Heat Networks: Code of Practice for the UK

Raising standards for heat supply

CIBSE

chpa

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2014

FOREWORD

This Code of Practice has been produced as a joint project between CIBSE and the Combined Heat and Power Association (CHPA). If Heat Networks are to form a significant part of our future low carbon energy infrastructure in the UK then they need to be designed, built and operated to a high standard to deliver customer satisfaction. This Code has been produced to assist in achieving that aim by raising standards right across the supply chain.

Setting minimum (and best practice) standards should provide greater confidence for specifiers and developers. Standards can also be included in the tendering/contracting process to specify minimum standards set out in the Code. The adoption of this Code of Practice by developers could ultimately be used to support marketing by providing assurance to customers and property purchasers that the District Heating scheme has followed a set of design, installation and commissioning standards. The assurance provided by the standards should therefore have a significant effect on the DH market.

We hope to introduce training, accreditation and registration of Heat Network Professionals to ensure that the skills necessary to implement the Code of Practice are available across the sector. The Code of Practice, supported by these trained professionals should provide a step change in the district heating sector.

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The initial draft of this Code of Practice was prepared by AECOM under contract to CIBSE and in association with the CHPA. The principal author was Paul Woods.

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I. Introduction

1.1 Overall Purpose

The development of Heat Networks (or District Heating) in the UK is increasingly recognised as an important component in the UK's future energy strategy (DECC, 2013) Heat Networks can address the 'energy trilemma' by meeting the following **Aims**:

- To reduce greenhouse gas emissions through the use of a wide range of low carbon and renewable heat sources
- To improve security of energy supply by diversifying the energy sources for heating and reducing our dependence on fossil fuel imports
- To offer a more cost-effective source of low carbon heat

A major challenge will be to deliver a high standard of service to customers, who will have had good long-term experience using gas-fired boilers. Therefore, a high quality installation offering good reliability, a long life, low carbon intensity of heat supplies and low operating costs will be key. The cost-effectiveness of the heat supply will also depend on achieving low cost finance over a long period of time and funders will also be looking for long-term performance and reliability.

This Code of Practice is therefore written to:

- improve the quality of feasibility studies, design, construction, commissioning and operation by setting minimum requirements and identifying Best Practice options,
- deliver energy efficiency and environmental benefits,
- meet good customer service levels,
- promote long-lasting heat networks in which customers and investors can have confidence.

The Code applies to heat networks designed to supply new developments and networks that are retrofitted to supply existing buildings. Although many issues are common, networks for new buildings require careful design to keep heat losses low whereas the design of networks for existing buildings is often constrained by the existing heating systems in the buildings.

It is intended that the Code will be supported by a training programme and an accreditation scheme for those practitioners delivering projects under the Code.

1.2 The Structure of the Code

The Code is written to cover all **Stages** of the development cycle of a project from feasibility through design, construction, commissioning and operation.

The core of the Code is structured by:

- the typical sequence of a project by **Stage** from feasibility through to operation and maintenance;

- for each project Stage, a number of **Objectives** are set;

- for each Objective a number of **Minimum Requirements** are defined to achieve the Objectives.

All of these Requirements will need to be met if the project is to comply with the Code. The Code may be used either for the entire project or for a particular stage but the greatest value will be obtained when it is followed for all stages.

The project **Stages** are described in Figure 1 which shows the Heat Networks Plan of Work from briefing through feasibility, design, construction, commissioning and operation. The Code is structured around the stages in this Plan of Work and each section/stage is colour coded to reflect this. Figure 1 also shows the key responsibilities and how these relate to the major **Themes** set out below. An intrinsic part of meeting the Code of Practice is to recognise the interlinked nature of the whole process i.e. it may only take one weak link for the whole heat network supply chain to fail.

Indeed a successful heat network project will only be realised when the key design principles have been properly considered and implemented from initial feasibility through to operation in an integrated manner.

This is often made more difficult by the fragmented nature of the industry and the procurement of schemes. It is common to find that the feasibility work is carried out by a consultant, the detailed design and construction by a design and build Contractor and the operation and maintenance by a separate operating company. The procurement approach should consider the risks involved in this fragmentation and the lack of incentives for each party involved to deliver an optimal scheme. Where such separation cannot be avoided the Code of Practice should assist in achieving a more optimum integrated design that ensures operational costs are fully taken into account in the design development stages and that the system is correctly commissioned prior to the operational phase.

As the Code is designed to be as prescriptive as possible some of the Requirements are set to achieve minimum acceptable standards. However, it is recognised that an important role for the designer is to identify options for decision by the Client body together with the costs and benefits for each option. In most cases within each Objective further information is provided on what could represent Best Practice, which the various parties should also consider adopting.

Each Stage of the Project will have complied with the Code when it has been demonstrated that all Minimum Requirements have been met. However, the complexity and variety of Heat Networks means that alternative solutions that do not meet the Minimum Requirements can also be used and will be compliant provided a justification is made against the overall Aims stated above.

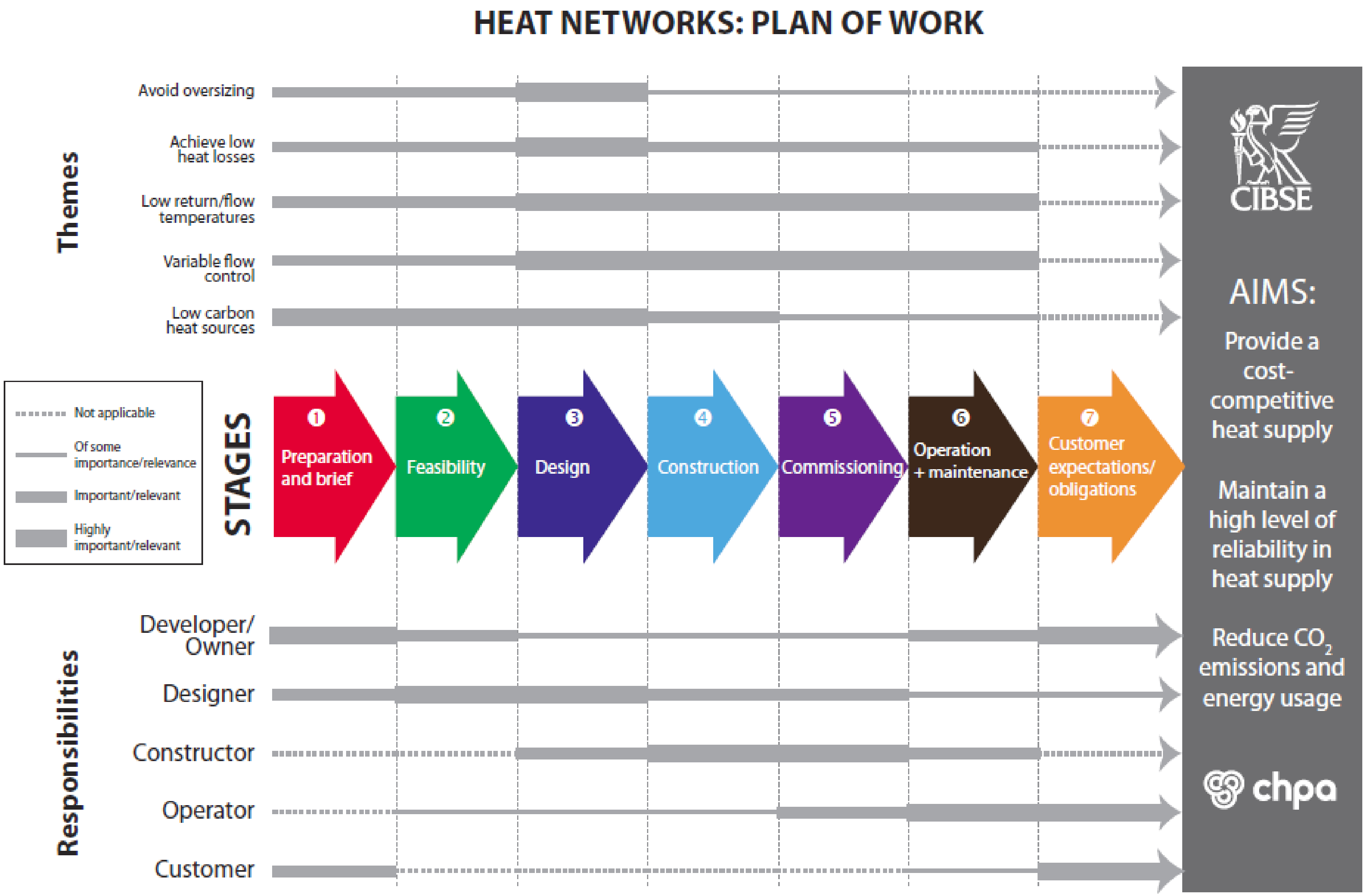


Figure 1 – Typical Plan of Work for a Heat Network Project

1.3 Themes

The principal ways in which the high level Aims are achieved are through the following broad **Themes** which need to be considered in each Stage of the project:

- **Correct sizing of plant and network**

When dealing with new technology designers will be naturally cautious and this can give rise to conservative designs that are more costly and have lower performance

- **Achieving low heat network heat losses**

There is evidence that network losses in some schemes are relatively high, especially for distribution systems within newly constructed apartment blocks. The economic and environmental impact of network heat losses depends on the type of heat source - if this is a low carbon and low cost source there would be less impact than for a high cost or high carbon source. However, in most cases, high heat losses will lead to higher carbon emissions, higher operating costs and a higher risk of overheating so designers need to consider ways to reduce the heat losses as far as practical.

- **Achieving consistently low return temperatures and keeping flow temperatures low**

For a given flow temperature, a low design return temperature will reduce peak flow rates leading to smaller pipes and lower costs. Maintaining low return temperatures under part-load conditions is important to keep heat losses and pumping energy low. Designing for lower operating temperatures will result in higher efficiencies with some types of heat sources e.g. heat pumps and steam turbine extraction. If the design return temperatures are not maintained in operation then the heat network capacity will be reduced. Achieving low return temperatures starts by correct selection and balancing of radiators and other heat emitters within the building which is often the responsibility of the building owner and designer and not the Heat Network owner/operator.

- **Use of variable flow control principles**

Using variable flow control systems will result in lower flow rates and lower return temperatures at part-load. Variable speed pumps are used and should be controlled to maintain a minimum pressure difference at the extremities of the network. This important control principle will reduce heat losses and pumping energy.

- **Optimising the use of low carbon heat sources to supply the network**

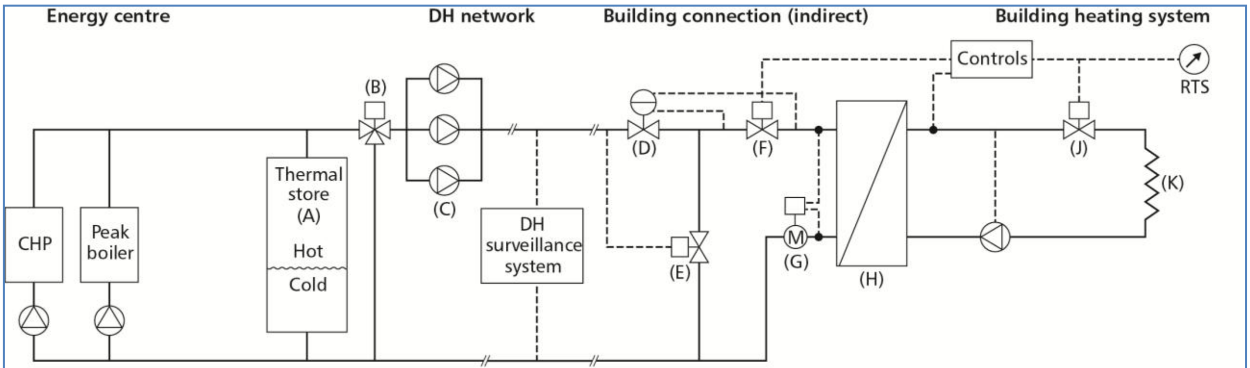
A primary driver for using Heat Networks is to enable low carbon heat sources to be used. These need to be sized to deliver a high proportion of the annual heat demand. The control systems and any thermal storage should be designed to maximise the contribution of low carbon heat and to ensure the efficient and cost-effective operation of these heat sources.

- **Delivery of a safe, high quality scheme where risks are managed and environmental impacts controlled**

At all stages from feasibility through to operation these safety, quality and environmental impact need to be to the fore, and this could involve the adoption of international standards: ISO 9001 for quality management, ISO14001 for environmental management, ISO 18001 for occupational safety and ISO 31000 for risk management. In addition the Asset Management Standard PAS 55 is relevant for the development and operation of the scheme. The PAS 55 standard '*provides objectivity across 28 aspects of good asset management, from lifecycle strategy to everyday maintenance (cost/risk/performance). It enables the integration of all aspects of the asset lifecycle: from the first recognition of a need to design, acquisition, construction, commissioning, utilization or operation, maintenance, renewal, modification and/or ultimate disposal.*'[1]

By focusing on these **Themes** throughout the project the Heat Network will be better able to deliver efficient, cost-effective and low carbon heat to customers.

Many of the key features needed for an efficient Heat Network are illustrated in the schematic diagram of Figure 2.



(A) Thermal store to minimise use of peak boiler and maximise income from CHP electricity

(B) Control valve to provide variable flow temperature

(C) Variable speed pumps with a range of duties to suit demand pattern controlled on pressure difference in network

(D) Differential pressure control valve to limit maximum flow and limit pressure across control valve (F)

(E) Temperature controlled bypass at extremities of network

(F) Two-port control valve to ensure variable volume in DH network and to vary secondary temperature

(G) Heat meter to encourage careful use of energy

(H) Plate heat exchanger sized for close return temperatures

(J) Two-port control valve to maintain low return temperature with balancing facility to set flow rate and return temperature

(K) Heat emitters sized to give low return temperature

Figure 2 – Key features of an efficient Heat Network (direct connection can also be used and may be more energy efficient)

[1] The Institute of Asset Management https://theiam.org/knowledge/What-PAS-55

1.4 Responsibilities

A typical heat network project involves a number of different organisations which all need to work together for success to be achieved. In general the responsibilities will be clear from the context of the Requirements. The Code needs to be adopted by all parties involved in developing the Heat Network and should not be simply made a contractual requirement on one party.

Each project will be different but the following table describes the typical responsibilities that may be carried out by each organisation.

Organisation	Responsibility
Central and Local Government	Central Government sets overall heat policy, develops appropriate incentive mechanisms and works to remove barriers to Heat Networks Local Government promotes the strategic vision and develops supporting policies especially in relation to planning policies
Owner/Developer of the Heat Network This may be a local authority, a housing association, building management organisation, a private sector ESCo, a public-private partnership or a community energy company	Define strategic scope and future proofing requirements for the systems Appoint CDM Co-ordinator Appoint project team Arrange finance Lead the planning application process Commission the designer Appoint the construction contractor Develop and sign the contracts for construction, operation and heat sales
Owner/Developer of new buildings	Determine peak demands (by the project design team) and agree with the Heat Network Operator Estimate projected annual consumptions (by the project design team) and agree with the Heat Network Operator Define design operating temperatures for the building services and losses in the secondary network and agree with the Heat Network Operator Ensure that the need for low return temperatures under all load conditions is understood by the design and construction teams Establish phasing plan for the development Lead the planning application process for the new buildings Commission the building services correctly Operate the building in accordance with the Heat Network Operator recommendations (or instruct their facilities manager to do so)
Owner of Existing Buildings	Determine peak demands and agree with the Heat Network Operator Estimate projected annual consumptions and agree with the Heat Network Operator Determine opportunities to modify secondary system and its operation to benefit the Heat Network
Feasibility study consultant	Survey existing buildings Determine peak demands and annual consumptions and provide and independent view of these Develop concept design and operational philosophy Estimate projected annual consumptions Evaluate existing and new heat sources

	Economic analysis including capex and opex estimates, projection of heat prices, whole life cycle cost analysis Environmental benefits and impacts Identify key Planning issues and risks
Heat Network Designer	Produce designer's health and safety risk assessments Design to achieve a cost-effective and efficient network Select optimum routes and resolve infrastructure obstacles Select pipe types/trenching methods Specify quality requirements Check design intent is implemented through construction Assist in the planning application process Make allowance for future expansion e.g. design in valved and capped tees
Heat Network Construction Contractor	Manage health and safety on site Quality control of installation Liaise with other utilities and highways authority Liaise with designer for route variations and ensure stress analysis is carried out on any changes
Commissioning Contractor	Develops detailed commissioning procedures to ensure the design intent is realised and enable a smooth handover to the operational phase
Heat Network Operator and Maintenance Contractor	Health and safety for operatives, customers and the public Provide input and advice during design development and construction Provide a reliable heat service Operate a procedure for handling customer complaints Maintain water treatment Maintain Energy Centre plant and equipment in accordance with PPM schedules Operate the system in accordance with the design Continually review for efficient operation Life cycle maintenance and repair of plant Monitor network alarms and rectify faults Metering and billing of customers Maintain statistics and provide reports Provide information to customers
Final customer for the heat	Enter into contracts for the purchase of heat and recognise and fulfil their own obligations under the contract

Supporting Sections of the Code

It is intended that the Code will be used in a range of market sectors and applications and these are described in Section II.

The Code also includes in section III a summary of legislation that is likely to be encountered in the course of developing a Heat Networks project. This is provided for general guidance and readers should consult the latest position directly from Government sources.

The Code is intended to cover all types of scheme for both existing buildings and new buildings, and for residential, commercial or institutional buildings. The key issues that impact on each of these sectors are discussed in section IV.

II. Scope

The scope of the Code is designed to cover all scales of Heat Networks - in principle any project that involves the linking of heat supply to more than one dwelling or more than one building. The Code is applicable to both new buildings and existing, although priorities and opportunities differ between these applications in important ways as discussed in section IV.

The Code is not intended to provide general design guidance, rather it is aiming to set minimum standards. The user should consult published guidance that is available and which is detailed in Appendix B.

Central Plant

Although the emphasis in the document is on the development of the Heat Network itself, reference is also made to minimum requirements for the heat source at the central plant or Energy Centre in as far as this impacts on the overall Heat Network system. More detailed Guidance for the design of Energy Centre plant can be found in other documents published by CIBSE and other bodies (see Appendix B).

The Code excludes Requirements for the building to house the Energy Centre plant or other equipment and associated building services where the Building Regulations need to be followed.

District Cooling

The Code does not set requirements for District Cooling (DC) as such systems are generally of a more bespoke nature supplying specific buildings. However, where appropriate, mention is made of District Cooling systems where the requirements in this Code are equally applicable to DC or to highlight design issues that are unique to DC. Guidance on the design of DC is available from ASHRAE (ASHRAE, 2013) reflecting the greater use of DC in the USA.

III. Legislation

This section describes in broad terms the scope of legislation that is likely to impact on Heat Networks development. It is not intended to be comprehensive nor in sufficient detail to enable compliance to be tested so it is essential that readers consult the latest regulations normally available on Government websites.

It should be noted that some regulations are devolved to the administrations of Scotland, Wales and Northern Ireland and there are important differences.

Health and Safety Legislation

Although the Health and Safety at Work Act is fundamental, the Construction Design Management Regulations (CDM) will govern all stages from design through to operation. The Control of Substances Hazardous to Health Regulations (COSSH) Regulations 2002 and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 are also likely to apply in most cases. During the operating phase the control of legionella risk is an important consideration and the HSE Code of Practice L8 (HSE, 2013) needs to be followed.

Planning legislation

Obtaining planning permission under the Town and Country Planning Acts for any new construction is a fundamental requirement. Planning permission for a new heat network will be required for major schemes and separately for the Energy Centre. Where the project consists solely of buried pipework it is unlikely that planning permission will be required for the network itself but it may be needed for any major site compounds needed for storage of materials and other construction purposes.

For new build schemes the planning permission may be part of the application for the development itself and local planning policies may have a strong influence on the nature of the energy solution to be used including the incorporation of renewable energy. Planning policies may encourage the use of Heat Networks as they can use a wider range of low carbon technologies some of which may only be available at scale. For example, the London Plan requires developments to make provision for future connection and connecting to existing heat networks.

Early consultation with the Planning Authority is recommended to establish the extent of permissions required and which policies will be applied when considering the application.

Planning approval may impose other construction requirements with conditions dealing with removal of waste, storage of materials, dust and noise nuisance. There may be a requirement to comply with the Considerate Contractors scheme.

Local Authority Legislation

The Government has indicated that Local Authorities should play a leading role in the development of Heat Networks. The legislation that provides powers to Local Authorities to develop and operate heat networks and sell heat energy is contained in:

- For London, the LCC (General Powers) Act 1949

- Local Government (Miscellaneous Provisions) Act 1976.
- Local Government Act 2000 – this contains the well-being powers which have been used by LA’s to promote and participate in heat network projects
- Local Authority procurement is covered by the Public Contracts Regulations 2006
- Local Authorities can also procure schemes through the Utilities Regulations
- Planning and Energy Act 2008 - Local Authorities are allowed to set up their own standards regarding Carbon emissions target in buildings, possibly higher than National standards.

State Aid legislation is also important when developing business structures, for example, public sector intervention in the form of grants are likely to be limited to 40% of a project’s capital costs, particularly where there is a private sector developer. A Local Authority may wish to set up a separate organisation to develop Heat Networks similar to an Arms Length Management Organisation (ALMO) that has been used to provide local housing needs. The legal status and the degree of control by the Council and extent of function provided by such companies needs to be carefully considered as this will impact on how the procurement regulations will apply.

Design and Construction legislation

Building Regulations

The Building Regulations govern the construction of new buildings and refurbishment works. The main impact on Heat Networks arises where part of the compliance route is to use a low carbon heat supply to achieve the required CO_2 emissions.

There is provision within the non-domestic regulations for a Heat Network Operator to provide the carbon intensity of the heat supply to be used in the CO_2 calculations. If this CO_2 intensity from the heat network is less than 150g/kWh of heat supplied then the designer will be able to take account of the benefit of a low carbon heat supply as part of the low carbon design solution, which may add value to the project.

For the domestic regulations, information is required for the SAP modelling which details how the heat is produced, the proportion from CHP for example. A template for the necessary input data is given in Appendix E.

This approach potentially provides an incentive for buildings to connect to a Heat Network, particularly as we move towards the 2016 Zero Carbon Homes standard and where Allowable Solutions may provide further support for low carbon heat networks.

The Part L Compliance Guides for Dwellings and Non-Dwellings contain information on CHP and heat networks.

New Road and Street Works Act

It is normally necessary for organisations wishing to install heat networks in the public highway to obtain a NRSWA Section 50 Licence from the Local Authority. The licence imposes important obligations on the holder to give suitable notice of its operations and to provide record details of all installed equipment. A particular feature of this Licence will be the highways management and traffic plans which have to be prepared, submitted and then implemented.

Early contact with the Local Authority Highways Department and other statutory undertakers working or with systems installed in the area is recommended. There will be a need to obtain licences for site compounds and there may be payments to be made for loss of car parking spaces. There may be opportunities for co-ordinating the heat network installation with other utility works or road resurfacing programmes.

Contact may also be necessary with the Highways Agency, Network Rail, British Waterways or the Environment Agency where major crossings are envisaged.

Energy Efficiency Directive

The Energy Efficiency Directive 2012/27/EU is being transposed into UK legislation. Heat networks are covered in three main ways:

- The requirement for EU Member States to establish the potential for District Heating and report to the EC regularly on uptake of DH

- A requirement for district heating and cooling installations greater than 20 MWth input, including those on heat networks, to perform a cost-benefit analysis to consider opportunities for using CHP or recovering waste heat. The results of the CBA must be taken into account by the national authorities when providing consent for the operation of the installation.

Requirements related to the metering and billing of heating and cooling supply
The Energy Efficiency Directive requirements for metering and billing apply to both the non-domestic and domestic sectors. Heat meters are required to be installed at each multi-customer building supplied by a Heat Network and individual customer heat meters are to be installed for all new developments and where a relevant major renovation is undertaken. This requirement is for both individual dwellings and for industrial/commercial consumers in multi-occupancy buildings. In addition, Heat Network Operators need to retrofit individual heat meters at each unit supplied unless it can be shown that this is not cost-effective or technically feasible. Where individual heat meters are shown not to be cost effective or technically feasible, heat cost allocators (HCAs)[2] have to be installed unless they too are not cost effective. A national methodology for determining the cost-effectiveness and technical feasibility of heat meters and heat cost allocators in compliance with the UK regulations is under development.

Operational legislation

The Energy Act 2013

The Energy Act 2013 makes provision for the setting of Contracts for Difference which will support renewable energy electricity generation, including CHP plant that might supply Heat Networks. For plant larger than 5MWe, the CfD is replacing Renewable Obligation Certificates (ROCs) from 2017. For renewable plant below 2MWe, they will be able to continue accessing the small-sale Feed-in tariff scheme.

The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001

[2] Heat Cost Allocators have not been used in significant numbers in the UK in recent years and are not discussed further in this Code

This rules that operators need to determine if they meet the Order's requirements to qualify for an exemption from supply licence requirements. Such an exemption will be important to obtain if planning a 'private wire' electricity network in association with the Heat Network.

Renewable Heat Incentive and Feed-in-tariffs

These financial mechanisms exist to promote renewable electricity and heat generation which will be of importance to Heat Networks which intend to use such heat sources including: large-scale heat pumps, biomass boilers, and small-scale bioenergy CHP.

CHPQA scheme

The CHPQA system is a method for establishing the relative performance of a CHP system using a Quality Index, which is related to how much CHP heat is used over the year. A QI over 100 is termed 'Good Quality' and if this threshold is met then it is possible to access specific support mechanisms, including an exemption from the Climate Change Levy for electricity used on-site and tax relief under the Enhanced Capital Allowance scheme.

Carbon Price Support (CPS) payments

Payments need to be made under the CPS for electricity generated by fossil fuels. However, fuel used in a CHP to generate heat is not liable for CPS. CPS payments are not required for systems below 2MWe. From April 2015, fuel used for CHP-generated electricity used on site will not be liable for CPS.

CRC Energy Efficiency Scheme

Under the CRC Efficiency scheme large national energy users are required to report on their energy use and make a payment that is related to the carbon emissions associated with the energy used. Neither the gas used in a CHP nor CHP-generated electricity exported off-site need to be reported in the CRC. The scheme treats a supply from a Heat Network as zero carbon emissions which is a potentially a useful but small benefit to the scheme. Local Authorities and Universities will be within the remit of the CRC.

EU Emissions Trading Scheme (EUETS)

If the Energy Centre has more than 20MW thermal input, then it will need to be included within the EUETS. This will require payments based on the fuel used. However, there are free allocations for CHP systems. An opt-out provision was set by DECC's legislation for small emitters and hospitals in the UK for Phase III of the EUETS.

Energy Company Obligation (ECO)

This scheme requires large energy users to deliver carbon emissions reductions, usually energy efficiency improvements to housing however a number of Heat Networks have also been supported under this scheme and in the future Heat Networks will be allowed as a Primary Measure. under the CERO and CSCO parts of the ECO but with some pre-requirements.

Consumer legislation

There is no specific legislation that covers the sale of heat; however, the sale of heat is governed by consumer protection legislation and subject to the supervision of the Office of Fair Trading.

IV. Applications for Heat Networks – Challenges and Opportunities

New Build Applications

For new build applications the major consideration is usually how the Heat Network can contribute to meeting planning policies, Building Regulations and other Client requirements. For example, those defined by reference to the BREEAM standard or similar scheme for dwellings or communities.

New buildings will have much higher standards of fabric insulation and air-tightness than existing buildings. Consequently the heat losses from the network will be more significant and close attention to the design to minimise such heat losses will be critical. In this context the heat network is not just the buried network between any residential blocks but also the pipework from any block entry point up to each dwelling. Indeed it is this latter element which contributes most to heat losses and poor design can lead to not just excessive heat losses but also over-heating of corridors/common areas.

New buildings offer important opportunities to utilise lower operating temperatures, as the new heating systems can be designed accordingly, with consequent benefits of lower network losses and more efficient central plant.

At the feasibility stage it can be difficult to estimate the peak heat demands and annual heat consumption with accuracy as reliance must be made on modelling, often with limited information. Wherever possible the designer should check estimates against operational data from similar schemes.

The project is likely to be developed in phases and full occupancy may not be achieved initially so the heat demand will build up slowly over time. In some prestige London developments occupancy levels are low and this may impact negatively on the operation of the scheme for some years to come. This leads to a need for designs to provide for future flexibility without significantly increasing the costs for the early phases.

Retrofit Applications

In retrofit applications, heat demands can often be estimated using actual fuel use data.

Heat Network operating temperatures will typically be determined by the highest temperatures used in certain buildings and working with these building owners/operators to reduce operating temperatures would benefit the whole scheme. What may have become common operating practice in an existing building may not align with the original design criteria. The building itself may have been upgraded reducing the heat demand enabling lower temperatures to be adopted with no loss of service.

A suitable location for a central plant (and with room for future expansion) is often difficult to find, especially in a city centre area, although consideration should always be given to using distributed peak and standby capacity and existing boilers to reduce the space needed at the Energy Centre.

Without the policy support from planning or defined Client requirements commonly found with new build, customers are only likely to connect with a clear commercial benefit, although in some sectors the low carbon intensity of heat supplied from the network will also be a factor in the decision.

Mixed developments of new and existing

These developments are seen where the new development is subject to policies which promote Heat Networks and which can then be used as a catalyst to initiate a Heat Network to supply adjacent existing buildings. Alternatively, some schemes have started by serving existing buildings such as Council offices and then extended to supply adjacent new developments.

The developer of the new build may have to provide additional space on site for plant to supply a wider area, but again consideration should be given to using the boiler plant in existing buildings for top up and standby.

The design of the wider network may impose constraints on the new development that may not be optimal e.g. higher operating temperatures. However, there may also be opportunities to use the return water from the existing development as the flow circuit to the new.

Commercial and contractual issues are typically more complex, however for any heat network to develop it will naturally contain a mix of new and existing buildings and therefore this should not be considered as an insurmountable obstacle.

Figure 3 - New build housing supplied by a Heat Network – Greenwich Millennium Village

Figure 4 - Existing buildings supplied by a new Heat Network – Stafford Cripps Estate Islington

1. Preparation and briefing

Objectives:

1.1 To commission the Project in accordance with the Code of Practice
1.2 To agree contracts that are fair and equitable with customers
1.3 To define appropriate service levels for the heat supply

Objective 1.1 – To commission the Project in accordance with the Code of Practice

Why is this objective important?

The Owner/Developer organisation will wish to procure a Heat Network that will provide a high level of service for customers, be reliable and cost-effective. The Owner/Developer will also need to comply with planning conditions set for new developments or other requirements for delivery of environmental benefits for a community. This organisation may be a local authority, an ESCo, a property developer or a community organisation but all will ultimately be responsible for the performance of the project and should therefore take the lead in implementing this Code.

Minimum Requirements

✓ 1.1.1 The Owner/Developer shall ensure that this Code of Practice is included as a key requirement in briefs and specifications for the delivery of:

- Feasibility studies
- Design services
- Construction contracts
- Commissioning contracts
- Operation and Maintenance contracts

✓ 1.1.2 The Owner/Developer shall monitor implementation of the Code on a regular basis, and at the end of each stage of the project, the compliance of the scheme against the Requirements listed under each objective, seeking to obtain evidence that the requirement has been met

✓ 1.1.3 The Owner/Developer shall ensure all those working on project conduct an effective handover process between each stage

✓ 1.1.4 The Owner/Developer shall provide feedback to CIBSE as to the operation of the Code and any points where compliance has been found to be too onerous or impractical so that the Code can be progressively improved

✓ 1.1.5 The Owner/Developer shall ensure that suitably qualified people are employed on the project appropriate to each stage

✓ 1.16 the Owner/Developer shall provide designers will clear responsibilities using the guidance in the BSRIA Design Framework where appropriate

Best Practice

It is expected that in the future a system of accreditation for individuals or companies who have the capability, systems and expertise to develop and operate Heat Networks will be set up and Best Practice could then be to use such accredited individuals or companies to implement the scheme. It could also be Best Practice to appoint an independent accredited individual to carry out an audit of the project to check and certify that all of the Code Requirements have been met and an audit report produced.

Objective 1.2 – To agree contracts that are fair and equitable with customers

Why is this objective important?

Any successful business needs loyal customers which will continue to purchase the product and pay their bills. For a natural monopoly such as a Heat Network this is particularly important. Customer satisfaction and retention will depend to a large degree on having fair and equitable contracts.

Minimum Requirements

- ✓ 1.2.1 the contract offered to domestic heat customers and micro-businesses shall be in compliance with level 2 of the Independent Heat Customer Protection Scheme (IHCPS) where the rules of this scheme permit
- ✓ 1.2.2 the contracts for the sale of heat to non-domestic customers shall not discriminate between customers except for valid reasons including in relation to technical issues such as capacity, temperature, capital contribution etc
- ✓ 1.2.3 a target level of availability of heat supply shall be agreed for planned and unplanned shut-down periods which recognises the cost-benefit balance in setting the target
- ✓ 1.2.4 compensation payments shall be made to customers where the supply has been interrupted and the targets not achieved by an agreed margin, and for domestic customers, compensation shall be in accordance with the terms of the IHCPS
- ✓ 1.2.5 the maximum response time to attend to a heat supply fault shall be clearly defined; different times may be set for faults occurring outside the heating season or for emergencies
- ✓ 1.2.6 specific arrangements shall be made to identify vulnerable customers and provide additional support as appropriate, in accordance with the IHCPS
- ✓ 1.2.7 the method for providing alternative heating supply to vulnerable customers or to all customers in the event of a prolonged fault shall be defined

Best Practice

The IHCPS makes provision for a higher service standard of Level 3 and this could constitute Best Practice under this Code. Best Practice for non-domestic customers could include a contractual requirement on the customer to deliver network return temperatures below a set level with a system of penalties for higher and discounts for lower return temperatures.

Objective 1.3 – To define appropriate service levels for the heat supply

Why is this objective important?

It is important that the service level for the heat supplied is defined as ultimately this will determine the design and hence the costs of delivering the heat. A clear statement of service level will enable customers to understand the service offered and there will be less likelihood of disputes occurring.

Minimum Requirements

- ✓ 1.3.1 an external air temperature shall be defined at which the heat supply capacity shall be at its maximum – the design external air temperature shall be determined using appropriate guidance, taking account of the location of the scheme
- ✓ 1.3.2 the maximum heat supply capacity (in kW) for each customer shall be defined at the design external air temperature and for the assumed flow and return temperatures of the Heat Network. This also defines the maximum flow rate from the Heat Network
- ✓ 1.3.3 the minimum flow temperature that will be available from the network in the summer period shall be defined, taking account of the use of variable flow temperature control and heat losses from the network
- ✓ 1.3.4 the variation in flow temperature of the network against external air temperature shall be defined
- ✓ 1.3.5 for systems where the supply of space heating is shut-down in summer, the dates when space heating will be unavailable or the external air temperature above which it will be shut-down shall be defined
- ✓ 1.3.6 for systems which are planned to operate intermittently the operating hours when the heating is unavailable shall be defined (e.g. at night)
- ✓ 1.3.7 the point at which the heat supply shall be metered shall be defined and the arrangements for gaining access to read the meter shall be detailed
- ✓ 1.3.8 the arrangements for monitoring the supply to the customer, recording of flow and return temperatures, pressures, flow rates and annual consumptions shall be defined; a regime for this monitoring system shall be defined including periodic checks/calibration

Best Practice

Best Practice would involve the provision of regular information to customers regarding their demand profiles and operating conditions with the aim of improving the overall operation of the Heat Network for the benefit of both suppliers and customers. Best Practice could include penalties/payment deductions for failure to meet service levels. Best Practice could involve an on line portal for consumers to view their energy consumption data.

Set of questions (please write your answer in the response form):

Q 12. Do you know of a guidance that could be used to set out the external air temperature at which the heat supply capacity shall be at its maximum under the Objective 1.3?

Q 13. Are there any requirements in the Preparation & Brief Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

2. Feasibility

Objectives:

2.1 To achieve sufficient accuracy of peak heat demands and annual heat consumptions

2.2 To identify the most suitable low carbon heat energy sources and location of an Energy Centre

2.3 To determine the location of top-up and standby boilers and use of existing boilers

2.4 To select suitable operating temperatures

2.5 To define heat network distribution routes, pipe sizes and costs

2.6 To determine building connection costs including heat metering

2.7 To minimise the negative impacts of phasing of the development

2.8 To assess operation and maintenance needs and costs

2.9 To conduct a consistent economic analysis and options appraisals

2.10 To analyse risks and carry out a sensitivity analysis

2.11 To assess environmental impacts and benefits

2.12 To develop preferred business structures, contract strategy and procurement strategy

Objective 2.1 – To achieve sufficient accuracy of peak heat demands and annual heat consumptions

Why is this objective important?

An estimate of both the peak heat demand (kW) and annual heat consumption (MWh p.a.) is the first step in any feasibility work. These estimates will determine: the capacity of the heat production plant, the capacity of the heat network and the potential revenues for the scheme. These estimates are therefore fundamental to the feasibility study and sufficient accuracy is needed.

For existing buildings the estimates will mainly rely on fuel use as recorded by meters and other site information. It will normally be of benefit for the building owner and the Heat Network operator to examine opportunities for energy efficiency before committing to the investment in the heat network so as to avoid unnecessary investment in capacity and less efficient operation.

For new buildings, a modelling approach will be needed. It is important that the modelling reflects the expected operation of the building in practice which may differ significantly from modelling needed to show compliance with the Part L of the Building Regulations.

Minimum Requirements

- ✓ 2.1.1 for existing buildings, heat demands shall be estimated on a monthly basis using actual fuel used from meter readings wherever available and an assessment of existing equipment efficiencies, taking account of any potential for investments in energy efficiency

- ✓ 2.1.2 the data shall be analysed to estimate the heat demand for domestic hot water, any system losses within the building and space heating

- ✓ 2.1.3 the space heating element shall be adjusted by means of degree days to provide a monthly heat demand profile for an average year using an appropriate baseline temperature for the building concerned (although it is important that in any later analysis the sensitivity of this profile is tested for extremes)

- ✓ 2.1.4 an understanding of the daily, weekly and annual occupancy pattern of each building shall be established to inform the Energy Centre design and the need for thermal storage together with any future expected changes which may have an impact

- ✓ 2.1.5 peak demands shall be estimated from: a knowledge of the installed boiler capacity and how these are operated in practice, , benchmarks using floor areas and age of the building, or from half hourly gas meter readings if available and supplemented by modelling using CIBSE TM54 (CIBSE, 2013). Benchmarks for peak and annual heat demand estimates based on floor areas which can be used in feasibility studies are given in the following references:

- CIBSE TM46: 2008 Energy benchmarks (for existing buildings)
- CIBSE Guide F: Energy Efficiency in Buildings (for existing buildings)
- BSRIA BG9/2011 Rules of Thumb, 5th Edition (for new buildings)
- BSRIA BG14/2003 Rules of Thumb, 4th Edition (for existing buildings)

✓ 2.1.6 future heat demands for extensions of the network shall be estimated in a similar way and a sensitivity analysis carried out to show the impact on the heat network and energy centre design

Best Practice

Best Practice could be to obtain hourly or half-hourly fuel use data from meters throughout the year where this is available or to install monitoring equipment to establish the demands more accurately. Best Practice would also include the use of operational data from other similar sites to generate a heat demand profile. From this data an annual heat load duration curve can be produced.

Best Practice could be to take account of local climates such as the heat island effect in large cities when assessing space heating demands and the lower demand for hot water that may be seen in summer (due to higher cold water feed temperatures and lower temperatures used for showers).

District Cooling also requires an estimate of cooling demand which for existing buildings is often hard to establish as cooling is rarely measured directly and electricity use for chillers is also not usually metered separately. Cooling demand tends to be more peaky than heat demand and more limited in duration – for offices typically for weekday afternoons in the summer months. For new buildings dynamic simulation modelling can be used to provide the cooling demand profiles.

Objective 2.2 – To identify the most suitable low carbon heat energy sources and the location of an Energy Centre

Why is this objective important?

One of the benefits of Heat Networks is that they can use a variety of heat sources and at the feasibility stage it is important to consider a range of solutions and identify the best mix of heat sources for any given project. The project should not proceed to the next stage without a firm decision on the type of suitable heat sources even if the exact capacities of each will be refined later.

Minimum Requirements

- ✓ 2.2.1 all available heat sources and technologies shall be reviewed and the most suitable compared in more detail. This shall include renewable sources and local waste heat sources

> Note: In many cases, especially for smaller schemes a generic assessment may be referenced as a way of meeting this requirement to save on development costs. However local sources of heat should always be considered.

- ✓ 2.2.2 the heat sources shall be compared primarily on the basis of whole life costs, contributions to CO_2 reductions and technology risk profile

- ✓ 2.2.3 the heat sources shall also be compared on the basis of: availability, sustainability credentials including origin of fuel (especially for biofuels), transport requirements and security of supply issues

- ✓ 2.2.4 a mix of heat sources shall be considered recognising that lower capital cost but higher running cost sources may be advantageous to meet peak demands (e.g. gas-fired boilers)

- ✓ 2.2.5 financial incentives such as FiTs, RHI and ROCs shall be identified and the life cycle cost comparisons carried out both with and without these incentives, and a cost of carbon may also be used as an alternative approach. Modelling shall also include the impact of any CCL exemptions, LECS, CRC, EUETS and in particular the impact that constructing a network and linking buildings will have on such current costs, either positive or negative,

- ✓ 2.2.6 an operating model shall be set up to establish the size of each heat source and how much heat they will generate annually, this will provide the data on fuel and electricity use and, in the case of CHP, electricity generated, for use in the economic model. The model shall take account of the potential benefits from thermal storage at least in an approximate way. The efficiencies used in determining fuel use shall be gross (higher) calorific value to avoid this common error which leads to under-estimating fuel costs. The model shall also include realistic assumptions on the efficiency, availability and output of each plant item. The model shall also include an analysis of the network primary and secondary losses from the work undertaken in accordance with Objective 2.5

- ✓ 2.2.7 the operating model shall be set up to use a month by month heat demand profile together with a way of differentiating between night period and day period or weekdays and weekends if there are significant differences in heat demand expected

- ✓ 2.2.8 a suitable energy centre site shall be selected from a range of options comparing these across a number of criteria such as: proximity to heat loads, visual impact, noise disturbance, flue emissions and air quality impact, viability of fuel supply and electricity connection, space for both initial plant and for expansion, fresh air supply for combustion which shall be via natural ventilation wherever possible, access for plant installation, removal and fuel deliveries

- ✓ 2.2.9 even where different types of heat sources are used, a large number of energy centres on the network shall be avoided as this will lead to a reduction in the economies of scale and the network will become hydraulically complex to operate to maximise the use of LZC plant

- ✓ 2.2.10 future potential heat sources and the potential growth in demand shall also be considered in relation to fuel type and CO_2 emissions, recognising that the wider electricity supply system will change over time as it decarbonises

Best Practice

A Best Practice operating model would adopt an hour by hour approach throughout the year. Even if the knowledge of daily demand profiles is limited this type of modelling will be more accurate and is often required to establish how a scheme will operate in practice, particularly where there are multiple consumer types, a range of heat sources and thermal storage.

> Note: Although the use of operating models are important to determine the most likely operating costs and revenues, it should be recognised that the actual heat demands will vary depending on occupant behaviour and the weather and the system needs to be designed to be flexible and to meet a wide range of heat demands as efficiently as possible.

Objective 2.3 – To determine the location of top-up and standby boilers and use of existing boilers

Why is this objective important?

To ensure a satisfactory level of service it is normal practice to include gas-fired boilers as standby plant should the primary heat source fail. Such boilers are often also used to help meet demands during the coldest weather, often referred to as top-up duty. These boilers can be located either at the Energy Centre or distributed within the scheme or some intermediate arrangement between these two extremes. In some cases the existing boilers within buildings can be retained for these top-up and standby duties. The disposition of the top-up and standby boilers will determine not only the capital cost of the boiler plant but also of the heat network - as distributed boilers would allow the network to be sized only to deliver heat from the primary heating source which may be half or less of the peak capacity. The location of the boilers also influences the security of heat supply and the need to allow for temporary boilers in the event of a failure of the heat network. It is therefore important that this issue is considered at the feasibility stage and an optimal approach developed.

Other forms of back-up heat supply may also be considered to provide operational flexibility – for example the use of electric heating for domestic hot water storage systems.

Minimum Requirements

- ✓ 2.3.1 discussions shall be held with the heat customers to determine their requirements with respect to security of supply and the capacity and condition of existing boilers
- ✓ 2.3.2 the feasibility study shall examine the options of centralised boilers and distributed boilers, including the incorporation of existing boilers into the scheme where appropriate and make suitable recommendations.
- ✓ 2.3.3 consideration shall be given to the principles of hydraulic control to be employed to ensure that use of the low carbon heat supply source is maximised, especially where multiple heat generation sources and distributed boilers are used
- ✓ 2.3.4 the options appraisal shall take account of the space required for boiler plant and the associated cost of any building area needed

Best Practice

Best Practice could also include consideration of additional heat recovery, where applicable, on the lead top up and standby boiler to improve system efficiency as these boilers may well be older less efficient units and capable of upgrading.

Objective 2.4 – To select suitable operating temperatures

Why is this objective important?

Operating temperatures are a key aspect of Heat Network design and will determine both the capital cost of the network and the heat losses and pumping energy. The temperatures selected will also determine the efficiency of the heat source (especially for heat pumps and steam turbine extraction) and also the volume of thermal store required for a given energy storage. Whilst there will be scope for further optimisation during the design stage, the feasibility stage needs to be based on assumptions which are practical and achievable. These assumptions can then be used to carry out the pipe sizing and produce the cost and performance data needed for the feasibility stage.

Minimum Requirements

- ✓ 2.4.1 discussions shall be held with each building owner/operator to determine the temperatures used for their existing heating system under peak demand conditions and the potential for reducing these especially the return temperature. It is important that any original design temperatures are established and if the building/boiler plant is currently operating to a different regime establish why this is taking place and whether current practices can be changed for the benefit of the proposed network

- ✓ 2.4.2 the most suitable operating temperatures for the heat sources selected shall be identified, taking account of how efficiencies will vary with operating temperatures

- ✓ 2.4.3 the flow temperature shall be reduced as demand falls (weather compensation) to reduce heat losses under part load conditions unless a detailed analysis taking account of pumping energy and return temperatures shows that this approach is not viable

- ✓ 2.4.4 the difference between flow and return temperatures on the primary Heat Network under peak demand conditions shall be greater than 30°C for supply to new buildings and greater than 25°C for existing buildings, to reduce the capital costs of the network, unless a detailed analysis of life cycle costs and performance shows otherwise

- ✓ 2.4.5 the option of using one set of operating temperatures for the heat source and the thermal store and a second set for the Heat Network, so that flow temperatures on the network can be varied independently of the heat source and the energy storage capacity maximised, shall be analysed

- ✓ 2.4.6 the temperature difference that occurs at any hydraulic separation (i.e. at a heat exchanger) shall be taken into account in defining operating temperatures; the use of multiple levels of hydraulic separation shall be discouraged

- ✓ 2.4.7 the flow temperature shall be sufficient to heat the domestic hot water to the required temperature with good temperature control and to minimise health risks from legionella growth

- ✓ 2.4.8 if the use of polymer carrier pipes, or other materials, is considered advantageous then the acceptable maximum temperatures (and pressures) of the plastic pipe to deliver a 30 year design life shall be determined (which may involve the use of variable flow temperatures) and the overall benefit of such pipe systems assessed accordingly

- ✓ 2.4.9 for new building services systems the operating temperatures for heat emitters shall be selected to be as in Table 2.1 below:

Table 2.1 - Preferred design operating temperatures for new building services systems (i.e. secondary or tertiary systems)

Circuit	Flow temperature	Return temperature
	°C	°C
Radiators	max 70	max 40
Fan-coil Units	max 60	max 40
Air Handling Unit	max 70	max 40
Underfloor heating	See Note	See Note
Domestic DHWS instantaneous heat exchanger on load	min 65	max 25
Domestic DHWS cylinder with coil heat up from cold	min 70	max 45
DHWS calorifier with external plate heat exchanger	min 70	max 25

Note: underfloor heating systems will typically operate with floor temperatures below 35°C and typically flow temperatures of 45°C which is advantageous for heat networks as this will result in low return temperatures.

- ✓ 2.4.10 for existing buildings, at a feasibility stage, it can be assumed that radiator circuits designed for 82°C flow 71°C return can be rebalanced to achieve lower return temperatures, as radiators are normally oversized, e.g. to achieve 80°C flow 60°C return, especially where fabric improvements have been made subsequently to the original heating installation

- ✓ 2.4.11 the approach temperature – the difference between the primary return temperature and secondary return temperature across a plate heat exchanger shall not exceed 5°C

- ✓ 2.4.12 for existing buildings the type of control system (e.g. two-port or three-port control) shall be established and discussions initiated about possible improvements

Best Practice

Best Practice approach could be to carry out a specific temperature optimisation study taking account of all impacts to derive lifecycle costs and environmental performance for a range of temperatures. Best Practice could seek to achieve return temperatures lower than in the table above and consider more complex ‘cascade’ systems where the return temperature from a space heating circuit is used to pre-heat cold feed to a centralised DHWS for example in a building such as a hotel or leisure centre. Best Practice approach temperatures for heat exchangers could be reduced to 3°C. However it is important to check that there is sufficient heat transfer at low loads and low flow rates when low velocities may occur within the heat exchanger and detailed consultation with the heat exchanger supplier is recommended. The temperatures of future potential heat demands and heat sources should be considered.

Operating Temperatures for District Cooling

District Cooling systems are more constrained in operating temperatures than District Heating, as they have to operate between a minimum flow temperature close to 0°C and a return temperature below the typical space temperature of 20°C. Within a single building typical temperatures of 6°C flow and 12°C have become established. In order to reduce pipe sizes District Cooling systems increase the delta T to about 10°C e.g. 5°C flow 15°C return. Even so the pipe sizes will generally be much larger than for the heating supply. As a result, direct connection should be considered to avoid a further deterioration of temperature difference.

The use of chilled beams is favourable for DC as a higher return temperature is possible. The possibility of supplying chilled beams from the return from air handling units in a cascade manner would also be beneficial for DC.

Objective 2.5 – To determine heat network distribution routes, pipe sizes and costs

Why is this objective important?

The capital cost of the heat network is likely to be a major component of the project cost and will therefore influence the economics. The routes for the network will define the length, installation difficulty and hence cost. The feasibility of the routes needs to be established especially where there are major barriers such as road or rail crossings.

Note: Although pre-insulated pipe systems with steel carrier pipe manufactured to EN 253 are commonly used there are a range of other materials available for the carrier pipe: PEX, PB, PP-R and more innovative design using GRE (glass reinforced epoxy) or other multi-layer plastic composites. These all have different characteristics and can result in lower costs depending on the application and should be assessed either at the feasibility stage or early in the design stage. In general, polymer pipes, at least for smaller diameters, will have lower installation costs because of the greater flexibility and because fewer connections are needed. A further option to the designer is the use of twin-pipe systems which offer lower heat losses and lower installation costs.

Minimum Requirements

- ✓ 2.5.1 routes shall be selected to minimise the length of the network to reduce both capital costs and heat losses
- ✓ 2.5.2 routes through service areas of the connected buildings shall be identified to reduce the costs associated with the buried network
- ✓ 2.5.3 consideration shall be given to the feasibility of the routes in relation to major barriers such as major roads, railways, rivers and canals
- ✓ 2.5.4 existing utility service plans shall be reviewed and routes shall be selected to avoid major known existing utility services or areas where services are known to be congested.
- ✓ 2.5.5 discussions with the Highways Department in the Local Authority and other utilities shall be held at an early stage, where appropriate, to identify constraints and opportunities to co-ordinate the heat network installation with other works that may be planned e.g. re-surfacing of roads, other utility works etc
- ✓ 2.5.6 an initial pipe sizing calculation shall be carried out to establish network costs using the following guidelines on typical flow velocities

For steel pipes:

Pipe size ID (mm) (for EN253 pipe)	Typical velocity (m/s)
54.5	0.85
107.1	1.2
160.3	1.6
210.1	1.9
263.0	2.2
312.7	2.5

For polymer pipes:

Pipe size OD and pipe wall thickness (mm)	Typical velocity (m/s)
25 x 2.3	0.7
40 x 3.7	0.9
63 x 5.8	1.1
90 x 8.2	1.3
125 x 11.4	1.5
160 x 14.6	1.6

- ✓ 2.5.7 an alternative pipe sizing approach based on achieving approximately 250Pa/m pressure drop in each branch may be used, however higher pressure drops can be acceptable on non-critical side branches

- ✓ 2.5.8 if higher velocities than 3m/s are used a specific transient pressure check shall be carried out simulating the effect of valve closure and pump trips and the resultant pump discharge pressures from the energy centre

- ✓ 2.5.9 the thickness of insulation shall be selected when assessing pipe costs, and greater thickness may be required especially for areas of low heat density, for high cost heat sources and for new build schemes.

Note: Steel pipe to EN253 is typically available with three different insulation thicknesses (Series 1, 2 or 3). Some manufacturers of pre-insulated polymer pipes offer pipes with an increased thickness of insulation. See also Objective 3.5 for system heat loss requirements at design stage

Best Practice

Best Practice could include obtaining and reviewing drawings of the existing utilities and other record information in the area covered by the heat network to determine additional barriers e.g. no space underneath certain roads due to congestion of other utilities or opportunities e.g. the use of existing service tunnels, basements etc. This could be supplemented by undertaking ground penetrating radar surveys to map existing services at critical points. More detailed calculations to optimise the pipe sizing to minimise life cycle costs taking account of: construction costs, electricity used for pumping and heat losses may be carried out. This is a requirement at the design stage but could be considered as best practice at a feasibility stage.

Objective 2.6 – To determine building connection costs including heat metering

Why is this objective important?

Building connection costs and heat metering are significant costs and need to be taken into account in the economic evaluation. Either direct (where the heat network water is used within the building) or indirect connections (where a heat exchanger separates the heat network water from the building heating system) may be used.

Minimum Requirements

- ✓ 2.6.1 consideration shall be given to whether direct or indirect connections are required at building level and dwelling level and the type of domestic hot water service provision (see Appendix F)
- ✓ 2.6.2 cost estimates shall reflect the type of connection and the capacity of supply including the provision of redundancy of heat exchangers (e.g. 2 at 60% maximum demand)
- ✓ 2.6.3 the capacity of the building connection shall reflect the peak demand (see Objective 2.1) and whether the network is to supply the peak or only a proportion of the peak (See Objective 2.3), taking care not to oversize the heat exchangers
- ✓ 2.6.4 costs shall be included for the supply to each building to have a heat meter installed in accordance with the Energy Efficiency Directive.
- ✓ 2.6.5 for new dwellings, costs shall be included for each dwelling to have a heat meter installed in accordance with the Energy Efficiency Directive
- ✓ 2.6.6 a separate study shall be undertaken to determine if retrofitting dwelling level heat metering to existing dwellings is cost-effective and desirable and costs included as necessary
- ✓ 2.6.7 for all buildings a suitable method of heat meter reading and billing shall be defined and cost estimates prepared for both capital and operating costs for at least a system of billing at quarterly intervals or less

Best Practice

Best Practice could be to specify an energy display device linked to the heat meter to provide additional information to users in real time, including the amount of heat energy currently being consumed, and over recent periods of time, together with the costs incurred.

Figure 2.2 – Example of an energy display device linked to a heat meter (reproduced courtesy of Vital Energi)

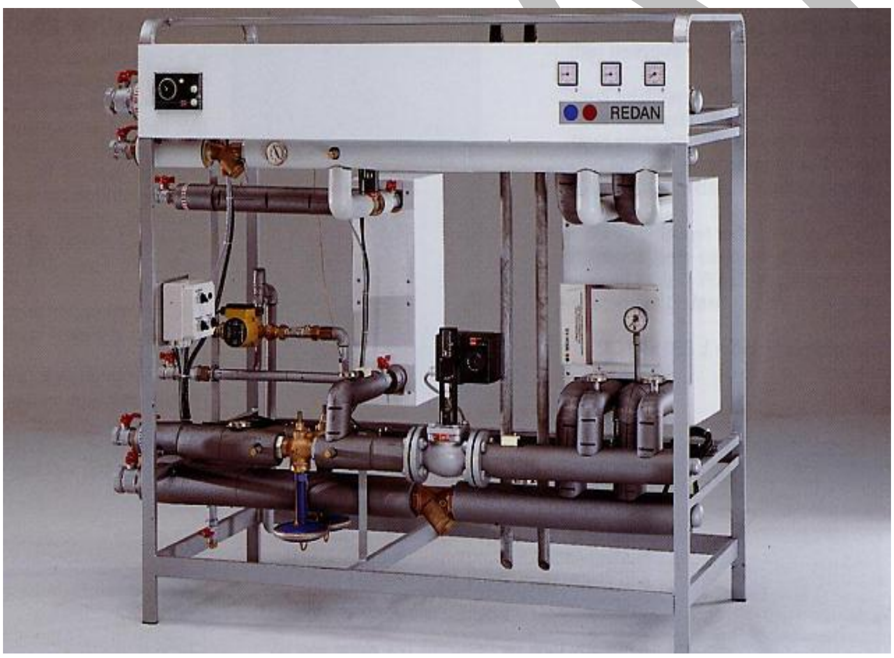


Figure 2.3 – Indirect connection packaged unit for a commercial building

Objective 2.7 – To minimise the negative impacts of phasing of the development

Why is this objective important?

Most large heat networks will be developed in phases whether new build or existing. This raises issues on the need to make provision for future expansion of the scheme and the planned installation capacity of the central plant. Such decisions will need to minimise initial investments whilst maintaining environmental benefits. For new buildings, there will be a period of load build-up that is not just related to the phasing of construction but also the progressive occupancy of the building.

Minimum Requirements

- ✓ 2.7.1 an overall phasing plan shall be produced showing which buildings will be connected, by when, and how the heat demand will build up over time
- ✓ 2.7.2 provision shall be made in pipe sizing to allow for future expansion in later phases - this provision shall be based on realistic expectations to avoid unnecessary over-sizing and additional cost
- ✓ 2.7.3 the primary heat source such as a CHP plant shall be planned to be installed only after the heat demand has built up to a suitable level. For new build schemes, where the planning policy has required a low carbon heat network, early agreement needs to be reached with the planning authority on the timing of the installation of the low carbon heat source (for example when 50% of the site has been developed)
- ✓ 2.7.4 for large schemes, multiple primary heat sources may be required to maintain environmental benefits during the build-up period. However, this should not compromise the long-term operational efficiency significantly
- ✓ 2.7.5 the energy centre location shall be selected taking account of the overall planning constraints of the scheme, the phasing of the network, and, where suitable, consideration shall be given to the use of temporary plant
- ✓ 2.7.6 if there is a cost penalty in the early years and these costs have to be passed on to customers a clear explanation shall be provided justifying the charges

Best Practice

A phased development has the advantage that monitoring and recording of energy usage data in the early phases can be used to inform the design, construction and commissioning of later phases. Best Practice could be to calibrate operational and hydraulic models using this data. Best Practice could also consider opportunities to reduce carbon emissions in future phases of the network, e.g. identifying alternative/additional heat sources, future heat loads etc. Clearly Best Practice could be to design the system to limit the cost penalty in early years (see 2.7.6).
Best Practice could be to set a carbon intensity of heat from the network at all stages and then meet this in design and operation, even when taking into account phasing of the development.

Objective 2.8 – To assess operation and maintenance needs and costs

Why is this objective important?

Operation and maintenance needs to be considered at the feasibility stage so that costs can be included in the economic model. The main costs will be for fuel and electricity and the main revenues will be for heat sold and in the case of CHP, electricity sold. Electricity may be sold to a licensed supplier or sold direct to customers via a ‘private wire’ network.

Estimates also need to be made for non-energy operating costs. It is useful to split these costs into fixed and variable costs.

Minimum Requirements

- ✓ 2.8.1 an operational model shall be set-up for use in the economic analysis which shall calculate the energy balance for the system including network heat losses from which operating costs and revenues can be determined for use in the economic model
- ✓ 2.8.2 maintenance costs shall be estimated for: CHP or other primary plant maintenance, peak boiler maintenance, network maintenance (including the surveillance system, make-up water and water treatment) and building connection maintenance
- ✓ 2.8.3 costs shall be estimated for heat meter reading and billing
- ✓ 2.8.4 costs shall be estimated for staffing, management, business rates, insurances and other overheads
- ✓ 2.8.5 the cost of parasitic electricity consumption for pumping energy, ventilation and burner fans, lighting etc within the Energy Centre shall be included. In the absence of detailed information a figure for such electricity use of **2%** of annual heat supplied to the heat network shall be used
- ✓ 2.8.6 a long term repair/replacement strategy shall be developed to ensure that the true long term costs of maintaining the plant required for the scheme are fully taken into account

Best Practice

Best Practice could be to base costs on data obtained from actual operating schemes where full details of the scheme are available to ensure it is of a similar type to that being proposed.

Objective 2.9 – To conduct a consistent economic analysis and options appraisals

Why is this objective important?

The feasibility stage needs to establish a technically feasible scheme but also produce an economic analysis of the scheme which typically compares a number of options with respect to lifecycle costs of heat supply and rate of return on the investment in a consistent manner.

Minimum Requirements

- ✓ 2.9.1 the scheme shall be analysed using a discounted cashflow model taking account of all costs and revenues, capital and operating, over a defined period of analysis
- ✓ 2.9.2 the analysis shall be conducted in accordance with the Owner/Developer's requirements and agreed in advance – this may or may not accord with the requirements set out below and the Owner/Developer's requirements shall take precedence
- ✓ 2.9.3 the cashflow model shall normally be constructed for a 25 to 30 year period and shall include costs for capital equipment replacements as needed (e.g. CHP plant)
- ✓ 2.9.4 energy prices shall be obtained either from existing customer's contract prices, where available, market indices such as Heren, or for larger schemes using published quarterly prices as published by DECC
- ✓ 2.9.5 revenues from heat sales shall initially be determined by setting these equal to the heating costs that the customer would have incurred over the same period if maintaining the existing equipment in operation
- ✓ 2.9.6 where there are viable retrofit energy efficiency measures these shall be included in the analysis whether for the case of retaining conventional heating or for the heat networks case
- ✓ 2.9.7 the cashflow shall normally be set up in real terms excluding general inflation however the approach shall be agreed in advance with the Client body
- ✓ 2.9.8 the discount rate to be used shall reflect the cost of capital to the investor e.g. for UK public sector investments this is normally set to 3.5%, for other investors alternative figures shall be used and agreed in advance with the Client body
- ✓ 2.9.9 the project real pre-tax Internal Rate of Return (IRR) and the Net Present Value (NPV) of each scheme option shall be determined
- ✓ 2.9.10 the IRR and NPV shall be calculated initially for a base case assuming current energy prices remain constant for the analysis period in real terms

Best Practice

Best Practice could include the creation of a detailed year 1 Profit and Loss (P&L) and balance sheet and a simplified indexed P&L and balance sheet for the duration of the scheme.

Objective 2.10 – To analyse risks and carry out a sensitivity analysis

Why is this objective important?

At a feasibility stage it is important to consider the risks of the project and a sensitivity analysis can assist in quantifying the impact of these risks. This will aid the decision as to whether to take the project to the next stage. A risk register should be produced during the feasibility stage and maintained throughout the project, being reviewed regularly, particularly when a decision is being made to proceed to the next stage.

Minimum Requirements

- ✓ 2.10.1 a risk register shall be developed by means of a risk analysis workshop considering risks in different categories including:

  - Health, safety and environment
  - Construction costs and programme (including impact of phasing of new developments)
  - Performance of plant and equipment
  - Broader economic risks – future energy prices, regulation
  - Planning
  - Customer acceptance, heat sales volume risk, bad debt
  - Reputational risk

- ✓ 2.10.2 the risk analysis shall examine the likelihood and severity of each risk and propose mitigating actions. The likelihood and severity of each risk shall be rescored assuming the proposed mitigation measures are in place

- ✓ 2.10.3 where actions can be taken to mitigate risks these shall be assigned to an individual to take forward

- ✓ 2.10.4 a sensitivity analysis shall be carried out to show the impact of each major risk on the project economics where possible, and to test the mitigation approach including:
  - assessing impacts of construction cost overspend and program overruns
  - varying heat demands both for predictions for new build, and for where existing buildings do not connect or connect later than planned
  - projections of future fuel and electricity prices such as those published by the Interdepartmental Analysts Group (IAG)[3],

  The aim of this analysis is to establish the impacts on the IRR and NPV and the impact on heat prices if the IRR and NPV is held constant.

Best Practice

Best Practice could include carrying out more detailed studies of particular risk mitigation measures so that the project can move into the next stage with a lower risk profile.

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[3] Inter-departmental Analysts Group, HM Treasury

Objective 2.11 – To assess environmental impacts and benefits

Why is this objective important?

As a key purpose of a heat network is to help meet our climate change goals an analysis of the reduction in CO_2 emissions between the current system and the proposed heat network is important. However, there are also negative environmental impacts that need to be considered, in particular NOx and particulate emissions, noise and visual impact. Some understanding of impacts during construction may also be important to consider at feasibility stage. It is assumed that more detailed work would be needed during the Design Stage to support a planning application, see Objective 3.13, however initial discussions with planners will be helpful at this stage.

Minimum Requirements

- ✓ 2.11.1 CO_2 emission calculations shall be based on published emission factors and realistic efficiencies for central plant both for the full build-out and the early years of growth. For new build schemes, emission factors used in Part L of the Building Regulations should be used for consistency with compliance calculations. For existing buildings alternative emission factors may be used where these are more appropriate e.g. those published by Defra or those used in the CRC scheme.

- ✓ 2.11.2 heat losses from the network and electricity used for pumping and other purposes shall be taken into account in the CO_2 emissions calculations

- ✓ 2.11.3 NOx emissions and particulate emissions shall be estimated. A dispersion model to assess ground concentrations would not normally be undertaken at this stage unless these emissions were considered to be a significant factor in the viability of the project

- ✓ 2.11.4 where biofuels or other low carbon fuels are used there shall be an assessment of wider environmental impacts such as their sustainability credentials of production, processing and transport requirements

- ✓ 2.11.5 normally an acoustic survey is not undertaken at this stage however the selection of a site for the Energy Centre shall take account of the potential for noise impacts and seek to minimise these by appropriate choices

- ✓ 2.11.6 the choice of a suitable site for the Energy Centre shall take into account visual impact issues. At this stage, visual impact will be quantified by considering the plan area and height of the Energy Centre and stack.

- ✓ 2.11.7 pre-application discussions shall be held with the local Planning Authority to establish the key policies and issues which will enable a planning application strategy to be developed for the next stage of the work

Best Practice
Best Practice could be to calculate the life time CO_2 savings taking account of changes to the electricity and gas systems over time and the likely plant replacement options.

Objective 2.12 – To develop preferred business structures, contract strategy and procurement strategy

Why is this objective important?

Although a feasibility stage report may have been commissioned solely to consider the technical aspects it is normal at this stage to also begin to develop an implementation strategy and to consider issues of ownership, control, contracts and procurement. A separate Business Case may be produced at this stage or at a later date during the design stage.

Minimum Requirements

✓ 2.12.1 a range of options shall be considered for the construction, ownership, and operation of each business aspect of the scheme:

- Heat generation
- Heat distribution
- Heat supply

Typically this will involve discussions on the roles of the public sector, the private sector or a special purpose vehicle with joint public and private shares; some of the more common options are illustrated in the matrix below:

OPTION	Energy Centre		Heat Network		Heat Supply
	Own	Operate	Own	Operate	
A	PSC	PSC	PSC	PSC	PSC
B1	LA	LA	LA	LA	LA
B2	LA	PSC	LA	PSC	LA
C	SPV	SPV	SPV	SPV	SPV
D1	PSC	PSC	LA	LA	PSC
D2	PSC	PSC	LA	LA	LA
E1	LA	LA	PSC	PSC	PSC
E2	LA	LA	PSC	PSC	LA
F	COC	COC	COC	COC	COC

LA = Local Authority
PSC = private sector company
SPV = public-private special purpose vehicle
COC = community owned company

✓ 2.12.2 The assessment of the preferred business vehicle shall take account of the following key aspects:

- Finance – how is the investment capital to be raised for the project?
- Risk – how should the high level risks be allocated?
- Governance – where does overall control of the development of the scheme best lie?
- Exit strategy at the end of any contractual period (see 2.12.5 below)

- ✓ 2.12.2 when the overall business strategy has been defined then the contracts required to be put in place shall be described in terms of who the contracting parties are in each case and a diagram showing the proposed organisation/contractual structure being proposed
- ✓ 2.12.3 the contracts required for fuel and electricity purchase and electricity sale shall be defined
- ✓ 2.12.4 the procurement strategy shall be developed following on from the contract strategy
- ✓ 2.12.5 consideration shall be given as to the position at the end of any long-term contract for operation, including the condition of the plant at terminations and the period allowed during which the operation of the scheme can be re-tendered

Best Practice

Best Practice could include consideration of the potential for scheme extensions and new connections and could include a list of the main stakeholders to be contacted in the future. This may include owners of individual properties as well as building owners such as social landlords.

Set of questions (please write your answer in the response form):

Q 14. Do you know of other factors that could be considered to identify the most suitable low carbon heat energy sources and location of an Energy Centre under the Objective 2.2?

Q 15. Do you have any suggestion on a framework that could be developed to facilitate the production of a phasing plan for new buildings between the building developer and the heat network developer under the Objective 2.7?

Q 16. Is the Code of Practice making sufficient distinction between new networks and extensions with regard to the phasing of development under the Objective 2.7?

Q 17. Do you agree with the principles and hypothesis underpinning the economic analysis and options appraisals at the feasibility stage under the Objective 2.9? Please give reasons for your answer, including any alternative suggestion for an acceptable economic analysis.

Q 18. Is the principle that the CO2 emission calculation shall take into account heat losses from the network and electricity used for pumping and other purpose an appropriate guiding principle to ensure that new heat networks will have lower carbon emissions under the Objective 2.11?

Q 19. Are there any requirements in the Feasibility Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

3. Design

Objectives:

3.1 To design for safety in construction, operation and maintenance

3.2 To achieve sufficient accuracy of peak heat demands and annual heat consumptions

3.3 To select suitable building interfaces, direct or indirect connections

3.4 To design or modify suitable space heating and domestic hot water services systems

3.5 To achieve an energy-efficient heat network

3.6 To achieve a low cost network – optimisation of routes and pipe sizing for minimum life cycle cost

3.7 To achieve a reliable network with a long life and low maintenance requirements

3.8 To select heat metering, prepayment and billing systems that are accurate and cost-effective

3.9 To achieve an efficient heat distribution system within a multi-residential building, and to reduce the risk of overheating

3.10 To design a cost-effective and efficient central plant

3.11 To optimise the use of thermal storage

3.12– To update and refine the economic analysis, risk analysis and sensitivities

3.13 To assess environmental impacts and benefits

Objective 3.1 – To design for safety in construction, operation and maintenance and to achieve quality of design

Why is this objective important?

Reducing health and safety risks is of primary importance in any project. The designer has a key role to carry out a designer’s risk assessment and then to mitigate these risks by taking appropriate design decisions. The designer needs to consider how the design will be constructed and operated. The health and safety of the general public during construction must be considered particularly as heat networks are often installed through publicly accessible areas.

There is a need to set general standards for the design work and for this to follow recognised standards.

Minimum Requirements - Safety

- ✓ 3.1.1 the Client body shall recognise their role and obligations under the CDM Regulations and register the project as one governed by the CDM Regulations prior to the start of the design process
- ✓ 3.1.2 the Designer shall diligently carry out the requirements under the CDM Regulations carrying out a Designer’s Risk Assessment at an early stage of the design
- ✓ 3.1.3 the Designer shall mitigate risks in construction, operation, maintenance and decommissioning as far as possible and provide a risk register containing the residual risks for use in the construction stage
- ✓ 3.1.4 the design shall provide sufficient access around plant and equipment in the Energy Centre to enable safe maintenance to be carried out including access/egress and handling of equipment/parts associated with any repair/replacement works
- ✓ 3.1.5 the design shall locate valve chambers and other facilities across the heat network requiring access (including surveillance system monitoring terminals) in a suitable location so that safe operation and maintenance can be carried out
- ✓ 3.1.6 adequate access and other provisions shall be made to enable safe replacement of plant in the future. A plant replacement strategy report shall be produced during the design stage
- ✓ 3.1.7 trench depths shall be minimised as far as possible to reduce the risks to trench operatives, provided these are in accordance with the network pipe manufacturer’s guidance, EN standards and that the network design is not compromised.
- ✓ 3.1.8 consideration shall be given when selecting suitable operating temperatures to safety risks for both Heat Network operators and customers.
- ✓ 3.1.9 an assessment of residential customers shall be carried out to establish if low surface temperature radiators and temperature control of hot water outlets is required even when not a regulatory requirement

- ✓ 3.1.10 a fire risk assessment shall be carried out to determine if non-combustible insulation or metallic casing is to be specified anywhere on the network

- ✓ 3.1.11 the requirements of the COSHH and DSEAR Regulations shall be taken into account in developing the design

Minimum Requirements – Quality

- ✓ 3.1.12 The appointed designer shall be certified under ISO 9001: 2008 Quality Management System

- ✓ 3.1.13 The design shall be developed so that the Heat Network Operator can achieve ISO 14001 and ISO 18001 certification

Objective 3.2 – To achieve sufficient accuracy of peak heat demands and annual heat consumptions

Why is this objective important?

At the design stage the values used for peak heat demand will determine the capacity of the heat network, the capacity of the building connections, the capacity of the peak boilers and this will therefore determine much of the capital cost. The annual heat consumption and daily demand profiles will determine the capacity of the primary heat source such as a CHP plant and the capacity of the thermal store, also important elements of the capital cost. The annual heat consumption will determine the heat revenues that could be received to finance the project.

For new buildings the heat demand estimates should be produced by the appointed building services designer although the Heat Network designer may have valuable advice to offer based on previous experience. It is vital that a consensus is reached at this stage to avoid the potential for significantly oversizing or undersizing the network.

For existing non-domestic buildings it will normally be the responsibility of the customer to define the peak heat demand that they wish to contract for and to provide an estimate of their annual heat energy consumption, however this analysis should be with the close involvement of the Heat Network designer/operator who may be able to draw on experience of supplying similar buildings.

For existing residential buildings, the Heat Network company will need to estimate peak and annual demands based on modelling or experience from supplying buildings of similar size and type, or where block boilers are used from fuel consumption data.

In both new build and retrofit schemes there are significant uncertainties in how the heat demands may develop over time and there will be a need to make a judgement regarding the potential for expansion. In practice some oversizing is not a major economic penalty as the pumping energy will be lower. Similarly, within the pressure constraints of the system, it will be possible to supply more heat than the original design through the same network by increasing pump pressures and operating energy. This means that most networks if conservatively designed will have considerable flexibility in the heat demands that can be economically supplied.

Diversity of Demand

With large heating systems it is important to consider the impact of diversity in demand. The diversity factor at any point in the network can be defined as:

$$\frac{\text{Peak demand that occurs at this point in the heat network (kW)}}{\text{The sum of the peak demands at each customer supply point downstream (kW)}}$$

The design peak demand at each customer is normally the maximum demand that the heat network can supply which is set at commissioning by limiting the maximum flow rate. This may be higher than the actual heat demand of the building experienced as design margins are often built-in.

On very large systems with a wide mix of customers the overall diversity factor (space and hot water heating) at the heat supply point can be significant e.g. up to 70% which would enable pipe sizes near to the supply point and peak boiler capacities to be reduced accordingly. However on smaller systems with a single type of customer it would be prudent to assume a 100% diversity factor.

A **special case** is the use of instantaneous hot water heat exchangers which may have peak demands of 35kW to 50kW per dwelling. The probability of all hot water outlets being in use at any one time is very remote and so the diversity factor is significant close to the demand points. The diversity factor to be applied to these systems is critical to avoid oversizing of local pipework. From experience a diversity factor curve to be applied at each point in the network depending on the number of demand points as given in the Danish standard DS 439:2009 is recommended although other curves are available (see Figure 3.2).

Data is currently being collected on diversity factors seen in practice on UK schemes for both space heating demand and domestic hot water demand for use in future revisions of the Code.

In some circumstances there may be very little diversity even for domestic hot water, e.g. for buildings such as student accommodation blocks where use patterns may be more coincident.

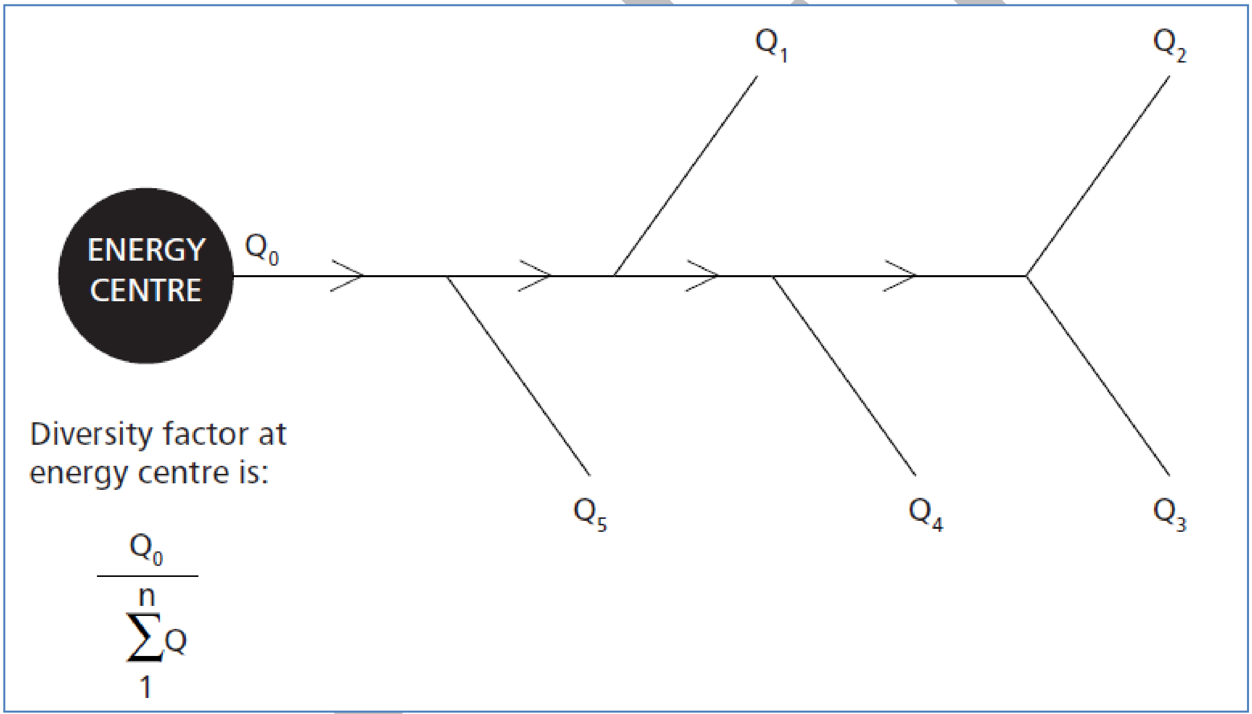

Figure 3.1 – Diagram to show definition of diversity factor

Minimum Requirements

- ✓ 3.2.1 peak demands for existing buildings shall be assessed by the customer from a combination of data on fuel use (accounting for system efficiency), existing boiler use, and building simulation modelling or other calculation of heat losses as appropriate; this assessment should be supported by the Heat Network designer who may be able to use data from monitoring demands at similar buildings to assist

- ✓ 3.2.2 for existing non-domestic buildings, space heating consumptions in each month shall be estimated by the customer, in conjunction with the Heat Network designer, from fuel or heat meter readings together with a degree day analysis to produce heat consumptions for each month for an average year taking account of the location of the building, the required internal space temperature and an appropriate baseline temperature for the building.

- ✓ 3.2.3 for existing dwellings, calculations shall be carried out by the building Owner/Developer (e.g. local authority or housing association) using established calculation methodologies and these calculations shall be agreed with the Heat Network designer. For private dwellings the Heat Network designer shall carry out the calculations. Sample dwelling types shall be used where necessary to determine peak heat demands and annual consumptions for space heating and hot water and then extrapolated for the whole area/load

- ✓ 3.2.4 for new non-domestic buildings heat demands shall be estimated using modelling software and by using the guidance in CIBSE Guide F and TM46, other sources of benchmark data or data obtained from similar operational schemes

- ✓ 3.2.5 for new dwellings, heat demands shall be estimated using standard design calculation methodologies based on the proposed fabric standards

- ✓ 3.2.6 for dwellings, the space heating consumption shall be profiled using degree days to obtain monthly consumptions and a 24 hour variation in demand created for heating and hot water demand

- ✓ 3.2.7 the peak demands for the **domestic hot water service only** and where instantaneous hot water heat exchangers are used shall be diversified using one of the diversity curves in Figure 3.2 with the exception of the BS6700[4] curve which can be seen to be more conservative than other sources for larger schemes.

The widely used diversity curve from the Danish standard DS439 is derived from the following equation in DS439:

$P_{max} = 1.19 * N + 18.8 * N^{0.5} + 17.6$ (kW)

Where:

P_{max} is the total heat rate required for DHW production for the group of dwellings

N is the number of dwellings

From this equation by putting N=1 it can be seen that the heat rate for a single dwelling has been taken as 37.5kW which is typical, however the diversity factors will be similar if larger DHW heat exchangers are used. For 1000 dwellings the diversified heat demand reduces to 1.8kW per dwelling

Alternatively where the designer has access to measured demand data from sites of a similar type a diversity factor derived from such measurements may be used.

[4] BS 6700 has now been replaced by BS 8558

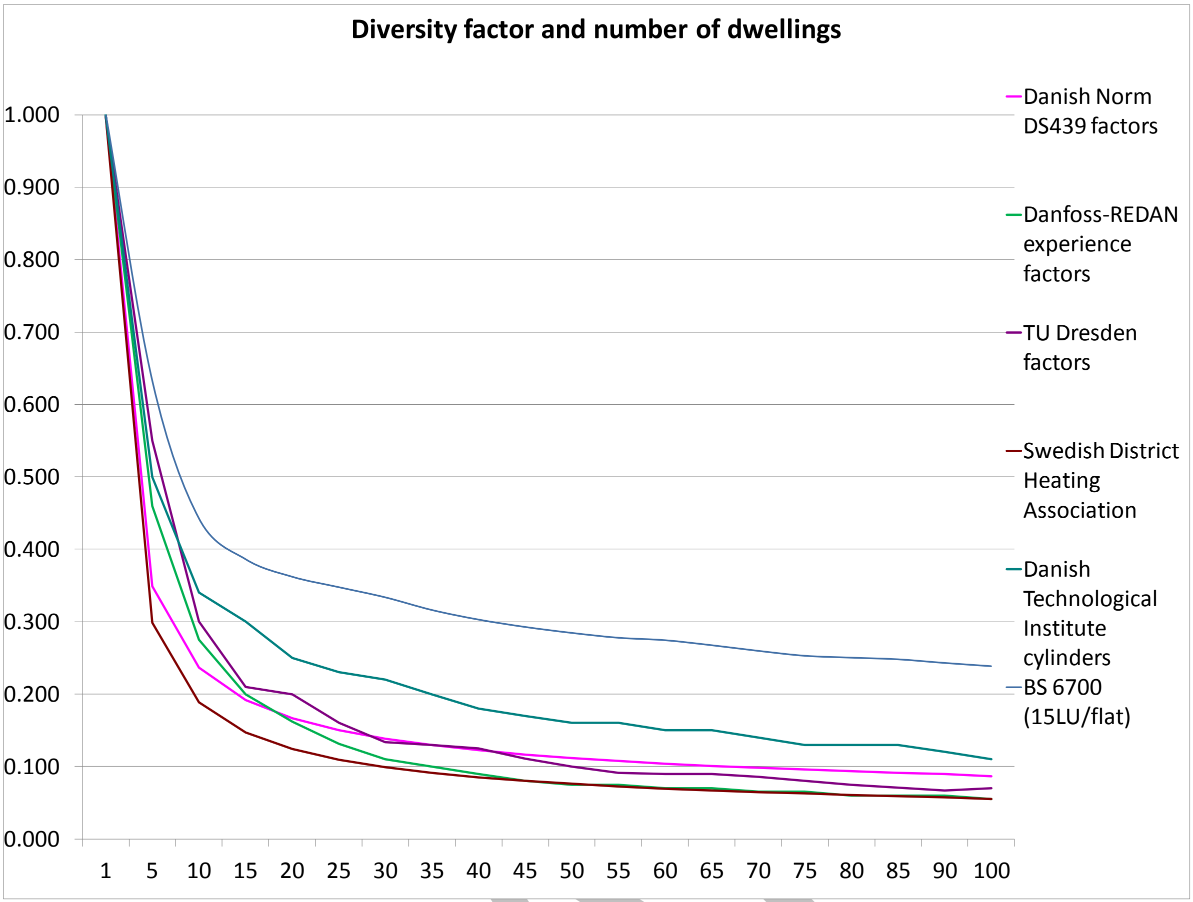

Figure 3.2 – Diversity factors for instantaneous domestic hot water systems for dwellings (with acknowledgement to SAV Ltd)

> Note: For new residential buildings with more than 200 average size dwellings, diversified demand has been typically found to be less than 3kW per dwelling for space heating and 2kW per dwelling for DHWS heating. If calculations indicate otherwise then a further review should be carried out to check on the assumptions used.

Best Practice

If time permits and it is appropriate, peak demands should be determined by monitoring the heat currently supplied to the building or its fuel use, under external design conditions using existing or temporary meters and recording data at hourly or half-hourly intervals. It is now more common to find half-hourly gas meters and if available this data should be used to help produce a heat profile for a typical year for use in the operating model and to determine peak demands.

A full year's data would be very valuable and needs to include monitoring of external air temperature so the data can be normalised. The installation of new meters or setting up logging of data using a BEMS should be considered at an early stage in the project.

Objective 3.3 – To select suitable building interfaces, direct or indirect connections

Why is this objective important?

A fundamental design choice is whether the buildings or dwellings are directly connected to the heat network (where the water in the network flows directly through the heating circuits of the building) or indirectly where a heat exchanger is used to provide a physical barrier to the water. The choice has an impact on cost and operating temperatures and pressures. Both types have been used in UK schemes with indirect connections more prevalent. Direct connection can also use a mixing control valve such that the secondary flow temperature can be set lower than the primary flow temperature and can be varied with outside air temperature.

Indirect connection has the following benefits:

- Any leaks within the building are limited as there is a hydraulically separate system of limited volume
- The building's heating systems are not subject to the higher Heat Network pressures so radiators, valves etc do not need to have high pressure ratings and the Heat Network pressures do not need to be constrained
- Building and network water is kept separate so there is less scope for contractual disputes over contamination or loss of system water if these systems are in different ownership

Direct connection has the following benefits:

- Lower cost than indirect as it is a simpler system
- Less complex, fewer components, so lower maintenance cost and fewer points of failure
- No need for secondary pumping energy
- No increase in primary return temperatures across a heat exchanger
- More compact – less plantroom space needed
- No risk to supply from fouling of heat exchanger

Minimum Requirements

✓ 3.3.1 a study shall be carried out to assess the costs and benefits of direct and indirect connections at a building level and at an individual dwelling level; this study may be project specific or generic where a number of projects are being developed to a standardised design to keep costs down

✓ 3.3.2 where indirect connection is used the heat exchanger shall be sized with an approach temperature (primary return temperature – secondary return temperature) of less than 5°C

✓ 3.3.3 where boilers are being retained within the building for use at times of high demand the connection design shall ensure that the heat network heat supply is prioritised and the boilers used only when required to supplement this. This may be achieved by connecting the heat network supply either in series with the boilers i.e. into the return circuit or in parallel. The parallel connection requires the flow into the boilers to be controlled so that the supply from the heat network is maximised.

- ✓ 3.3.4 for either direct or indirect systems large bodied strainers with fine mesh shall be specified to reduce the risk of dirt accumulating on valves and heat exchangers

- ✓ 3.3.5 for either direct or indirect systems control valves shall be two-port so that a variable volume control principle is established

- ✓ 3.3.6 the design of plantrooms for the Heat Network interface substations shall provide sufficient space for maintenance access and for future replacement of equipment. It shall provide suitable power supplies including or use when carrying out maintenance, lighting, ventilation, water supply and drainage facilities

Best Practice

The responsibility of the Heat Network operator should include the heat distribution system within a block of flats wherever possible. Whenever there is a hydraulic break in a system there will be an increase in return temperature which will increase heat losses and reduce the temperature difference on the primary network leading to higher costs (for a fixed flow temperature). Where apartment blocks are connected it could be considered to be Best Practice to have either an indirect connection at the dwelling or at the entry to the building but not both. However, where there are high tower blocks, static pressures need to be considered and a further hydraulic break may be needed.

Best practice, especially for new build residential schemes could be to design the connections so that the HIU is accessible from outside the dwelling to enable maintenance to be carried out although all user controls and meter displays shall be internal to the dwelling.

Where indirect connection is used Best Practice could include sizing the heat exchanger with an approach temperature (primary return temperature – secondary return temperature) of less than 3°C.

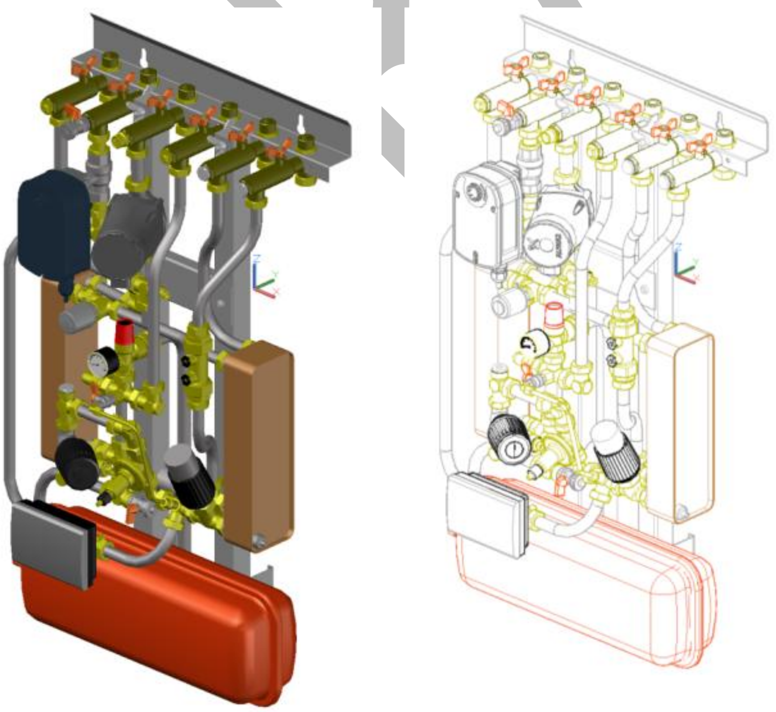

Figure 3.3 – Typical dwelling hydraulic interface unit - indirect with instantaneous domestic hot water heat exchanger (reproduced courtesy of Vital Energi)

Objective 3.4 – To design or modify suitable space heating and domestic hot water services (DHWS) systems

Why is this objective important?

Where a new building is planned to be connected to a heat network or where major refurbishment is being carried out the designer has a number of design choices available for the heating and domestic hot water services (DHWS). How these services are designed can have a significant impact on the capital costs and operating costs of the heat network. For example achieving consistently low return temperatures will reduce capital costs for the network and thermal store, result in lower heat losses and pumping energy and in some cases reduce the cost of low carbon heat production.

It is emphasised that the most important design decision that impacts the Heat Network – the design return temperature for the heating systems – is not in the control of the Heat Network Designer. Hence the building developer/Owner/Developer and their building services designers have an important responsibility to ensure that the design return temperature is optimised for the system as a whole. However the Heat Network Designer needs to take a pro-active role in engaging with the developer or Owner/Developer of the buildings to explain the importance for the Heat Network of maintaining low return temperatures and will specify the maximum return temperature acceptable.

For retrofit situations it may be more acceptable to the customer to make minimal changes to the existing system – for example, in dwellings, retaining a hot water cylinder if one exists or installing instantaneous hot water if a combi-boiler is currently used. However the impact on the heat network of these decisions still needs to be assessed.

Appendix F provides guidance and descriptions of the various options available for space heating and DHWS heating in relation to supply from Heat Networks.

Minimum Requirements

- ✓ 3.4.1 a specific design study shall assess the heat losses of the building, the output of the existing heat emitters and select heating circuit operating temperatures for peak design conditions. These should reduce the return temperature as far as practical and propose how the new operating temperatures will be achieved through re-balancing or other changes
- ✓ 3.4.2 the study shall also consider how the system operates at part-load and how low return temperatures can be achieved under part-load conditions including modification of the control system. This study shall be developed with the Heat Network Operator or designer
- ✓ 3.4.3 a specific design study shall review the options for domestic hot water services and assess the costs and benefits for the building concerned. This study shall be developed with the Heat Network Operator or designer
- ✓ 3.4.4 for new building services systems (in existing or new buildings), temperatures for the heating and hot water service circuits shall be optimised but shall comply with the limits given in Table 3.1 below

Table 3.1 - Preferred operating temperatures for new building services systems

Circuit	Flow temperature	Return temperature
	°C	°C
Radiators	max 70	max 40
Fan-coil Units	max 60	max 40
Air Handling Unit	max 70	max 40
Underfloor heating	See Note	See Note
Domestic DHWS instantaneous heat exchanger on load	min 65	max 25
Domestic DHWS cylinder with coil heat up from cold	min 70	max 45
DHWS calorifier with external plate heat exchanger	min 70	max 25

Note: underfloor heating systems will typically operate with floor temperatures below 35°C and typically flow temperatures of 45°C which is advantageous for heat networks as this will result in low return temperatures

- ✓ 3.4.5 coils within dwelling cylinders shall be oversized to deliver lower return temperatures on heating from cold or use an external plate heat exchanger as for 3.4.6

- ✓ 3.4.6 centralised DHWS storage heating shall use an external plate heat exchanger (controlled with a two-port valve) and not a coil within the storage vessel, in order to provide lower return temperatures

- ✓ 3.4.7 where there is a risk of scaling of heat exchangers from hard water consideration shall be given to the use of a centralised softening plant or other form of scale prevention

- ✓ 3.4.8 flow temperatures for the space heating circuit shall be selected so that flow rates to individual radiators or fan-coil units (FCUs) can be set-up accurately to achieve the design return temperature. For new dwellings, with low space heating demands, flow temperatures of 50°C to 60°C are likely to be needed with a return temperature of 40°C otherwise the flow rate may be too low

- ✓ 3.4.9 for new heating systems, the radiator pipework shall be sized to provide a sufficiently rapid response of the radiator circuit and micro-bore pipework shall be considered for low flow rate systems

- ✓ 3.4.10 the secondary pump (if indirect connection) or differential pressure control valve (if direct connection) shall be selected to provide a low pressure difference, approximately 0.25bar, across the radiator circuit to assist in setting the correct flow rates to each radiator. Variable speed pumps shall be considered.

- ✓ 3.4.11 pre-settable thermostatic radiator valves designed for low flow rates shall be used. These valves are designed with integral adjustable apertures enabling a flow rate to be set for a given pressure difference. As these openings are very small, a fine mesh strainer shall be incorporated in the circuit - particularly important for direct connection systems

- ✓ 3.4.12 room temperature control shall be provided by thermostatic radiator valves, fitted to all radiators in the circuit, which will reduce volume flow rates and hence return temperatures under part-load

- ✓ 3.4.13 all cold water service and potable water pipework shall be insulated in accordance with the Building Regulations to avoid heat gain from adjacent heating service and minimise legionella risk and where possible installed in separate risers to the heating distribution

- ✓ 3.4.14 pipework, heat exchangers and other components within a hydraulic interface unit (HIU) shall be insulated to reduce heat losses and unwanted heat gains

- ✓ 3.4.15 where an HIU is installed in a cupboard consideration shall be given to providing high and low level ventilation openings if any equipment is affected by high ambient temperatures

- ✓ 3.4.16 the location of the HIU within a dwellings shall be such that it can be removed and replaced without major disruption and changes to walls, fixtures or fittings

Best Practice

Best Practice could include the use of heating systems with return temperatures below 40°C. The lowest return temperatures are usually obtained from radiators which are connected as ‘top entry and opposite bottom exit’.

Where centralised DHWS are used Best Practice could be to use a two-stage heating system where the return from the space heating circuit is used to pre-heat the cold feed to the DHWS. This usually results in a lower return temperature on the DH circuit.

The use of variable speed pumps for the dwelling radiator circuit is recommended as Best Practice to reduce electricity use and the need for high bypass flows.

The use of wall mounted thermostats for use with radiator valves could be considered to measure the air temperature in the room, not adjacent to the radiator.

In commercial buildings, TRVs where used could be specified to be limited to a suitable maximum design temperature (e.g. 22°C). Appropriate tamper proof fittings would be provided to prevent adjustment other than by the facilities management staff.

Objective 3.5 – To achieve an energy-efficient heat network

Why is this objective important?

The energy efficiency of the heat network will influence the environmental benefits and the operating costs and hence the overall economic case for the network. As with most energy systems there is an economic balance to be made between energy efficiency and capital cost. The requirements set out below have been found to be appropriate in most cases but the designer should carry out an economic appraisal to determine an optimal design.

The energy inputs required to operate a heat network are:

- Heat energy input to compensate for heat losses on the network less the heat gained from friction loss
- Electrical energy input for pumping needed to overcome friction within the network

Even though most of the electrical energy is recovered as heat it will have a higher cost and CO_2 content than the heat energy which is typically supplied from a low cost and low carbon source.

The selection of operating temperatures for peak design conditions and how they vary with demand requires an optimisation study for any given scheme as it will be impacted by the type of heat supply plant and the characteristics of the heat network. The designer has also to consider constraints such as the temperatures used for existing heating systems and the degree that these can be varied. Hence the Requirements given below may not be valid in all cases and may be over-ruled by the conclusions of a detailed study for an individual scheme.

Minimum Requirements

- ✓ 3.5.1 the design shall seek to minimise the total length of the network

- ✓ 3.5.2 the type and thickness of insulation shall be selected to minimise lifecycle costs i.e. balancing additional capital cost with the value of the heat energy saved, and shall take account of degradation of the insulation over time

- ✓ 3.5.3 the total network heat loss shall be calculated for the heat network between the Energy Centre supply point(s) and the point of connection to each building, taking realistic weighted average flow and return temperatures

- ✓ 3.5.4 the calculated total annual heat loss from the network up to the point of connection to each building when fully built out shall not exceed **15%** of the sum of the estimated annual heat consumption of all of the buildings connected

- ✓ 3.5.5 a specific study shall be carried out to determine optimum operating temperatures for the scheme to minimise life cycle costs, taking account of: heat losses, pumping energy, the cost of the heat network, the cost of the building services and the cost of heat production

- ✓ 3.5.6 unless the study in 3.5.5 shows otherwise, the design flow temperature on the heat network i.e. under peak demand conditions, shall be less than 95°C

- ✓ 3.5.7 the study shall consider whether reducing flow temperatures under part-load conditions will be advantageous, generally this will be the case as heat losses will reduce even though pumping energy will increase

- ✓ 3.5.8 the network return temperature at peak demand conditions shall be set as low as possible taking account of the constraints and where feasible shall be less than 70°C for supplies to existing buildings and less than 50°C for supplies to new buildings

- ✓ 3.5.9 existing building heating systems shall be investigated and agreement reached with the building owner to modify operating temperatures where possible to achieve secondary return temperatures less than 60°C, which can typically be realised as there will usually be some oversizing of the secondary heating system

- ✓ 3.5.10 the control system at each building connection whether using direct or indirect connections shall only use a variable volume principle and two-port control valves

- ✓ 3.5.11 variable speed pumps shall be used and controlled to maintain a minimum pressure difference at the extremities of the network

- ✓ 3.5.12 multiple pumps shall be selected to match the network's requirements at part-load e.g. a summer pump with lower flow rate and lower head could be included

- ✓ 3.5.13 where bypasses are required to maintain flow temperatures above a minimum level at times of low demand, temperature controlled bypass valves are preferred. Where fixed bypasses are used, the flow rate shall be limited by means of a differential pressure control valve and regulating valve to no more than 1% of peak demand flow at all times, unless a detailed calculation shows that a higher rate will be required. In residential schemes the standby flow rate through instantaneous hot water heat exchangers will normally be sufficient to maintain the flow temperatures without the need for other bypasses (see also 3.9.4).

Best Practice

For Best Practice the calculated total annual heat loss from the network up to the point of connection to each building when fully built out should not exceed **10%** of the sum of the estimated annual heat consumption of all of the buildings connected. Best Practice would be to achieve return temperatures below 55°C for a scheme supplying only existing buildings and below 40°C for a scheme supplying only new buildings.

District Cooling systems also need to consider pump selection carefully as there may be a wider variation in demand than for heating. Variable speed pumps are important as the volume of water to be pumped is greater and any temperature gain through the pump is a disadvantage not a benefit.

Objective 3.6 – To achieve a low cost network – optimisation of routes and pipe sizing for minimum life cycle cost

Why is this objective important?

The cost of heat networks is a major barrier to their implementation and the designer needs to take every opportunity to minimise cost. Costs should be minimised over the life of the asset using discounted cashflow analysis to produce designs with minimum Net Present Cost but with due regard for opportunities for future proofing. The type of pipe system and the construction techniques used also have an impact on costs. For example, the use of polymer pipes can reduce installation costs as no compensation is necessary and the flexibility assists in circumventing other services. Special installation methods can also be used e.g. the pull-through technique or horizontal directional drilling.

Minimum Requirements

- ✓ 3.6.1 the design shall be developed to minimise the overall length of the network and hence reduce costs and heat losses
- ✓ 3.6.2 pipe sizing shall be carried out to minimise the life cycle cost taking account of capital cost, pumping energy cost and heat loss cost (see Figure 3.4)
- ✓ 3.6.3 routes shall be selected where appropriate to avoid major roads and to utilise ‘soft dig’ areas, subject to consultation with local residents as such areas may have high amenity value
- ✓ 3.6.4 above ground routes e.g. in underground car parks and other service areas within connected buildings shall be examined as this can lead to major cost savings although expansion provision needs to be considered, there may be higher heat losses and greater risk of accidental damage
- ✓ 3.6.5 drawings of all existing buried services shall be obtained to assist in selecting a suitable route
- ✓ 3.6.6 surveys of all surface equipments, manholes etc along the route together with ground surveys using ground penetrating radar shall also be carried out together with trial holes at critical points where necessary to establish a viable route
- ✓ 3.6.7 the designer shall assess the range of pipe materials and systems available and select the optimum system for each section of the network, taking account of capital cost, operating cost including heat losses and lifetime, for the operating temperatures and pressures selected
- ✓ 3.6.8 the location of the Energy Centre shall be considered at an early stage in the design as its location can have a major influence on the costs of the network.

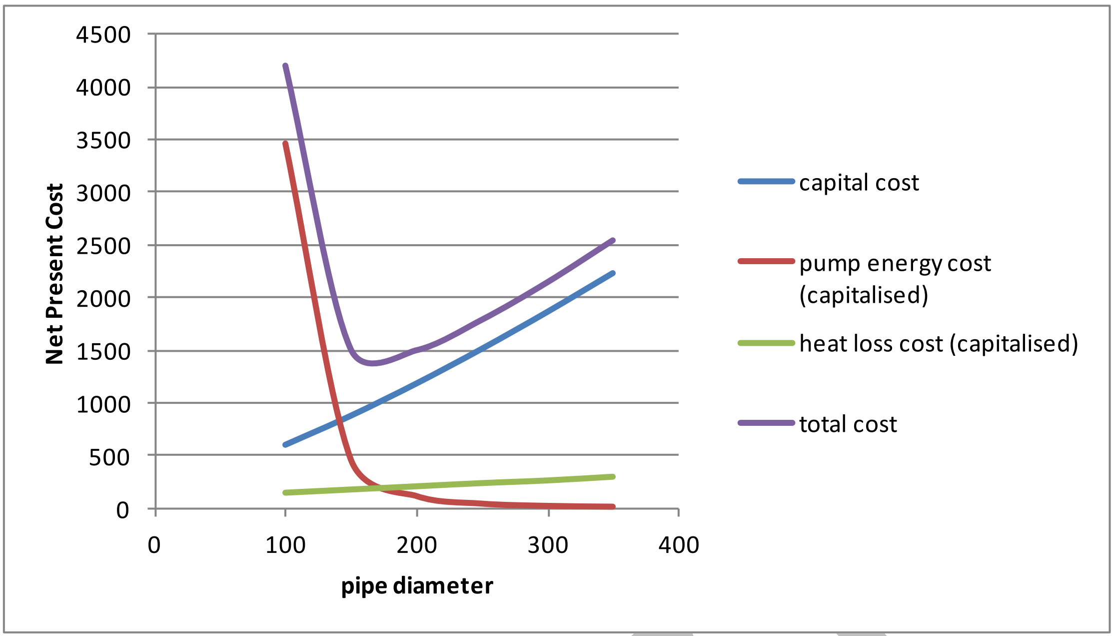

Figure 3.4 – Typical optimisation of pipe sizes on life cycle cost basis (reproduced courtesy of AECOM)

Best Practice

Best Practice could involve the use of industry standard Heat Network analysis software, e.g. Termis or equivalent, to improve the optimisation process.

District Cooling systems may use steel pre-insulated pipework as it provides a good vapour seal preventing condensation on the steel carrier pipe. As the flow temperature is close to the ground temperature the heat losses are relatively small especially for larger diameter pipes and so some schemes have used conventional un-insulated polyethylene pipes, normally used for potable water applications, with a significant saving in capital cost.

Objective 3.7 – To achieve a reliable network with a long life and low maintenance requirements

Why is this objective important?

A heat network is a high capital cost asset and usually needs a long period to provide a sufficient return on investment. It is therefore essential that the network is designed for a long life and low maintenance requirements. In addition, reliability is very important if customer satisfaction is to be obtained.

There is a range of pipe materials available in addition to the pre-insulated steel systems produced to EN253. Polymer materials and glass-reinforced epoxy may offer advantages with respect to cost and performance and should be considered. Similarly twin pipe systems can offer advantages including lower heat losses and lower trenching costs. In some cases a mix of systems may be the most suitable approach.

Achieving a high quality installation is also critical (see Objective 4.2).

Minimum Requirements

- ✓ 3.7.1 the full range of pipe systems and materials shall be assessed for suitability for use in each part of the network and appropriate selections made taking account of cost and performance; this requirement may be satisfied by a generic study of the options available where a standardised design has been developed to reduce costs

- ✓ 3.7.2 routes for the heat network shall provide a minimum separation distance of 0.6m from adjacent services to reduce the risk of third party damage to either the heat mains or other utilities

- ✓ 3.7.3 if a steel carrier pipe is used for the buried sections, the designer shall specify pre-insulated pipe systems that comply with EN253 and associated EN standards (see Appendix C) and the design shall be developed in accordance with EN13941

- ✓ 3.7.4 the joint closure system whether using heat activated mastic lined shrink sleeves or fusion welded joint casings shall allow for an air test to be carried out to prove that the joint is sealed against ground water ingress

- ✓ 3.7.5 where shrink sleeve type joints are used there shall be an additional protection seal at each end of the joint (dual sealing)

- ✓ 3.7.6 where pipe systems other than steel are to be used the designer shall verify that a minimum 30 year life is predicted for the operating temperatures and pressures that are expected

- ✓ 3.7.7 diffusion barriers shall be installed around the outside of the insulation and in the case of polymer pipes also on the outside of the carrier pipe

- ✓ 3.7.8 pre-insulated isolating valves shall be used for isolating sections of the buried network and shall be directly buried with access to the valve spindle provided by using self-draining enclosures and not a conventional valve chamber

- ✓ 3.7.9 the pre-insulated pipe shall terminate above ground or inside the building and an end cap fitted to the insulation to prevent water ingress, especially during construction
- ✓ 3.7.10 isolating valves shall be located at each branch to a customer or group of customers and immediately adjacent to the main run so that a fault in a local circuit can be isolated and the remainder of the scheme remain in operation.
- ✓ 3.7.11 the design shall consider the need for further in-line isolating valves, the provision of looped networks, the location of standby boilers and the provision for connecting temporary boilers when developing the overall strategy for maintaining supplies in the event of a leak at any point in the network, taking account of the probability of failure, the likely impact and cost of improving resilience
- ✓ 3.7.12 isolating valves in secondary circuits within buildings shall be located where there will be good access available from public spaces
- ✓ 3.7.13 isolating valves for residents emergency use shall be located within the property immediately after the service enters the property (or just outside) so that these can be easily shut-off by the resident in the event of a leak within the property
- ✓ 3.7.14 a surveillance system in accordance with EN 14419 shall be specified for steel pipe systems
- ✓ 3.7.15 stress analysis of steel pipe systems shall be carried out by a specialist in accordance with the requirements of EN13941
- ✓ 3.7.16 pipe expansion of buried sections shall be permitted through the use of bends and loops or the use of pre-stressing techniques. The use of expansion bellows shall be avoided on buried sections. Expansion of above ground sections shall be permitted through the use of bends and loops.
- ✓ 3.7.17 the steel pipe system shall be installed at the minimum depth as recommended by the manufacturer unless a greater depth is necessary to avoid existing buried services
- ✓ 3.7.18 manufacturer's recommendations on depth of burial for polymer pipe shall be followed
- ✓ 3.7.19 marker tape shall be specified to be installed above each line of pipe
- ✓ 3.7.20 site and factory welds for steel systems shall be specified as being subject to non-destructive testing in accordance with the requirements of EN13941 as a minimum
- ✓ 3.7.21 where polymer pipe systems are used the designer shall specify a water pressure test according to EN 806-4 and manufacturer's recommendations

- ✓ 3.7.22 there shall be provision at the Energy Centre for the control of water quality with facilities for:

- softening of make-up water
- chemical dosing with automatic dosing based on pH monitoring or make-up water monitoring, suitable for the pipe materials being used
- sampling for testing
- sidestream filtration using a bag filter and a magnetic filter

Best Practice

The installer of the system may be willing to offer an extended warranty on the materials and possibly installation of the system (e.g. for up to 20 years) and it would be Best Practice to establish the availability, scope and cost of such warranties at the time of tender, including whether these are underwritten through an insurance scheme.

For steel systems, the use of fusion welded casing joints could be considered as Best Practice to provide greater confidence in the prevention of water ingress which could cause corrosion of the steel, however a higher quality of training is required. Larger diameters where the highest security of jointing is needed would more easily justify the use of this type of joint.

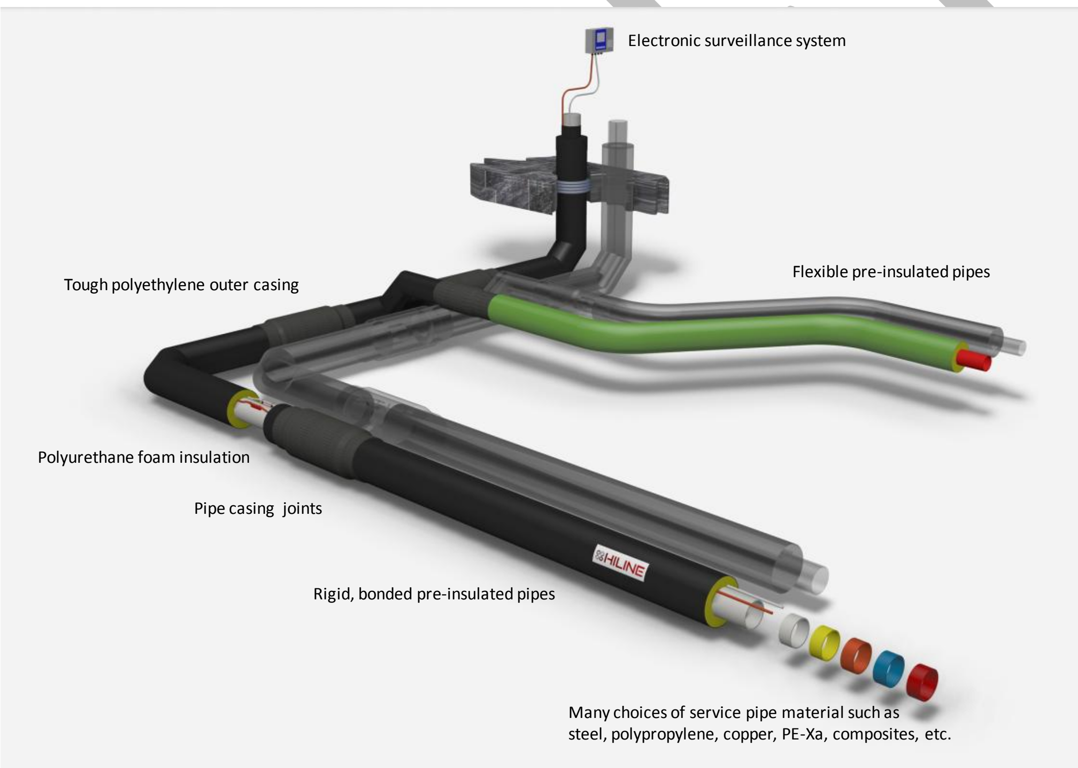

Figure 3.5 – features of a typical pre-insulated pipe system (reproduced courtesy of CPV)

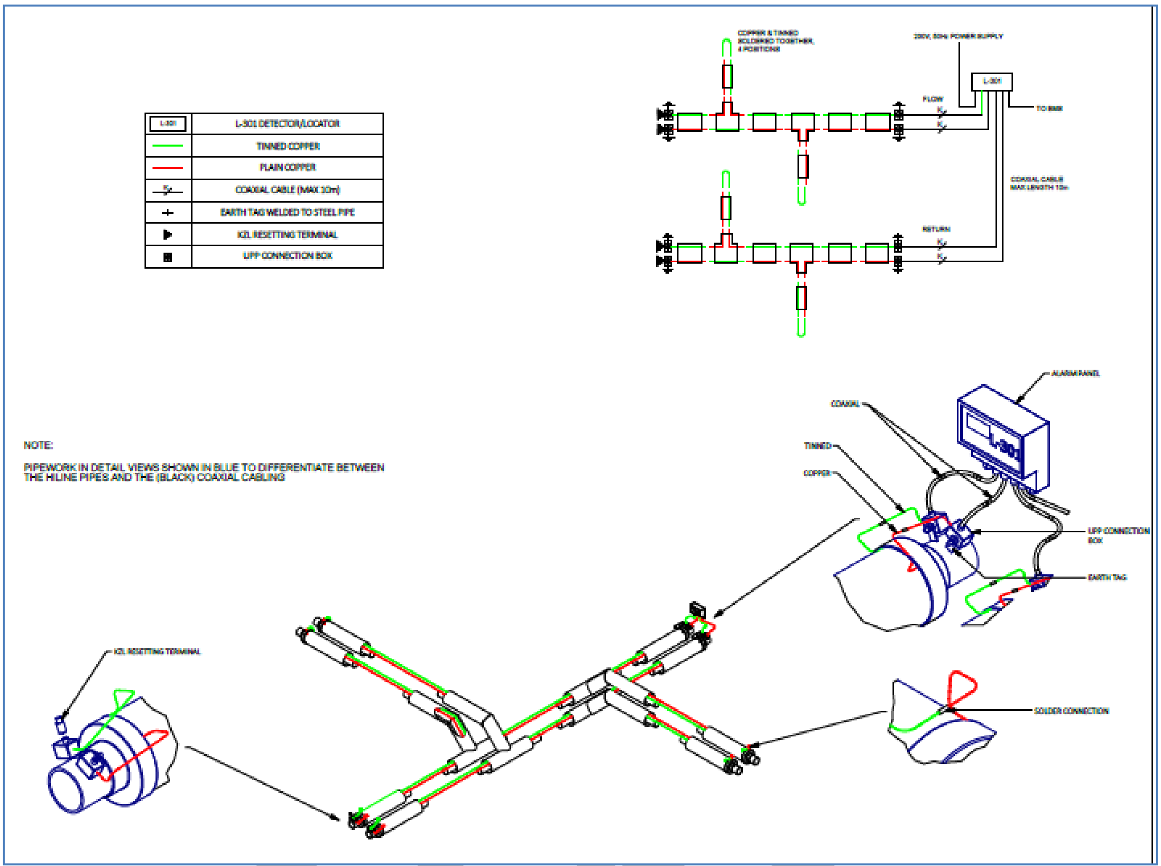

Figure 3.6 - Diagram of a typical surveillance system (reproduced courtesy of CPV)

Objective 3.8 – To select heat metering, prepayment and billing systems that are accurate and cost-effective

Why is this objective important?

Customer acceptance of a heat metering system is important if revenues are to be secure and customer satisfaction with the overall system maintained. Individual dwelling heat meters are a requirement under the Energy Efficiency Directive (EED) for all new buildings and for buildings undergoing major refurbishment. Building-level meters are also a requirement under the EED for all multi-apartment/multi-purpose buildings connected to a heat network. All other premises served by a heat network must undertake cost effectiveness and technical feasibility assessments for the installation of individual meters or heat cost allocators.

Minimum Requirements

- ✓ 3.8.1 heat meters shall be in accordance with the Measuring Instruments Directive (MID) and shall be Class 2 accuracy
- ✓ 3.8.2 metering of heat, electricity and fuel may also need to be in accordance with requirements of the Renewable Heat Incentive, or the CHPQA scheme as required for the individual Energy Centre solution
- ✓ 3.8.3 heat meters shall be of the type with no moving parts in the water flow measurement component, ultrasonic meters are most commonly used
- ✓ 3.8.4 the minimum static pressure stated by the heat meter manufacturer shall be met in at all times for each meter and this requirement shall be taken into account in the overall hydraulic design; if cavitation occurs this can severely impact the accuracy of the meter
- ✓ 3.8.5 a strainer shall be fitted upstream of the meter with a mesh size as advised by the manufacturer
- ✓ 3.8.6 the meter installation shall be designed taking account of the manufacturer's recommendations with respect to orientation, the minimum length of straight pipe before and after the meter and ensuring that it is possible to easily access the meter and integrator for maintenance, calibration and taking readings
- ✓ 3.8.7 in dwellings, heat meters shall be installed in a tamper proof enclosure to reduce the potential for fraud and/or shall be fitted with security seals
- ✓ 3.8.8 a pre-payment system (where fitted) shall have an emergency facility whereby a limited amount of heat energy can be purchased before automatic disconnection results
- ✓ 3.8.9 on larger schemes (more than 500 dwellings) a full Automatic Meter Reading (AMR) system shall be specified to record and report:
    - heat sent out from central plant
    - heat delivered to each main building
    - heat delivered to each dwelling

Note: Direct data readings should be obtained using M-bus communications or other proven AMR technology. Heat meters that provide data via pulsed outputs are not normally recommended for use with AMR systems

- ✓ 3.8.10 where mains electricity is used for the meter, non-volatile memory or battery back-up shall be included, where batteries are used a minimum lifetime of 5 years shall be specified

- ✓ 3.8.11 In addition to individual unit metering, buildings containing multiple units shall also be metered at the heat exchanger or point of supply into that building

- ✓ 3.8.12 the minimum frequency of data collection and billing shall be quarterly for residential and micro-businesses and monthly for non-residential customers

Figure 3.7 – Typical heat meter (reproduced courtesy of Vital Energi)

Objective 3.9 – To achieve an efficient heat distribution system *within a multi-residential building* and to reduce risk of overheating

Why is this objective important?

Controlling heat losses from the network is important to maintain the energy efficiency benefit of the overall system and to reduce costs to customers. It is normally the case that heat losses from the small diameter branches to the final customer are the most significant as the total length of such branches is relatively high. Where there is a block of flats the secondary pipework within the building can also have significant heat losses e.g. losing heat in corridors and service areas. In winter these losses may provide useful heat into the building but this heat is uncontrolled and occurs before dwelling meters if installed. In summer the heat gain may cause unacceptable levels of overheating especially in corridors where the pipework may be run in the ceiling void.

This objective is particularly important for new residential buildings (and existing buildings being thermally upgraded) where space heating demands are low and the secondary network heat losses can therefore be relatively high in percentage terms. Overheating risks will also be more of a concern in a well insulated building. It is essential that the designer considers this issue from the outset as the best solution is likely to have architectural implications.

There are a number of reasons why the heat losses from secondary networks may be higher than an acceptable limit and these should all be reviewed:

- Length of pipe installed, especially the use of horizontal runs in corridors
- High flow and return operating temperatures and fixed bypasses leading to high return temperatures under part load
- Insufficient thickness of insulation specified
- Insulation not specified over valves, fittings and pipe supports
- Oversized pipe
- Poor temperature control in communal spaces where these are actively heated

Minimum Requirements

✓ 3.9.1 when designing the heat distribution system within a block of flats the primary aim shall be to minimise the length of pipework. In blocks of flats this typically will require more vertical risers so that the use of horizontal distribution pipework within corridors is minimised see Figure 3.8

✓ 3.9.2 where new secondary systems are to be installed, these shall be designed for low temperature operation, maximum temperatures of 70°C flow with 40°C return from space heating circuits and 25°C from instantaneous DHWS heat exchangers (see also Objective 3.5)

✓ 3.9.3 the use of bypasses shall be minimised - where instantaneous heat exchangers are used, the standby flow will normally result in a sufficient bypass flow. Fixed bypasses shall not be used and any bypasses shall be temperature controlled so that the bypass only operates when flow temperatures are below a minimum set point

- ✓ 3.9.4 bypass flows within the dwelling Hydraulic Interface Unit (HIU) to maintain the DHWS instantaneous heat exchanger in readiness shall be temperature controlled so that return temperatures are at least 5°C below the outlet (tap) water set-point

- ✓ 3.9.5 the maximum heat loss from an individual pipe shall be in accordance with Table 3.2 below:

Table 3.2 – Maximum heat loss rate

	Maximum permitted heat loss based on fluid temperature of 75°C and still air of 15°C
Outside Pipe Diameter (mm)	W/m
17.2	8.1
21.3	8.2
26.9	9.1
33.7	10.2

Note: these heat loss rates are approximately 10% less than those given in Table 15 of BS5422 and the required insulation thicknesses may impact on depth of ceiling void so early discussions with the Architect should be held to agree the depth available

As an illustration, the minimum insulation thicknesses that will enable these loss rates to be achieved for mineral fibre and phenolic foam types are given in Table 3.3 below.

Table 3.3 – Minimum insulation thickness

	Minimum thickness of insulation for λ = 0.040W/mK	Minimum thickness of insulation for λ = 0.021W/mK
Outside Pipe Diameter (mm)	mm	mm
17.2	40	15
21.3	50	15
26.9	50	15
33.7	50	20

- ✓ 3.9.6 all valves and fittings shall be insulated

- ✓ 3.9.7 pipe supports shall use rigid low conductivity inserts to maintain the insulation quality at the support

- ✓ 3.9.8 the insulation shall be continuous and close fitting at all joints

- ✓ 3.9.9 heating pipework shall not be run adjacent or below cold water pipework

- ✓ 3.9.10 pipe sizing shall be based on realistic diversified demands (see Objective 3.2)

- ✓ 3.9.11 care shall be taken to avoid oversizing of distribution pipes, recognising that peak demands in final branches will only occur for a short period, as the oversizing will lead to higher heat losses

- ✓ 3.9.12 heat losses from the heat network within the building shall be calculated, from the point of connection to the heat meters in each dwelling, and shall not exceed **20%** of the estimated annual heat consumption of the building and an iterative design process shall take place to ensure this is achieved.

- ✓ 3.9.13 the calculations shall be based on the predicted average flow and return temperatures, taking account of the return temperatures that will occur in low demand periods which may be determined by the HIUs operating in standby mode for example

- ✓ 3.9.14 the risk of overheating in summer shall be assessed and additional insulation to that given above shall be specified if necessary, or alternative pipe routes selected

- ✓ 3.9.15 where the heat network runs in corridors a calculation of all internal gains including pipe heat losses shall be carried out and suitable provision made for ventilation of these corridors to avoid unacceptable internal temperatures in summer

Best Practice

Best Practice could be to achieve a heat loss from the heat network within the building of less than **15%** of the estimated annual heat consumption of the building

A Best Practice design could avoid the use of any distribution pipework in corridors, use shared risers and hence minimal branch lengths into dwellings and could provide controllable ventilation to risers such that heat losses would provide useful heat gain in winter but would be ventilated outside the building in summer to limit overheating as far as possible.

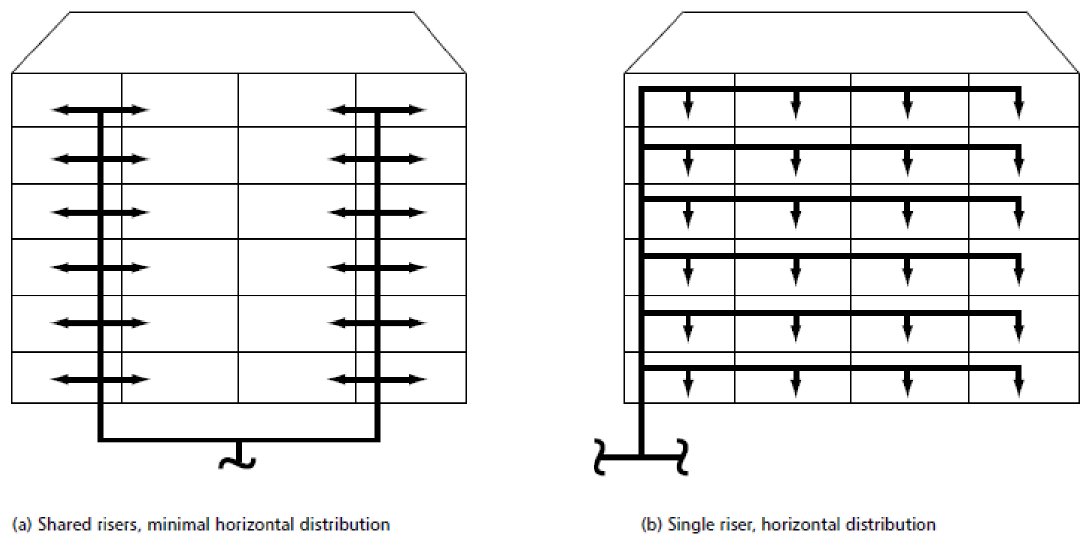

Figure 3.8 – Benefits of using shared risers compared to horizontal runs for typical flat layouts

Objective 3.10 – To design cost-effective and efficient central plant

Why is this objective important?

The principal rationale for any heat network is that heat can be produced at lower cost and with a lower carbon content at a central plant than at a building level. In particular certain heat sources are only feasible at scale (e.g. deep geothermal, energy from waste). The economic case for the heat network will depend on achieving the cost and environmental benefits at the central plant.

Designers will need to refer to detailed guidance on various aspects of central plant design as appropriate, which are listed in Appendix B. This Objective highlights some key requirements to provide a focus to the design in respect of the overall heat supply and impacts on the heat network

Minimum Requirements

- ✓ 3.10.1 the primary low carbon heat source shall be sized to deliver the required percentage of the annual heat demand to deliver the required carbon benefit within the economic constraints of the scheme

Note: For example, a CHP plant would be typically sized to provide 60% to 80% of the total heat demand of a scheme with the balance from gas-fired boilers

- ✓ 3.10.2 the average CO_2 content of the heat supplied over the year shall be calculated in g/kWh heat delivered and made available to designers of buildings that may wish to connect and to Owner/Developers of existing buildings

- ✓ 3.10.3 the average CO_2 content of the heat supplied at the buildings shall be less than 150g/kWh, after taking into account heat losses and pumping energy

- ✓ 3.10.4 CHP plant shall be selected to meet the above requirements and taking account of the need to operate effectively at the full range of heat demands across the year. An hour by hour operating model shall be set-up to evaluate a range of CHP sizes and number of CHP units

- ✓ 3.10.5 a control philosophy shall be developed to define how the central plant shall be controlled to maximise the use of the low carbon heat source and to enable operation of all plant at the highest efficiency possible

- ✓ 3.10.6 the fuel supply requirements shall be identified at an early stage and discussed with fuel suppliers especially with respect to pressures and volumes in the case of gas supply, capacity and voltage with respect to electrical supply and storage volumes, delivery method and fuel handling for biomass systems. The use of gas boosters shall be avoided where possible and only operated when required by the boilers or CHP

- ✓ 3.10.7 where CHP is used, consideration shall be given at an early stage to the connection to the local Distribution Network Operator's system to establish whether there are fault level constraints or other operating conditions and to establish the cost and timescales for the connection

- ✓ 3.10.8 where CHP is used, options for the sale of electricity shall be determined at an early stage as this may have implications for the wider electricity network design e.g. there may be an opportunity for direct supply of electricity to meet electricity demands in local buildings

- ✓ 3.10.9 the operating temperatures proposed for the heat network shall be considered in the development of the central plant solution. It should be recognised that return temperatures are often higher in practice than the design condition, especially at part-load, and this uncertainty needs to be allowed for in the design. In some cases the central plant selection will have a strong influence on the operating temperatures to be used e.g. when using centralised heat pumps or steam extraction from steam turbines

- ✓ 3.10.10 in developing the design the requirements of the local planning authority shall be considered at an early stage including the local environmental impacts of visual intrusion, noise and emissions to air

- ✓ 3.10.11 the conclusions of the feasibility stage regarding the disposition of top-up and standby boilers shall be reviewed and updated including whether these boilers are to be located within existing buildings or centrally or a mix of these two extremes

- ✓ 3.10.12 where condensing boilers are specified the circuit shall be designed to maximise the opportunity for condensing conditions to occur

- ✓ 3.10.13 the circuits shall be designed to enable the CHP to operate without premature shut-down as a result of high return temperatures – care shall be taken to avoid adverse transient conditions by avoiding the use of a common flow and return header and ensuring there is recirculation around the boilers to control boiler off temperatures at start-up and shut-down (see also CIBSE AM12)

- ✓ 3.10.14 the pipework, vessels, and flanges shall be insulated, valves and strainers shall be insulated with flexible jackets that can be easily removed and replaced.

- ✓ 3.10.15 the layout design of the Energy Centre shall take into account the needs of the operator and provide suitable maintenance facilities, storage for spares and access space to carry out maintenance work to a high quality and in a safe manner

- ✓ 3.10.16 the layout of the Energy Centre shall take into account the requirement to replace plant in the future without undue disruption and in a safe manner

- ✓ 3.10.17 consideration shall be given to the likelihood that the next plant replacement may be of a different technology

- ✓ 3.10.18 the ventilation of the plantroom shall be by natural means wherever possible to reduce the use of electricity for ventilation fans

- ✓ 3.10.19 the design shall consider the impact of leakage of water from plant failure and seek to minimise the damage this might cause by providing adequate drainage and mounting electrical and control equipment at a higher level

- ✓ 3.10.20 oil tanks and transformers shall be bunded to contain leakage in the event of a fault

Best Practice

Best Practice could be for the primary low carbon heat source to be sized to deliver a higher proportion of the annual heat demand e.g. 75% to 80%, to maximise the carbon benefit and for the average CO_2 content of the heat supplied at the buildings to be less than 100g/kWh, after taking into account heat losses and pumping energy.

Best Practice could include consideration of the use of top-up and standby boilers within customer's premises to supply the network when needed to reduce the need for new boiler capacity on the network.

Best Practice could also include designing using BIM techniques and 3-D visualisation.

Best Practice could include insulating all pump bodies.

Figure 3.9 – Design of an Energy Centre using BIM (image courtesy of AECOM)

District Cooling systems can similarly use a range of cooling sources including absorption chillers, vapour compression chillers or in some places river water. The main objective is to obtain a significant difference in cost and efficiency from using centralised chillers compared to local chillers installed in buildings. This could be obtained for example by being able to use evaporative cooling towers or heat rejection to a river. Additional advantages can be obtained if the DC system is linked to a Heat Network where the heat rejected can be utilised as a heat source for a heat pump supplying the Heat Network.

Objective 3.11 – To optimise the use of thermal storage

Why is this objective important?

Incorporating thermal storage has a number of benefits:

- Smoothing of the daily variation in heat demand reducing the use of peak boilers – normally of a benefit in the 'shoulder months'
- Enabling a CHP plant to operate during times of higher electricity price (day-time) and shutting down at times of low electricity price (night-time)
- Enabling extraction from steam turbine and operation of heat pumps to be prioritised during times of low electricity price (night-time)
- Enabling biomass boilers to operate continuously
- Enabling plant to operate at full output for fewer hours rather than at part-load where it would be less efficient
- Reducing the number of starts of low carbon plant especially CHP units
- Allowing the peak heat network capacity to be reduced and hence smaller pipes, by using local distributed stores

The design and sizing of a thermal store requires an operating model that uses predicted heat demand profiles on an hour by hour basis for a full year

Minimum Requirements

✓ 3.11.1 the size of a thermal store shall be optimised by using an hour by hour simulation to achieve minimum life cycle costs or to meet other specified criteria and shall allow for a mixing zone which effectively reduces the useful volume available

✓ 3.11.2 the store shall be designed to operate with the maximum temperature difference available which may mean that it uses a flow temperature higher than the network flow temperature

✓ 3.11.3 where possible a single store shall be used to minimise cost and heat losses

✓ 3.11.4 each store shall have a minimum height to diameter ratio of 2, with a ratio of 3 or higher being preferred

✓ 3.11.5 the dimensions of the store shall take account of practical considerations including: space constraints, transport constraints, planning requirements, structural implications and manufacturing processes

✓ 3.11.6 the store shall be designed to minimise turbulence and to promote stratification by using large diameter connections at entry and exit points and hence low flow velocities and internal baffle plates at the entry and exit points which maximise the stored volume (see Figure 3.14)

✓ 3.11.7 where multiple stores are used these shall be connected in series to maximise useful storage volume

- ✓ 3.11.8 a minimum of 5 temperature sensors shall be installed on the vessel, aligned vertically to enable the operation of the store to be monitored, or an equivalent alternative system shall be used to provide the same or better facility

- ✓ 3.11.9 connections to the store shall be such that the flows in and out of the store are only the difference between the scheme heat demand and the central plant production not the total heat demand. A common header arrangement shall not be used – the thermal store itself provides this function (see Figure 3.17)

- ✓ 3.11.10 the store shall be insulated to minimise lifecycle costs and meet the performance requirements with respect to temperature loss

- ✓ 3.11.11 the central plant shall be controlled so that the low carbon heat source (e.g. a CHP unit) is turned on whether the temperature of the top of the store drops below a set-point (when the store is 'empty') and turns off when the temperature at the bottom of the store rises above a set-point (when the store is 'full'). More complex controls may also be used to maximise the commercial benefit of the store e.g. to maximise income from electricity generation at certain times of the day

- ✓ 3.11.12 the control system shall be such that low carbon heat is delivered to meet the heat demand as the first priority with any surplus heat available being stored for later use

- ✓ 3.11.13 the control systems shall take account of transient conditions when plant is started and stopped to ensure that only hot water is delivered to the top of the store so as to avoid spurious temperature signals being given to the heat generating plant

Best Practice

It is likely that the benefits of thermal storage will become more significant in the future so planning for additional storage to be added could be a Best Practice approach. The use of inter-seasonal storage could be considered for some heat sources (e.g. solar thermal).

Figure 3.10 – The thermal store at Dickens Estate Portsmouth

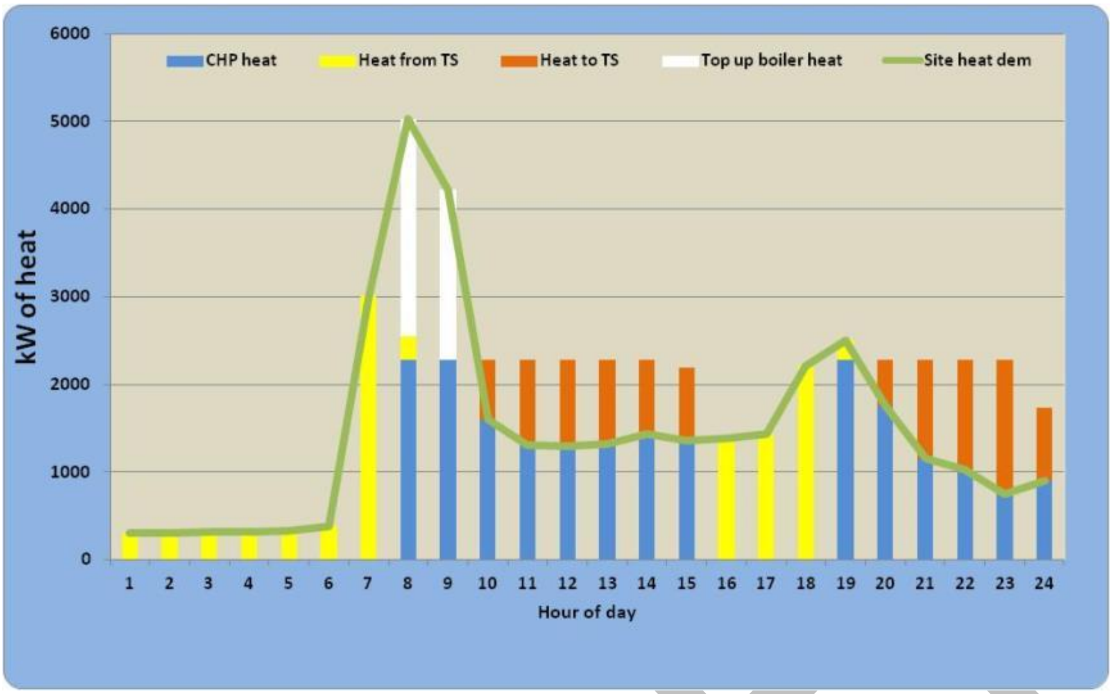

Figure 3.11 – Illustration of CHP modelling with thermal store over a 24 hour period (reproduced courtesy of AECOM)

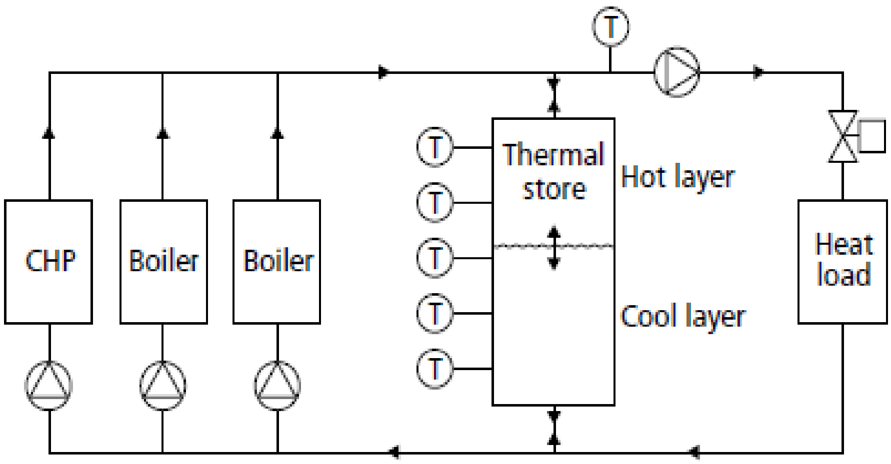

Figure 3.12 – Simplified schematic of a thermal store (reproduced from CIBSE AM12)

Objective 3.12 – To update and refine the economic analysis, risk analysis and sensitivities

Why is this objective important?

During the design stage and at the end of this stage the economic analysis shall be updated to reflect the latest design, the plant performance and the cost estimates. This may lead to a need for Value Engineering to maintain a sound business case.

The economic model can also be used in conjunction with a risk analysis to assess the impact of risks and the benefits of mitigation.

A wider range of sensitivities may be investigated at this stage using the economic model.

Minimum Requirements

✓ 3.12.1 the economic analysis shall be updated using the predicted performance of central plant as designed, the latest cost estimates and the more accurate estimates of network heat losses, boiler standing losses, pumping energy and other parasitic electricity uses

✓ 3.12.2 the risk register shall be reviewed and updated and progress on actions assigned for mitigation monitored

✓ 3.12.3 a sensitivity analysis shall be conducted using the risk register as a starting point so that each risk can be quantified in terms of impact on IRR, NPV and heat selling price. This shall also include assessing the potential benefit from defined risk mitigation measures

✓ 3.12.4 as a minimum the following sensitivities shall be included:

- heat sales volume
- delays in the connection of buildings to the network
- downtime of primary heat source e.g. CHP unit
- variations in future fuel and electricity prices
- out-turn construction cost
- construction programme over-run
- non-fuel operating and maintenance costs and management costs

✓ 3.12.5 a separate analysis which assigns monetary value to the CO_2 saved (e.g. using DECC's social cost of carbon) shall also be undertaken

Best Practice

Where a P&L/Balance sheet is prepared in accordance with Best Practice for Objective 2.9, this should also be updated. The risk analysis could follow the principles of ISO31000.

Objective 3.13 – To assess environmental impacts and benefits

Why is this objective important?

At the design stage a more detailed evaluation of environmental impacts and benefits will be required to support a planning application, to comply with legislation and to make the case for the project in terms of CO_2 reductions.

Minimum Requirements

- ✓ 3.13.1 the emissions from the central plant shall be assessed and a dispersion model used to determine stack height and to calculate the impact on ground level concentrations or other sensitive receptors, especially of NOx and where appropriate PM_{10}
- ✓ 3.13.2 where gas-fired CHP (>300We) is to be used without further treatment in an air quality management area the TA-Luft 50% standard for NOx of 250mg/Nm^3 shall be specified
- ✓ 3.13.3 where biomass boilers are used the particulate emissions shall be assessed and suitable control technologies selected.
- ✓ 3.13.5 biomass shall be sourced from sustainable sources and consideration given to the transport energy required
- ✓ 3.13.6 an acoustic survey shall be undertaken to establish background noise levels in the area of the energy plant and the requirements for the design of the Energy Centre acoustic control set accordingly
- ✓ 3.13.7 the CO_2 savings and carbon intensity of the heat supplied shall be calculated for the project together with projections on a year by year basis as to how these might change in the future as the electricity grid is decarbonised

Best Practice

A Best Practice approach in an air quality management area would be to use a higher stack to disperse pollutants more widely or to use exhaust gas treatment.

The use of a fuel cell CHP could also be considered to reduce environmental impacts.

An evaluation of the embodied energy within the pipe materials used could be undertaken.

Set of questions (please write your answer in the response form):

Q 20. Is the total annual heat loss cap from the network up to the point of connection to each building set out at 15% of the estimated annual consumption of all the building connected to the scheme suitable to ensure that new built heat network achieve a reasonable efficiency? If not, what might be a reasonable cap under the Objective 3.5?

Q 21. Would the requirements to achieve an efficient heat distribution system within a multi-residential building set out above be effective tools in addressing the issue of overheating during the summer season? What additional requirement, that is cost-effective, could be implemented under the Objective 3.9?

Q 22. Are the cost-effective and efficient central plant requirements set out in Objective 3.10 suitable for small businesses? If not, how should they be tailored under the Objective 3.10?

Q 23. Are there any requirements in the Design Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

4. Construction and installation

Objectives:

4.1 To reduce health and safety risks to staff, customers and the general public

4.2 To achieve a high quality heat network construction to deliver a long life asset

4.3 To provide a high quality hydraulic interface unit and building connection construction to provide good customer service levels

4.4 To reduce adverse environmental impacts of construction

Objective 4.1 – To reduce health and safety risks to staff, customers and the general public

Why is this objective important?

Reducing health and safety risks is of primary importance in any project and established Contractors will recognise their responsibilities. This section is not intended to be comprehensive but will emphasise particular risks associated with heat networks. The health and safety of the general public must be carefully considered as heat networks are generally installed through publicly accessible spaces.

Minimum Requirements

- ✓ 4.1.1 the CDM Co-ordinator shall be appointed and a Health and Safety Risk Register established taking forward the residual risks identified at the Design Stage
- ✓ 4.1.2 The guidance issued by HSE in HSG47 (HSE, 2014), shall be followed to minimise health and safety risks associated with excavation around buried services
- ✓ 4.1.3 all trenches and site compounds shall be securely fenced off to avoid risks to the general public with appropriate warning signs
- ✓ 4.1.4 trench walls shall be properly supported at all times and kept clear of ground water and debris (see Figure 4.1)
- ✓ 4.1.5 tools and equipment shall not be left unattended at any time and shall be stored in secure facilities outside working hours
- ✓ 4.1.6 when welding, suitable screens shall be placed to protect the public
- ✓ 4.1.7 traffic management systems and pedestrian signs shall be carefully considered and follow the NRSWA 1991 Code of Practice recommendations and after liaison with the appropriate authorities
- ✓ 4.1.8 spoil heaps shall be minimised by removing surplus from site at frequent intervals
- ✓ 4.1.9 when working with heating pipes the risk of scalding shall be identified especially to residential customers who are vulnerable and pipe protection shall be provided especially on primary side pipework
- ✓ 4.1.10 detailed design carried out by the Contractor shall take account of the future needs for safe maintenance of plant and equipment

Figure 4.1 – Trench wall supports (reproduced courtesy of AECOM)

Objective 4.2 – To achieve a high quality heat network construction to deliver a long asset life

Why is this objective important?

Heat networks are designed to have a long life and be very reliable however this is only realised where a high standard of construction is also achieved. Much of the detailed requirements for pre-insulated steel pipes systems are set out in EN13941 and the Code Requirements given below only emphasise the most important of these. There are fewer potential risks arising from poor installation of pre-insulated polymer pipes using compression sleeve joints however a high standard of installation is still important.

Minimum Requirements

- ✓ 4.2.1 where a steel pre-insulated system is selected this shall comply with EN253 and associated standards and shall be installed in accordance with EN13941 and manufacturer's instructions and guidance. Where a pre-insulated polymer pipe system is selected this shall be installed in accordance with the manufacturer's instructions and guidance

- ✓ 4.2.2 for pre-insulated steel systems, the Project Class of the system under EN13941 shall be defined which determines the appropriate stress calculation methodology and NDT requirements (see 4.4.2 of EN13941)

- ✓ 4.2.3 for pre-insulated steel systems, prior to installation commencing, the designer shall confirm that the necessary stress analysis check has been carried out in accordance with EN13941. This design check shall also be carried out on any deviations in the route that may arise during construction

- ✓ 4.2.4 all fitters employed to install the steel pipe system shall have received training in the joint system in accordance with Annex C of EN489 and hold current certificates; for polymer pipe systems all fitters shall receive specific training in the pipe system and the jointing system

- ✓ 4.2.5 the Contractor shall provide documentary evidence that quality inspections have been made at each stage of the installation process covering as a minimum:

    - trench inspection prior to installing pipes
    - steel welding NDT using ultrasonics
    - closure welding or shrinking
    - closure air test prior to foaming
    - continuity checks on surveillance system
    - trench inspection prior to backfilling
    - compaction around pipes and marker tape
    - system pressure test (strength test)
    - final surfacing and re-instatement

- ✓ 4.2.6 there shall be a system of independent inspection to verify that the above quality checks are being undertaken including written records of sample checks carried out

- ✓ 4.2.7 each steel weld or polymer pipe joint shall be numbered and the individual welder or jointer responsible shall be identified on a register. The same process shall be followed for joint closures

- ✓ 4.2.8 pre-insulated materials shall be stored in accordance with manufacturer's instructions, site foaming materials shall be kept in insulated containers

- ✓ 4.2.9 NDT of steel welds shall be carried out in accordance with EN 13941 for the appropriate Class and in addition the first 10 welds of each welder shall be subject to NDT. Ultrasonic testing is normally used.

- ✓ 4.2.10 welding shall only be carried out under suitable conditions with the welding area covered during inclement weather

- ✓ 4.2.11 welding equipment for PE casings or polymer pipe shall be checked regularly and calibration certificates made available

- ✓ 4.2.12 the insulation on above ground pipework shall be specifically checked and an inspection report issued prior to cladding or covering up by building finishes to confirm compliance with the specification for thickness and type of insulation, continuation of insulation at joints, supports, flanges, valves and all other fittings

- ✓ 4.2.13 trenches shall be kept dry and free of debris at all times

- ✓ 4.2.14 on completion of each section the network shall be flushed to remove debris using specialist flushing equipment in accordance with BSRIA Guide BG29 – Pre-commission cleaning of pipework systems

- ✓ 4.2.15 the installation contractor shall provide an "as installed" layout drawing of the network indicating all joint position with GPS co-ordinates, and any route deviations from the original approved design. This drawing shall be included in the maintenance manual for the scheme

- ✓ 4.2.16 for steel pipes there shall be a detailed wiring diagram for the surveillance system and this shall be certified correct upon commissioning and included in the maintenance manual for the scheme. The system shall be 'mapped' both following installation and prior to charging the network. This shall be held as part of the "as installed drawings" to provide datum references and facilitate the location of leaks. Future and periodic mapping shall be carried out as part of the maintenance regime and compared to the datum mapping. The systems shall be tested and calibrated to achieve an accuracy in location detection of +/- 1m

- ✓ 4.2.17 following the flushing the system shall be filled with treated water

Best Practice

Chemical cleaning of the pipe system could be used however care needs to be taken to ensure all chemicals are flushed out before refilling and safely discharged. This process can be difficult to control in an installation where customer connections are being progressively completed. Best Practice could include maintaining a photographic record of each section of the network taken just prior to backfilling the trench.

Objective 4.3 – To provide a high quality hydraulic interface unit and building connection construction to provide good customer service levels

Why is this objective important?

The hydraulic interface unit (HIU) is a key component of the heat network system as it provides user control, ensures hydraulic balance within the heat network and may also include a domestic hot water heat exchanger. It should also be designed to have low maintenance requirements and perform reliably over a long period of time. The required customer service levels of the heat supply will only be achieved from a high quality HIU and building connections to non-domestic buildings.

Minimum Requirements

- ✓ 4.3.1 HIUs for dwellings shall be selected to deliver the required design performance and test results shall be available to substantiate this, particularly with regard to the temperature control of domestic hot water under a range of pressure differences and draw-off rates

- ✓ 4.3.2 the heat meter installation shall be installed in accordance with EN1434 and strictly in accordance with manufacturer's instructions taking care that the flow meter is installed in the correct orientation, with sufficient straight length upstream and downstream, in the correct pipe (flow or return) and that the temperature sensors are installed in the correct way

- ✓ 4.3.3 fittings connecting the HIU to the Network shall be selected and installed to operate under current and future network pressures and temperatures with an appropriate level of quality assurance.

- ✓ 4.3.4 the controls systems for building connections shall be fully checked prior to commissioning including a point to point check that sensors are correctly addressed and that all sensors are working correctly

Best Practice

Best Practice could include the testing of the HIU performance against established standards such as the Swedish standard F103-7: April 2009.

Objective 4.4 – To reduce adverse environmental impacts of construction

Why is this objective important?

Although the ultimate aim of a Heat Network project is to provide an environmental benefit there will be negative environmental impacts during construction which need to be identified and minimised as far as possible.

Minimum Requirements

- ✓ 4.4.1 the Contractor shall commit to following the requirements of the Considerate Contractor scheme
- ✓ 4.4.2 the Contractor shall manage the site to recycle waste and minimise the risk of waste being blown off site into surrounding areas by collecting and storing waste as soon as it is created
- ✓ 4.4.3 dust shall be controlled by using sprays on road surfaces which shall be cleaned regularly
- ✓ 4.4.4 fuel use for site vehicles and machinery shall be monitored and minimised - engines shall be turned off when not in use for long periods
- ✓ 4.4.5 water use shall be minimised and waste water shall be sent to road drains only where unavoidable, run-off into local waterways shall be prevented
- ✓ 4.4.6 spoil heaps shall be covered to avoid rain run-off carrying sediment which may block drains
- ✓ 4.4.7 noise and other disturbance to residents shall be minimised and agreed site operating hours adhered to at all times
- ✓ 4.4.8 trees and other landscaping shall be protected from damage with qualified arborists or landscape architects consulted as necessary

Best Practice

Best Practice could include the provision of large and easily readable posters fixed to the site hoardings explaining the nature of the works and the wider district energy scheme and carbon benefits. Best Practice could include the use of the Civil Engineering Environmental Quality System (CEEQUAL) with a target to achieve Very Good or Excellent.

What is CEEQUAL?

CEEQUAL is the international evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and works in public spaces, and celebrates the achievement of high environmental and social performance.

CEEQUAL aims to assist clients, designers and contractors to deliver improved project specification, design and construction of civil engineering works. The scheme rewards project and contract teams who go beyond the legal, environmental and social minima to achieve distinctive environmental and social performance in their work. In addition to its use as a rating system to assess performance, it also provides significant influence to project or contract teams as they develop, design and construct their work, because it encourages them to consider the issues in the question set at the most appropriate time, and to strive to secure the CEEQUAL score their work deserves.
See www.ceequal.co.uk

Set of questions (please write your answer in the response form):

Q 24. Do you agree with the principles and requirements underpinning the high quality heat network construction Objective 4.2 set out above?

Q 25. Are there any requirements in the Construction & Installation Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

5. Commissioning

Objectives:

5.1 To achieve consistently low return temperatures through commissioning building heating systems/controls

5.2 To provide HIU commissioning and heat network balancing to ensure demands are met at all times

5.3 To commission the heat metering and meter reading system to deliver accuracy and customer service

5.4 To commission the central plant to deliver an efficient and reliable service

5.5 To provide smooth handover and sufficient information for the the operations team

Objective 5.1 – To achieve consistently low return temperatures through commissioning building heating systems/controls

Why is this objective important?

One of the most critical aspects of the design and operation of a heat network is the return temperature. The flow temperature is often set by limits on the central plant and other equipment. For a given flow temperature it is the return temperature that governs the capacity of the network, the capacity of a thermal store, the efficiency of heat production at the central plant, the pumping energy and the network heat losses. However the heat network operator has little control over the return temperature as this is mainly a function of the building's heating system and its controls. Maintaining a low return temperature through the life of the network will be important but the initial commissioning is particularly important as it will be harder to change settings once the system is in operation.

This is in part a cultural change – operatives commissioning heating systems using gas-fired boilers within the building are more concerned to achieve high flow rates and ensure radiators deliver their output. There is a tendency as a result to set flows and hence return temperatures higher than the design value. With heat networks, an alternative approach needs to become the norm, where flow rates are balanced to no more than the design value and achieving the correct return temperatures are the main commissioning objectives. In other words the heating system is used to extract as much heat as possible from the water supplied by the heat network before returning it.

Minimum Requirements

- ✓ 5.1.1 written commissioning procedures shall be produced for each type of heating circuit, building on the commissioning plan established during the design stage and based on CIBSE Commissioning Code M and other guidance
- ✓ 5.1.2 all operatives involved in commissioning shall receive training in the importance of achieving low return temperatures
- ✓ 5.1.3 a commissioning record sheet shall be used to enter the return temperatures from the space heating circuits after the system has been running in constant operation for over 30 minutes
- ✓ 5.1.4 10% of the heating circuits shall be independently inspected to establish whether the design return temperatures have been achieved and further tests and rectification work shall be undertaken as necessary. If when testing this 10% there is a failure of greater than 10% then these tests shall be expanded to a further 10% and this procedure repeated
- ✓ 5.1.5 for a dwelling heating system the radiators shall be fitted with pre-settable thermostatic radiator valves designed for use with low flow rates and adjusted to give the required return temperature and the design flow rate for the radiator concerned. Note: for new build schemes this is typically the responsibility of the Developer
- ✓ 5.1.6 the total flow to the radiator circuit shall be adjusted to the design conditions using the controls at the HIU - this may be a variable speed pump, a balancing valve or an

adjustable differential pressure control valve for direct connection systems. Note: for new build schemes this is typically the responsibility of the Developer

Best Practice

A check on the average temperature difference achieved across any circuit can be established by the use of a heat meter that records volume and energy (see Figure 5.1 below).

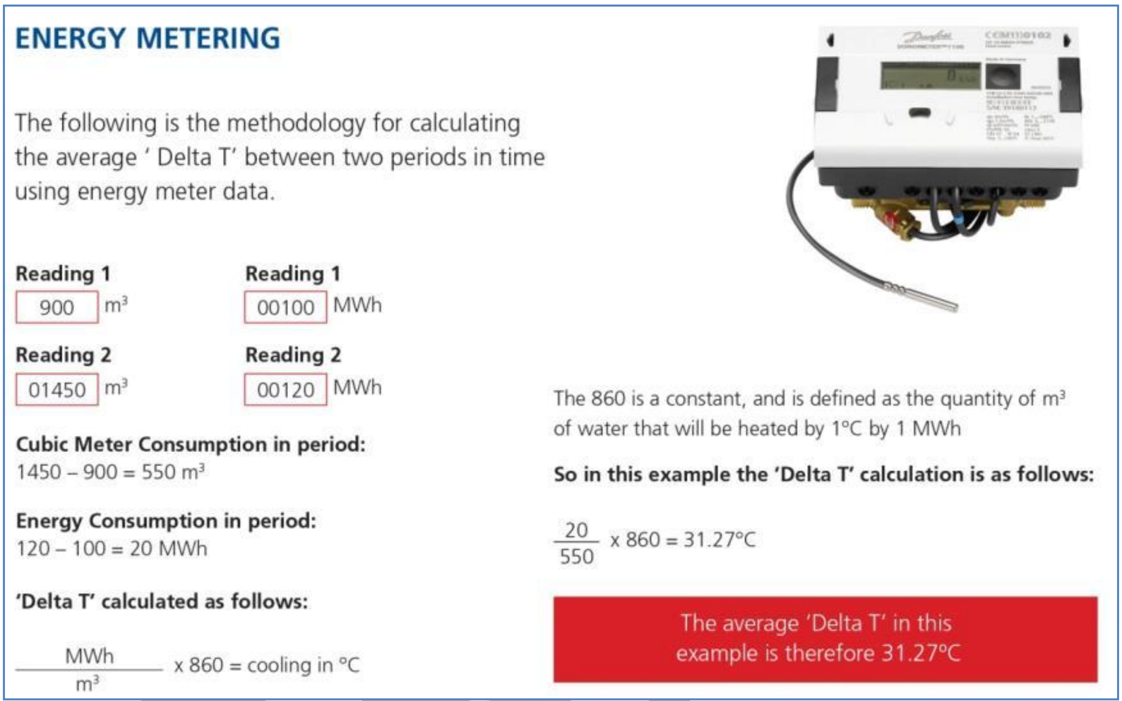

Figure 5.1 – Method for establishing the average temperature difference from two heat meter readings (reproduced courtesy of SAV)

Objective 5.2 – To provide HIU commissioning and heat network balancing to ensure demands are met at all times

Why is this objective important?

A fundamental requirement for the heat network is to deliver the required amount of heat to each customer, critically at the times of peak demand.

This is achieved by ensuring that each customer cannot take more than the design flow rate that has been set in the supply contract (typically defined as a kW supply rate at defined flow and return temperatures).

In addition, for residential properties, a Hydraulic Interface Unit (HIU) is often used to provide a central control and metering point at each dwelling. This unit requires checking and commissioning.

Minimum Requirements

- ✓ 5.2.1 the HIU shall be commissioned in accordance with the Heating and Hot Water Industry Council (HHIC) Commissioning Checklist for HIUs (see Appendix D).
- ✓ 5.2.2 commissioning engineers shall receive training in the importance of commissioning and achieving the correct return temperatures before commencing work
- ✓ 5.2.3 at each point of supply to the customer the maximum flow rate shall be adjusted to the design value using the adjustable differential pressure control valve and, if necessary, regulating valves
- ✓ 5.2.4 the flow rate shall be measured using the flow rate function of the heat meter
- ✓ 5.2.5 all measured data and set points on valves etc shall be recorded on the commissioning record sheet and a copy provided to the customer
- ✓ 5.2.6 any flushing loops shall be closed off before commissioning starts
- ✓ 5.2.7 where bypass valves are installed the flow rate shall be set up under minimum system flow conditions

Best Practice

To provide an additional check on the maximum flow rate setting for non-domestic customers, an independent flow measuring device such as a calibrated orifice plate could also be included.

Objective 5.3 – To commission the heat metering and meter reading system to deliver accuracy and customer service

Why is this objective important?

The heat metering system is fundamental to the operation of the scheme enabling revenues to be collected and to provide feedback to customers on their energy use.

Minimum Requirements

- ✓ 5.3.1 There shall be an initial check prior to commissioning that the installation has been carried out in accordance with EN1434, manufacturer's instructions and the MID, particularly in relation to meter location, orientation and sensor installation as appropriate for the specific meter
- ✓ 5.3.2 where a pre-payment system is installed there shall be a number of ways that credit can be purchased by residents including by telephone and, if in person, from sufficient local outlets
- ✓ 5.3.3 the correct reporting of kWh from each meter through the Automatic Meter Reading (AMR) system shall be demonstrated and these readings must be repeatable
- ✓ 5.3.4 the meter shall be monitored for a short period on load to establish that flow rate and temperatures are being recorded and that the data received by the AMR is credible
- ✓ 5.3.5 a hand calculation check shall be carried out to prove that the conversion to kWh from the flow rate and temperature measurements is correct
- ✓ 5.3.6 a reconciliation calculation shall be carried out between the central plant meters, main building meters and dwelling meters from which system losses can be estimated
- ✓ 5.3.7 a meter register shall be prepared and maintained detailing:
    - the meter serial number
    - the postal address of the property
    - the communications address for the AMR
    - the date commissioned
    - the initial reading
    - the date of last calibration
- ✓ 5.3.8 a full metering strategy diagram for each main building shall be developed, as shown in CIBSE TM39
- ✓ 5.3.9 an information pack shall be provided to the customer as to the functioning of the heating system, its controls, heat meter and the pre-payment system if used. It shall also comply with the requirements of the IHCPS. The pack shall be written to be visually attractive and easy to understand and not a collection of manufacturer's leaflets. It shall contain a list of FAQs and suitable answers.

Best Practice

A follow up visit to the property could be arranged to ensure that the customer understands how to operate the heating system and the metering and billing or pre-payment process. Information packs could be translated into other languages. Best Practice could involve recording and storage of data for an extended period. Outputs from the AMR could be displayed on the web including the average percentage heat loss from the network. This could also include information on the central plant inputs, outputs and efficiency.

Objective 5.4 – To commission the central plant to deliver an efficient and reliable service

Why is this objective important?

Well designed and installed central plant can still fail to deliver an efficient and reliable service if it has not been properly commissioned and tested. Without adequate testing, faults will only emerge during the early years of operation - which typically are then more expensive and disruptive to resolve.

Minimum Requirements

- ✓ 5.4.1 the Operating Philosophy and the Functional Controls Specification documents shall be reviewed and a commissioning and testing procedure established to demonstrate compliance with these documents. This may involve some proving and testing at various times during the first year of operation when suitable system loads are available. Alternatively, the load may be artificially induced by changing set points or using load banks

  It is important not just to commission each item of plant in the energy centre but also the integrated operation of the entire plant to deliver the required levels of service at the expected levels of operation and efficiency.

- ✓ 5.4.2 there shall be a specific demonstration to show that the low carbon heat source is controlled to operate as the lead unit and to maintain its output as secondary heat sources are brought on line

- ✓ 5.4.3 each sensor point connected to the BEMS/SCADA system shall be checked to prove that it is correctly addressed and providing a consistent and correct signal

- ✓ 5.4.4 the stable and efficient operation of the plant shall be demonstrated at all expected load conditions and especially at minimum load conditions

- ✓ 5.4.5 the Energy Centre shall be commissioned following the recommendations in CIBSE Commissioning Code M and BSRIA Guidance and an energy balance carried out to ensure metering is working correctly

- ✓ 5.4.6 a specific check shall be carried out at times of minimum demand (summer nights) to confirm that bypass flows have been correctly set up and controlled

- ✓ 5.4.7 the operation of the variable speed pump system shall be checked to verify that the required pressure differences are achieved at all points of the network and that excessive pressure differences are not found at periods of low flow

- ✓ 5.4.8 on completion of the commissioning a written handover process shall be followed to enable the operating organisation to take full control.

- ✓ 5.4.9 the construction team and the designer shall be contractually appointed in a supporting role for 12 months following handover to carry out seasonal checks and to fine tune the control system.

Best Practice

Best Practice could be to appoint the project team to deliver the Soft Landings approach as defined in BSRIA soft landings specification which covers a 3 year period after initial commissioning

Figure 5.2 - Inside the King’s Cross Energy Centre (reproduced courtesy of Vital Energi)

Objective 5.5 – To provide smooth handover and sufficient information for the operations team

Why is this objective important?

In order to encourage good energy efficient operation it is essential to ensure correct handover procedures are followed. A key part of this is to provide the operations team with all the necessary information about the heat network including O&M manuals, log books and metering strategies

Minimum Requirements

5.5.1 the handover procedures shall follow those laid down by CIBSE and BSRIA

5.5.2 a full O&M manual shall be provided for the heat network including controls strategies and commissioning records. This shall also include: records of material specifications for the network, as installed drawings, stress analysis report, TDR mapping of surveillance system, copies of pressure tests and NDT tests

5.5.3 appropriate customer instructions shall be developed and distributed to customers at handover, supplemented by customer training if necessary

5.5.4 where appropriate, TM31 log books shall be put in place for each main building and central heat interface unit

5.5.5 metering strategies shall be provided for the whole heat network, main buildings and the central plant room

Set of questions (please write your answer in the response form):

Q 26. Do you agree with the principle that 10% of the heating circuits shall be independently inspected to establish whether the design return temperatures have been achieved and further tests and rectification work shall be undertaken as necessary set out in Objective 5.1 above?

Q 27. Are there any requirements in the Commissioning Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

6. Operation and maintenance

Objectives:

6.1 To reduce health and safety risks to staff, customers and the general public

6.2 To achieve cost-effective, accurate, reliable heat metering, prepayment and billing systems

6.3 To maintain a high level of reliability and a long life for the heat network

6.4 To deliver a cost-effective efficient maintenance of central plant that maintains a long life for the asset

6.5 To provide appropriate monitoring, reporting of central plant, including reliability, CO_2 emissions

6.6 To maintain the building connections to provide good customer service

6.7 To minimise environmental impacts of operation and maintenance

Objective 6.1 – To reduce health and safety risks to staff, customers and the general public

Why is this objective important?

In operation, the health and safety of staff, customers and the general public shall be of paramount importance. Whilst legislation exists to enforce many risk mitigation measures, Heat Networks have some specific operating risks which are emphasised below.

Minimum Requirements

- ✓ 6.1.1 there shall be a Disaster Recovery Plan detailing the chain of command and communications required in the event of a major incident and all staff shall be trained in these procedures
- ✓ 6.1.2 the COSSH and DSEAR Regulations may apply and shall be followed
- ✓ 6.1.3 the Heat Network operator shall be certified under ISO18001, the Occupational Health and Safety standard
- ✓ 6.1.4 The Energy Centre and plantrooms containing heat exchangers, pumps and other equipment shall be kept locked and access controlled appropriately even where they are on customer's premises
- ✓ 6.1.5 isolating valves within dwellings for use by residential customers shall be installed and labelled as 'emergency shut-off' with advice given to customers on emergency procedures in the event of a leak within the dwelling
- ✓ 6.1.6 a fire risk assessment shall be carried out and fire alarm and detection systems and any fire suppression systems shall be checked regularly in accordance with regulations
- ✓ 6.1.7 where centralised domestic hot water systems are used these shall be checked regularly and records kept of any water treatment carried out, in accordance with HSE Guide HSG274 Part 2, 2014
- ✓ 6.1.8 space temperatures within compact plantrooms may be higher than normal which may impact on the safety of operatives and working regimes shall be planned accordingly.
- ✓ 6.1.9 surface temperatures on equipment and pipework may be higher than normally found in heating systems especially in plantrooms in buildings connected to a heat network and suitable warning notices, guards and training shall be provided and maintained
- ✓ 6.1.10 when lagging needs to be removed for maintenance or repair purposes it shall be refitted as soon as practically possible and when it must be left off for an extended period suitable barriers/notices shall be put in place

Objective 6.2 – To achieve cost-effective, accurate, reliable heat metering, prepayment and billing systems

Why is this objective important?

The revenue for a scheme is dependent on the heat metering system employed and significant management costs and cashflow costs can be expended if customers lack confidence in the system, query bills or have difficulty understanding the charges.

Minimum Requirements

- ✓ 6.2.1 for residential customers, the heat meter shall be inspected at regular intervals including a check to detect tampering, in accordance with the IHCPS
- ✓ 6.2.2 the heat meter shall be exchanged and recalibrated at suitable intervals, which are determined from evidence gained from removing a small sample of meters and testing these for accuracy
- ✓ 6.2.3 if battery operated, the batteries shall be replaced at the appropriate time and to provide a suitable margin before failure
- ✓ 6.2.4 on a change of residency the new occupant shall be provided with a new set of operating instructions for the system and the meters checked and read either on site or using the AMR within a defined period and in accordance with the IHCPS
- ✓ 6.2.5 bills shall be prepared in accordance with the Energy Efficiency Directive and the Independent Heat Customer Protection Scheme (IHCPS)
- ✓ 6.2.6 customer's heat consumption shall be monitored and where significant divergence from typical trends are seen, investigations shall be undertaken to ensure the heat meter and AMR system is operating correctly
- ✓ 6.2.7 where a prepayment system is used, the adjustment of the meters to reflect any price changes shall be carried out within one month.

Best Practice

For residential schemes a distribution curve for all heat meters on a monthly basis could be prepared for each dwelling size (e.g. number of bedrooms) and the meters with abnormal readings can then be identified and passed to the meter maintenance engineer, for further investigation.

For larger non-residential customers it could be Best Practice to inspect the heat meter at least annually and to continuously monitor the readings to identify abnormal readings that could indicate a fault.

Objective 6.3 – To maintain a high level of reliability and a long life for the Heat Network

Why is this objective important?

A Heat Network is a high cost capital asset and the investment has to be justified over a long operating period. It is essential that investors have confidence that the asset can be maintained in operation without undue maintenance costs. If there is a leak in the system repairs are costly because of the need to excavate and reinstate the ground which may be a major road. If the leak is difficult to find then the repair costs can be even higher. In addition, a high standard of reliability is required to deliver a satisfactory heating service to customers. The quality of materials, design and construction of the heat network are important in determining the reliability of the system but there are important aspects of operation that can enhance the life of the system and maintain reliability.

Minimum Requirements

✓ 6.3.1 a comprehensive water treatment regime shall be implemented including:

- Regular monitoring of pressure difference across strainers and sidestream filter and removal for cleaning as required
- Chemical dosing to control pH levels to a narrow tolerance; normally this tolerance is +/0.25 with a set point between 9.25 to 10.25
- Chemical dosing to control oxygen levels
- Chemical dosing to be automatic based on monitoring of make-up water supplemented by manual weekly checks on water losses and monthly analysis of water chemistry
- Biocide dosing where operating with flow or return temperatures below 60°C
- Make-up water shall be softened prior to adding to the system

✓ 6.3.2 chemical dosing shall be carried out in accordance with the recommendations of the appointed specialist water treatment company who must have knowledge of heat networks; the recommendations will vary with the metals used in the system

✓ 6.3.3 the system shall also be monitored to detect leaks by weekly recording of make-up water and for larger systems daily. Any anomalies shall be investigated immediately

✓ 6.3.4 the surveillance system shall be maintained in operation with alarm signals reported through the main control system. All alarms shall be investigated and the location of the fault identified and repairs carried out as required.

✓ 6.3.5 to minimise the risk of third party damage, record drawings of the network, location of valve chambers and building entry points shall be maintained and provided to the local Highways Authority and other utility service providers on request, in both hard copy and digital format, and for new buildings, the Architect, Building Services Engineer and Developer as required

✓ 6.3.6 regular inspections of isolating valves and valve chambers shall be carried out at 6 monthly intervals to ensure valves remain operable and corrosion is not occurring

- ✓ 6.3.7 in the event of a leak causing a shutdown of the system, the system disaster recovery plan (DRP) shall be followed to provide temporary heating to customers or in the case of a short term interruption to advise customers in advance of the timing and reason for the interruption

- ✓ 6.3.8 comprehensive records of water treatment, water test results and repairs on the system shall be kept as these will be very valuable in assessing the life of the system should the network be the subject of a future sale or transfer

- ✓ 6.3.9 pressures and temperatures shall also be recorded to check the network has not been regularly subjected to excess pressure or temperature, particularly important for plastic pipe systems and to identify any cycling of the network

Best Practice

The use of a Reverse Osmosis plant to provide a very high standard of water quality from the outset could be considered as Best Practice.

The provision of test coupons to monitor the corrosion in the system could be used.

Objective 6.4 – To deliver a cost-effective, efficient maintenance of central plant that maintains a long life for the asset

Why is this objective important?

A high quality maintenance regime for the central plant will improve energy efficiency, provide a more reliable service, maximise environmental benefits and prolong the life of the plant. There are a number of established standards and industry guidance available including specific guidance for each type of heat source that might be used. The following generic requirements shall be followed.

Minimum Requirements

- ✓ 6.4.1 the basis for the planned maintenance regime shall be in accordance with the PAS 55 standard following the Plan-Do-Check-Act cycle of continual improvement

- ✓ 6.4.2 maintenance on central plant shall be according to manufacturer's instructions and BSRIA Guide BG3/2008 *Maintenance for Building Services* and CIBSE Guide M *Maintenance Engineering and Management*

- ✓ 6.4.3 all staff shall have received appropriate training before operating or maintaining any equipment

- ✓ 6.4.4 the operations team shall undertake a process of continual improvement to achieve optimum efficiency for the scheme at all times, based on effective monitoring of all energy flows and optimisation of controls. This will include technology reviews to consider investment which could be made on a financially viable basis to improve the system efficiency

- ✓ 6.4.5 a periodic inspection (at least annually) by senior management of the organisation responsible for the operation of the scheme shall be undertaken to demonstrate to the operators the importance that is attached to this phase of the project

- ✓ 6.4.6 major plant maintenance shall always be scheduled to minimise any interruptions in heat supply and wherever possible there shall be sufficient resilience in the system to prevent supply interruptions

- ✓ 6.4.7 whilst in part a function of the return temperatures to the scheme, the organisation responsible for operating and maintaining the energy centre and network shall do this in a manner which wherever practically possible delivers not only a high quality cost-effective service but one which involves supplying heat at the design carbon intensity and they shall take ownership of these issues and work with the building owner and operator to achieve the design return temperature.

Best Practice

Best Practice could include the continuous monitoring of the performance of the whole system to aid in optimising the operation.

Objective 6.5 – To provide appropriate monitoring and reporting of central plant

Why is this objective important?

It is important to monitor the operation of the central plant and to provide regular reports to the Owner/Developer so that a high standard of performance can be maintained. These reports may be standardised and use Key Performance Indicators based on the requirements listed below. The details of the reporting requirements will typically form part of any contract for the operation of the plant.

Minimum Requirements

✓ 6.5.1 an operating report shall be produced, at an agreed interval (e.g. monthly, quarterly, annually) to be issued to the Owner, which shall contain the following information:

- Health and safety incidents
- A full energy balance for the scheme including:
  - heat sent out from energy centre
  - heat delivered to customers
  - network heat losses (estimated from meter readings)
  - heat produced by each heat source
  - electricity generated
  - electricity consumed for parasitic loads
  - fuel used for each device
- CO_2 emissions from direct combustion of fuel to generate heat
- Indirect CO_2 emissions from electricity use and displaced CO_2 emissions from electricity generation
- Net CO_2 emissions
- Water make-up volumes (on a weekly basis)
- Water quality test results
- Availability of heat supply
- Unplanned downtime (customer minutes lost), plant failures and faults that occurred
- Planned downtime (customer minutes lost) and maintenance activities carried out
- Forward look on maintenance work over the next quarter

✓ 6.5.2 an annual report shall include the information in 6.5.1 and also information on:

- the strategic development of the scheme e.g. customers added, new extensions planned
- an overview of the heat supply and the way the heat was generated over the year
- calculation of average CO_2 emission factor for heat over the year
- information on other environmental impacts such as NOx emissions

✓ 6.5.4 the annual report shall be made publicly available electronically and issued to customers as hard copy by request, subject to any confidentiality requirements

Best Practice

More frequent reports e.g. issued on a monthly basis could constitute Best Practice.

Objective 6.6 – To maintain the building connections to provide good customer service

Why is this objective important?

The interface between the building heating systems and the Heat Network is critical in delivering customer satisfaction.

Minimum Requirements

- ✓ 6.6.1 provide a maintenance service in accordance with the requirements of the IHCPS for domestic customers
- ✓ 6.6.2 the need for servicing of the HIUs in domestic properties shall be assessed to minimise costs to residents whilst providing an acceptable level of service with respect to reliability and performance
- ✓ 6.6.3 building connections for non-residential customers systems shall be inspected to minimise costs whilst providing an acceptable level of service with respect to reliability and performance and at a maximum interval of 6 months
- ✓ 6.6.3 suitable strainers shall be provided and inspected regularly at intervals based on experience to prevent debris in the Heat Network damaging the building interface equipment
- ✓ 6.6.4 regular checks shall be made on the pressure drop across heat exchangers to indentify level of fouling
- ✓ 6.6.5 plantrooms shall be kept locked to prevent unauthorised access
- ✓ 6.6.6 a clear signing showing demarcation between different Owner/Developers shall be provided with lock offs to prevent tampering.
- ✓ 6.6.7 a Process and Instrument Diagram and valve schedule shall be affixed to the wall of the plant room.
- ✓ 6.6.8 contact details of who maintains plant and who to call in the event of an emergency shall be affixed inside the plant area and on the wall externally

Objective 6.7 – To minimise environmental impacts of operation and maintenance

Why is this objective important?

Although the overall aim of the Heat Network is to reduce environmental impact this is often seen only in terms of reducing global CO_2 emissions. It is also important to operate the Heat Network and its central plant to minimise impact on the local environment.

Minimum Requirements

- ✓ 6.7.1 the operation of the scheme and the Heat Network Operator shall be certified to ISO14001
- ✓ 6.7.2 the CO_2 content of heat delivered to customers shall be calculated regularly and reported to customers and the carbon intensity of heat supplied shall be delivered in accordance with the scheme design
- ✓ 6.7.3 emissions from all combustion plant shall be analysed on an annual basis
- ✓ 6.7.4 a boiler combustion test shall be carried out annually and any remedial works required as a result of these tests should be undertaken as soon as practically possible
- ✓ 6.7.5 noise measurements shall be taken at intervals of not more than 5 years to ensure original design conditions are being maintained
- ✓ 6.7.6 due to the nature of heat networks it is likely that from time to time due to failures or maintenance works that water is lost from the system. It is essential that any such discharges are dealt with rapidly as these volumes could be large even from a small leak due to the nature of networks and suitable health, safety and environmental procedures to deal with such eventualities shall be put in place
- ✓ 6.7.7 in the event that there are regular failures of or discharges from the plant or network a review should be undertaken of these and a plan put in place to rectify these issues to prevent recurrence

Set of questions (please write your answer in the response form):

Q 28. Do you agree with the periodic framework of the central plant's operating report to be issued to the Owner set out in Objective 6.5 above?

Q 29. Are there any requirements in the Operation & Maintenance Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

7. Customer expectations and obligations

Objectives:

7.1 To provide reports on energy supply and use and bills that are clear and informative

7.2 To develop communications with customers that meet Customer expectations

7.3 Obligations to be met by Customers

Objective 7.1 – To provide reports on energy supply and use and bills that are clear and informative to meet customer's expectations

Why is this objective important?

Customers are entitled to receive information on the way in which their energy is produced and supplied, on their own energy use and to receive bills which are clearly set out. In this respect a supply of heat should be no different to the supply of any other type of utility service. The customer may also jointly own part of the heat network and so has an interest in its operation.

Minimum Requirements

- ✓ 7.1.1 clear information shall be given to the customer with regards the tariff structure, detailing the standing (fixed) and variable charges and all other elements of the bill (metering, routine maintenance, response service, VAT etc.), how the charges have been derived and any assumptions used, in a transparent manner and in accordance with the IHCPS

- ✓ 7.1.2 the residential heat customer shall receive a bill at least once per quarter and non-residential customers once per month based on actual meter readings clearly itemising: the energy used, the charge for energy, the charge for availability, the charges for any maintenance any other standing charges and VAT, in accordance with the IHCPS

- ✓ 7.1.3 customers shall be offered the choice of whether they wish to receive a bill electronically or in paper format

- ✓ 7.1.4 where pre-payment systems are used the heat customer shall be provided with an annual statement showing the amount of energy used and the total charges made

- ✓ 7.1.5 the heat customer shall receive a statement annually comparing the heating charges for the heat network supply with the equivalent charges for alternative means of heat supply including mains gas and electricity, taking account of maintenance and capital replacements costs, in accordance with the heat cost comparator in the IHCPS

- ✓ 7.1.6 the heat supplier shall provide an annual statement for the scheme detailing the amount of heat energy supplied to the network from each energy source

- ✓ 7.1.7 the heat supplier shall provide an annual statement of the heat losses on the network based on meter readings where available

- ✓ 7.1.8 the heat supplier shall provide an annual statement of the parasitic electricity used to deliver the heat (pumping energy and other Energy Centre electricity use)

- ✓ 7.1.9 the heat supplier shall provide annually the CO_2 content of the heat delivered to the customer (taking account of heat losses and pumping energy) and a comparison with the emissions from other standardised energy supply systems such as: individual gas-fired boilers, direct electric heating or heat pumps.

Best Practice

Best Practice could involve providing bills at more frequent intervals, using actual meter data not estimates, and installing smart heat meters so users can see in real time via energy display devices their heating use and the heating cost.

Best Practice may also include a discount on the bill if the return temperature achieved is consistently lower than a specified threshold (most likely to be suitable in contracts with non-domestic customers)

Best Practice may include reporting on NOx emissions as well as CO_2 savings as this may be the main negative impact of the scheme.

Best Practice could also include an online display of the overall system performance, environmental benefits and any general fault updates

Objective 7.2 – To develop communications with customers that meet customer expectations

Why is this objective important?

Customer satisfaction can be improved from good communication. Often customers are more dissatisfied because of lack of information provided about a problem than the problem itself.

Minimum Requirements

- ✓ 7.2.1 the heat supplier shall provide general information about the operation of the scheme at least on an annual basis in the form of a newsletter. This shall include information on availability of the heat supply over the year and reasons for any outages and the terms under which compensation payments will be paid
- ✓ 7.2.2 the heat supplier shall provide notice of any interruptions of supply at least 2 days prior to any planned works and as soon as possible for any unplanned works
- ✓ 7.2.3 the heat supplier shall make specific arrangements to communicate with vulnerable customers regarding any interruption to supply
- ✓ 7.2.4 the heat supplier shall ensure that all customers are aware of a Helpline phone number to call in an emergency or to report a fault
- ✓ 7.2.5 the heat supplier shall set up a complaints procedure and a dispute resolution procedure and ensure customers are aware of this
- ✓ 7.2.6 the heat supplier shall provide information to prospective buyers or renters about the heat network and the expected charges

Best Practice

Best Practice could include the issue of more frequent newsletters, the setting up and engagement with a customer representative body and the provision of more detailed information on the operation of the scheme.

Best Practice could include automatic notification of customers (or nominated contacts) via text message in the event of any interruption of service.

Best Practice could include providing information to customers about maintenance work that affects public areas including the reasons for the work and the expected duration.

Objective 7.3 – Obligations to be met by Customers

Why is this objective important?

A successful heat network also depends on the co-operation of the heat customers. This section sets out obligations that customers should be encouraged to accept and these obligations should be provided to all customers on the scheme when joining and at regular intervals thereafter.

Minimum Requirements

- ✓ 7.3.1 customers shall understand the importance of return temperatures and ensure that their system operates as designed and take and act on advice provided by the heat network operator
- ✓ 7.3.2 customers shall not tamper with the system and shall not touch the valves or any parts of the system except designated user controls
- ✓ 7.3.3 customers shall check whether their system is at fault before calling the heat network operator in case it is an issue with their building heating system
- ✓ 7.3.4 customers shall treat operatives with respect and understand that if a heat network failure has taken place then the operator will be doing all that they can to resolve the issue, but by virtue of it being a heat network there are likely to be multiple customers affected
- ✓ 7.3.5 customers shall pay charges levied in accordance with the contract between the Customer and the Supplier in a timely manner recognising that the heat supplier is operating a local business with specific funding
- ✓ 7.3.6 customers shall not draw water from the heat network system as the treated water is costly to replace in the system and water quality can suffer
- ✓ 7.3.7 customers shall not use heat network plantrooms for storing of other equipment and shall also keep these areas locked and prevent unauthorised access

Set of questions (please write your answer in the response form):

Q 30. Should a requirement be added to the Code of Practice to establish that consumer heat tariff charges incentivise low return temperatures and charge a penalty for not returning the water for heat connections without separation between the primary and secondary systems? Please state your reasoning.

Q 31. Are there any requirements in the Customer expectations and obligations Stage that should, in your view be added, removed or modified? Please explain your reasoning with evidence where appropriate.

REFERENCES

ASHRAE (2013) *District Cooling Guide* (Atlanta, GA: American Society of Heating Refrigeration and Air-Conditioning Engineers)

CIBSE (2013) TM54, '*Evaluating Operational Energy Performance of Buildings at the Design Stage*,' (London: Chartered Institution of Building Services Engineers)

DECC (2013) *The Future of Heating*, DECC (London: Department for Energy and Climate Change)

HSE (2013) L8: *Approved Code of Practice 'Legionnaires' disease – The control of legionella bacteria in water systems* (London: Health and Safety Executive)

HSE (2014) HSG47: *Health and Safety Guidance 47: Avoiding Danger from Underground Services* (London: Health and Safety Executive)

See also Appendix B – Related regulatory requirements and guidance

APPENDICES

Appendix A - Glossary of Terms and Acronyms

Term	Definition
Automatic Meter Reading (AMR)	
Building Information Modelling (BIM)	
Combined Heat and Power (CHP)	
Control of Substances Hazardous to Health (COSSH)	
District Heating (DH)	
Domestic hot water service (DHWS)	
Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)	
Energy Centre (EC)	
Heat Networks (HN)	
Hydraulic Interface Unit (HIU)	
Independent Heat Customer Protection Scheme (IHCPS)	
Measurement Instruments Directive (MID)	

Appendix B – Related regulatory requirements and guidance

Regulatory Requirements

HM Government (1998) The Gas Safety (Installation and Use) Regulations 1998 (SI 1998/2451) (London: The Stationery Office). [Available from http://www.legislation.gov.uk/uksi/1998/2451, accessed 25 August 2015]

HM Government (2013) L1A: *Conservation of fuel and power in new dwellings*

----- L1B: *Conservation of fuel and power in existing dwellings*

----- L2A *Conservation of fuel and power in new buildings other than dwellings*

----- L2B: *Conservation of fuel and power in existing buildings other than dwellings*

--------- *Part L Compliance Guide for Heating – Dwellings*

--------- *Part L Compliance Guide for Heating – Non-Dwellings*

HSE (2013) L8 Approved Code of Practice: *Legionnaires' disease – The control of legionella bacteria in water systems*

HSE (2014) HSG 274 Part 2: *Legionnaires' disease – The control of legionella bacteria in water systems* (this document contains technical guidance in support of L8)

EU (2012)2012/27/EU: *Directive of the European Parliaments and of the Council on Energy Efficiency*

HMIP (1993) *Guidelines on Discharge Stack Heights for Polluting Emissions* HMIP Technical Guidance Note (Dispersion) D1 (London: The Stationery Office).

Relevant Guidance and Further Reading

BRE (due for publication in 2014) *Technical Guide to District Heating*

BSRIA (1996) AG 20/95: *Commissioning of pipework systems – design considerations*

BSRIA (2002) AG 16/2002: *Variable-flow water systems – Design, installation and commissioning guidance*

BSRIA (2007) BG 2/2007: *Combined Heat and Power (CHP) for Existing Buildings – Guidance on Design and Installation*

BSRIA (2008) BG3/2008: *Maintenance for Building Services*

BSRIA (2010) BG2/2010: *Commissioning water systems*

BSRIA (2012) BG 29/2012: *Pre-Commission Cleaning of Pipework Systems*

BSRIA (2013) BG 50/2013: *Water Treatment for Closed Heating and Cooling Systems*

BSRIA (2014) BG 6/2014: *A Design Framework for Building Services* (4th Edition)

BSRIA (2014) BG 45/2014: *How to Procure Soft Landings*

Carbon Trust (2009) CTG012: *Biomass heating – A practical guide for potential users*

CIBSE (2008) Guide M: *Maintenance Engineering and Management*

CIBSE (2013) AM12: *Combined Heat and Power for Buildings (CHP)*

CIBSE (2010) AM14: *Non-Domestic Hot Water Heating Systems*

CIBSE (2001) Guide B: *Heating, Ventilating, Air Conditioning and Refrigeration*

CIBSE (2012) Guide F: *Energy Efficiency in Buildings*

CIBSE (2007) KS10: *Biomass Heating*

CIBSE (2013) TM13: *Minimising the Risk of Legionnaires' Disease*

CIBSE (2008) TM46: 'Energy Benchmarks,'

CIBSE (2010) Commissioning Code W: *Water distribution systems*

HSE (2014) HSG47: *Avoiding Danger from Underground Services*

Euroheat (2008) *Guidelines for District Heating Substations* (Brussels, Belgium: Euroheat & Power) [Available from http://www.euroheat.org/Technical-guidelines-28.aspx, accessed 26 August 2014]

Euroheat (----) *District Heating Handbook* (Brussels, Belgium: Euroheat & Power)

Frederiksen S. and Werner S. (2013) *District Heating and Cooling*

GLA (2013) *District Heating Manual for London* (London: Greater London Authority)

HHIC (2013) *Benchmark - Commissioning checklist for HIUs* (Kenilworth: Heating and Hotwater Industry Council)

HVCA (2008) TR37: *Installation of Combined Heat and Power (*London: Building and Engineering Services Association)

UKDEA (due to be published) *A Guide to Developing District Energy Schemes in the UK*

International Energy Agency – District Heating and Cooling Annexes

IEA (2011) *District Heating and Cooling* (website) IEA Annex X (International Energy Agency). http://www.iea-dhc.org (accessed May 2012).

Institution of Gas Engineers and Managers

IGEM (undated) *Gas fuelled spark ignition and dual fuel engines* IGEM/UP/3 Edition 2 (Kegworth: Institution of Gas Engineers and Managers).

IGEM (2005a) *Soundness testing and purging of industrial and commercial gas installations* IGEM/UP/1 Edition 2 (Kegworth: Institution of Gas Engineers and Managers).

IGEM (2005b) *Gas installation pipework, boosters and compressors on industrial and commercial premises* IGEM/UP/2 Edition 2 (Kegworth: Institution of Gas Engineers and Managers).

IGEM (2009a) *Commissioning of gas fired plant on industrial and commercial premises* IGEM/UP/4 Edition 3 (Kegworth: Institution of Gas Engineers and Managers).

IGEM (2009b) *Application of compressors to natural gas fuel systems* IGEM/UP/6 Edition 2 (Kegworth: Institution of Gas Engineers and Managers).

IGEM (2004) *Application of natural gas and fuel oil systems to gas turbines and supplementary and auxiliary-fired burners* IGEM/UP/9 Edition 2 (Kegworth: Institution of Gas Engineers and Managers).

Guidance published by Suppliers, Contractors and Manufacturers

SAV: *Low Carbon System Design - a whole system approach "70ºC flow / 40ºC return"* [Available from http://www.sav-systems.com, accessed 25 August 2014]

District Cooling

ASHRAE (2013) *District Cooling Guide* (Atlanta, GA: American Society of Heating Refrigeration and Air-Conditioning Engineers)

Appendix C – BS, EN and ISO Standards

Heat Networks

EN 253 (2013) *District heating pipes – Preinsulated bonded pipe systems for directly buried hot water networks – Pipe assembly of steel service pipe, polyurethane thermal insulation and outer casing of polyethylene* (includes Amendment A1:2013)

EN 448 (2009) *District heating pipes. Preinsulated bonded pipe systems for directly buried hot water networks. Fitting assemblies of steel service pipes, polyurethane thermal insulation and outer casing of polyethylene*

EN 488 (2013) *District heating pipes – Preinsulated bonded pipe systems for directly buried hot water networks – Steel valve assembly for steel service pipes, polyurethane thermal insulation and outer casing of polyethylene*

EN 489 (2009) *District heating pipes. Preinsulated bonded pipe systems for directly buried hot water networks. Joint assembly for steel service pipes, polyurethane thermal insulation and outer casing of polyethylene*

EN 13941 (2009) *Design and installation of Preinsulated bonded pipe systems for district heating*

EN 15632 (2009) *District heating pipes. Pre-insulated flexible pipe systems* (Parts 1, 2 and 3)

EN 15698-1 (2009) *District heating pipes. Preinsulated bonded twin pipe systems for directly buried hot water networks. Twin pipe assembly of steel service pipe, polyurethane thermal insulation and outer casing of polyethylene*

EN 14419 (2009) *District heating pipes – Preinsulated bonded pipe systems for directly buried hot water networks – Surveillance systems*

Hot water systems

BS 7592 (2008) *Sampling for Legionella bacteria in water systems. Code of practice*

BS 8558 (2011) *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages*

Dansk Standard (2009) DS 439: *Code of Practice for domestic water supply installations* (Charlottenlund, Denmark: Dansk Standard).

Heat Meters

EN 1434 (2008) *Heat meters. Data exchanges and interface*

Above ground pipe insulation

BS 5422 (2009) *Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating with the temperature range from -40°C to 700°C* [amended by Corrigendum, November 2009]

General standards

ISO 9001 (2008) *Quality Management Systems*

ISO 14001:(2004) *Environmental Management Systems*

BS OHSAS 18001 (2007) *Occupational Health and Safety Management Systems*

PAS 55 (2008) *Publicly Available Specification for the Optimal Management of Physical Assets*

Appendix D – Checklist for commissioning Hydraulic Interface Units

HEAT INTERFACE UNIT COMMISSIONING CHECKLIST

This commissioning checklist is to be completed in full by the competent person who commissioned the HIU as a means of demonstrating compliance with the appropriate Building Regulations and then handed to the customer to keep for future reference.

Failure to install and commission according to the manufacturer's instructions and complete this Benchmark Commissioning Checklist may invalidate the warranty. This does not affect the customer's statutory rights.

Customer name:	Telephone number:
Address:	Email:
HIU Make and Model:	
HIU Serial Number:	
Commissioned by (PRINT NAME):	Registered Operative ID number:
Company name:	Telephone number:
Company address:	Email:
	Commissioning date:
Installer name:	Installation company:
Installer contact telephone number:	
Building Regulations Notification Number (if applicable)	

HIU TYPE		
1. Hot water only. (1 DHW PHE no Heating controls).	Yes	
2. Direct Apartment Heating Unit (1 DHW PHE with Apartment Heating Controls).	Yes	
3. Indirect Apartment Heating Unit (1 DHW PHE and 1 Apartment Heating PHE with Controls).	Yes	
4. Heat Only (Direct) (No plate heat exchanger just Heating Controls).	Yes	
5. Heat Only (Indirect) (1 Apartment heating plate heat exchanger with Heating Controls).	Yes	
6. HIU with integral cylinder.	Yes	
7. HIU to be connected to a cylinder.	Yes	
NOTE: If connecting HIU to an external cylinder, have you checked compatibility?	Yes	

DISTRICT SYSTEM (COMMUNITY HEATING SYSTEM)				
Primary Control arrangement:		Control Valve within HIU		Control Valve outside HIU
Balancing arrangements:		Pressure Independent		Differential Pressure
HIU Flow Regulation:		On/Off		Modulating
Differential pressure across HIU: (if applicable)				kPa
Static District pressure: (max system pressure)				bar (g)
District flow temperature:				°C
Flow control valve setting: (if applicable)				
Flow control valve type: (if external)				
Make:		Model:		
Size:		Type:		
Primary pressure system breaks:				Yes
Flushing bypass fitted and closed:				Yes
Dwelling isolation valves fitted:				Yes
If 'Yes' where:				
Strainer checked and cleaned if necessary:				Yes

*All installations in England and Wales must be notified to Local Authority Building Control (LABC) either directly or through a Competent Persons Scheme. A Building Regulations Compliance Certificate will then be issued to the customer.

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HEAT INTERFACE UNIT COMMISSIONING CHECKLIST (cont'd)

DWELLING SYSTEM								
Heat emitters type:	Radiators		Underfloor system		MVHR		Fan Coil	
Controls section:								
Time and temperature control to heating:	Room thermostat and Programmer/Timer				Programmable Room Thermostat			
					Load/Weather Compensation			
Time and temperature control to Hot Water:	Cylinder thermostat		HIU		Not applicable			
Hot Water Zone Valves: (Stored)	Fitted				Not applicable			
Thermostatic radiator valves:	Fitted				Not applicable			
Automatic Bypass to System:	Fitted within HIU				Fitted outside HIU			
Design Detail:								
Pump setting: (if applicable)								
Auto bypass setting: (if adjustable)								
Radiator circuit:					Radial		Manifold	
If 'Manifold' where is it:								
Number of heating zones:								
Cold fill pressure: (bar) (heating circuit)								
Expansion vessel pre charge pressure valve: bar (g)								
Filling loop disconnected and capped:					Yes		Not applicable	
Safety valve setting: bar (g)								
Discharge pipework has been connected:			Yes		(In accordance with the relevant regulations)			
Separate air vent's: (external to unit)					Yes		Not applicable	
If 'yes', location:								
Secondary Strainer fitted:							Yes	
Cold water meter installed?			Inside unit		Outside unit		None	
Drain cocks fitted:							Yes	

DOMESTIC HOT WATER MODE								
Type:	Instantaneous		Vented Store		Unvented Store		Thermal Store	
Store Details: (If present)								
Make and model:								
Serial number:								
Date commissioned:								
Appropriate Benchmark Commissioning Checklist completed for cylinder: (if not instantaneous)							Yes	
Instantaneous systems only: (types 1,2,3)								
What is the incoming static cold water pressure at the inlet to the system? bar (g)								
Has a strainer been cleared of installation debris (if fitted)?					Yes		Not applicable	
Is the installation in a hard water area (above 200ppm)?					Yes		No	
If yes, has a scale reducer been fitted?							Yes	
What type of scale reducer has been fitted?								
What is the hot water temperature set to?								
DHW recirculation fitted?					Yes		No	

HEAT METERS				
Heat Meter commissioned?	Yes		No	
Error Codes cleared?			Yes	

ALL INSTALLATIONS		
The HIU system complies with the appropriate Building and Trading Regulations?	Yes	
The system has been installed in accordance with the manufacturer's instructions?	Yes	
If an external cylinder has been connected, compatibility with HIU has been checked?	Yes	
The manufacturer's literature, including the Benchmark Checklist and Service Record, has been completed clearly and left with the HIU?	Yes	

Commissioning Engineer's Signature	
Commissioning Engineer's Name and Company: (Printed)	
Date:	
(To confirm satisfactory demonstration and receipt of manufacturer's literature)	

*All installations in England and Wales must be notified to Local Authority Building Control (LABC) either directly or through a Competent Persons Scheme. A Building Regulations Compliance Certificate will then be issued to the customer.

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Appendix E – Template for SAP models using Heat Networks

Applying district heat network performance parameters to the Standard Assessment Procedure (SAP2012)

Reference Document: The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2012 edition
Published on behalf of DECC by: BRE, Garston, Watford, WD25 9XX

SAP is an energy assessment tool for dwellings. It is designed to calculate annual carbon emissions for England Building Regulations Part L 2013 compliance checking.

A district heat network is entered into SAP by use of the 'Community Heating' system selection.

Plant selection

Single or multiple plant items can be input into the tool including CHP and different fuel types as listed in SAP2012 Table 12. The fuel, efficiency and proportion of heat from each energy centre plant item must be calculated and provided to the SAP energy assessor.

Efficiency

Boiler efficiency must be calculated in accordance with the methodology provided in Appendix D of SAP2012. The winter efficiency should be used for all parts of the year and the summer efficiencies excluded from the calculations.

CHP efficiencies are defined for heat as the annual useful heat, excluding dumped heat, supplied by a CHP scheme divided by the total annual fuel input. For power efficiency the total annual power output is divided by the total annual fuel input.

Proportion of heat

The proportion of heat for each plant item is based on annual operational records allocating the proportion of useful heat energy each item provides. In the case of new systems this is based on the design calculations.

Distribution losses

Default distribution losses based on system type can be used if any of the following are met:

- The only dwellings connected to any part of the network are flats, or
- The total trench length of the network is no longer than 100 metres, or
- The linear heat density is not less than 2 MWh/year per metre of network.

Where these are not met the losses must be calculated in accordance with section C3 of SAP2012.
Hot water

Where hot water in addition to space heating is provided the system entered into the SAP tool must include the storage volume of cylinders and/or HIUs assigned to each dwelling. The relevant loss factors should be entered as provided in Table 2 and 2a of SAP2012. Where neither applies the calculation should assume a cylinder of 110litres and loss factor of 0.0152 kWh/litre/day.

Appendix F – Guidance on types of building connections

Space heating systems

Objective 3.5 and Appendix G below discusses the selection of operating temperatures for the heat network. The space heating circuit within the building needs to be designed to be compatible with the network temperatures. The building services designer should aim to achieve as low a return temperature as practical as this will benefit the Heat Network. This can be achieved by:

- Selecting lower mean heating circuit temperatures and using larger heat emitters to compensate
- Reducing the flow rates to the emitters to create a wider temperature difference and hence a lower return temperature

The first option will add to the costs of the heating systems but may be beneficial overall taking account of the heat network costs. The second option requires consideration of balancing and control and also the need to ensure that flow velocities in pipework are not too low resulting in sluggish response.

Even where the existing heating system has been designed for the conventional 82°C flow 71°C return, it is usually possible to reduce the flow rates to provide an 82°C/60°C radiator circuit temperatures resulting in only a small loss of output (typically about 12.5% for these temperatures). An assessment of building heat loss and existing heat emitter sizing may establish that even lower temperatures can be used, especially where fabric improvements have been made subsequent to the original heating installation. It is also important to investigate whether the control system can be modified to a variable volume control system that will maintain low return temperatures under part-load operation.

Domestic Hot Water Services (DHWS)

Hot water services can be generated with a storage system or instantaneously and either centrally or at a dwelling or outlet level.

Storage hot water systems have the following design advantages and disadvantages:

Pros

- Lower peak demands in the final branch pipework to the dwelling
- Storage provides a degree of standby enabling short-term interruptions of the network supply to be tolerated in summer, especially where electric immersion heaters are also installed as back-up
- Opportunity to provide intermittent heat supply from the network to reduce heat losses from local branch pipework and there is no need for thermal bypasses
- Opportunity to schedule the time when the heat from the network is used (e.g. use of night-time heating if a heat pump based heat network is used)

Cons

- Possible to ‘empty’ the tank if long demand duration
- Heat losses from the cylinder need to be taken into account and may contribute to summer overheating in well insulated properties
- Water needs to be stored at 60°C for legionella control
- Where a domestic storage cylinder with a coils is used, return temperatures will generally be higher than for instantaneous except in the unlikely case of heating up from cold
- Space is required in the dwelling for the storage cylinder

Instantaneous hot water systems have the following design advantages and disadvantages:

Pros
- No limit to duration of hot water supply
- Low return temperatures achieved when drawing off hot water
- Compact design, releasing space within dwelling
- Low heat losses from heat exchanger (when insulated) so minimal impact on overheating risk

Cons
- Higher flow rates and diameters in branches serving 5 or less dwellings
- Heat exchanger needs to be kept warm at all times to give good response time, this can lead to higher return temperatures in off periods and higher losses from branch pipes
- No opportunity for short interruptions of heat network supply without impacting the service
- Risk of scaling in hard water areas especially with high primary side temperatures
- May have higher maintenance costs for control valves and heat exchanger especially where the HIU is located within a dwelling and so less accessible; good water quality will minimise these costs

Centralised hot water services have the following design advantages and disadvantages:

Pros
- Lower cost for heat exchanger equipment as it is centralised
- Lower maintenance costs as simpler system at dwelling
- No space required in dwellings
- No heat losses within dwellings so no impact on overheating risk
- Legionella risk can be controlled as water is stored and circulated at 60°C with a maximum return temperature of 50°C (see L8, HSE)
- Space heating circuit can have variable flow temperature to limit heating use (valuable for unmetered schemes)
- Space heating circuit can be shut down entirely in summer (subject to contractual arrangements) reducing secondary pipework heat losses in summer
- Opportunity for use of a two-stage DHWS system where cold feed water is pre-heated by space heating return

Cons
- Higher cost for distribution pipework (as 4-pipe system – flow and return heating and flow and return DHWS) More space is required in risers for 4 pipes
- Additional heat losses in winter from DHWS flow and return as well as space heating flow and return (although latter can be smaller than for a two-pipe system which offsets this disadvantage)
- Separate metering of hot water use is needed resulting in higher costs – (this could be an advantage in providing feedback of energy use data and volume based metering for hot water use is low cost however a more complex metering and billing system would result)

Individual dwelling hot water services have the following design advantages and disadvantages:

Pros

- A single heat meter can be used for both space and water heating
- Space required for secondary distribution is less (2-pipe not 4-pipe)

Cons

- More space is required within the dwelling although for instantaneous DHWS this is relatively small

The options available for dwelling heating systems in apartment blocks are given in Figures F1 to F6 below.

In the new build sector individual dwelling instantaneous hot water heat exchanger systems predominate due to their compactness and because lower return temperatures can be achieved compared to cylinders with coils.

Where centralised hot water is produced external plate heat exchangers should be used instead of coils and this would also be a good technical solution for individual dwellings. Existing buildings will have a wider range of designs with the 4-pipe centralised hot water system popular with unmetered social housing.

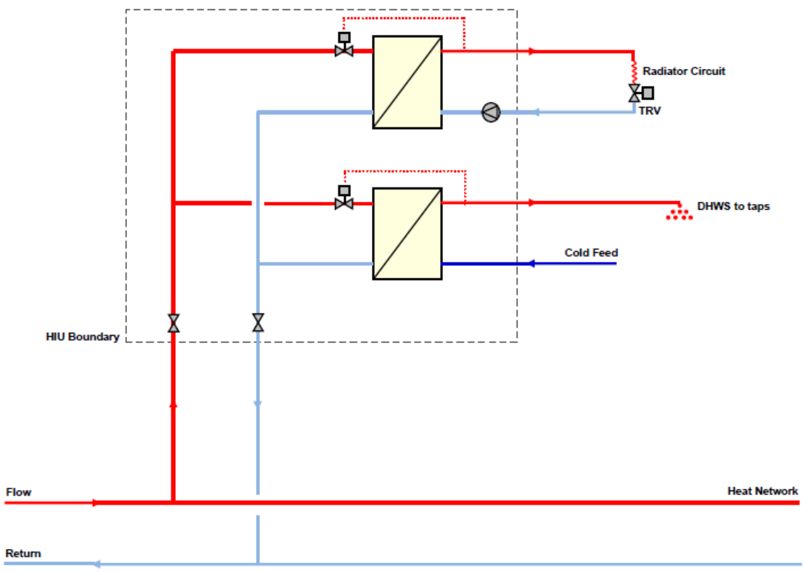

Figure F1 – Indirect space heating and instantaneous hot water heating

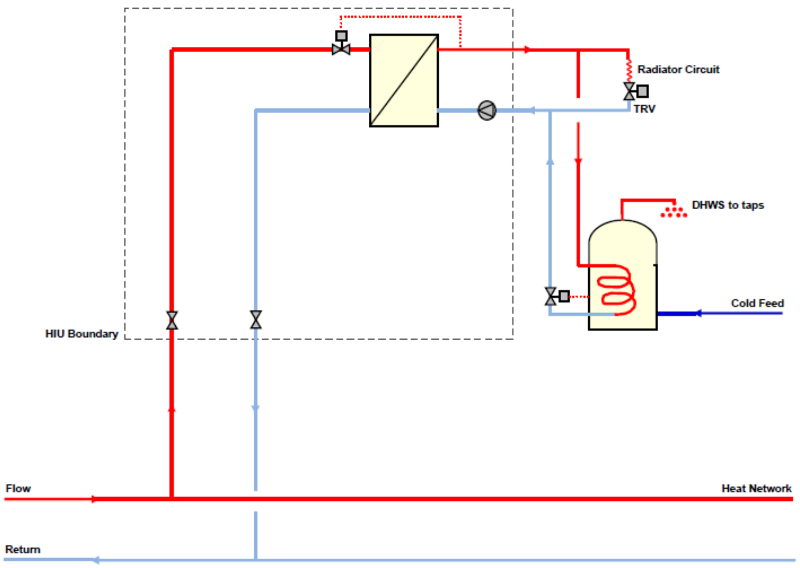

Figure F2 – Indirect space heating and hot water cylinder (external plate heat exchanger for the hot water storage is also possible)

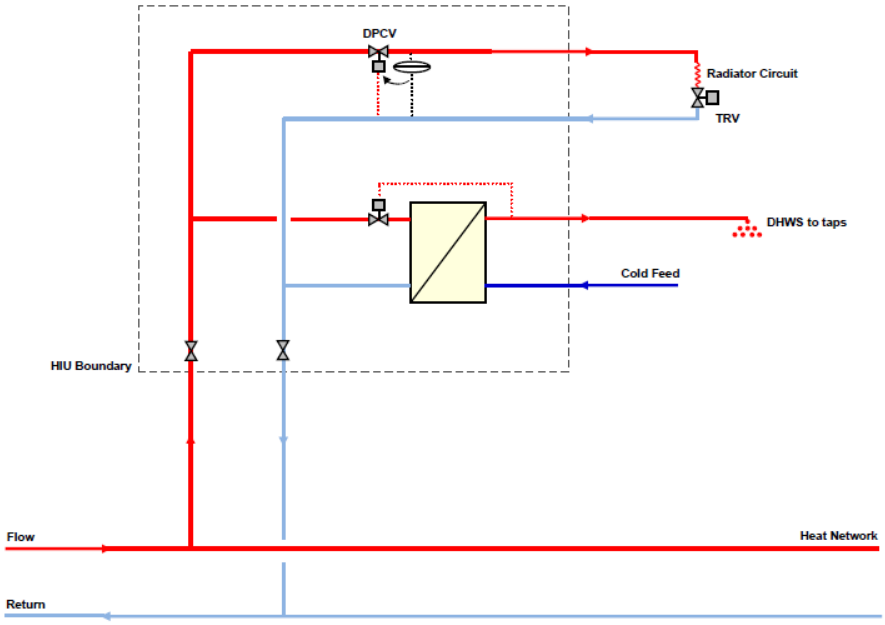

Figure F3 – Direct space heating and instantaneous hot water heating

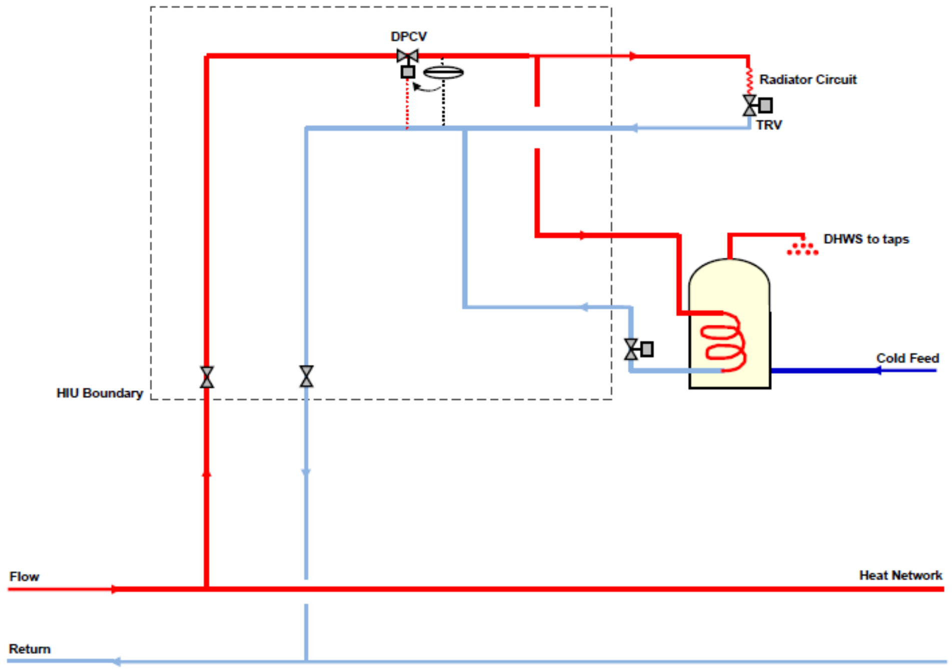

Figure F4 – Direct space heating and hot water cylinder (external plate heat exchanger for the hot water storage is also possible)

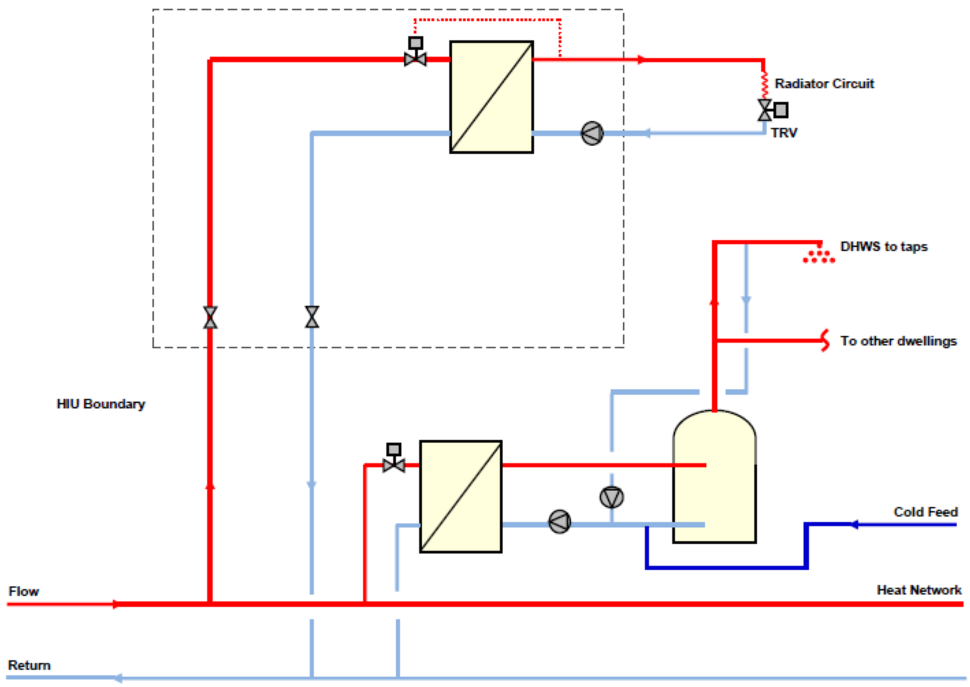

Figure F5 – Indirect space heating and centralised hot water

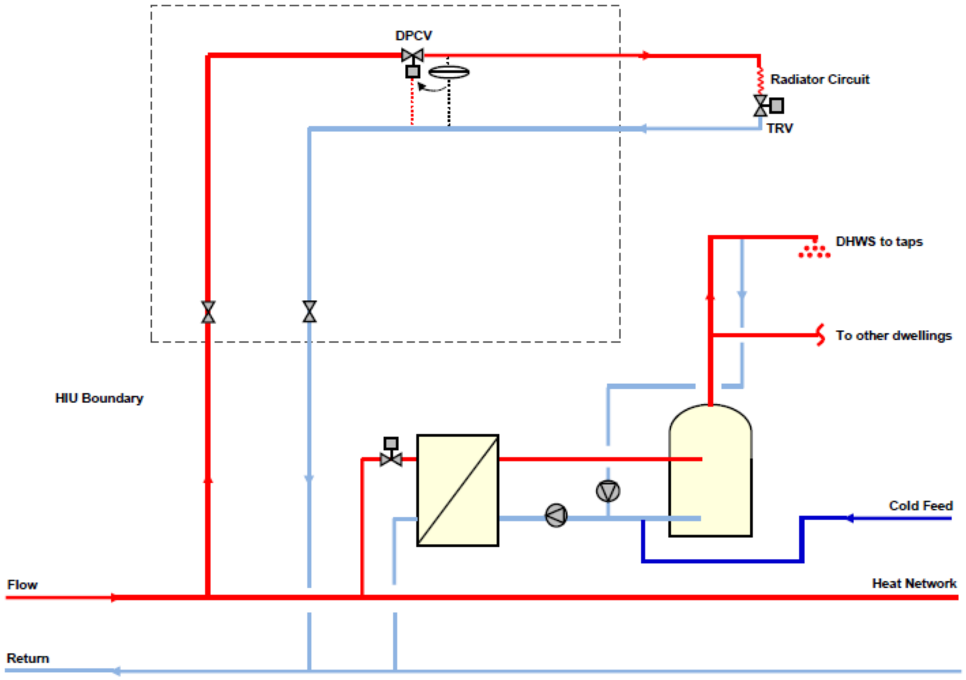

Figure F6 – Direct space heating and centralised hot water

Appendix G – Guidance on achieving an energy-efficient Heat Network

Length of network

The most fundamental requirement is to minimise the length of the installed network. This will also normally be driven by a requirement to minimise capital costs. The overall density of development will be a major factor in the length of the network but the designer should consider other issues, including the location of the Energy Centre, and assess the various options for network routes.

Pipe sizing

If the pipe is oversized then heat losses will be higher. This may arise as a result of over estimates of peak heat demands (see Objective 3.2) or a failure to analyse the network to minimise lifecycle costs (see Objective 3.6).

Operating temperatures

A key factor is the selection of operating temperatures. Lower operating temperatures will result in lower heat losses. However, pumping energy and the capital cost of the network will be lower if flow rates are reduced by increasing the *difference* between flow and return temperatures. As these two requirements cannot both be satisfied there is a need for optimising the temperatures within any heat network.

The network cannot be analysed in isolation from the building services within the customer's buildings and the heat source(s). Lower operating temperatures and lower return temperatures can be achieved through appropriate building services design i.e. by using larger heat emitters and selecting suitable approaches to controls. This may lead to higher costs for the building services but lower costs overall. The operating temperatures selected for the network can have an impact on the efficiency of the heat source and hence its cost and CO_2 content.

There has been a trend over the last 30 years towards the use of lower operating temperatures so as:

- to reduce heat losses from the network
- to obtain energy efficiency benefits at the heat production plant especially where heat is extracted from a steam cycle or where a heat pump is used

The analysis also needs to consider the operation over the year not just at peak demands. Reducing the flow rates at part load using variable volume control principles and limiting bypass flows is important to limit pumping energy and to maintain low return temperatures and hence low heat losses from the return pipe. The use of a variable flow temperature, with a higher temperature used for short peak demand periods can also be advantageous.

The selection of operating temperatures for peak design conditions and how they vary with demand requires an optimisation study for any given scheme as it will be impacted by the type of heat supply plant and the characteristics of the heat network. The designer has also to consider constraints such as the temperatures used for existing heating systems and the degree that these can be varied. **Hence the Requirements given below may not be valid in all cases and may be over-ruled by the conclusions of a detailed study for an individual scheme.**

Insulation levels

Although operating temperatures are important the selection of the pipe system itself and the insulation type and thickness also have an important influence on the heat losses. The network losses will need to be calculated for a range of design choices and taken into account in an overall economic analysis. In particular consideration shall be given to:

- the thickness of insulation available for pre-insulated pipe systems manufactured to EN253 (typically three thicknesses are available)
- the thickness and type of insulation available for pre-insulated flexible polymer pipe systems where a range of heat losses can result
- with steel systems, the provision of a diffusion barrier to contain the low conductivity gas within the foam insulation and in the case of polymer pipes, a diffusion barrier to prevent water diffusing into the insulation through the carrier pipe
- the use of twin pipe systems – two carrier pipes in one casing which will result in lower heat losses

Pump selection

The use of variable flow control systems and variable pump speeds to match the variation in flows and pressures will lead to much lower pumping energy than for constant flow systems. However, operating a variable speed pump at very low speeds is not advisable due to losses in the control invertors and consideration should be given to selecting a range of pump duties, with respect to both flow and head, to better match the network part-load conditions.

It is emphasised that the heat network will only rarely if ever operate at its peak design condition and for the majority of the time the demands will be much lower than this, typically 10% to 25% of peak (see Figure G1). This has implications for the selection of pumps, the sizing of pipes and the setting of bypass flows.

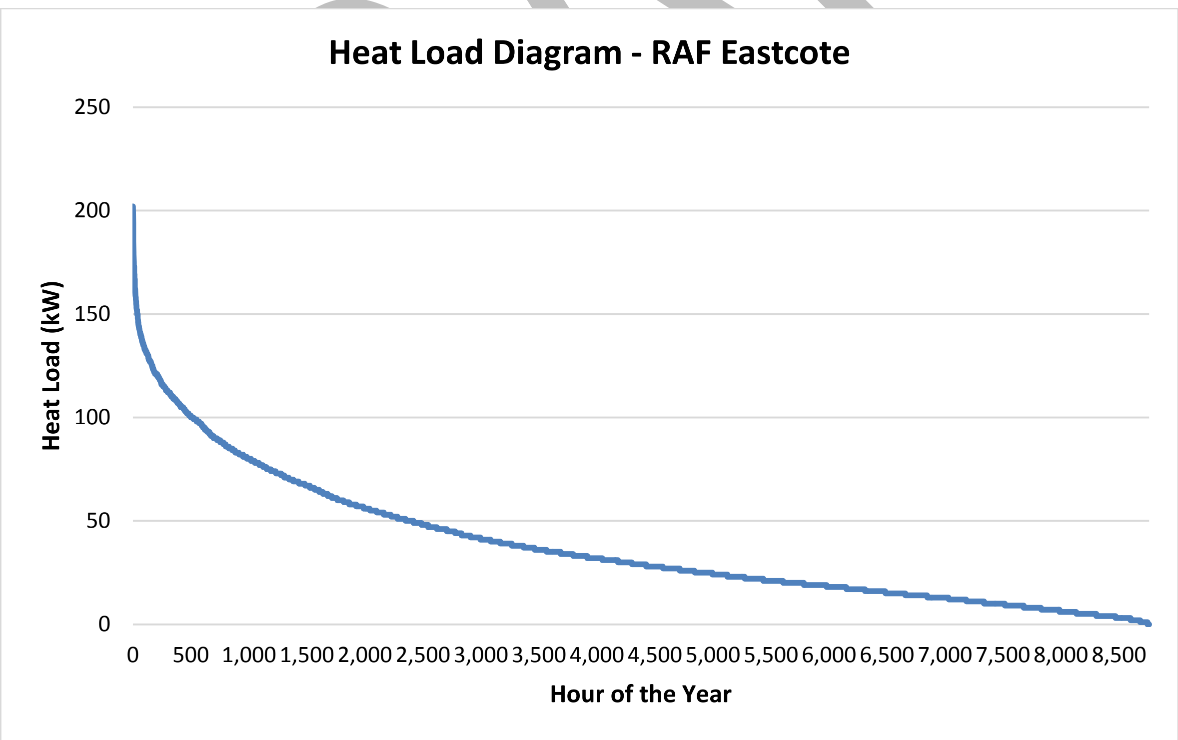

Figure G1 – Load duration curve for typical new build scheme of 50 houses (reproduced courtesy of Vital Energi)