ENERGY SYSTEMS TOOLKIT

Heat Network Module

BACKGROUND

The Energy Systems Toolkit (the 'Toolkit') is aimed at organisations, community groups or businesses, at different stages in the project development process, whether exploring ideas to develop into a project or additional options to include in a current project. The Toolkit aims to provide further information to organisations on energy systems topics that will help determining whether a project idea is viable or highlight alternative options that should be considered. The Toolkit also provides support through the development process to construction, highlighting any support available to them. This could include:

- Signposting businesses or communities to additional support (technical or financial) in developing their project, to potential project partners or to potential sources of funding;
- Provide detail on key considerations and barriers across different technology projects; or
- Highlight different technology projects and themes that have been developed successfully across Scotland.

For each of the topics, the guidance provided will be informative and will indicate the actions to be taken and the next steps the organisations should take to progress.

The Toolkit links to other relevant guidance documents, such as the **CARES Toolkit,** which can be used in parallel.

INTRODUCTION TO THE HEAT NETWORK MODULE

This module will discuss the steps to follow in developing an opportunity for a district heating scheme and putting together a business case for the district heating scheme.

Objectives

The first thing to decide is why the heat network is being developed and which of those reasons is most important. Examples include:

- to provide low cost heat to properties which currently are only able to use more expensive sources of heat. – for example, electric heating, LPG boilers or oil boilers.
- to allow a low carbon heat source to be used
- as a way of using heat which is currently being wasted, such as from a factory (or distillery for example).

The approach taken to developing the network, depends upon what the purpose of the network is and what information is known at the outset.

WHAT DOES A HEAT NETWORK CONSIST OF?

A typical heat network will consist of:

1) An energy centre – where the heat is generated
2) A heat network – to distribute the heat
3) Building connections
4) Building heating systems

Energy Centre

This is where the heat is generated. On small heat networks this may be a containerised plant room. On a larger system, such as that supplying part of a town, it would be a large, purpose built building.

Figure 1: Gas CHP Energy Centre providing heat to approximately 2,000 flats

There are often two heat sources for a heat network:

1. A baseload heat generator such as a CHP engine or biomass boiler. This supplies heat for most of the year
2. A peak load boiler which has a much larger capacity, so that it can meet the highest heating requirement, but is typically only used for a short period

For small heat networks, serving a few houses only, it may be appropriate to have a single heat source, however in this instance it is usually necessary to have an adequate thermal storage for the system to run efficiently and reliably.

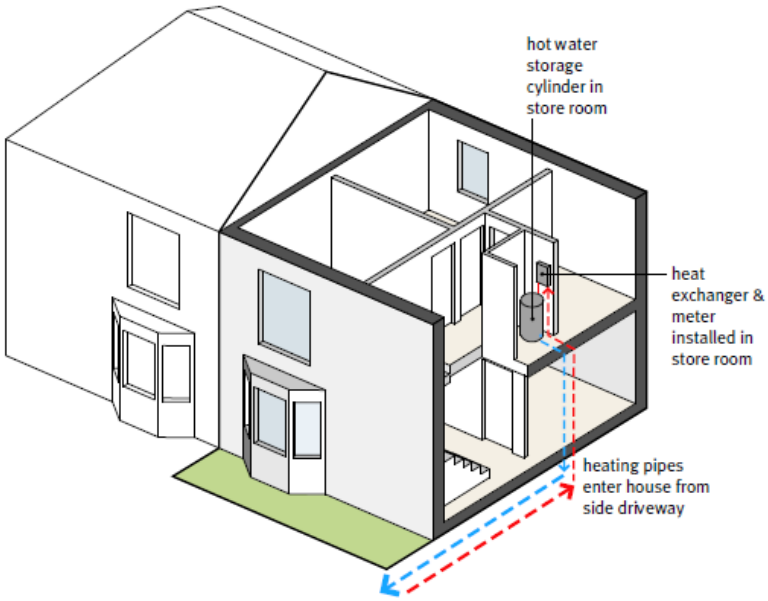
Many heat networks include some form of heat storage, known as a thermal store. Adding a thermal store allows a heat generator to store heat when relatively little heat is required. This stored heat is supplied later. The simplest type of thermal store is a large, insulated, tank of water. For small networks a thermal store, or buffer tank, can allow a single heat source to meet the varying demands reliably.

A heat network

This is the system of pipes which connect the energy centre to the heat loads. The pipework can be plastic or metal, is always insulated and is usually buried. The pipes are normally buried to protect them.

Building connections

This is the equipment required for the network to transfer heat into the heating system in the building. This equipment is usually packaged for each property in a Heat Interface Unit (HIU).



Case Study: 20th Century Semi-detached House

Existing heating system:

- Oil boiler with radiators

Energy efficiency improvements:

- Cavity wall insulation or external insulation
- Double glazing
- Loft insulation

Heating system changes:

- Connect to existing hot water cylinder
- Heat interface unit (HIU) in cupboard adjacent to hot water cylinder cupboard connects house heating system to heat network.
- Use existing radiators in the property.

Figure 2: Example house connected to district heating Source: Ricardo Energy & Environment/John Gilberts Architect

Building heating systems

Every building connected to the district heating network will require a water based heating system, sometimes referred to as a wet system. Properties which are heated by electric heaters would require a wet system installed, this usually involves replacing the electric heaters with radiators or underfloor heating.

The way the heating system in each building is designed and controlled will affect the performance of the whole network. In particular the temperature at which water returns to the system is very important. When a heat network is being planned it is important to include what works are required to each property to allow the heat network to operate efficiently. These alterations may be minor in many properties which already have radiators or wet underfloor heating.

WHAT IS GOING TO BE HEATED?

The starting place for any heat network is to identify how much heat is required and where it is required. The total heating requirement for a whole year is the first thing to consider when determining if a network is likely to be viable. The times at which heat is required is also important.

It is necessary to determine what heat loads there are in the study area and the distances between them, in order for the viability of the network to be assessed.
A rural village with 100 houses with a heat load of 15,000kWh houses, through a heat network of 1000m is going to be supplying 1,500,000kWh, or 1,500kWh per m.

A heat network connecting a hospital with a heat load of 8,000,000kWh of heat to a large secondary school requiring 5,000,000kWh of heat per annum, through a network of 1000m is going to be supplying 13,000kWh per m of pipe. In the second example, the pipe would be larger and therefore more expensive but it remains significantly more likely that it is going to be financially viable because the amount of heat provided per m of pipe is greater.

For that reason, the early development of heat networks has been to either supply new developments, or to connect anchor loads. The heat provided per m of pipe is an important metric for considering the viability of a heat network.

New developments

It is significantly more cost effective to install a heat network in a development at the time of construction than install it into existing buildings. It is usually possible to reduce the installation costs as well as make cost savings compared to the alternative. If district heating is being installed in a housing development it would not be necessary to install a heat source in each house or connect gas supplies to them. This can offset the cost of the heat network.

Anchor loads

In order for a heat network to be viable it is necessary for it to supply as much heat as possible, from as small a network as possible. This can be most easily achieved in the first instance by connecting a small number of large loads rather than a large number of small loads. These large, predictable heat loads are known as anchor loads, and identifying potential anchor loads is the first step.

Examples include:

- Swimming pools
- Schools
- University buildings
- Hotels
- Hospitals
- Care homes

By supplying a large amount of heat to a single client the network is certain of getting a significant amount of income which can provide commercial certainty. Secondly, once heat is supplied to a large heat load it is more economically viable to add additional, smaller heat loads which are nearby.

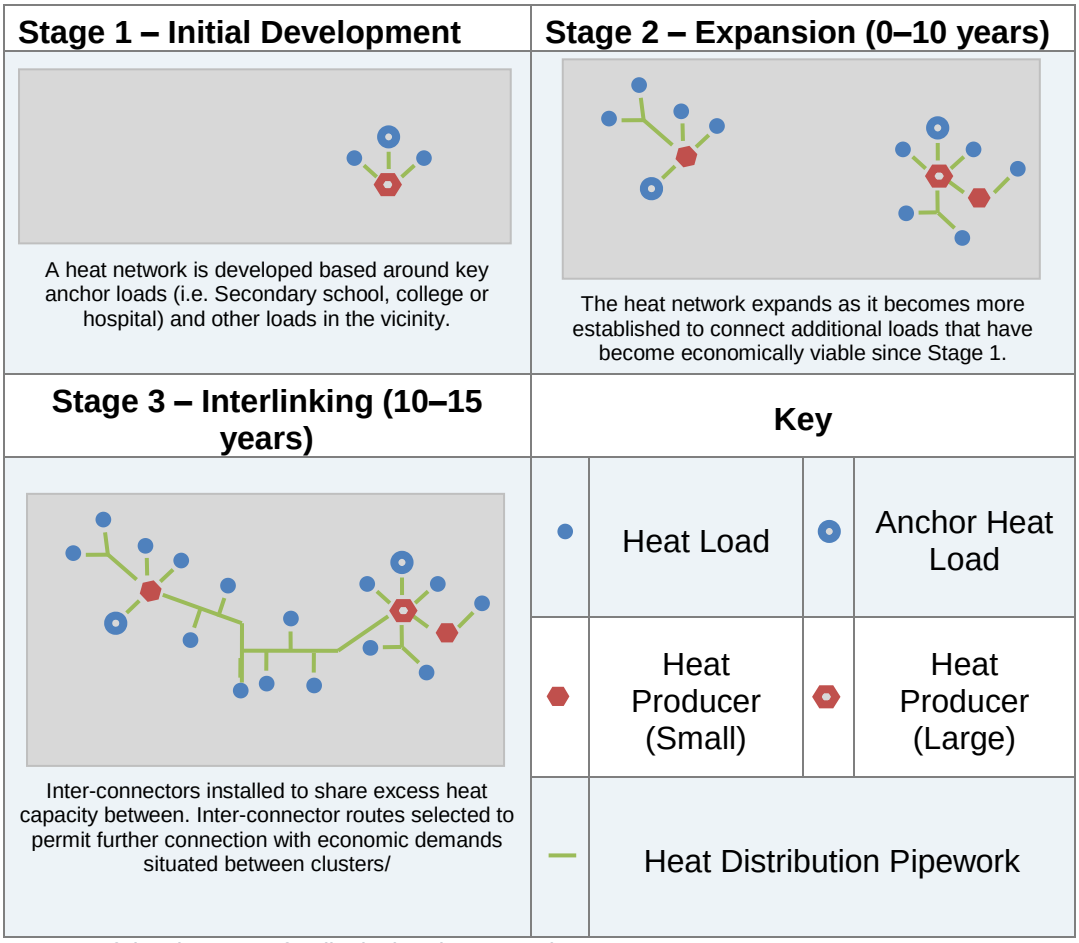


Figure 3: Stages of development of a district heating network:

Heat networks in cities, therefore tend to grow in stages, with the addition of a new anchor load allowing the subsequent or contemporaneous connection of nearby smaller loads. Identifying anchor loads is important to a heat network being viable.

Case Study

Pultneytown Biomass district heating (Wick)

A district heating scheme was first installed in Wick in 2004, however it suffered years of operating problems and financial difficulties due to the failure of the wood gasification CHP system.

The system was purchased by Highland Council who sold it at auction to Ignis Biomass. Ignis installed a new biomass boiler and heat metering and the scheme is now operating successfully.

Housing associations

Where existing domestic heat loads are to be supplied it is particularly useful if there are housing associations properties. There are several advantages:

1) There is a single customer that the network supplies;
2) Housing associations themselves have targets for energy efficiency and carbon reduction, e.g. Energy Efficiency in Scottish Social Housing (EESSH). If housing association properties are supplied with low carbon heat from a heat network this may save them finding another means of meeting these requirements;
3) The cost of heat from a heat network is usually less expensive than the alternatives. Many housing association properties are traditionally heated with electric heating which can be expensive to run.

Even if the properties managed by a housing association are only part of the housing in an area, they can be a useful way in getting a heat network into an area of housing and providing some financial certainty.

Complimentary loads

A heat network is most likely to be viable if heat customers require heat constantly all day and all year. In practice most sites require varying amounts of heat at different times of day and throughout the year. Where a property has periods that it requires little or no heat it is ideal if a nearby property needs heat at those times, for example a school or business will require heat at a different time from houses, so if connected to a single network, the use of the network is optimised.

Heat maps

One way of determining the heating requirement of an area is to look at a heat map. The Scottish Government has produced Heat Maps for all of Scotland[1]. This can be used as part of a feasibility study to identify where there are heating requirements and approximately how much heat they require. Heat maps are available upon request subject to various terms.

HOW ARE THEY GOING TO BE CONNECTED?

Once the heat loads have been identified, the next step is to determine the size of the network required to connect them. While the sizing of pipework and determining the final route of pipework will need to be done by a suitably qualified engineer it is useful to find out approximately what length of network is going to be required.

It is beneficial for several reasons for the heating network to be kept as short as possible to minimise:

- The cost of the pipework and its installation
- Heat losses
- Energy required to pump water around the network.

[1] http://heatmap.scotland.gov.uk/

HOW IS THE HEAT TO BE GENERATED?

For some projects it will be known what the potential heat source is going to be, for example where the purpose of the heat network to find a use for heat which is currently wasted, or to generate more heat from an existing heat source which is under-utilised, for example an existing biomass boiler.

Where the source of heat is yet to be determined it will usually be necessary to do a feasibility study to determine what heat sources may be suitable.

The following table shows some typical sources of heat:

Heat source	Requires	Financial support
Gas Combined heat and power (CHP)	Mains Gas	Not Eligible for Renewable Heat Incentive (RHI) Eligible for Climate Change Levy(CCL) exemption if Combined heat and power quality assurance (CHPQA – good quality CHP)
Biomass boiler	Access for fuel deliveries	Eligible for RHI
Biomass CHP	Site with both electricity demand and heat demand	Eligible for RHI Contract for Difference (CFD) Can supply electricity to a use a private wire network , which can be a source of revenue
Large heat pumps	Over 1000kWth, a source of surface water (e.g. a loch or a major river).	Eligible for RHI
Air source heat pump		Eligible for RHI. At the time of writing are only likely to be viable when supplying a heat network on new properties or where replacing electric heating, due to RHI rate.
Heat recovery	Industrial site with waste heat	Not eligible for RHI. Possible grant funding sources.

Where anchor loads have been identified, it may be worth finding out

- If any of those sites have existing renewable or low carbon heat sources which are under-utilised and could supply heat to the network. For example, a school has a biomass boiler.
- What attributes each site has which may make certain technologies more or less feasible. For example adjacent to the sea or a large Loch for a water source heat pump.
- If there are any heat sources nearby with capacity available. The average load factor of biomass boilers in the RHI scheme is 15%. If an existing renewable heat source is located near to the proposed district heating scheme it may be that it is capable of providing a significant proportion of the heat required by the district heating scheme.

Case Study

Glenshellach District Heating System, Oban - District heating scheme - Biomass: wood chip

This district heating scheme uses a 650kW biomass district heating system to provide heat to 89 homes built and owned by the West Highland Housing Association (WHHA) supplying a new housing development by a housing association, near Oban.

Initial performance was problematic, due to the issues above, principally, the supply of wet and inconsistent fuel and the low load on the boiler caused by the phased development. The system is fitted with a back-up oil boiler which was used extensively and during a repair period when the wood boiler tubes were attended to.

Since a reliable supply of drier woodchips has been sourced, operation has improved, however, the boiler would work better with a greater constant load, and the suggested extension to serve the hospital would improve efficiency, increase output and revenue.

WHAT PRICE CAN HEAT BE SOLD FOR AND HOW IS IT GOING TO BE PAID FOR?

To determine the financial viability of a heat network it is important to know what price the heat can be sold for. This will also influence whether the heat network is able to reduce heating costs. Where the network is to heat existing buildings the first step is to determine the existing cost of heat for the sites to be supplied.

This involves:

1. Finding out what type of heat source is used at present in p/kWh
2. Determining cost of fuel used (in kWh)
3. Estimating approximately what the efficiency of the heat source is.

For example, if a rented property is heated by fuel oil (paid for by the tenant), which costs 4.4p/kWh using a boiler of approximately 80% efficiency, the cost of the heat delivered is 4.4/80% = 5.5p/kWh.

In addition the boiler will need to be replaced at some point. Therefore the true cost of heat delivered will be higher than 5.5p/kWh.

However, in order to convince new heat users to connect to the heat network it is likely that savings will have to be offered to both the tenants as well as the owner. This means that the heat delivered will need to cost less than 5.5p/kWh and not just be lower than the true cost of heat.

Commercial entities

From a commercial perspective there are a number of roles to be performed:

1) Operate the heat generator and sell the heat to the network
2) Operate the heat network
3) Sell heat to customers

At a fundamental level, someone needs to be responsible for generating the heat and supplying it to the network, someone needs to be responsible for effectively transporting the heat to every property and someone responsible for selling that heat to customers. This will require metering the heat used by each property and billing accordingly. In a simple scheme it may be that one network operator performs all of these roles. On larger or more complex networks there may be several suppliers of heat to the network and it may be necessary to have separate commercial entities with heat being sold to the network by the operators of the heat sources and for the network operator to sell that heat on to customers.

It needs to be decided what legal and commercial structure is going to be so that the costs, income and risks can be calculated for each.

There are a number of commercial models for heat networks, in some properties the heat usage has been included in rent or factoring charges rather than heat usage on site being billed for. The heat network regulations require that the usage in each property is metered.

In order to model the income from a scheme it will be necessary to decide whether heat users are going to be charged solely for the heat they use or if there is going to be a component of flat-rate charging.

THE BUSINESS MODEL

In order to complete a high level analysis of whether a heat network is likely to be viable it will be necessary to determine:

- The approximate capital cost of the heat source.
- The capital cost of the heat network including:
    - Pipework from heat source to each property
    - Pumping stations
    - Heat interface unit (HIU) in each property
    - Alterations within the properties (e.g installation of radiators)

- How much heat is going to be delivered in total (in kWh)
- Price that heat is sold at (in p/kWh)
- RHi rate?
- How much heat is going to be lost from the network (this may be as little as 10% in a well designed network)
- Cost of fuel used
- Maintenance costs

Once budget estimates are known for the above, then a business case can be completed.

FINANCIAL SUPPORT

There are a number of sources of finance and incentives available for different parts of the network:

Heat Network Partnership

This includes Scottish Enterprise, Scottish Government, Strego, the Scottish government, Scottish futures trust and Energy Savings trust to promote and support district heating.
http://www.districtheatingscotland.com/District heating loan fund

This loan fund was set up by the Scottish government to provide loans for low carbon and renewable technologies to help organisations implement district heating for the benefit of local communities.
http://www.energysavingtrust.org.uk/scotland/grants-loans/district-heating-loan

Innovation infrastructure fund

Grant funding is available for communities to investigate and develop projects that link local energy generation with local energy use, or projects that wish to develop innovative distribution and storage solutions.
http://www.localenergyscotland.org/communities/generating-your-own-electricity/financial-support/infrastructure-and-innovation-fund/

Low Carbon Infrastructure Transition Programme

A range of support mechanisms including project development, expert advice and funding (where applicable) is available through the Low Carbon Infrastructure Transition Programme (LCITP) to support the development of substantive private, public and community low-carbon projects across Scotland.
http://www.gov.scot/Topics/Business-Industry/Energy/Action/lowcarbon/LCITP/eligibility-criteria

Non-domestic RHI

The Non-Domestic Renewable Heat Incentive (RHI) is a government environmental programme that provides financial incentives to increase the uptake of renewable heat by businesses, the public sector and non-profit organisations.

Eligible installations receive quarterly payments over 20 years based on the amount of heat generated.

To be eligible for RHI grant funding must not have been used to fund the renewable heat source. However it is possible to fund the district heating infrastructure wholly or partly through grant funding provided the renewable heat source has not been.

The Ofgem website has up-to-date information on the RHI tariffs:
https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-non-domestic-rhi

Contract for Difference

A Contract for Difference (CFD) is a private law contract between a low carbon electricity generator and the Low Carbon Contracts Company (LCCC), a government-owned company. A generator party to a CFD is paid the difference between the 'strike price' – a price for electricity reflecting the cost of investing in a particular low carbon technology – and the 'reference price'– a measure of the average market price for electricity in the GB market. It gives greater certainty and stability of revenues to electricity generators by reducing their exposure to volatile wholesale prices, whilst protecting consumers from paying for higher support costs when electricity prices are high.

The UK government CFD scheme includes biomass CHP which can be used for district heating schemes.

REGULATIONS AND CODES OF CONDUCT

There are a very significant number of regulations which need to be followed when designing a heat network and there is a significant amount of guidance available for sizing different elements of the system. These regulations are not listed here.

Heat networks: Code of Practice for the UK

Published by CIBSE and the Association for Decentralised Energy.

This is comprehensive guidance for the designers and operators of the district heating network. Designing, installing and operating a district heating network can involve a number of parties having different responsibilities. It is essential that not only do all parts of the network work together but that every party is clear on their role. The CIBSE Guidance provides clarity on this and is therefore useful reading for those developing a heat network. It also provides comprehensive references.

Heat network metering and billing regulations: compliance and guidance.

The Heat Network (Metering and Billing) Regulations 2014 implement the requirements in the Energy Efficiency Directive with respect to the supply of distributed heat, cooling and hot water. These regulations will need to be complied with and have an impact on the commercial models which can be followed.

The Energy Efficiency Directive promotes energy efficiency in the EU by laying down rules to overcome challenges in the supply and use of energy.

https://www.gov.uk/guidance/heat-networks

CIBSE (2014) AM15: Biomass heating (London: Chartered Institution of Building Services Engineers)

Provides guidance on installation of biomass heating.

http://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I76dAAC

BSRIA (2007) BG2/2007: Combined Heat and Power (CHP) for Existing Buildings

Guidance on Design and Installation (Bracknell: Building Services Research and Information Association).

Provides guidance installation of CHP systems.

https://www.bsria.co.uk/news/article/1982/

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