumes that the domestic and non-domestic connections will agreed to connect to the heat network. This may not be the case which would impact the heat offtake, the heat density and in turn the commercial viability.	H
Incorrect assessment of thermal loads	If the thermal loads have been assessed incorrectly, or there is future plans to reduce them (through energy efficiency measures, change of operations etc.) and this has not been captured correctly this will impact the heat offtake, heat density and reduce the long term commercial viability.	M
Network interconnection demarcation points	The connection of the two networks leads to more complex operation and management of the network including heat supply agreements, supplier of last resort agreements and demarcation points for both the heat distribution network and interconnection network. This may increase the legal complexity of the project with potential to add unforeseen cost implications.	L

9.3 Additional notes

Whilst heat is still an unregulated industry, the infrastructure and project timeframes are long-lasting, and the industry is likely to become regulated during the scheme. Therefore the network owners will need to accommodate and meet these standards as they come into being. To mitigate undesirable impacts of this, any scheme should be designed, from inception, to meet best practice guidelines (which are likely to be used to inform the regulations). The result being that adhering to any new regulations should not be arduous. It should be noted that in general, the industry sees the possibility of regulation as a positive thing, one which will add consumer protection and improve confidence in the industry.

10 Conclusion

This report has reviewed the commercial and technical viability of a heat network across two clusters in Bridgend. A review of the heat demand has found that the dwellings connected are generally clustered which benefits the heat network due to the increased heat density. However there are some outlying properties connection to which should be reviewed as they required extensive lengths of pipe to connect comparably small heat offtake. The non-domestic buildings are all in cluster 9. The commercial viability of the scheme could be improved by connecting other key non-domestic buildings throughout both clusters.

An assessment of the energy centres showed that there were no significant barriers to development. However the energy centre in cluster 8 is located in a residential area and this may be a risk to planning consent.

A network spine route has been developed avoiding key constraints where possible. It is estimated that 50 km of trench is required to connect the specified connections. High risk areas include utilities congestion immediately north of the energy centre in cluster 9, and the bridges crossing the railway in cluster 9. These are unavoidable due to the energy centre placement but may cause programme delays and costs increases if not managed effectively.

A transmission pipe was developed connecting the two energy centres. Connecting the two energy centres will improve the resilience of both networks along with other key benefits but will add complexity, heat losses and pumping costs to the network. The key risk associated with the installation of the interconnection pipe is crossing the River Ogmore, and the railway immediately adjacent to the energy centre in cluster 9.

The estimated total costs for the entire development across both clusters and including the interconnection pipe is £155 m. A high level assessment of the costs associated with outlying connections has shown that £4 m could be saved when removing 2 dwellings from the network.

Key market barriers to the development will be meeting this capital costs along with uncertainties regarding long term demand.

The key risks associated with the energy centre development is anticipated to be the heat pump source, as this is currently unclear, and it is not known if this source is available or can provide the required temperatures while meeting industry standards.

The key risks associated with the network and interconnection development are cost increases due to diversions and infrastructure reinforcements, and securing energy supply agreements with anchor loads.