District Heating Strategy Factsheet

Planning Heat Network Infrastructure

Contents

1 Learning Objectives and Outcomes

1.1 Learning Objectives

The learning objectives for this module are to:

- Understand the principle of linear heat density; and
- Understand how this can be applied to identify opportunities for district heating.

1.2 Learning Outcomes

The learning outcomes for this module are to:

- Describe the principles of linear heat density;
- Identify opportunities for heat networks;
- Describe the main components of heat network infrastructure;
- Be able to sketch potential network routes

2 Introduction

Identifying opportunities for heat network projects and designing the layout pipework is a vital step in the strategic planning of district heating. To improve the efficiency of any network and minimise capital costs, the overall length of network should be minimised where possible. In many cases, networks will only be financially viable where the high costs of installing pipework infrastructure can be offset by sufficient heat sales through the network over a reasonable length of time. As such, the value of connecting new heat loads to a network should be considered in relation to potential heat sales revenues and required infrastructure investment. At the strategic planning stage, it is not practical to consider the feasibility of proposed schemes in detail. Instead, the concept of "Linear Heat Density" can be used to estimate the financial viability of potential heat networks at an early stage. This sheet will outline how concepts such as linear heat density can be used to enable the strategic identification and planning of networks before highlighting a number of tools and datasets that can be used to inform decision making.

3 Heat Network Infrastructure Components

A heat network is a system of insulated pipes that deliver heat from a centralised source to a number of connected buildings. Heat can be transferred in the form of hot water or steam, however modern, efficient systems tend to distribute low temperature hot water. Heat networks can facilitate the efficient generation of heat through the co-generation of heat and power or the recovery of waste heat from industrial or commercial processes. Heat networks also allow for the deployment of renewable heat technologies which are not often practical on an individual building level such as geothermal or large scale heat pumps. A number of different heat generating technologies might supply a heat network, either from a single source or from multiple energy centres. The design of components that constitute a heat network can be influenced by a number of factors including operating temperature, building compatibility, heat demand, infrastructure barriers and cost. The components that constitute a heat network can be broken down as follows:

3.1 Pipework

- District heating pipework is available in three standards of insulation thickness (series 1,2 or 3)
- Steel pipes are required for higher operating temperatures and pressures, while polymer pipes can be used at lower temperatures and pressures
- Pipes are available either in separate flow and return lengths or with flow and return pipes encased within the same insulation jacket
- The diameter of pipework depends on the required capacity for any given length of pipe, the flow rate and the operating temperature of the network. Higher temperature networks can deliver the same quantity of heat through smaller diameter pipes than networks which operate at a lower temperature. Generally, smaller diameter pipes can cost considerably less, as shown by table 2. However despite their larger pipe sizes and higher capital cost, networks which operate at lower temperatures can be more efficient in terms of heat loss and can enable a greater variety of renewable heat sources to feed into the network.

3.2 Pumps

Pumps play an inportant role in the design and efficiency of a heat network. Pumps are required to circulate water around the system and overcome the friction between water and the pipe wall. A minimum pressure difference between the extrematies of the network must be maintained in order to maintain supply to all consumers. At any given time the pumping energy required to maintain this pressure differential is determined by:

- Network Flow Temperature
- Topography of the proposed pipe route
- Heat Demand

The installed capacity of pumps on the heat network must be able to maintain the pressure differential under peak demand conditions. However, varaible speed pumps should be used to allow for increased efficiency under part load. the network design, a balance is to be sought between flow temperature, heat losses and required pump power. At the strategic planning stage, it is important to consider that the capital cost pumps and the operational cost of pump power is increased where there is a large height difference beween the extrematies of the network or where flow temperatures are lower.

3.3 Thermal Storage

The purpose of thermal storage is to reduce differences between the timing of heat production and consumption. This allows for heat to be produced when most economically or environmentally beneficial, for example for a CHP engine to take advantage of high electricity sales tarriffs. The sizing of a thermal store should be considered at the detailed design stage using a half-hourly operational model of the proposed network. At the strategic planning stage, the maximum space availiable for thermal storage due to space, transport and planning constraints should be considered when siting an energy centre.

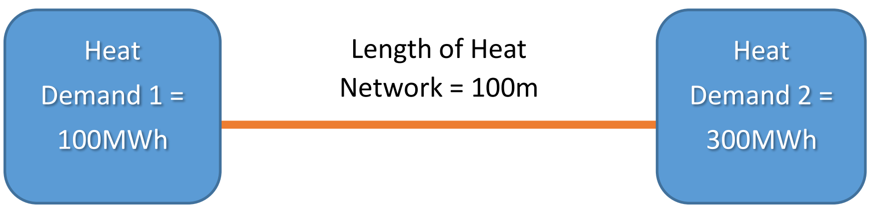
3.4 Heat Interface Units and Consumer Heating

Heat networks require a wet heating system within buildings connected to the network. The point of connection beween the heat network and internal heating system of consumers is known as the "Heat Interface Unit". This unit includes a heat exchanger, distribution pump and heat metering equipment and for domestic properties is typically similar in size to a conventional combi-boiler.

Retrofit district heating networks may require wet heating systems to be installed or upgraded in proposed proposed connections. To improve the efficiency of a heat network, allowing for lower return temperatures and for the network to opperate a lower flow temperature, radiatiors within existing buildings may need to be repaced or rebalanced. This is an important cost to consider when targeting existing buildings as potential connections.

4 Identifying Opportunity Areas

At the strategic planning stage of heat networks, it is important to consider where to focus development resources. It is also important to have a basic understanding of where local networks might develop and the potential for these



$$\text{Total Heat Demand} = 400\text{MWh/Year}$$

$$\text{Linear Heat Density} = \frac{\text{Total Heat Demand}}{\text{Length of Network}}$$

$$= \frac{400}{100}$$

$$= 4\text{MWh/m/Year}$$

Figure 1 Calculation of linear heat density

to join into area wide schemes in the future. The principle of “linear heat density” can be used to help identify potential areas for district heating. The Linear density of a heat network is the total heat demand, divided by the total length of pipe (Figure 1). The resultant figure serves as a useful marker for financial viability because the high capital costs of heat network infrastructure must be offset by sufficient heat sales through the network over a reasonable period of time. As such, a higher linear heat density generally indicates improved financial viability. Based on successful schemes in the UK and Scandinavia, a benchmark of 4MWh/m/year can be used to indicate potentially successful schemes.

The following approach can be applied using linear heat density with data from the Scotland Heat Map to highlight areas of opportunity for district heating:

- Firstly, the point level demand data for each property in the heat map is divided by 4MWh to provide a maximum length of network for each point to maintain a linear heat density of 4MWh/m.
- Secondly, using the resultant length in meters, a buffer around each point can be created. Areas where buffers overlap suggest opportunities for connecting multiple properties as part of a heat network.
- Opportunity areas which contain more than a threshold number of connections can be used to determine heat network opportunity areas. Zones can then be created based on analysis of the underlying heat demand density data and geographical boundaries such as roads, rivers and infrastructure barriers. This process is outlined in Figure 3.

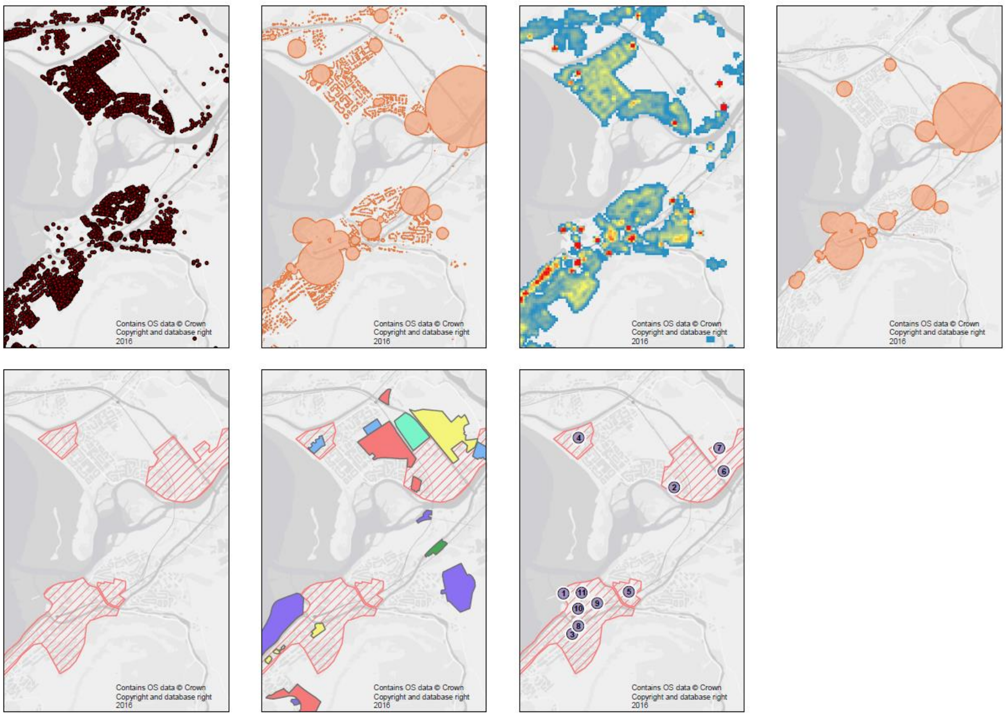


Figure 2 Zoning Heat Network Opportunity Areas Fort William

5 Sketching Potential Heat Networks

Designing the layout of heat network pipe infrastructure is a vital step in the identification and strategic planning of district heating projects. To improve the efficiency of any network and minimise capital costs, the overall length of network should be minimised where possible. In many cases, networks will only be financially viable where the high costs of installing pipework infrastructure can be offset by sufficient heat sales through the network over a reasonable length of time. At the strategic planning stage, it is not practical to consider the detailed design of a network and instead, the proposed route should be sketched using the following basic principles:

- Minimising network length
- Where possible utilise “soft dig” areas
- Where possible avoid costly wayleave agreements by following public rights of way
- Avoid costly infrastructure barriers such as railway lines, major thoroughfare or waterways

For this analysis, the key anchor heat loads were identified by sorting the loads within each opportunity area by annual heat demand. A proposed network was then sketched using the basic principles outlined above.

6 Estimating Heat Demand for New Development sites

A key consideration when developing a heat network strategy is to identify the most suitable new development sites to safeguard for future district heating expansion. The most suitable sites are those which could feasibly connect to planned or existing district heating networks. To understand the feasibility of connecting new development sites, it is necessary to estimate their heat demand. This can be done using the following information:

- Indicative Housing Capacity
- Housing Density
- Site Area
- Developable area of the site
- Indication of proposed uses for Mixed Use sites, including information on potential anchor load buildings (e.g. new school, new hospital)
- Housing type
- Suitable benchmarks e.g. CIBSE TM46

7 Heat Network Modelling

Once opportunity areas for distict heating have been identified, high level assessment of potenial heat networks in these areas can allow projects to be prioritised. A number of models are availaible to evaluate the financial viability and potential carbon savings from proposed district heating networks. All modelling conducted as part of strategic planning is likley to be at a high level and would require a more detailed assessment prior to any investment decision making.

The District Heating Opportunity Assessment model, available on the District Heating Scotland website summarises address level data from the Scotland Heat Map; provide primary plant, back up plant and thermal store sizing; and provides high level cost estimates for the following components:

- Thermal Store
- Energy Centre
- Consumer Connections

8 Data Sources

To inform the selection of heat network opportunity areas and to allow for high level modelling of network viability, a number of datasets are avaiable.

8.1 Scotland Heat Map

The Scotland Heat Map was developed to support the activities of local authorities in planning for district heating. The national dataset includes a data point for each property in Scotland, referenced by a Unique Property Reference Number (UPRN). Each data point has an associated annual heat demand Figure, expressed in kWh/year. Data on heat demand has been derived from a number of sources and varies in terms of confidence from 1 (low) to 5 (high) as described in table 1 below.

Table 1 Summary of Data Quality in the Scotland Heat Map

Confidence Level	Definition	Explanation
1	Floor area polygons	The floor areas are based on OS polygons for properties assigned a UPRN. This does not account for number of storeys. A single “average” demand benchmark is used and so there is no variation with building type. There is a risk that UPRNs may be assigned to geographical features with no heat demand.
2	Building data but no age category or floor area	The Assessor and ePIMs data provides information on the building use, age and floor area of properties. In some cases, parts of this information is missing which reduces the confidence.

3	Building data with age category and floor area	The Assessor and ePIMs data provides information on the building use, age and floor area of properties.
4	Building data with additional energy efficiency, heating system or broad energy use data (where public buildings).	Scottish Government hold data on procurement and energy performance certificates of properties which provide an estimate of the building heat demand. This data can be relied upon with good confidence
5	Actual energy billing data	The public sector energy billing data provides accurate building heat demand information.

8.2 Home Analytics

The Home Analytics dataset is developed by the Energy Saving Trust and provides essential data on the Scottish housing stock. This data is provided down to the address level and is available to the Scottish Government and local authorities in Scotland to assist in developing, targeting and delivering policies, schemes and programmes designed to:

- Improve energy efficiency;
- Install renewable micro-generation technologies;
- Alleviate fuel poverty.

Home Analytics is a combination of two types of data: actual values and modelled values. Actual values are obtained from a variety of sources, such as EPC records, HEED installation records, HEC records, SGN gas meter data, OS AddressBase & MasterMap Topography layer and the Scottish Census. In cases where a property record is not available for a particular variable, models are used to impute (i.e. predict) the value of the variable based on the other building attributes and energy efficiency characteristics of the property. Table 2 shows the proportion of actual and modelled data for each variable in the Home Analytics Dataset.

Table 2. Home Analytics Actual Data Vs Modelled Data

Variable	Actual Data (% of Total)	Modelled Data (% of Total)
Property age	33%	67%
Primary property tenure	48%	52%
Secondary property tenure	41%	59%
Habitable rooms	32%	68%

Primary fuel type	77%	23%
Secondary fuel type	35%	65%
Cylinder insulation type	15%	85%
Cylinder insulation thickness	16%	84%
Meter type	38%	62%
Wall construction	48%	52%
Wall insulation	43%	57%
Loft insulation	41%	59%
Glazing type	28%	72%
Boiler efficiency (A-G)	28%	72%
SAP rating band (A-G)	32%	68%
SAP rating (A-G)	32%	68%
Total floor area	32%	68%
RdSAP fuel bill	32%	68%