Programme Area: Smart Systems and Heat

Project: WP2 Bridgend Area Energy Strategy

Title: Bridgend Local Area Energy Strategy – Assessment of Domestic Low Carbon Transition Pathways

Abstract:
Arup was commissioned to undertake a high-level desktop screening of the potential constraints not considered by the Energy Path Networks (EPN) tool on ten specific low carbon, domestic pathways in different clusters in the Bridgend County Borough Council (BCBC). These constraints were analysed for different clusters and each pathway was assessed for feasibility of domestic connection. The technologies considered were district heating, low temperature air source heat pumps (LT ASHP), hybrid heat pumps and biomass boilers. Each pathway was allocated a risk rating based on the constraints found for the implementation of these technologies at a domestic level.

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

Energy Path Networks

Task 001: Assessment of Domestic Low Carbon Transition Pathways

ESC0001263

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Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

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Contents

1 Executive Summary

Arup was commissioned to undertake a high-level desktop screening of the potential constraints not considered by the Energy Path Networks (EPN) tool on ten specific low carbon, domestic pathways in different clusters in the Bridgend County Borough Council (BCBC).

These constraints were analysed for different clusters and each pathway was assessed for feasibility of domestic connection. The technologies considered were district heating, low temperature air source heat pumps (LT ASHP), hybrid heat pumps and biomass boilers.

Each pathway was allocated a risk rating based on the constraints found for the implementation of these technologies at a domestic level, with the following results:

Table 1 Risk level rating for each domestic pathway

Pathway	Score
Detached houses, 1980-present age band, District Heat, cluster 7	L
Detached houses, 1980-present age band, District Heat, cluster 8	L
Semi-detached houses, 1945-1964 age band, District Heat, cluster 7	L
Semi-detached houses, 1945-1964 age band, District Heat, cluster 8	L
Terrace houses, pre-1914 age band, LT ASHP, cluster 3	L
Terrace houses, pre-1914 age band, LT ASHP, cluster 4	L
Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 3	L
Semi-detached houses, pre-1914 age band, Hybrid heat pump, cluster 3	L
Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 4	L
Terrace houses, pre-1914 age band, biomass boiler, cluster 3	M

The constraints found in this high-level study are minor for all technologies. Our initial view is that the technologies and pathways studied are technically feasible, with the majority categorised as low risk. The unit costs allocated for each technology may need to be revised when used for these specific clusters and property types, with no major cost changes expected.

Arup’s initial view is that biomass boilers for pre-1914 terrace houses in cluster 3 carry a medium risk. It is uncertain what proportion of these houses will accommodate the installation of a biomass boiler either through the front door or back garden. Air quality is unlikely to be an area of concern with the installation of around 300 biomass boilers for this pathway. This may become an issue at a later stage if a larger number of houses is included in the pathway. An air quality assessment should be carried out to understand the impact in the area of implementation.

2 Introduction

Arup was commissioned by Energy Systems Catapult (ESC) to undertake a high-level study to consider the feasibility and potential constraints of four individual housing clusters in the Bridgend County Borough Council (BCBC). Clusters 3, 4, 7 and 8 were analysed which have been highlighted in Figure 1.

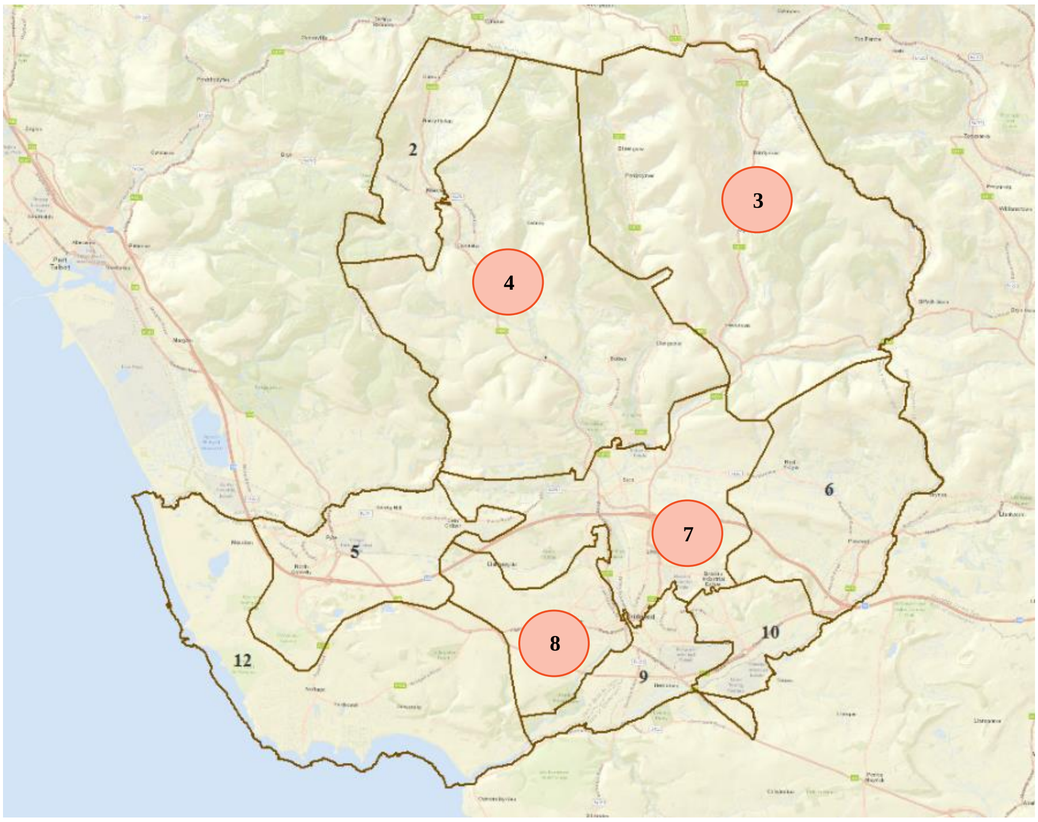


Figure 1. BCBC clusters assessed in this study

The following pathways and housing types discussed in this report:

- Detached houses, 1980-present age band, District Heat, cluster 7.
- Detached houses, 1980-present age band, District Heat, cluster 8.
- Semi-detached houses, 1945-1964 age band, District Heat, cluster 7.
- Semi-detached houses, 1945-1964 age band, District Heat, cluster 8.
- Terrace houses, pre-1914 age band, LT ASHP, cluster 3.
- Terrace houses, pre-1914 age band, LT ASHP, cluster 4.
- Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 3.
- Semi-detached houses, pre-1914 age band, Hybrid heat pump, cluster 3.

- Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 4.
- Terrace houses, pre-1914 age band, biomass boiler, cluster 3.

The analysis was based on tool output and data provided by ESC which included a UPRN register containing the transition pathways, building locations and heating system information. The proposed pathways were given to Arup to examine within the Bridgend Analysis Clusters maps, also provided.

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.

All pathways studied were limited to transition pathways where the original heating system is gas boilers. Other original heating systems were found for these pathways for a very small number of dwellings. Because of this, the analysis of those was omitted.

The following factors were considered in this study:

Technical Feasibility

A high level assessment of access to properties and installation of technologies which considered the practical deployment, space required, structural work and pipework for the new heating systems. Assessment of the area and description of the house was based on investigation of Google map data. The fuel supply chain for biomass boilers was also considered.

Flood Risk

The Natural Resources Wales (NRW) online maps were used to identify potential risks posed from flood-susceptible areas like rivers and/or surface water flooding. Each cluster was assessed separately to understand the flood potentials to all technology types within the areas and how this affected the houses within the cluster. This is not a detailed flood risk assessment and further study would be required prior to any work commencement.

Air Quality

The Air Quality Management Areas (AQMA) were obtained from Defra's AQMA Interactive Map 2017 and identified around the Bridgend area to ensure there were no specific constraints or management plans in place which could affect the deployment of the heating systems.

Ground Conditions

Geotechnical properties were studied through the Coal Authority online maps for the UK. Mine openings and Development High Risk Areas were identified in some clusters which pose risk of ground instability or public safety risk.

Heritage, Planning and Visual Impact

The Historic Wales's and British Listed Buildings' website identified multiple Grade II listed buildings in Bridgend County. There are 15 conservation areas in which they have been listed due to their history or external architectural features. Any extension to a dwelling in a conservation area must be compatible with the preservation or enhancement of the character or appearance of that area.

Noise Impact

This assessment included impact of construction and operation noise of the heating system to the occupants and surrounding locality.

3 Technical Feasibility

Technical feasibility of the transition pathways is assessed by technology. Each part includes analysis of practical deployment, space required, and structural work and pipework required.

3.1 District Heating

The following four pathways use district heating as final heating system:

- Detached houses, 1980-present age band, District Heat, cluster 7.
- Detached houses, 1980-present age band, District Heat, cluster 8.
- Semi-detached houses, 1945-1964 age band, District Heat, cluster 7.
- Semi-detached houses, 1945-1964 age band, District Heat, cluster 8.

It was found that the practical deployment of these four pathways is very similar, since these groups of detached and semi-detached houses have similar advantages and constraints to the implementation of a heat network. Additionally, the practical deployment of domestic connections is not affected by the cluster where these dwellings are located.

Where there are any discrepancies or further points to note, these are described separately.

3.1.1 Practical Deployment

There are approximately 1,800 houses in cluster 7 and over 2,000 houses in cluster 8 that are part of these pathways. These houses are mostly located in exclusively residential areas, away from congested town centres. Construction of heat networks over a number of years will have an impact in these two clusters, particularly due to the large number of houses requiring retrofitting works around the same time to connect to the heat network. This is not an area of concern for the deployment of district heating pathways because this is to be expected.

It is expected that the area is congested with utilities at a domestic-scale, typical of residential areas. The front of these detached and semi-detached houses are more readily accessible, since they have large private gardens, and are at times arranged back-to-back, or with their backs to a land with trees. Gas network maps from Wales & West Utilities show that the gas connections for this area are usually at the front of each house. A district heat connection at the front of the house would be typical for these properties.

There are rail tracks and river courses present in between the houses selected for these pathways, for both clusters 7 and 8. These are important constraints to the implementation of a heat network. This report analysed the distribution of the heat network into individual dwellings, therefore the presence of nearby river or rail tracks will not affect the domestic installation.

All houses in these pathways are within a 5-mile radius of Bridgend town with good transport connections. No major constraints are foreseen for the delivery of materials for construction and retrofitting.

There is currently no other district heating networks in this area, which means it is unlikely there are any skilled resources in the area to carry out this work. A contractor will have to bring resources to Bridgend to install a heat network and retrofit the houses' heating systems. This is not seen as a constraint to the implementation of this pathway but will impact the costs, particularly if several heat networks are to be installed within the same period which would require higher number of staff.

The possibility of the heat network pipes themselves to flood is unlikely but poses a risk. Leak detection and maintenance of the network equipment minimises this risk. This indoor flood occurrence would cause disturbance to the heating of multiple houses at a time.

3.1.2 Space Required

The transition from gas boilers to district heating includes a replacement of existing gas boilers with a Heat Interface Unit (HIU). A HIU for domestic applications is usually no larger than the gas boilers found in houses from the periods in these pathways (1945-1964 and 1980-present). Because of this, it is possible for the HIU to occupy the same place as the gas boiler with no additional space needed.

It would also be possible to locate the HIU at the outside of the house in a suitable enclosure, if necessary. The only requirement is for the HIU to be accessible for maintenance. Because of the variety of houses found within a single pathway, it is not possible to provide guidance on the ultimate location of a HIU, which is usually determined by the contractor upon retrofitting.

The existing radiators connected to the gas boilers would not need to be immediately replaced when transitioning to district heating. No additional space is required.

3.1.3 Structural Work and Pipework

A district heating connection to the dwellings can be provided at the front of the house for all four pathways. It is possible to allow the pipework to come into the house at the front, keeping in mind that visual impact should be minimised. This would reduce additional trenching (more expensive) or boxing in (more visual impact) to the side or back of the house. These detached and semi-detached houses appear to have sufficient space to carry out the connection works.

According to the UPRN data provided, all of these houses are built with cavity walls. It is important to note that drilling into an insulated cavity wall for the district heating connection can be more complicated than into uninsulated cavity walls. The UPRN data shows the majority of properties currently have unfilled cavity walls, which should reduce the potential impact on the programme or costs.

- Cluster 7, detached houses (1980-present): 53% unfilled cavity walls. No insulation is proposed with the transition.
- Cluster 8, detached house (1980-present): 83% unfilled cavity walls. No insulation is proposed with the transition.
- Cluster 7, semi-detached (1945-1964): 76% unfilled cavity walls. Insulation (loft or cavity wall) is proposed to the vast majority of these along with the transition to district heating.
- Cluster 8, semi-detached (1945-1964): 76% unfilled cavity walls. Insulation (loft or cavity wall) is proposed to the vast majority of these along with the transition to district heating.

Inside the house, the district heating network would terminate at the HIU. A review of these houses show that the more recent houses (1980-present) have a boiler flue at ground floor lever, while older houses (1945-1964) show a boiler flue on the ground or first floor. It is not possible to make a generalisation for any pathway regarding where the HIU is to be located. It is expected that additional pipework will be required to reconnect the existing wet heating system to the HIU. This is not a point of concern for the implementation of district heating.

3.2 Low Temperature Air Source Heat Pump

Two final heating systems in this study include the installation of heat pumps: LT ASHP and hybrid heat pump (LT ASHP and gas boiler). The common constraints regarding the use of LT ASHPs in five pathways are described below. Additional constraints relevant to the use of hybrid heat pump are described in section 3.2.2.

3.2.1 LT ASHP transition pathways

The following two pathways use LT ASHP (only) as final heating system:

- Terrace houses, pre-1914 age band, LT ASHP, cluster 3.
- Terrace houses, pre-1914 age band, LT ASHP, cluster 4.

The practical deployment of these pathways is very similar since they are terrace houses of the same era and will require the same installation works to be carried out. The implementation of this technology for pre-1914 terrace houses is analysed below.

3.2.1.1 Practical Deployment

The targeted dwellings in clusters 3 and 4 are in rural and residential areas and approximately 7 miles north of Bridgend city centre. The delivery of equipment and materials can be achieved by the main roads and rail lines (Maesteg in cluster 4) near the properties.

Materials that will be required are slabs and acoustic enclosures, to aid with noise pollution, visual pollution and adverse weather effects. The 500 L water cylinder to be installed as part of the LT ASHP pathway will also require floor mounting and additional pipework into the dwellings. This may not have been included in the capital costs of the EPN tool, and it will have a minor impact on the costs.

LT ASHP typically deliver hot water up to 55 °C for heating and domestic hot water. It is assumed Legionella is not an issue due to the water not being stagnant for extended periods of time, and that the EPN tool has taken temperature requirements to reduce Legionella growth in the calculation of the dwelling heat demand.

A LT ASHP will provide low temperature water to the existing heating systems sized for high temperature water. The radiator surface at each room will need to be increased in order to keep the pre-heat period (time to achieve desired temperature indoors) the same as currently. This translates into additional or larger radiators. This has been included in the EPN tool costs.

During cold weather, the Coefficient of Performance of the LT ASHP is expected to be lower. Seasonal variations have been allowed for in the EPN tool as part of their model of LT ASHP. Some unexpected poor performance of the LT ASHP can occur in moist conditions slightly above freezing temperature. With these environmental conditions the LT ASHP cools the air in order to heat the building. This causes the air to drop below freezing point on the LT ASHP externally. The ice formation blocks air flow and limits the capacity of the LT ASHP. To bring the unit back to full capacity the LT ASHP will go through a de-frost cycle. This spends energy without heating the building. This gives a low effective Coefficient of Performance.

A lower Coefficient of Performance also means that the LT ASHP will consume more electricity than expected for the same output, which will influence the electricity demand estimated by the EPN tool and may impact the availability from the grid supply.

3.2.1.2 Space Required

LT ASHPs can be installed outside a property to ensure free airflow and access for maintenance. Given that these are terrace houses, it would be suitable to install the heat pumps in the back garden. A flat surface is required for the stable positioning of the LT ASHP, preferably on a mounted concrete slabs. Where the garden is on a slope, some levelling might be required.

The majority of terrace houses in these pathways have an average floor space of 100 m^2, which allows for the installation of the 500 L water tank indoors. Pre-war terrace houses such as these may have narrower doors than modern houses. It is possible to purchase a 500 L tank of a diameter such that it can be transported through narrow doors. These tanks may have a height over 2 meters. It is uncertain the proportion of the houses in these pathways where smaller diameter/large height water tanks will be required.

If additional/larger radiators are adopted, additional space will be required in various rooms of the house. Space available should be assessed, particularly in crowded rooms with limited wall area such as the kitchen or bathroom.

Cluster 3

The majority of the houses in this cluster have a reasonably sized garden. A small proportion of the houses appear to have a small garden area on a slope (see Nant-y-moel), or have extensions that considerably reduced their back garden space. It would be possible to accommodate a LT ASHP in all instances. The LT ASHP can be mounted at height if space is not available.

Cluster 4

This cluster consists mainly of the town of Maesteg, with fewer slopes than the towns that form part of cluster 3. Gardens here are more likely to be on a flat surface. This facilitates the works to install a LT ASHP.

The majority of the terrace houses appear to have large back gardens. Most of these houses have extensions and sheds built that considerably reduced their back garden space. It is expected that LT ASHPs can be accommodated here.

3.2.1.3 Structural Work and Pipework

No major civil works are expected for this pathway to be implemented. The heat pump will require a smooth, even surface to be installed on. It can also be mounted at height with brackets where it does not cause any hazards and can be accessed for maintenance. Drilling into solid walls will not present any major issues unless contamination is found.

Additional pipework is required to connect the LT ASHP to the water tank indoors. The water tank could be located in the same location as the gas boiler to utilise the same pipework route. For the range of houses in these clusters, the location of boiler is unknown because the retrofit of the central heating system could have happened at any time. The heating system of two adjacent homes could be entirely different. This may have a minor impact on overall capital costs.

3.2.1.4 Grid constraints

An initial assessment of the network capacity of Western Power Distribution (WPD) in the area shows that the substations closest to clusters 3 and 4 have little capacity available (<10%). There is a risk WPD will not permit the supply to the required properties from these substations. There is available capacity south to the M4, representing approximately an available 10 MVA from the 11 kV substations.

The EPN model makes it unclear if LT ASHP and Hybrid heat pumps are the same electrical capacity. If the units have the same capacity, then their disposition does not affect the grid. If they are not the same capacity and the most onerous scenario has not been considered then this could be problematic, described below.

It is observed that the two technologies have been evenly interspersed. This is unlikely in real life application. If clusters of dwellings are installed with the same technology, this could form clusters of peak demand, possibly exceeding the grid connection allowance. A practical way forward for the Western Power Distribution would be to model the most onerous capacity across the selected properties. If the grid copes with the most onerous demand then any distribution will work.

3.2.2 Hybrid Heat pump

A hybrid heat pump is based on a LT ASHP providing space heating, while a gas boiler provides instantaneous domestic hot water and peak heating capacity for cold days. The following three pathways use hybrid heat pumps as final heating system:

- Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 3.
- Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 4.
- Semi-detached, pre-1914 age band, Hybrid heat pump, cluster 3.

The practical deployment of the semi-detached and terrace houses will be very similar and will require the same installation works to be carried out. Most considerations for the installations will be the same, except for the addition of a replacement gas boiler.

3.2.2.1 Practical deployment

The hybrid heat pump can be retrofitted using existing radiators, incurring no additional capital costs. No separate water tank will be required as the LT ASHP will have an internal thermal store.

No constraints are found in the implementation of hybrid heat pumps in these pathways.

3.2.2.2 Space required

The gas boiler is likely to be installed in the same location as the existing boiler, and does not need to occupy any extra space within the house. According to the data provided by the EPN tool, the hybrid heat pumps in these pathways are of smaller capacity than the LT ASHPs in the pathways from the previous section. They are expected to occupy the same space or less in the back garden of a property.

The terrace houses in cluster 3 and 4 chosen for hybrid heat pump installation are interspersed with the houses in the LT ASHPs pathways. The same analysis of available space applies. The majority of cluster 3 terrace houses appear to have a reasonably sized garden, while those in cluster 4 have larger gardens. The LT ASHP can be installed in back gardens by transporting it through the property, even if access to garden separately is not available.

The semi-detached houses in cluster 3 appear to have large garden spaces as well, and so installation of LT ASHPs does not appear to be a problem.

3.2.2.3 Structural Work and Pipework

No major civil works are expected for these pathways to be implemented. Additional pipework is required to connect the LT ASHP to the boiler indoors.

It is assumed that the previous gas boiler installation will have adequate flues and infrastructure works. This will create ease for the new gas boiler installation as the previous connections can be used or retrofitted.

3.2.2.4 Grid constraints

The LT ASHPs in hybrid heat pumps are sized to provide less heating than those assessed in the previous section, and so their electricity consumption is estimated to be lower. Grid constraints for hybrid heat pumps are expected to be the same as for LT ASHP.

3.3 Biomass Boilers

The following pathway uses biomass boilers as final heating system:

- Terrace houses, pre-1914 age band, biomass boiler, cluster 3.

There are five villages included in this cluster: Ogmore Vale, Blaengarw, Pontycymer, Nant-y-moel and Evanstowm. They will be assessed separately where required.

3.3.1 Practical deployment

Installing biomass boilers requires no changes to the current radiators. Biomass boilers cannot provide domestic hot water on demand. This could typically take from 30 minutes to two hours depending on the nature of the fuel. In order to achieve the maximum output from boiler and to accommodate for a rapid change in demand, a hot water storage tank is required for the system to be effective. The heating system described in this pathway appears to not include a hot water storage tank. This may not have been included in the capital costs of the technology. This additional cost could be offset by the resulting smaller boiler size.

Pre-war terrace houses such as the ones in this cluster may present the additional constraint of having narrower doors than modern houses. There is a variety of biomass boilers available in the market, with a width small enough to satisfy this requirement. Restricting to a specific boiler model that can be installed through the front door of the house may incur in additional capital costs. Where a front door installation is not possible, the back garden could be used for access since several houses have alleyways behind their back garden. It is uncertain the proportion of the houses in this pathway that could be accessed through the front door/back garden for plant delivery.

Biomass boilers also require more frequent maintenance than gas boilers. This needs to be provided by a skilled person. Ash removal and disposal also needs to be considered, which could be in the form of a separate bin per house, or a communal ash removal service for groups of houses in this cluster. This will also depend on the availability to dispose to landfill in this area, or whether a recycling company needs to be engaged to collect the ash. These factors will impact the operational costs. It is unclear if this has been accounted for in the fixed/marginal costs proposed.

The ability to deliver fuel to the houses (typically wood pellets) in this cluster is an important point to consider. There is currently no biomass fuel delivery strategy in cluster 3. It is assumed that fuel deliveries only need to happen a few times per year, based on storage at each house which can hold supply for several months. It is possible to achieve this with delivery trucks reaching each house with a biomass boiler. This requires input and support from BCBC. Some points to consider are:

- The majority of these villages only have access from the south for a large delivery truck. The M4 is close-by to allow better connection to the rest of the UK for fuel deliveries.
- The houses in the villages of Ogmore Vale, Blaengarw, Pontycymer, and Evanstown are usually on two-way roads, with space to allow for large delivery trucks. Cars usually park on these roads in front of the houses, so coordination will be needed for access to each property on fuel delivery days. There are also several groups of houses with alleyways behind their back garden, which could facilitate fuel delivery.
- The majority of terrace houses in the village of Nant-y-moel are along narrow two-way streets, with one lane usually occupied by rows of parked cars. Coordination will be needed for access to each property on delivery days. It is unknown if there is other space available to relocate the parked cars temporarily during delivery days.
- Fuel should be delivered close to the fuel storage. The back alleyways found behind several of these terrace houses may be accessible by foot, which could facilitate fuel delivery up to the storage place in the garden or indoors.

Alternatively, a wood pellet supplier may be located in the local area, so fuel stocking can be achieved individually by each consumer in smaller purchases. This would reduce fuel delivery issues.

There are plans for a 25 MW_e biomass plant to be built in Llynfi, near Llangynwyd within Bridgend County Borough. This is less than 10 miles from the villages in this cluster. It may be possible to consider using the same supplier as this biomass plant, which would facilitate the fuel deliveries.

3.3.2 Space required

Terrace houses in this cluster have an average floor space of 60 m^2. It is expected that the living space in these houses is already reduced and installing a biomass boiler indoors may be unfavourable to the consumers. The following analysis is done based on a biomass boiler installed in the back garden.

Space for this technology needs to account for the boiler, hot water tank, and fuel storage. This can be in the form of a shed, or a suitable enclosure to protect these from the environment. The hot water tank can be installed indoors to replace the gas boiler. Fuel, in the form of wood pellets, can be stored indoors in bags in a dry place, under cover, and contained so there is no fire risk.

The space required for the boiler is larger than just its dimensions. A biomass boiler requires certain clearance and ventilation to avoid overheating. A pellet storage box adjacent to the boiler is typically used for automatic feed of the boiler.

For the majority of the houses in this cluster, it would be feasible to use the garden space to install the boiler in a suitable enclosure and not sacrifice indoor area. The ground surface will have to be flat, so at times some levelling of the garden may be required. This is expected to add to the costs of implementing this technology.

Terrace houses at Bwlch-Y-Clawdd Road in Nant-y-moel are smaller and in a more crowded residential area, with a back garden on a steep slope. It appears there is not enough garden space to install a biomass boiler. Further study is recommended to assess what group of houses in Nant-y-moel are suitable for biomass boiler installation, indoor or outdoor.

3.3.3 Structural Work and Pipework

No major works are expected inside the house. The work for the pipe entry through solid walls for the connection to the pipework inside the house is expected to be similar to that of LT ASHPs. It is expected that additional pipework will be required to reconnect the existing wet heating system to the new location of the biomass boiler and storage tank.

Given the emissions produced by the biomass boiler, a new flue would be required to be taller than the highest window in these terrace houses, to avoid emissions entering the house. It may be more structurally complicated to have this standalone flue from the boiler enclosure in the garden. It would be more suitable to attach this flue to the house and rise along the back, if possible. A single flue up to the height of one metre above the height of the roof is allowed in Wales for biomass systems. This is discussed further under section 7.2.2.2.

For biomass boilers installed in the garden, a shed with a concrete floor can house the boiler, storage tank and fuel storage. Insulated pipework would carry the hot water to the house, so the shed should be located adjacent to the house, to minimise trenching and heat losses.

Following the analysis of technical feasibility, it was found that all technologies are achievable for the pathways studied. Capital and operational costs may need to be revised to include aspects mentioned in this section, but it is expected that the impact on cost will be minor. Further assessment of deployment of biomass boiler in cluster 3 is recommended to confirm installation and operation is possible in all the houses selected in this pathway.

4 Flood Risk

The flood risk assessment has been done by cluster groups with common technologies to be implemented. The effect on each technology is addressed within.

The Natural Resources Wales (NRW) online flood maps identify areas in Wales that are susceptible to flooding either due to rivers and seas and/or surface water flooding. Each cluster was assessed separately to understand the flood potentials to all technology types within the areas and how this may affect the houses within the cluster.

4.1 Clusters 7 and 8

4.1.1 District Heating

The two transition pathways in **cluster 7** contain a large number of properties where flooding is possible from rivers in the case of severe weather conditions, as shown in Figure 2. The affected areas are highlighted in red. The areas highlighted in yellow are houses which have a lower risk of flooding from surface water.

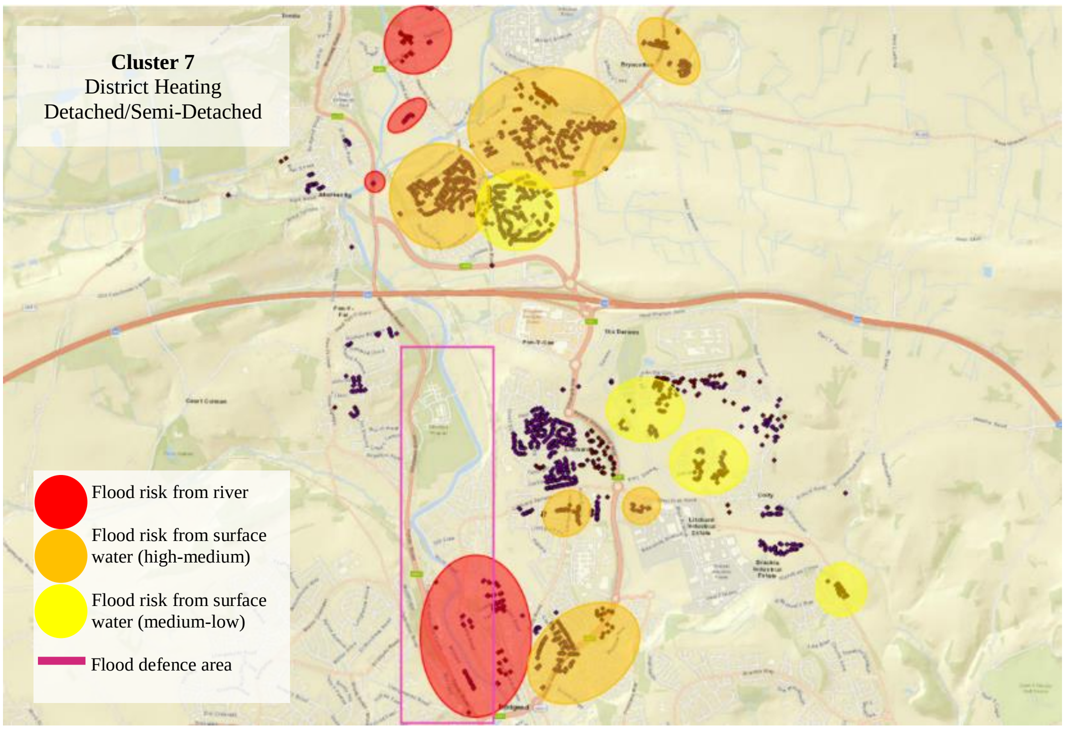


Figure 2. Cluster 7 dwellings under flood risk

The majority of **cluster 8** is free from a flooding risk. There are properties that will be affected by flooding and these have been highlighted in the red areas. The yellow shapes contain houses which have a lower risk of flooding from surface water.

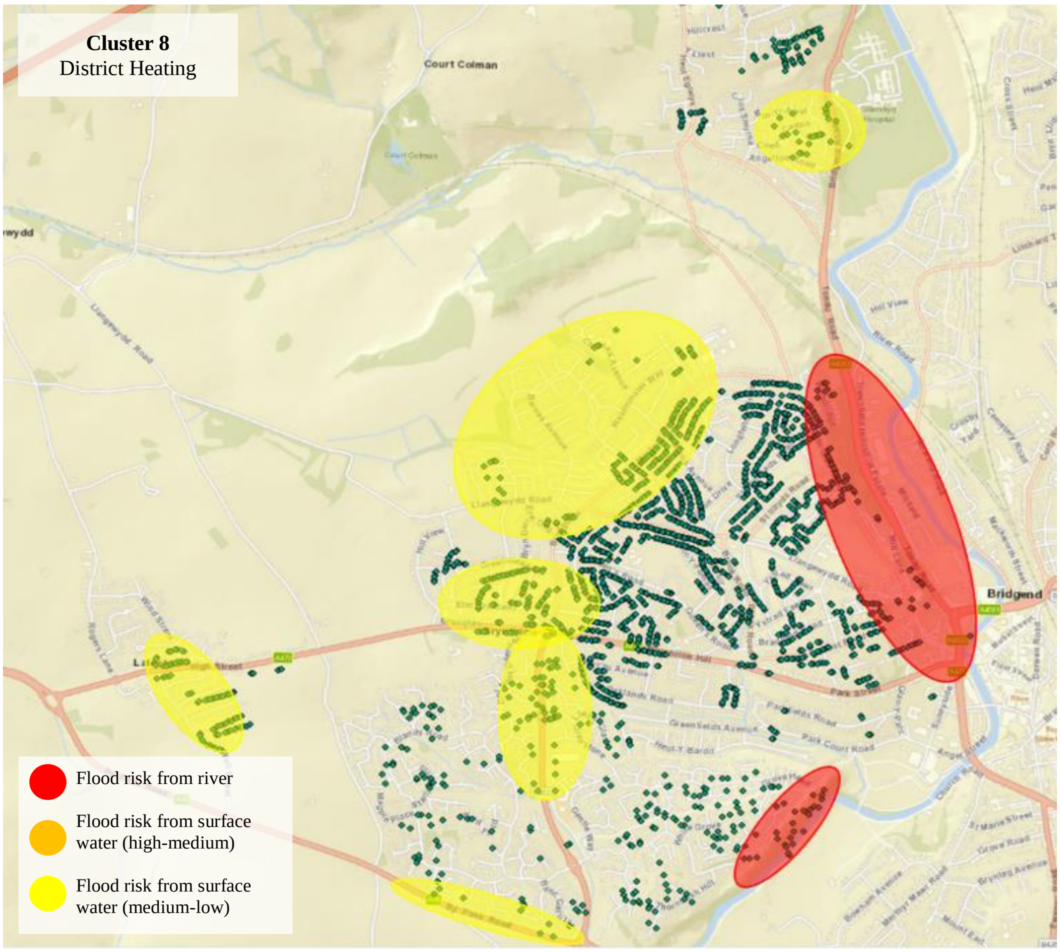


Figure 3. Cluster 8 dwellings under flood risk

4.2 Clusters 3 and 4

4.2.1 LT ASHP/Hybrid Heat Pump/Biomass Boilers

Cluster 3 contains properties where flooding is possible from rivers that would affect the areas highlighted in red (Figure 4). There is a higher risk that there may be flooding caused by high surface water. The majority of this cluster has a larger risk of flooding in general.

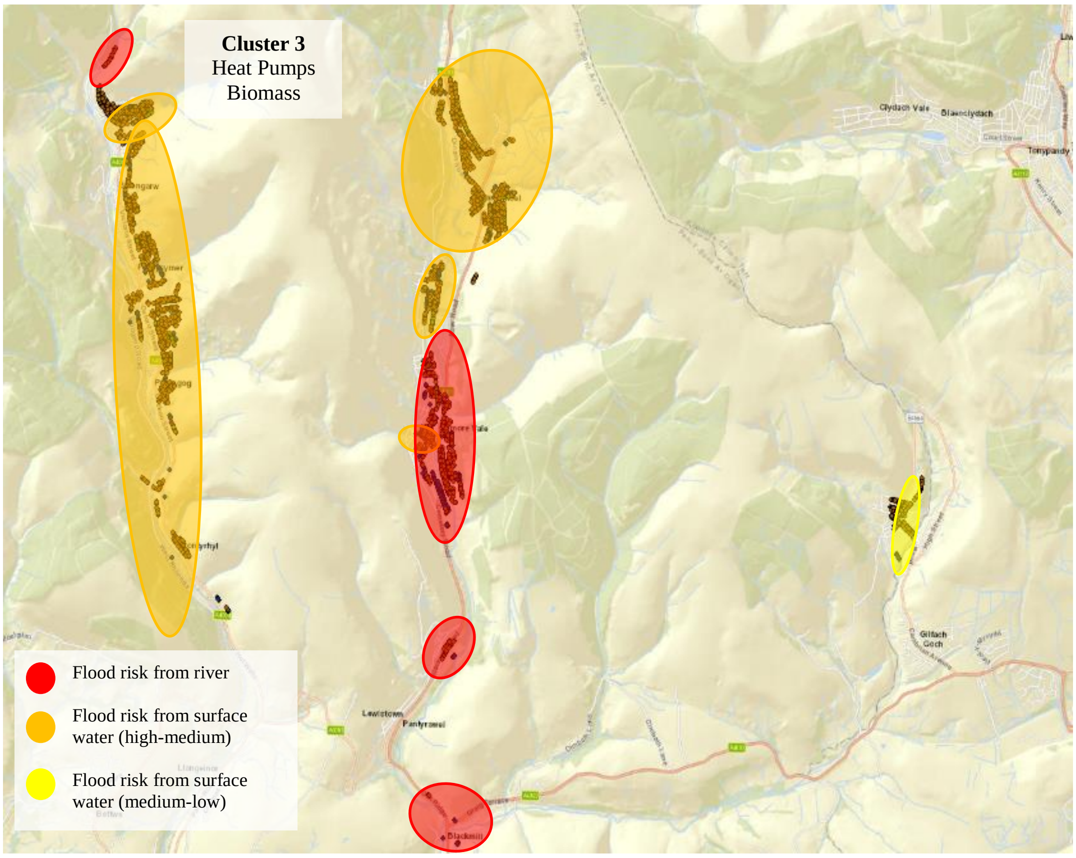


Figure 4. Cluster 3 dwellings under flood risk

The dwellings with LT ASHPs installed are affected by the flood-prone areas. LT ASHPs are to be installed outside of the dwellings hence the greater exposure to flood risk. The areas highlighted in red may require adequate elevation to endure the worst case flooding scenario. Areas with the potential of low surface water flooding could be installed outside on a concrete slab. These measures would reduce the risk and allow implementation of the LT ASHP and hybrid heat pumps in cluster 3.

Installation of biomass boilers in cluster 3 could be severely affected in the case of flood, potentially affecting the storage of the fuel as well as its delivery due to limited vehicle movement. The biomass fuel would need to be stored in an area that could be easily accessed by the resident in case of a flood but also prevent damage to the fuel. This storage could be located inside the dwelling in an area that is flood proof. If the storage is built outside, it will need to be elevated and contained in a waterproof outhouse, but the access may still be difficult. These measures would reduce the risk and allow implementation of biomass boilers in cluster 3.

Cluster 4 mostly contains properties where flooding is possible from rivers that would affect the areas highlighted in red. This cluster contains only LT ASHP and hybrid heat pumps. Potential damage to heat pumps is discussed above and can be mitigated.

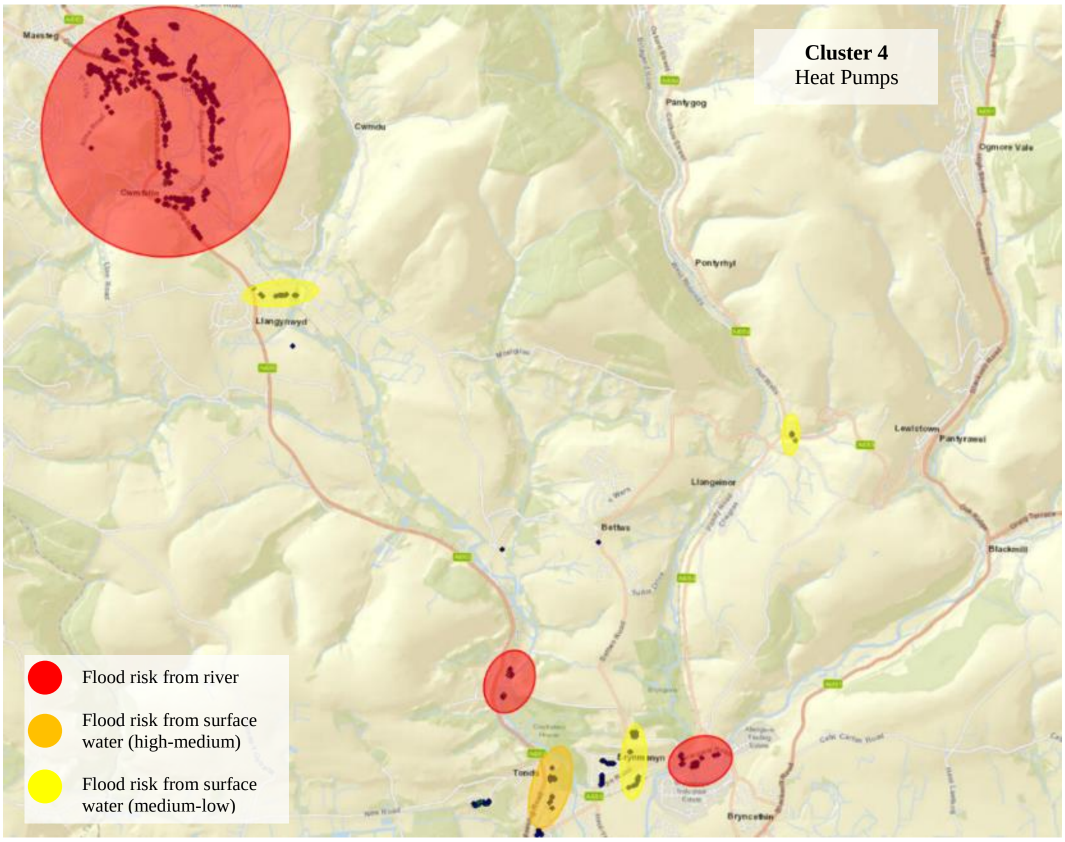


Figure 5. Cluster 4 dwellings under flood risk

The flood risk study found that there were varying levels of risk associated to each heating technology.

Clusters 7 and 8 with district heating installation would have minimal impact as water damage is not possible. LT ASHPs and hybrid heat pumps in clusters 3 and 4 could experience permanent damage to the electrical and controls installation inside. The mechanical components may still operate once dried. Puron/R410, a refrigerant used inside the LT ASHP and hybrid heat pumps, has a high global warming potential which could leak into the flood water and disperse into the locality causing detrimental effect. Mitigation measures can be taken to prevent damage by elevating the installation above the flood zone on a concrete slab.

Damage may occur through water ingress into the gas boiler required for the hybrid heat pump by water entering the combustion chamber or the controls of the system. Mitigation measures include wall mounting of the boiler or establishing a bund around it, elevated above the flood risk zone. Despite the possibility of the mechanical components operating after the flood, it may be more economical to replace the boiler and the LT ASHP instead of part replacements.

Cluster 3 further includes biomass boiler installations. The dwellings proposed for these installations are potentially at greatest risk of water damage to the technology. Water damage is likely to occur to the electrical and controls installation and would need replacement. If the water enters the ash store, this could solidify the ash causing complete damage to the boiler and the surroundings. Water entering the fuel store would spoil the fuel which would no longer be fit for purpose. Mitigation is difficult as the entire installation requires flood proofing including the area it is installed in. It is difficult to mount compared to a gas boiler, due to the larger size of the boiler.

As there are dwellings which are in flood risk zones for all technology types, it is advised to take out relevant flood insurance cover for ease of replacement in case of water damage.

5 Air Quality

The air quality analysis has been done by cluster groups with common technologies to be implemented. The effect of each technology on air quality is addressed within.

In order to achieve the national air quality objectives, local authorities in the UK review and assess air quality within their respective areas. This requires measuring air pollution and trying to predict the change in the upcoming years. The national air quality aims need to be met within set deadlines. If certain areas do not achieve those targets, they are declared as Air Quality Management Areas (AQMA). In that instance, the BCBC will need to put together a plan to improve the air quality.

The AQMA map is available in Lle, a Geo-Portal for Wales. This map was downloaded from the Welsh Government website into ArcMap and uses as a GIS layer to identify the areas around BCBC. A snapshot of this can be seen below.

Figure 6. Air Quality Management Areas near BCBC, Wales. (Extracted from ESRI ArcMap GIS using Defra's AQMA Interactive Map 2017)

AQMA guidelines show that the clusters studied in BCBC are not being monitored for their air pollution control. Currently, any developments occurring in that area are not be under strict monitoring. This is unlikely to change in the future because the majority of the towns in the BCBC are small, with no major traffic issues or industrial sites.

5.1 Clusters 7 and 8

5.1.1 District Heating

Despite Bridgend not being declared an AQMA, this does not exempt any increased construction activity for the district heating network. These emissions will still need to be monitored and meet the national air quality objectives and comply with pollution prevention controls.

HIUs produce no direct air pollutant emissions. Air quality is not expected to be affected by the domestic connection element of this technology.

5.2 Clusters 3 and 4

5.2.1 LT ASHP/Hybrid Heat Pumps

LT ASHPs produce no direct air pollutant emissions. There is no impact on the local air quality of these clusters due to LT ASHPs.

The gas boilers used in the hybrid heat pumps will contribute to pollution that may affect air quality. It is expected that new gas boilers will have to comply with stricter regulations which will limit the pollutants output. It is expected that the air quality of the area will not deteriorate with hybrid heat pumps.

5.2.2 Biomass Boilers

No full assessment of air quality is usually required for a single installation of biomass boiler for domestic purposes. It was found that a proposed 25 MW_e Llynfi biomass combustion plant located within the BCBC would not require a Detailed Assessment of air quality[1]. The Air Quality report produced by BCBC confirmed there were no areas of significant domestic solid-fuel use in the area.

Biomass boilers emit more pollutants than the existing gas boilers. The effect of installing a large number of biomass boilers in the rural towns of cluster 3 may require further assessment to study the cumulative effect. These towns are located relatively close to the coast which allows for more frequent air changes and the dispersion of pollutants. It is unlikely that around 300 biomass boilers located across five adjacent town wills create a concern for the local air quality.

Air quality may become a concern at a later stage if the EPN tool proposes a biomass boiler pathway for a larger number of houses. In this case, measures such as cyclonic filters may be able to help further minimise pollutants. An air quality assessment should be carried out in that instance to understand the impact in the area of implementation, taking into account topography and weather conditions.

[1] http://www.srs.wales/Documents/Pollution/Air-Quality-Reports/FINAL-Bridgend-Council-2016-Air-Quality-Progress-Report.pdf

It was found that local air quality is not affected by the implementation of district heating, LT ASHP or hybrid heat pumps. The installation of biomass boilers in a number of terrace houses in cluster 3 is not a concern. Other pathways with biomass boilers may require further study.

The emissions discussed in this section are dwelling specific and do not include the energy centre emissions. This has been further discussed in a separate, independent Arup report 'EPN District Energy & District Heating Deployment, Bridgend'.

6 Ground Conditions

A ground conditions assessment has been done by cluster groups with common technologies to be implemented. The effect of high risk areas and mine openings on each technology is addressed within.

The Coal Authority online maps identify areas in the UK where coal mines exist, and developments that are considered high risk. Development High Risk Areas (DHRA) contain specific recorded coal mining legacy risks which pose a ground instability or public safety risk to the surface. Sites in a Development High Risk Area are required to send a coal mining risk assessment to the local council, to be completed by a competent person. This will have a cost associated which may not be included in the current unit costs.

6.1 Clusters 7 and 8

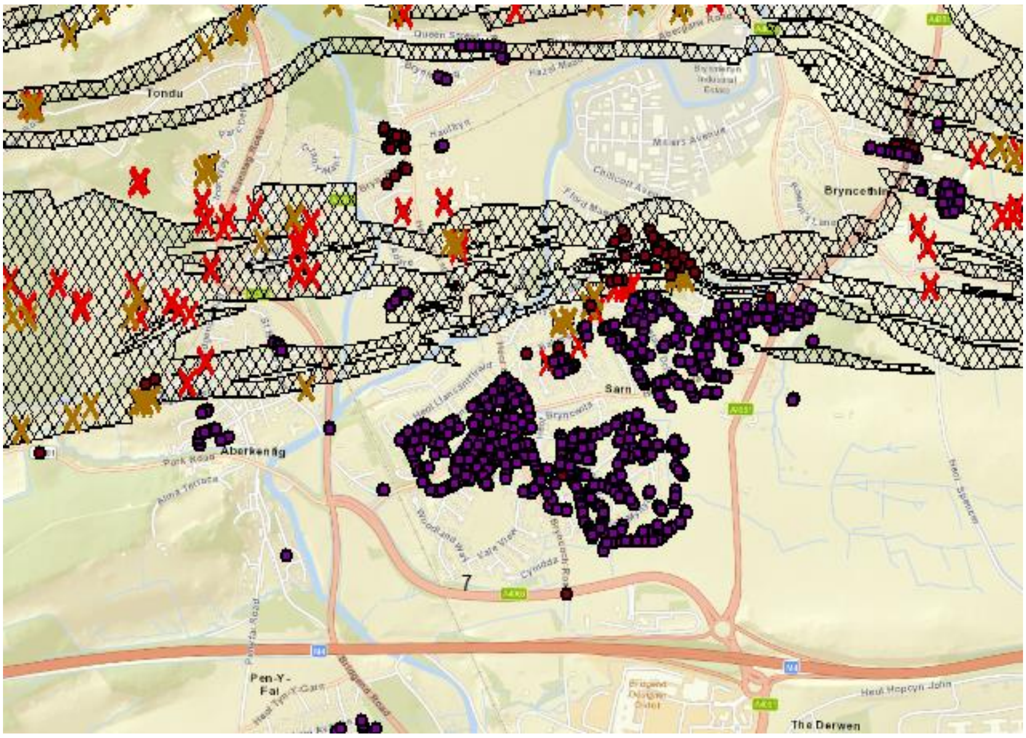
6.1.1 District Heating

Ground conditions are an important factor for the development of the heat networks proposed in these clusters. Feasibility of the whole heat network is beyond the scope of this task. Ground surveys and risk of contaminates should be included as part of the capital costs for this technology.

Further surveys will be required to understand the level of congestion in the roads from existing utilities, and assess whether sufficient space is available for new district heating pipework. If the ground is found to be contaminated, material disposal can be expected to be significantly more costly. BCBC could provide support for the implementation of district heating by producing the required ground surveys within defined areas of land.

From a domestic point of view, it is envisaged that the connection to the heat network would follow a similar route to that of existing gas connections, and at a depth of approximately one metre. The compulsory surveys for contaminated ground and utilities commissioned for the heat network should provide information about the expected ground conditions for the domestic connection.

DHRA and a small number of mine openings are located north of the M4. This affects a small proportion of the detached and semi-detached properties in **cluster 7**, around the village of Sarn. Works taking place in an identified DHRA are required to provide a coal mining risk assessment to the BCBC, highlighting risks to neighbouring occupiers, public safety, highway users, as well as mitigation measures. Mine openings represent a risk to the heat network to be considered when defining the route.



Development High Risk Area Ξ Ξ Mine Entry

Figure 7. Cluster 7: Detached and semi-detached properties; DHRA and mine openings

The detached and semi-detached properties in **cluster 8** are not located in a high risk area, or near any existing coal mine openings. Mine openings are not a concern in this cluster as it is not in the Coal Mining reporting Area.

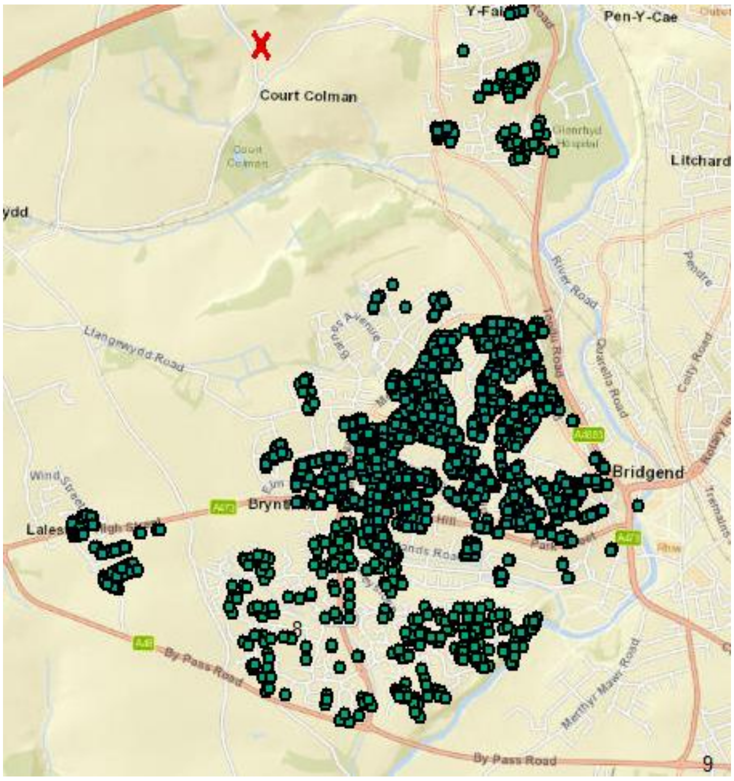


Figure 8. Cluster 8: Detached and semi-detached properties; DHRA and mine openings

6.2 Clusters 3 and 4

Cluster 3 features three different types of technologies of which only biomass boilers may be of concern. Cluster 4 is not of concern due to the installation of LT ASHP, which are not affected by ground conditions.

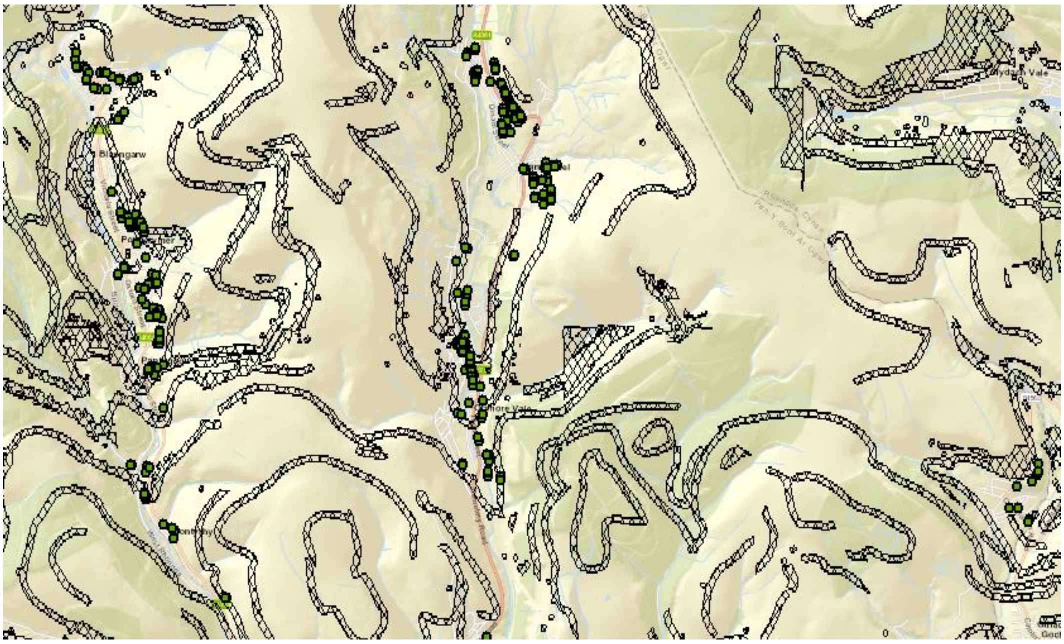
6.2.1 LT ASHP/Hybrid Heat Pumps

For both clusters, the installation of LT ASHPs involves superficial ground works, and so ground conditions have no impact in the assessment of LT ASHP installation.

6.2.2 Biomass Boiler

An excavation may be required for the enclosure of a biomass boiler outside the house, or trenching of the pipework up to the house. Planning may require surveys for contaminated ground. These costs should be accounted for as part of the capital costs for this heating system.

Figure 9 shows DHRA dotted across **cluster 3**, including part of the houses selected for this pathway. Works in a DHRA are required to provide a coal mining risk assessment to the BCBC, highlighting risks to neighbouring occupiers, public safety, highway users, as well as mitigation measures.



Copyright © 1995-2015 Esri
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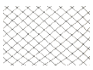
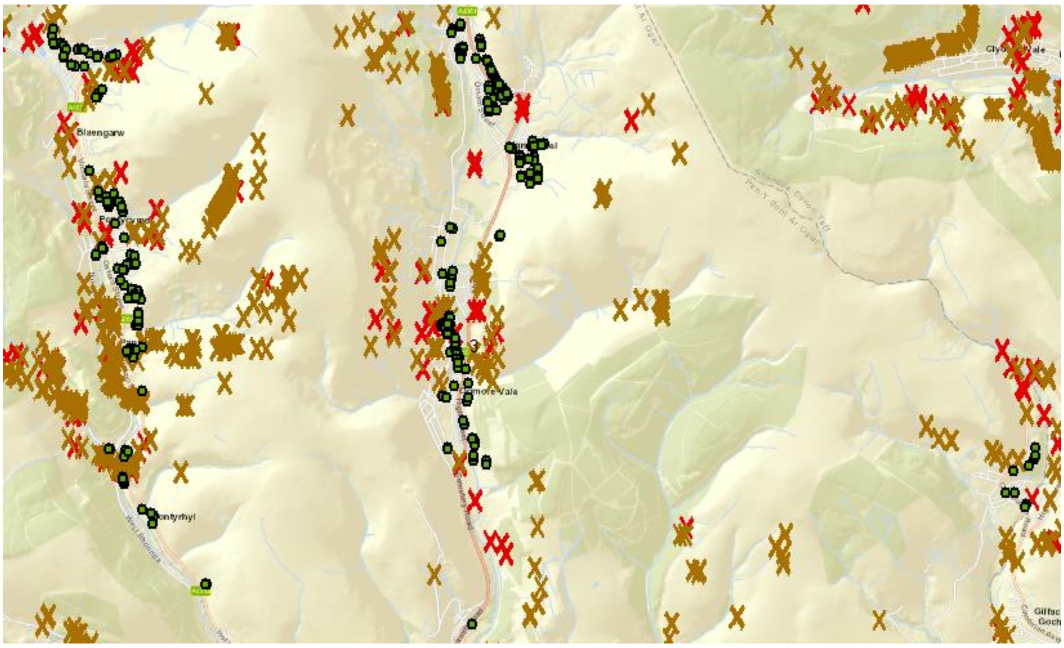
 Development High Risk Area

Figure 9. Cluster 3: Terrace houses with Biomass boiler; DHRA

Mine openings are also located in these areas (Figure 10), which will require precaution if located in the vicinity of the area for biomass boiler installation and trenching.



Mine Entry

Figure 10. Cluster 3. Terrace houses with Biomass boiler; mine openings

The high-level ground assessment of the clusters in this study found there are DHRA and mine openings in clusters 7 and 3. The installation of district heating connections and biomass boilers in these sensitive places may require further measures that are likely to increase capital costs. A detailed ground survey is required due to the high risk of mining activities and development high risk areas, as the exact location cannot be read from these maps with precision. If the dwelling in a pathway is located in those specific areas, high costs can be assumed to undertake relevant measures. For dwellings which are not directly in those areas, no additional measures will need to be taken, thus no additional costs required. LT ASHPs and hybrid heat pumps should not be affected by these issues in the ground.

7 Heritage, Planning and Visual Impact

A heritage, planning and visual impact assessment has been done by cluster groups with common technologies to be implemented. The effect of heritage buildings and local planning conditions on the implementation of each technology is addressed within. Visual impact of the technology is also addressed.

There are multiple Grade II listed buildings in BCBC area, which can be found on Historic Wales's and British Listed Buildings' websites. BCBC has 15 conservation areas. These are areas which are valued for their historic or architectural appearance and character, and therefore any extension to a dwelling in a conservation area must be compatible with the preservation or enhancement of the character or appearance of that area.

None of the clusters in this study include statutory/non-statutory site designations, according to the Natural England's Magic website of natural environment.

7.1 Clusters 7 and 8

7.1.1 Heritage

A small number of the semi-detached dwellings in **cluster 7** are located in the Coity conservation area.

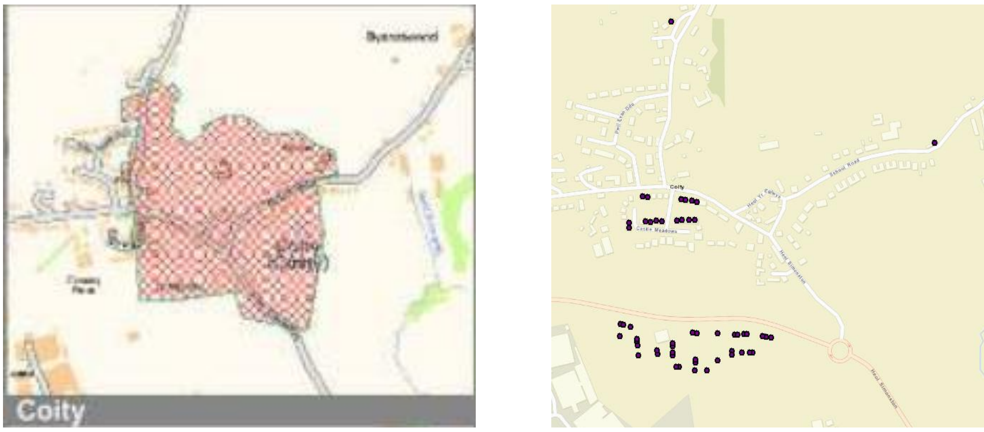


Figure 11. Coity Conservation Area and cluster 7 semi-detached houses, District Heating (Bridgend County Borough Council SPG 02 Householder Development)

A small number of the semi-detached dwellings in **cluster 8** are located in the Laleston and Newcastle Hill conservation areas, as shown in the figures below. There are also a number of listed buildings around Newcastle Hill (Figure 13).

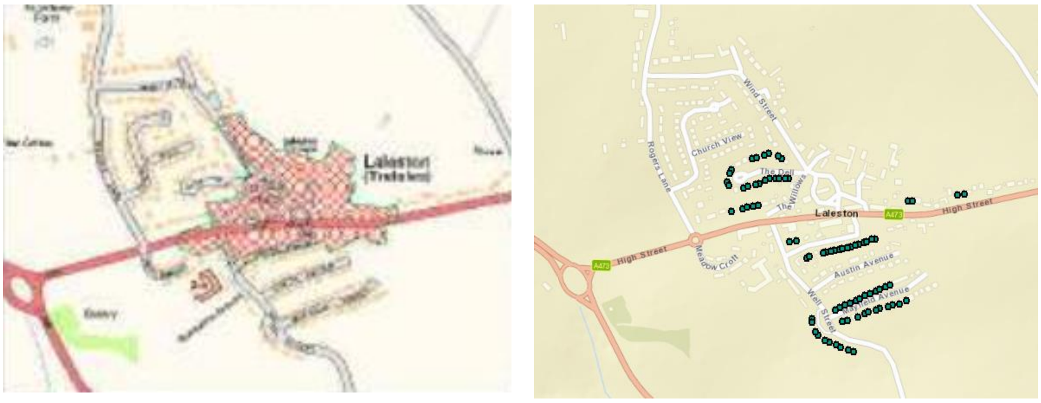


Figure 12. Laleston Conservation Area and cluster 8 semi-detached houses, District Heating (Bridgend County Borough Council SPG 02 Householder Development)

Figure 13. Newcastle Hill Conservation Area (Bridgend County Borough Council SPG 02 Householder Development) and Listed Buildings (historicwales.gov.uk)

7.1.2 Planning and Visual Impact

7.1.2.1 District Heating

The district heating proposed for these clusters has little visual impact in these residential areas, since it is expected the underground pipes will be trenched up to the house for connection. This connection, which may enter the detached and semi-detached houses at the front or side, may need to obey certain planning conditions, such as a maximum height or to be in an enclosure that blends with the rest of the house. This is more expected in conservations areas such as Coity, Laleston and Newcastle Hill.

The HIU has no additional visual impact if installed indoors. Similar measures as the ones to the connection pipework would have to be followed if installed outdoors to any side of the house.

Early engagement and discussions with the planning team will quickly inform about what is allowed by the BCBC for this technology. This obstacle can be avoided if the BCBC would give authorisation to specific amendments to a dwelling in order to connect to heat networks, in specific areas.

The BCBC could greatly facilitate the implementation of this technology in the future by adopting a Local Development Order to grant planning permission for installation of pipes, cables, and engineering works related to district heating within defined areas of land.

7.2 Clusters 3 and 4

7.2.1 Heritage

A large number of the semi-detached and terrace dwellings in **cluster 3**, for the hybrid heat pump, LT ASHP and biomass boilers transition pathways, are located within the Nant-y-moel Conservation Area.

Figure 14. Cluster 3 Nant-y-moel Conservation Area (Bridgend County Borough Council SPG 02 Householder Development)

A small number of the dwellings in **cluster 4**, for both the hybrid heat pump and LT ASHP transition pathways, are Grade II Listed Buildings located within the Derllwyn Road, Tondu Conservation Area.

Figure 15. Cluster 3 identified Listed Buildings in Derllwyn Road, Tondu Conservation Area (Bridgend County Borough Council SPG 02 Householder Development) and Listed Buildings (historicwales.gov.uk)

Figure 16. Cluster 4 Terrace Houses for Hybrid and LT ASHP

7.2.2 Planning and Visual Impact

The current small scale renewable energy schemes planning guidance issued by the National Assembly for Wales states the permitted developments for heat generating technology under 45 kW. The types of energy equipment for domestic premises that are currently considered permitted include:

- Single air source heat pump – it must comply with Microgeneration Certification Scheme planning standards or equivalent; no standalone wind turbine can be already installed; the compressor unit that doesn't exceed one cubic metre; it can't be within three metres of a boundary; not on a pitched roof or within one metre of a flat roof edge; it can't be on a roof or wall facing a highway and must be used solely for heating purposes.

- Single flue – for a biomass heating system (up to one metre above the height of the roof)

Planning permission would still be required for the installation of some energy technologies in conservation areas or if they affect a Listed Building. This is the case for Nant-y-moel (cluster 3) and Tondu (cluster 4).

7.2.2.1 LT ASHP

It is very likely that all LT ASHPs (for LT ASHP and hybrid heat pump) could be installed in a way that they are not visible from the streets, particularly if they are to be in the back gardens. Appropriate materials and colour treatment should also be used if any housing for the unit is required.

7.2.2.2 Biomass boilers

Works internal to the house to install biomass boiler technology currently requires no planning permission. A single flue is permitted, as long as it does not project by more than one metre from the highest part of the roof. The flue should be designed to be unobtrusive in views of the building, and use suitable materials and colours to blend in with the environment.

Some structures built on the land around the house are permitted under certain conditions, such as sheds and enclosures, as described in the Welsh Government's Guide for householders for permitted development rights.

Early engagement and discussions with the planning team will quickly inform about planning conditions to be expected in these specific clusters.

BCBC could facilitate the implementation of this technology in domestic premises in the future by stating the conditions for installing enclosures for heat generating technologies outside the house.

In general, it was found that planning does not pose a risk for the implementation of the technologies in this study. Exceptions are to be made for the conservation areas identified in this section. Various measures were identified where BCBC can provide support for the deployment of these technologies.

8 Noise Impact

The noise assessment has been done by cluster groups with common technologies to be implemented. The noise impact each technology is addressed within.

The Wales Noise Mapping website was used to obtain the below snapshot of the noise monitoring of the area of BCBC. It is generally considered good practice for developments to ensure that the existing ambient noise level of a site is not greatly increased at the nearest sensitive location, usually the nearest residential property.

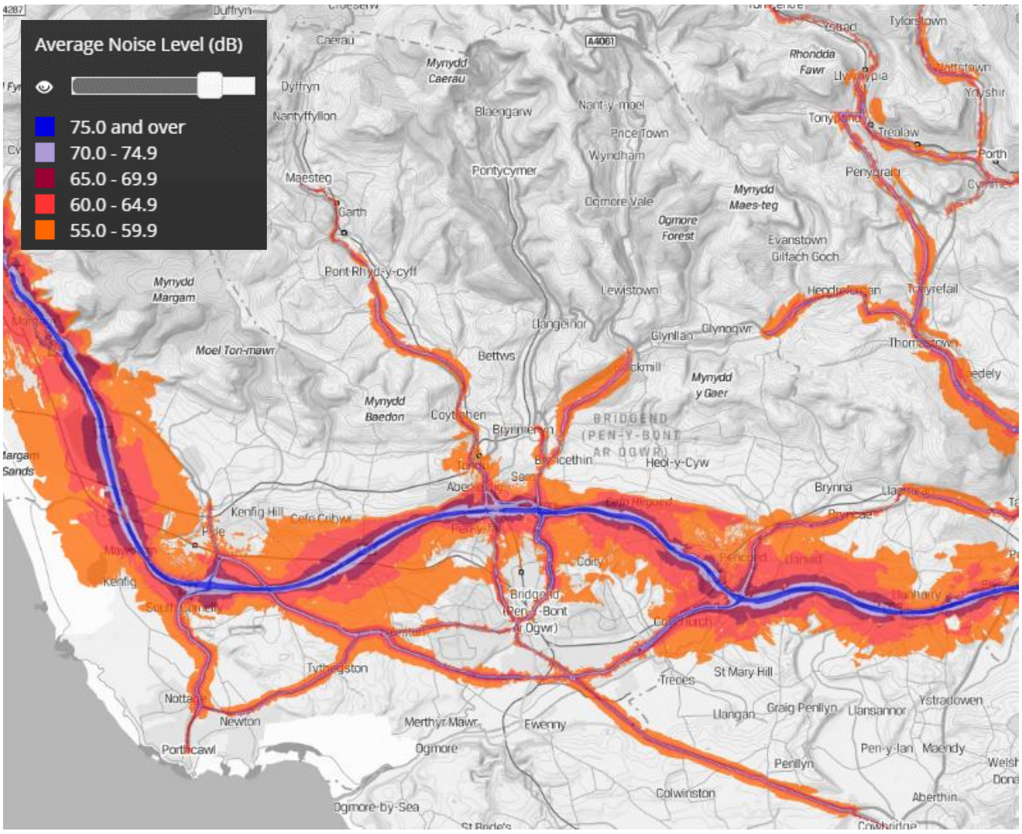


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Figure 17. Wales Noise Mapping, Bridgend County (Extracted from http://data.wales.gov.uk/apps/noise/)

8.1 Cluster 7 and 8

8.1.1 District Heating

Cluster 7 experiences a higher level of noise from traffic as the area is surrounded by roads and rail lines. The majority of cluster 8 dwellings are in a quiet, residential area with some noise disturbances from nearby traffic.

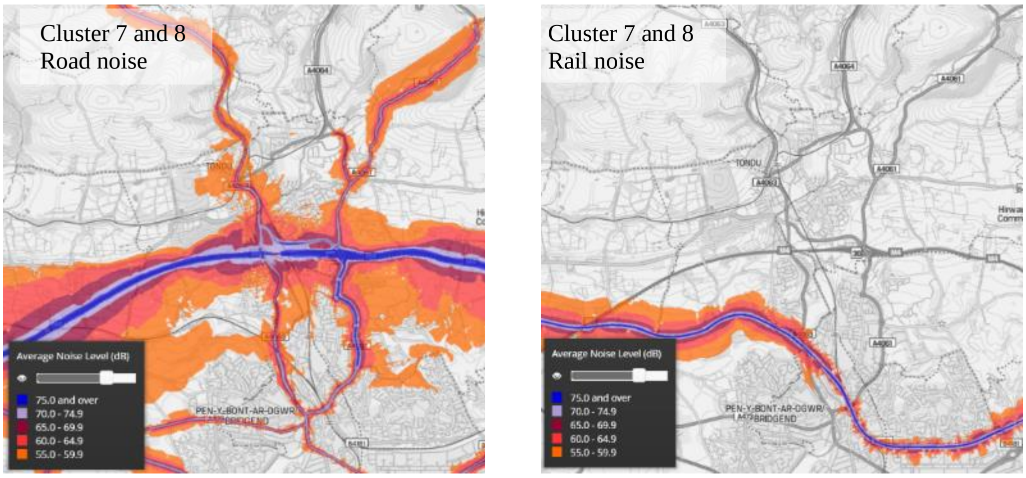

Figure 18. Cluster 7 and 8 noise maps

Construction noise is expected in these clusters for the installation of the heat network. The noise impact may be higher for cluster 8. General construction hours and rules apply, and it will be temporary.

There is no additional noise expected from the operation of a district heat network. The Heat Interface Units are not expected to produce any more noise levels than current gas boiler installations. Noise is not a concern for this technology.

8.2 Cluster 3 and 4

8.2.1 LT ASHP/Hybrid Heat Pump

Cluster 3 is a quiet residential localities in valleys, with minimum traffic exposure which can be seen in figure 19. Cluster 4 consists of another residential area that is located around a small town Maesteg, but is more exposed to noise due to the main road running through it.

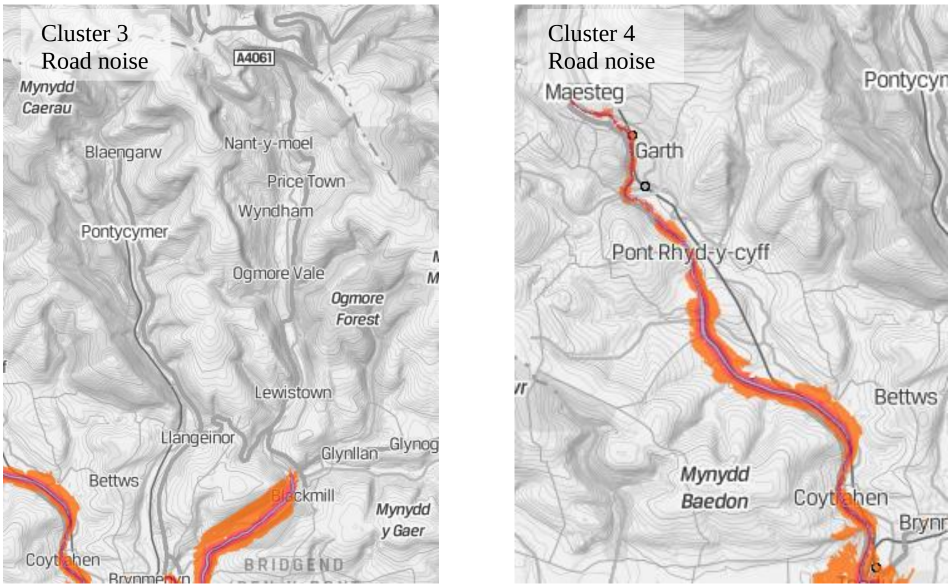

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Figure 19. Cluster 3 and 4 noise maps

Extracted from data.wales.gov.uk

The installation of LT ASHP and hybrid heat pump technologies means noise is emitted from the fan and compressor which can be a nuisance. There may be limited impact on the overall county noise emissions if installed in a single dwelling and an impact may be noticed in a cumulative installation. This is particularly true as the LT ASHPs are being proposed for rows of terrace houses in streets adjacent to each other.

Mitigation measures can be taken which would include placing the LT ASHP in acoustic enclosures that can contain noise and regulate air flow. The cost of these enclosures is dependent on the make and model of the LT ASHP and can be available in the range of £2,000 per enclosure. This can be deemed as significant as it is an additional 50% of the fixed capital cost proposed by the EPN tool. Anti-vibration mountings are also available which will further aid the reduction of noise emitted and disturbance to the adjacent houses. The implications of this may be that greater space is required for the installation of this technology. Locating the LT ASHPs at the rear of the properties would minimise disruption to pedestrians. This will minimise the risk of the BCBC restricting the number of LT ASHPs to install in certain areas.

8.2.2 Biomass Boiler

Biomass boilers can create more noise than gas boilers due to the solid fuel (wood pellets) employed. If the biomass boilers are located external to the dwelling as proposed, acoustic protection may be required.

Due to the rural nature of cluster 3, trucks delivering the fuel for the boilers may cause a noise disturbance to the locality, particularly as many of the developments in the cluster are located on very narrow streets. These issues can be managed and are not expected to obstruct the installation of biomass boilers in cluster 3.

Negotiations with the BCBC may be required to permit the installation of numerous biomass boilers and eventually to create local fuel stores to allow ease of accessibility.

In general, it was found that noise impact from these technologies can be mitigated with additional enclosure, to avoid disruption to the local areas. The support of BCBC may be required to allow the deployment of these technologies to a degree and avoid violating noise regulations.

9 Summary of findings for EPN pathways

The analysis performed in the previous sections allows us to reach the following conclusions regarding the potential constraints not considered in detail by the EPN tool, which may be a concern for the implementation of each pathway. A score has been given to account for the risk to the implementation of these technologies at a domestic level.

Table 2 Risks and risk rating rating for each domestic pathway

Pathway	Risks to implementation	Score
Detached houses, 1980 age band, District Heat, cluster 7	No concerns regarding installation of plant and domestic connections to a district heating network.	L
	High risk from flooding to the houses in this area, however this should not have a significant impact on district heating.	
	Development high risk areas and mine openings affect a small proportion of the properties around Sarn. Additional works to mitigate this may not be accounted for in the capital costs for this technology.	
	No concerns regarding heritage and planning.	
	No concerns regarding air quality or noise impact.	
Detached houses, 1980 age band, District Heat, cluster 8	No concerns regarding installation of plant and domestic connections to a district heating network.	L
	Low risk from flooding affecting a small proportion of the houses.	
	No concerns regarding heritage and planning.	
	No concerns regarding ground (based on coal maps), or air quality and noise impact.	

Pathway	**Risks to implementation**	**Score**
Semi-detached houses, 1945-1964 age band, District Heat, cluster 7	No concerns regarding installation of plant and domestic connections to a district heating network.	L
	High risk from flooding to the houses in this area, however this should not have a significant impact on the technology chosen.	
	Development high risk areas and mine openings affect a small proportion of the properties around Sarn. Additional works to mitigate this may not be accounted for in the capital costs for this technology.	
	Planning conditions may be expected for the district heating connection to the house in the Coity conservation area.	
	No concerns regarding air quality or noise impact.	
Semi-detached houses, 1945-1964 age band, District Heat, cluster 8	No concerns regarding installation of plant and domestic connections to a district heating network.	L
	Low risk from flooding affecting a small proportion of the houses.	
	Planning conditions may be expected for the district heating connection to the house in the conservations areas of Laleston and Newcastle Hill.	
	No concerns regarding ground (based on coal maps), or air quality and noise impact.	

Pathway	Risks to implementation	Score
Terrace houses, pre-1914 age band, LT ASHP, cluster 3	The installation of a low temperature heating system in pre-war houses requires the installation of larger radiators in order to maintain the pre-heat period. Additional/larger radiators require additional wall space inside the house.	L
	The EPN tool may not have considered the additional constraints on the grid network from implementing this pathway in a larger number of houses within a cluster.	
	The majority of the houses in this pathway has a large risk of flooding. Impact on a LT ASHP can be mitigated with no major impact to costs.	
	Planning permission may be required for installation of a LT ASHP in the Nant-y-Moel conservation area.	
	Acoustic enclosure and anti-vibration mounting can reduce the noise impact of a large number of ASHPs installed in quiet, rural towns. It is unclear if these measures have been incorporated in the capital costs.	
	No concerns regarding ground (based on coal maps), or air quality.	

Pathway	**Risks to implementation**	**Score**
Terrace houses, pre-1914 age band, LT ASHP, cluster 4	The installation of a low temperature heating system in pre-war houses requires the installation of larger radiators in order to maintain the pre-heat period. Additional/larger radiators require additional wall space inside the house.	L
	The EPN tool may not have considered the additional constraints on the grid network from implementing this pathway in a larger number of houses within a cluster.	
	The majority of the houses in this pathway has a large risk of flooding. Impact on a LT ASHP can be mitigated with no major impact to costs.	
	Planning permission may be required for installation of a LT ASHP in the Tondu conservation area and Grade II Listed Buildings.	
	Acoustic enclosure and anti-vibration mounting can reduce the noise impact of a large number of ASHPs installed in small towns. It is unclear if these measures have been incorporated in the capital costs.	
	No concerns regarding ground (based on coal maps), or air quality.	

Pathway	Risks to implementation	Score
Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 3	The EPN tool may not have considered the additional constraints on the grid network from implementing this pathway in a larger number of houses within a cluster.	L
	The majority of the houses in this pathway has a large risk of flooding. Impact on a LT ASHP can be mitigated with no major impact to costs.	
	Planning permission may be required for installation of a LT ASHP in the Nant-y-Moel conservation area.	
	Acoustic enclosure and anti-vibration mounting can reduce the noise impact of a large number of ASHPs installed in quiet, rural towns. It is unclear if these measures have been incorporated in the capital costs.	
	No concerns regarding ground (based on coal maps), or air quality.	
Semi-detached houses, pre-1914 age band, Hybrid heat pump, cluster 3	The EPN tool may not have considered the additional constraints on the grid network from implementing this pathway in a larger number of houses within a cluster.	L
	The majority of the houses in this pathway has a large risk of flooding. Impact on a LT ASHP can be mitigated with no major impact to costs.	
	Acoustic enclosure and anti-vibration mounting can reduce the noise impact of a large number of ASHPs installed in quiet, rural towns. It is unclear if these measures have been incorporated in the capital costs.	
	No concerns regarding ground (based on coal maps), or air quality or visual impact.	

Pathway	Risks to implementation	Score
Terrace houses, pre-1914 age band, Hybrid heat pump, cluster 4	The EPN tool may not have considered the additional constraints on the grid network from implementing this pathway in a larger number of houses within a cluster.	L
	The majority of the houses in this pathway has a large risk of flooding. Impact on a LT ASHP can be mitigated with no major impact to costs.	
	Planning permission may be required for installation of a LT ASHP in the Tondu conservation area and Grade II Listed Buildings.	
	Acoustic enclosure and anti-vibration mounting can reduce the noise impact of a large number of ASHPs installed in small towns. It is unclear if these measures have been incorporated in the capital costs.	
	No concerns regarding ground (based on coal maps), or air quality.	

Pathway	Risks to implementation	Score
Terrace houses, pre-1914 age band, biomass boiler, cluster 3	Terrace houses in Nant-y-moel appear to be smaller with a back garden on a steep slope. There may not be enough space in this area of the cluster to install a biomass boiler outdoors.	M
	Certain elements additional to the biomass boiler may not be accounted for within the capital costs, such as hot water tank, cyclonic filters, acoustic protection, and separate enclosure.	
	It is uncertain the proportion of these houses where a biomass boiler can be installed through the front door or back garden. There may be smaller sizes available in the market suitable for this use, but this may represent additional capital costs.	
	It is unknown if the maintenance costs allow for additional maintenance for biomass boilers and ash removal and disposal.	
	There is no existing biomass fuel delivery strategy. This may require input and support from BCBC to allow large truck deliveries in this area.	
	The majority of the houses in this pathway has a large risk of flooding. Impact to this technology can be mitigated at extra cost.	
	Air quality is unlikely to be an area of concern with the installation of around 300 biomass boilers for this pathway. This may become an issue at a later stage if a larger number of houses is included in the pathway.	
	Development High Risk Areas are dotted across this cluster. This is not a major concern for this technology as there are no major ground works expected.	
	While a single flue is normally “permitted” for biomass boilers (as long as it is no more than 1m above the roof), planning permission may still be required for the installation of flues in Nant-y-moel conservation area.	

The summary above shows that the constraints found in this high-level study are minor for all technologies. Mitigation measures are available for most of these constraints. The unit costs allocated for each technology may need to be revised when used for these specific clusters and property types, with no major cost changes expected.

Our initial view is that the technologies and pathways studied are technically feasible, with the majority categorised as low risk. Medium risk was allocated to biomass boilers for pre-1914 terrace houses in cluster 3. It is uncertain the proportion of these houses where a biomass boiler can be installed through the front door or back garden. Air quality is unlikely to be an area of concern with the installation of around 300 biomass boilers for this pathway. This may become an issue at a later stage if a larger number of houses is included in the pathway. An air quality assessment should be carried out to understand the impact in the area of implementation.

10 Appendix

This section of the report contains case studies of real world examples of retrofits of new heating systems. This is to represent the pathways proposed by EPN. These system examples include:

- Biomass boiler
- LT ASHP
- Hybrid heat pump
- Heat Interface Units to dwelling

District Heating Case Study

Information on the Albertslund case study was obtained from the following sources:

- Danish Energy Agency et al. "District Heating - Danish experiences." See: Stateofgreen.com
- "Albertslund Concept: Energy efficient renovation of homes and integrated energy efficient retrofitting of housing." See energy-cities.eu
- Jakob Klint 2009. "Local project in Albertslund – Denmark" See: Greencities.eu

There is a transitional shift in Denmark to move from existing DH networks to lower operating temperatures with the aim of reducing heat losses, increase efficiencies and integrate alternative sources of heat. Albertslund is a suburb in Copenhagen where 2,000 houses are planned to be renovated and converted to a low-temperature network as a replacement of the existing DH network. The system will undergo conversion from 90°C to a newly designed 50/25°C. In 2015, 544 houses were converted and now operate at low temperatures. Pipe heat losses were reduced by 75% from 3,500MWh/year to 850MWh/year through the retrofit scheme and better insulation. Significant property retrofit measures are part of the scheme, with an estimated cost of €180,000 per unit including low temperature radiators (or retrofit blower fans) and ground floor underfloor heating.

The new sections of the network will be completed via local shunt installations, where return water is mixed with the water from the ordinary flow line. Once all buildings in the wider area are converted, a separate line with low temperature from the heating station may be established. Using the shunt installations, it is possible to temporarily increase the temperature should it be required in a particular area.

Initially, only a select number of houses were involved in the project in order to be to understand consumer behaviour and how they would adapt to a new heating system. A smaller sample was also taken in order to test the various building types and heating system arrangements before a widespread conversion could take place in the future.

Biomass boiler case study

Information on the domestic biomass boiler case study was obtained from the following sources:

- Price Energy, Domestic biomass boiler installation, Lincolnshire.
  See: princeenergy.co.uk

The home owners opted for a domestic biomass boiler after considering options for their off-grid property in Holbeach, Lincolnshire. The value of this project was quoted at £17,000 with the installation taking 4 weeks which was completed in October 2013.

The 28 kW wood pellet boiler has been coupled with a Solar PV installation. The boiler has been fitted externally. The boiler is filled with wood chips manually every few days. A new pressurised hot water cylinder was required for the boiler. New radiators with valves were fitted.

The system has been described by the home owners as easy and reliable, and greener than their previous boiler.

Air Source Heat Pump Installation Case Study

Information on Mitsubishi Ecodan Air Source Heat Pump was obtained from the following sources:

- Mitsubishi Electric Corporation. ASHP case study, Wales.
  See: Mitsubishielectric.co.uk

This heating system was deployed in a in a 3-bedroom detached bungalow, in rural Wales. The installation was reported as effortless and comfortable as it was used in combination with existing radiators which reduced the programme time, cost of installation and disturbance to the residents.

The installation involved a 14 kW ASHP combined with a 4 kW solar PV system for additional electrical demands. This was carried out in May 2013. The transition was made from a previously installed electric storage heaters. The ASHP operates to maintain a 22 °C room temperature for 24 hours a day and 7 days a week. The residents found that over time their electricity costs had gone down.

Hybrid Air Source Heat Pump Installation

Information on Mitsubishi Ecodan Air Source Heat Pump was obtained from the following sources:

- Mitsubishi Electric Corporation. Hybrid installation, Bedfordshire. See: mitsubishielectric.co.uk

A 3-bedroom, detached family home in Bedfordshire installed a Hybrid ASHP for space heating and domestic hot water purposes. The product installation was a 5 kW unit with a 180 litre water cylinder combined with a gas boiler for peak demands and a wood burning stove. The transition was simply carried out as the existing radiators were used for this retrofit. The reported Coefficient of Performance for the system was rated at 3.0.

The installation was able to provide domestic hot water on demand with the hot water storage cylinder replenishing automatically when temperature falls below 43 °C. The bedroom temperature is maintained at 20 °C. The installation date was April 2017.

The 180 litre water cylinder occupies a storage cupboard. A 500 litre installation would require a larger space. The larger space requirement will be a limitation in smaller dwellings.