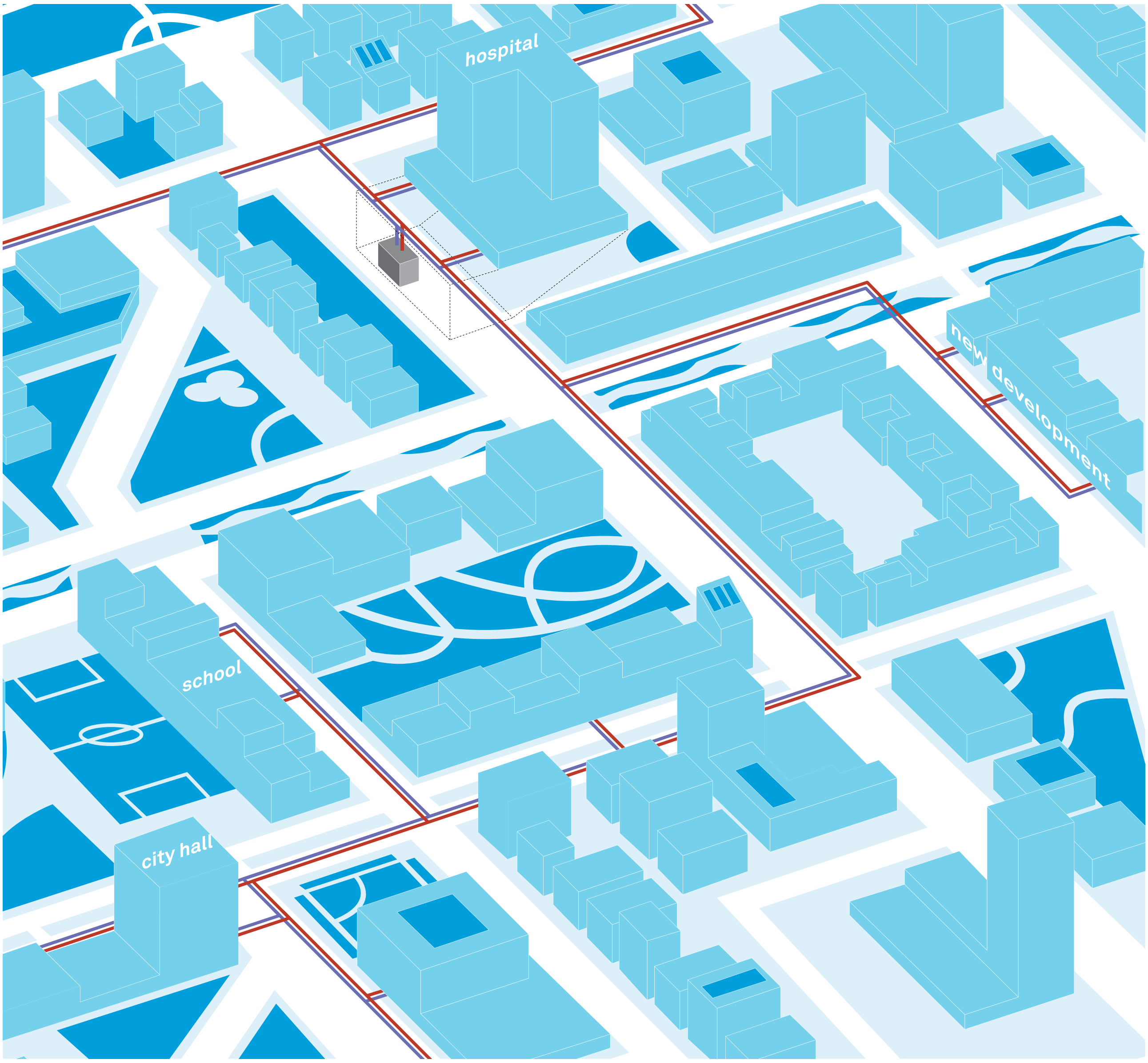

DISTRICT HEATING MANUAL FOR LONDON

MAYOR OF LONDON

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DISTRICT HEATING MANUAL FOR LONDON

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CONTENTS

GLOSSARY

AMR	Automatic Meter Reading
CCME Strategy	Climate Change Mitigation and Energy Strategy
CHP	Combined Heat and Power
CIL	Community Infrastructure Levy
CV	Calorific Value
D&B	Design and Build
DBO Contract	Design, Build, Operate Contract
DE	Decentralised Energy*
DH	District Heating
DHN	Decentralised Heat Network
DHW	Domestic Hot Water
DUKES	Digest of United Kingdom Energy Statistics
EMP	Energy Master Plan
EPR	Environmental Permitting Regulations
ESCo	Energy Services Company
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
HE	Heat Exchanger
HIU	Heat Interface Unit
IGT	Independent Gas Transporter
kW	Kilowatt (unit of power)
kWh	Kilowatt hour (unit of energy)
LDF	Local Development Framework
LDO	Local Development Order
MW	Megawatt (unit of power)
MWh	Megawatt hour (unit of energy)
NBP	National Balancing Point
NJUG	National Joint Utilities Group
NPV	Net Present Value
NRSWA 1991	New Roads and Street Works Act 1991
O&M	Operation and Maintenance
Pa	Pascal (equivalent to one newton per square metre)
PFI	Private Finance Initiative
PI Diagram	Process and Instrument diagram
RHI	Renewable Heat Incentive
ROC	Renewables Obligation Certificate
SLA	Service Level Agreement
SPD	Supplementary Planning Document
SPG	Supplementary Planning Guidance
SPV	Special Purpose Vehicle
UIP	Utility Infrastructure Provider

INTRODUCTION

1

Heat is the single biggest reason we use energy in our society. We use more energy for heating than for transport or the generation of electricity. The vast majority of our heat is produced by burning fossil fuels (around 80% from gas alone), and as a result heat is responsible for around a third of the UK's greenhouse gas emissions.

This is unsustainable. If the UK is to play its part in the global effort to combat climate change, we will need our buildings to be virtually zero carbon by 2050. The transformation of heat-generation and heat-use will create new markets and new opportunities. It is clear that district heating networks operating as part of a decentralised energy system have the potential to supply market competitive low to zero carbon energy in dense urban areas whilst providing long-term flexibility to accommodate new and emerging heat production technology and energy sources.

In the UK, a legally binding target was set in the Climate Change Act 2008 to cut UK carbon dioxide emissions (CO_2) by 80% by 2050 from 1990 levels, with at least a 34% reduction to be achieved by 2020. The UK is also subject to the target included in the 2009 Renewable Energy Directive to achieve 15% of its energy consumption from renewable sources by 2020.

Against this backdrop, London has implemented its own targets that go beyond those at national and international level. In October 2011, the Mayor of London published his revised Climate Change Mitigation and Energy (CCME) strategy, entitled 'Delivering London's Energy Future'[1]. The strategy focuses on 'reducing CO_2 emissions to mitigate climate change, securing a low carbon energy supply for London, and moving London to a thriving low carbon capital.' Specifically, the strategy reiterates the Mayor's target to achieve 25% of London's energy supply from decentralised energy sources by 2025.

With energy at the heart of our major cities' transformation to sustainable, resilient low-carbon communities, the delivery of new energy infrastructure will be critical to securing our energy future. It is in this context that the Mayor of London has produced this District Heating Manual for London. The DH Manual is intended to provide guidance to the development and delivery of district heating networks in London.

1.1 Status of DH Manual

This DH Manual is intended to be a practical, accessible and consistent guidance document. It is not intended to supersede other published technical standards or good practice guides, but its use is recommended for all projects supported by the Mayor's Decentralised Energy for London programme (so far as appropriate) and is commended to London boroughs, the public and private sector developers and the DE industry as a whole.

In order to ensure future flexibility, the DH Manual will not be published by the Mayor as formal supplementary planning guidance (SPG). Nevertheless, it may be suitable as a standard to be used in planning conditions and obligations, or to be cross-referenced by local planning authorities within their own supplementary planning documents on sustainable design or infrastructure delivery.

1 Mayor of London, October 2011. Delivering London's Energy Future. Available online at http://www.london.gov.uk/who-runs-london/mayor/publication/climate-change-mitigation-energy-strategy

1.2 Network Scale and Context

The Mayor's Climate Change Mitigation and Energy (CCME) strategy defines decentralised energy (DE) as 'low and zero carbon power and/or heat generated and delivered within London.' This definition covers a wide range of technology and scales, from single building schemes using microgeneration technologies to area-wide schemes connected to local power stations and large energy centres serving thousands of customers. With larger schemes entailing the use of district heating networks there are few UK guidelines as to their design and operation.

The Mayor's Decentralised Energy for London programme is focused on delivering DE at scale to maximise market competitiveness, and ensuring that smaller relevant projects are designed from the start to enable growth and connection into larger systems to achieve more economic and efficient operation. The term 'District Energy', as detailed in Table 1, is used in this context to distinguish between single building or single customer systems and those DH networks which serve multiple customers across an urban district or sub-region.

These initial networks are expected to form the major building blocks of what will over time become an interconnected London-wide district energy network. Building networks to a common set of standards will allow systems to operate at their most economic and enable expansion, increasing the opportunities for further development of system integration, efficiency, reliability and resilience.

This DH Manual therefore focuses on the 'District Energy' end of the scale range. The DH Manual will, however, still be relevant for the design of smaller stand-alone schemes, since these will be expected to be designed to connect to larger networks in the future.

	Type 1: Single development (small scale)	Energy is generated and distributed to a single development that may include a large single building and/or a number of buildings and customers (up to around 3,000 domestic customers). The plant may or may not be owned and operated by the energy users. This would include smaller communal heating schemes. It would also include larger onsite networks with CHP generation equipment in the order of 3MWe capacity and project capital costs in the region of £10 million. The Cranston Estate regeneration project in Hackney is a typical example.
District Energy	Type 2: Multi-development (medium scale)	These supply energy to more than one site, for which district heat networks are a necessary requirement. A wide range of customers and demand types may be involved, with a number of different generation systems connected typically totalling up to 40MWe in capacity. This scale could support up to 20,000 homes, public buildings, and commercial consumers. It is very likely that the plant would be owned and operated by a third party. The system could cost up to £100 million. The Olympic Park and Stratford City project is a recent example.
	Type 3: Area-wide (large scale)	These are large infrastructure projects constructed over a long period. Such schemes typically involve several tens of kilometres of heat pipe supplying 100,000 customers or more, and providing connection to multiple heat generators such as power stations. Capital costs of piping could exceed £100 million. It is likely that separate bodies would own and be responsible for different parts of the system. Such systems can take from five to ten years to deliver. The proposed London Thames Gateway Heat Network is an example.

Table 1. Three scales of decentralised energy
(http://www.london.gov.uk/sites/default/files/Energy-future-oct11.pdf)

1.3 Scope of the District Heating Manual

The DH Manual covers the following aspects of developing a DH network;

- The design principles and technical concepts for the physical infrastructure focusing on interfaces between heat production plants and network, network and consumer installations;
- Guidance on contract structures and management to help inform developers and project sponsors of appropriate options and the key issues to be considered when establishing delivery vehicles and determining procurement strategies;
- Guidance on the build up of tariff structures and associated charges that can reasonably be incorporated as part of a project's revenue streams; and
- Guidance on the relevant planning policy and typical requirements of local planning authorities.

The final section of the DH Manual considers opportunities to deliver more efficient, more viable DH systems through future technical, commercial and policy innovations. This section is intended to provide insight to the future role of district heating networks and to demonstrate the technology's flexibility.

The DH Manual specifically excludes any detailed guidance of heat supply technologies as there are many options and the appropriate heat source or sources for any network will vary by developer and project. Typical examples are provided in Section 2.2 Heat Production.

It is anticipated that heat supply will be from low cost heat sources including waste heat, low grade heat from CHP, gas fired CHP, and/or heat pumps. These technologies will usually be supported by peak/back-up boilers firing gas in order to minimise investment cost and provide necessary resilience to the energy centre heat supply.

DISTRICT HEATING IN LONDON

2

2.1 The Evolution of District Heating in London

The Mayor's first Energy Strategy was published in 2004, highlighting the growing issues of energy security and fuel poverty in London within the global problem of climate change and resource constraints. It outlined the energy hierarchy of 'Be Lean, Be Green, Be Clean' promoting reduction in energy consumption and efficient supply of renewable energy. The strategy committed to supporting the growth of decentralised energy generation as a core component of sustainable energy supply, and developing the electricity distribution network so that it could accommodate and facilitate increased decentralised generation.

This driver led to the first ever strategic decentralised energy planning across London and realisation of the London Heat Map (2009/10). The London Heat Map revealed that good opportunities for the creation of district heating networks exist across the capital and laid the foundations for detailed feasibility study work and the development of planning policies to support the development of DH networks particularly with a view to connect new development to those networks.

Further work to understand the technical and commercial elements needed to deliver district heating networks led to the publication in 2009 of a DE prospectus for London entitled 'Powering Ahead'[2]. Powering Ahead detailed the size of schemes envisaged and the commercial and contractual structures that would be needed to make each project happen. The document provided evidence that projects were beginning to take shape.

In 2010-2011 the Mayor undertook a major study, 'London Decentralised Energy Capacity Study – Phases 1-3' [3] to assess the potential for low and zero carbon energy supply in London. The results showed the following:

- There is considerable opportunity for London to generate its own energy, reducing the city's reliance on the national grid;
- Over half of the overall opportunity for decentralised energy in London is in medium and large-scale heat networks;
- A significant proportion of the opportunity for decentralised energy in London relies upon the use of Combined Heat and Power (CHP) generation; and
- There is also significant potential for micro-generation technologies in London.

This early work continued to shape the direction of the decentralised energy programme to date and as such, the greatest focus for the GLA has been on developing the heat networks. This is an area of market failure that has created a barrier to the development of city-scale decentralised energy projects capable of delivering the quantum of CO_2 emission reductions necessary at market-competitive prices. Modern district heating networks involve the use of low cost heat sources and their economic evolution in the urban environment depends on ensuring the interconnectability of smaller-scale schemes. This focus aims to ensure that linked schemes evolve into larger-scale networks able to take lower cost heat from larger scale more efficient plant, some utilising cheaper more difficult primary fuels.

More recently the updated London Plan[4] (July 2011) requires London boroughs to embed policies and proposals within their Local Development Frameworks (LDFs) in support of establishing DE network opportunities, with particular focus on heat networks.

2 Mayor of London, October 2009. Powering Ahead – Delivering low carbon energy for London. Available online at http://www.london.gov.uk/who-runs-london/mayor/publications/environment/powering-ahead-delivering-low-carbon-energy-london

3 Mayor of London, October 2011. Decentralised energy capacity study. Available online at http://www.london.gov.uk/priorities/environment/climate-change/decentralised-energy

4 Mayor of London, July 2011. London Plan.

As such, the Mayor's Decentralised Energy for London programme, launched in October 2011, began to engage with sponsors of potential DE projects, building on the legacy of earlier work. The programme has a key role in delivering the decentralised energy target by providing technical, commercial and financial advisory support to help bring decentralised energy opportunities to market. These actions will contribute to an increase in Londons' installed capacity and will build confidence in the market, catalysing sustained investment in an expanding network of decentralised energy schemes across the capital.

2.2 Heat Production

Larger scale decentralised energy schemes incorporating district heating networks offer an affordable way of achieving low carbon energy supply in densely populated areas such as London, meeting domestic, commercial and some industrial space heating and domestic hot water requirements.

The use of Combined Heat and Power (CHP) with DH results in the highly efficient use of fuel, up to 80-90% efficiency, with primary energy savings of 30-45% compared with the conventional separate generation to achieve the same quantity of heat and power. Due to the efficiency of CHP, emissions to the environment are approximately 30% less than in separate generation of electricity and heat. This is represented in Figure 1.

This DH Manual does not consider energy production technology in any great detail. Equipment manufacturers and consultants can provide this information on an individual project basis. The technology selection will depend on a range of considerations but will primarily be influenced by the economics of the project. A number of technologies may be used within a single energy centre to ensure efficient and reliable operation across the range of heat demands. The heat supply sources will effect the economics and carbon intensity of the DH scheme.

A principle of resilience should be applied to the heat production to ensure that should a heat source fail, then there is sufficient alternative heat supply available to meet consumer demands. In practice this usually means gas boilers are used for back-up and peak heat supply, but any source can be considered provided minimum service levels can be maintained.

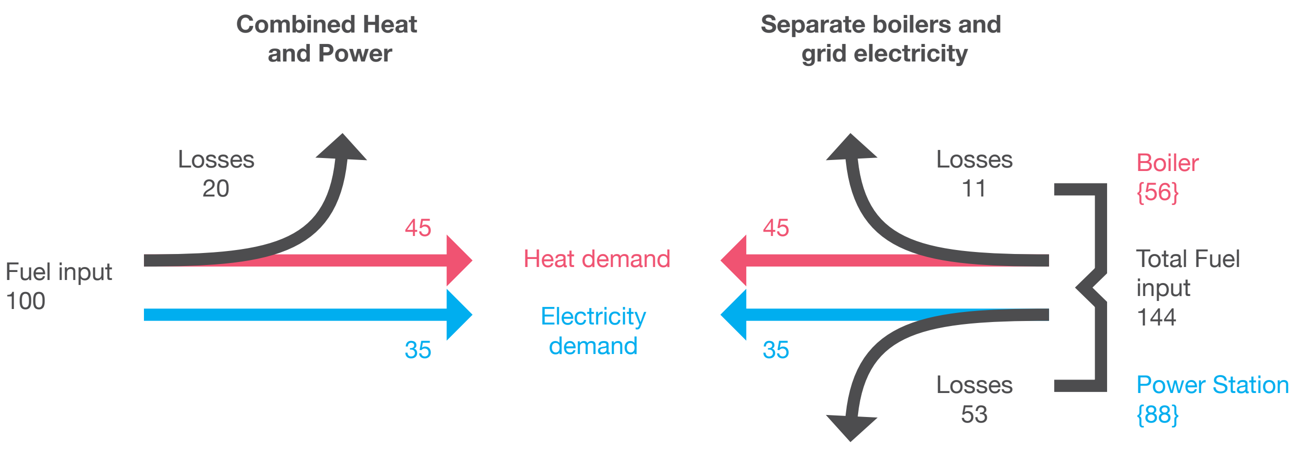

Figure 1. The Benefits of Combined Heat and Power (Source: CIBSE, Good Practice Guide, GPG388)

Figures 2 – 5 indicate some example arrangements of plant although there are many variations and alternatives available.

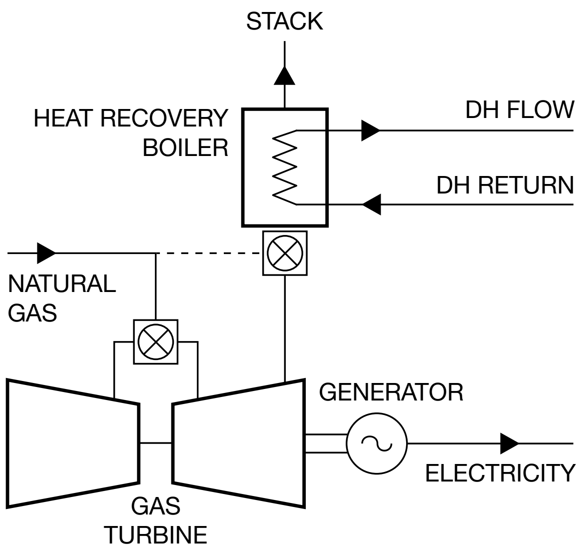

Figure 2. Typical DH from Gas Turbine CHP

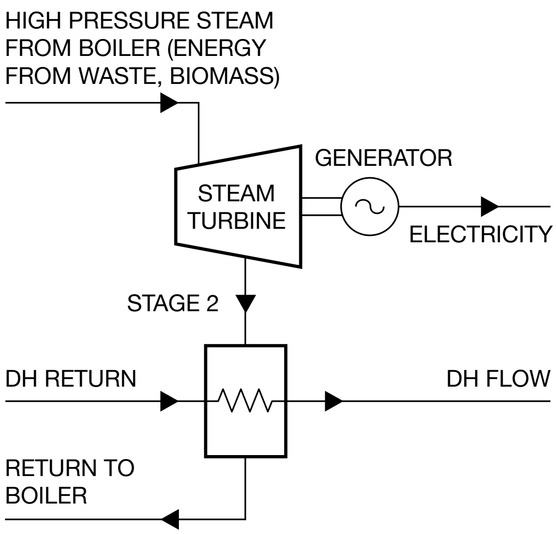

Figure 3. Typical DH from Energy from Waste or Biomass boiler and steam turbine

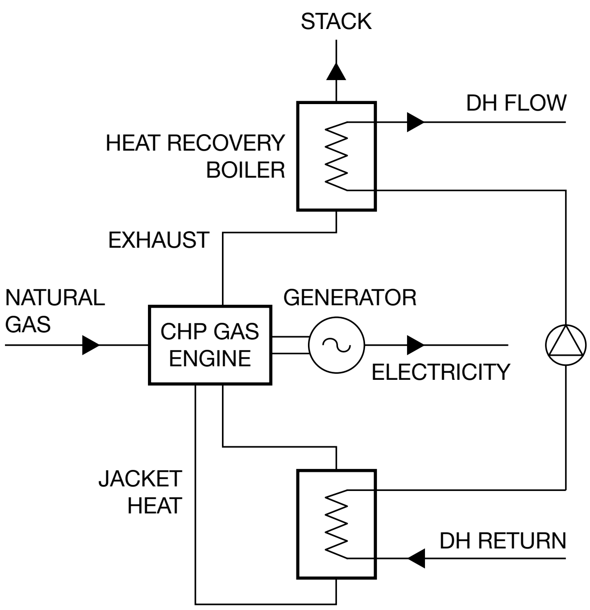

Figure 4. Typical DH from gas reciprocating CHP

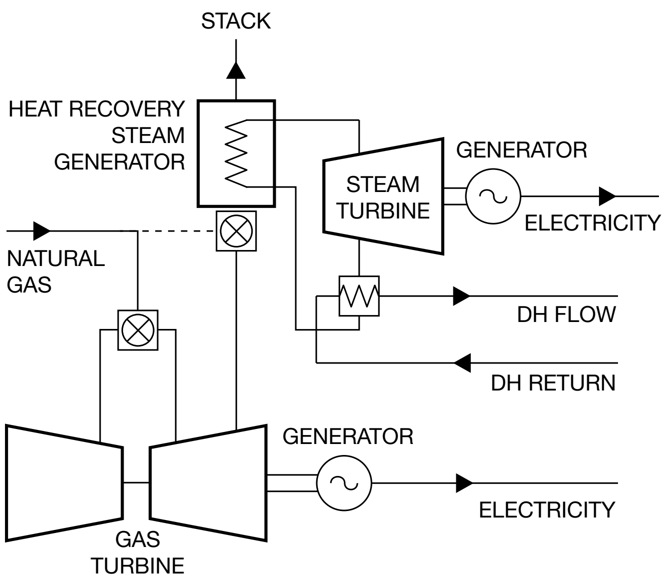

Figure 5. Typical DH from Combined Cycle Gas Turbine CHP

2.3 Heat Distribution

Heat is distributed in the form of hot water from the heat source(s) by means of district heating pipework to the consumers. Such are reliable, long life assets that can deliver heat regardless of the source. Indeed the heat source may change over time as the energy market and technologies change to favour new generation technologies or other more economic heat sources.

The flexibility of district heating is improved as networks are interconnected allowing access to lower cost heat sources. It may also be possible to decommission smaller energy centres and supply the interconnected network from larger energy centres with reduced maintenance cost. This would allow the decommissioned energy centre to be put to other use. In order to realise these benefits it is important to ensure that networks are built with a common design basis and this manual outlines a design standards that should allow these future benefits to be realised.

2.4 Benefits of a District Heating Network

The benefits of any DH scheme in brief are summarised in the Table 2 below.

	Benefits of a district heating network	Potential benefits of a strategic wide network

Consumer	• Small space requirement and safe operation;
	• Easy to control and operate;
	• Affordable cost and long term price stability;
	  ◦ DE systems can also help address fuel poverty and give peace of mind to vulnerable populations by:
	    ▪ ensuring the efficient management of heat provision;
	    ▪ providing more stable prices;
	    ▪ offering lower prices. District energy schemes can offer lower costs than microrenewables in achieving low or zero carbon energy supply.
	• Resilient design to provide secure heat;
	• Modern DH schemes are metered, consumers therefore only pay for what they individually consume.
		• A genuine heat market may develop allowing competition and lower costs;
		• Greater security of supply as multiple heat sources supply the same network.

Developer	• Lower cost solutions: a heat network may provide a lower cost method of achieving carbon targets than the equivalent deployment of microrenewables; • District Energy network can be set up as an attractive ESCo offering, adding development value or removing the developers need for long term engagement in the project.	• The opportunity to extract more value from existing energy centre assets. If a CHP engine can supply a greater heat load then it will generate a better return; • If the energy centre economics have been eroded through market or technical advances then a heat network connection will allow cheaper heat to be bought from elsewhere on the network than from a stranded asset on a small network; • The potential to decommission the energy centre plant, and have consumers on the network supplied fully by another energy supplier. This would reduce costs and would free up space for alternative uses.
London and the Environment	• Flexibility for fuel changes, possibility to optimise fuel mix; • Lower CO_2 emissions; • Potential for low carbon economy; • District Energy, together with Combined Heat and Power, is the most energy efficient way of providing heat to buildings.	• As networks are connected together greater use of more efficient plant can be made, reducing emissions and lowering carbon; • Step changes in energy production efficiency can be made as new and lower carbon heat sources become available and are less site specific; • Incentive to make better use of waste heat through energy from waste plant.

Table 2. Benefits of a DH network

In addition to the overall energy system efficiency and associated economic and carbon benefits, district energy offers a number of other advantages over the conventional stand-alone approach to building energy supply:

- They facilitate the deployment of embedded CHP and can thereby obviate the need for electrical network reinforcement and additional peaking plant in areas of development growth;
- They can be supplied by a number of different heat sources, either operating alone or as a combination of plant types.

Heat networks with thermal storage can decouple the timing of generation from that of supply. Using a thermal store at an energy centre can allow the efficient operation of the CHP irrespective of heat demand. Heat from the store can then balance the daily variations on heat demand, minimizing the need for heat only boilers.

The current reliance on fossil fuels for energy along with their inefficient use creates a vulnerability to energy price volatility. There is opportunity to change this exposure to fossil fuels which is increasingly important as future energy supply shocks will have a significant impact on the costs of living and doing business in the city.

Through smarter use of the energy that we already consume and opportunities such as large scale waste heat capture and distribution via District Heating Networks, London can meet its domestic energy needs while reducing the total fuel requirement, thereby delivering some protection against fuel capacity issues and fuel price fluctuation.

2.5 Development of District Heating Networks

The development of district heating networks relies on the identification of projects with the right mix of heat demands, connecting buildings and a motivated project owner. The Energy Masterplanning (EMP) process has been developed to identify opportunities for new networks in an area, and to set out a long-term vision for DH development.

The steps in the process are:

- Mapping energy demands in the area, considering ownership and control of these demands;
- Mapping energy supplies in the area, including local heat and fuel sources;
- Mapping existing and planned district heating schemes;
- Mapping new development in the area;
- Identifying suitable locations for energy centre (s); and
- Identifying routes for potential district heating networks.

The Masterplan sets out initial proposals for pipe routes and plant locations, as well as economic and environmental impacts of their implementation.

Following the production of an EMP, a feasibility study of an individual opportunity should be undertaken to assess it in more detail. The feasibility may consider the specific requirements of individual connecting buildings, the phasing of the network, the route of the network. A feasibility study will produce a robust conclusion on the economics and feasibility of the proposed network, and give all the technical information required to proceed with the procurement process.

Energy masterplans should outline existing, planned and proposed developments that may be of potential interest for future interconnection and should therefore play a key role in the considerations of a development's network design, such as placement of energy centres and the capacity of pipes to interconnect with other heat loads.

A number of London Boroughs are developing energy masterplans. These plans are developed from the data in the London Heat Map (www.londonheatmap.org.uk) and identify opportunities for district heating networks within the masterplan area both within the boroughs themselves and across borough boundaries. Energy Masterplans have resulted in the development of planning policies to promote district heating networks and the connection of new developments to those networks. A number of energy masterplans have proceeded to feasibility studies, summarised in Table 3.

New developments within the catchment area of these energy masterplans are designed with the capacity to connect to area wide DH network as phased contruction develops.

Where no future DH connections are foreseeable or identified within the energy masterplan the designer may reasonably wish to specify a network without future connection capability. However key design principles within this manual will still lead to a more economic future system, should interconnection take place at later time.

Area	Boroughs included	Area type	Energy masterplan undertaken	Feasibility study undertaken
Upper Lea Valley	London Boroughs of Enfield, Haringey, Waltham Forest	Opportunity Area	√	√
Vauxhall, Nine Elms and Battersea	London Borough of Wandsworth, Lambeth	Opportunity Area	√	√
Wembly	London Borough of Brent	Borough	√*	
Kingston	London Borough of Kingston	Borough	√*	
Westminster	City of Westminster	City	√*	

√* Not complete at time of publishing

Table 3. Status with development of Energy Masterplans

DISTRICT HEATING PRINCIPLES OF DESIGN

3

3.1 Components of a District Heating System

District heating (DH) systems comprise physical infrastructure, as well as contracts, regulatory structures and organisations, for the generation, distribution and consumption of heat within a city.

The boundaries of the network as covered by the DH Manual extend the from the heat source interface at the main low to zero carbon energy centre/s to the consumer heat interface and include:

- Heat source interface between heat production plants and network. The heat source interface will comprise the plant and equipment to accept the heat supplied by the Heat Supplier into the DH network.
- DH network route (i.e. the pipes)
- Consumer heat interface between the network and the heat consumer. The consumer heat interface will comprise the equipment to deliver the heat from the network to the customer.

3.2 Design Considerations

There are key design considerations that should be addressed when conceptualising and implementing DH system design and these cover consumer demand and connections, heat distribution networks and heat generation sources.

Typically, modern DH systems are constructed and operated based on sound economic criteria using standardised, technically proven and high quality solutions. Investments are made based on analysis of economic viability. The heat sales tariff structure reflects the actual costs, and the DH systems must be competitive compared to alternative heating methods. The key issue to be achieved during the design and operation of any DH system to provide heat to the customers under all conditions.

The importance of customers is central to good DH design. The design of a DH network should first consider consumer connections and the consumer heat needs for space heating and domestic hot water, and any industrial heat use that may be connected. From this starting point

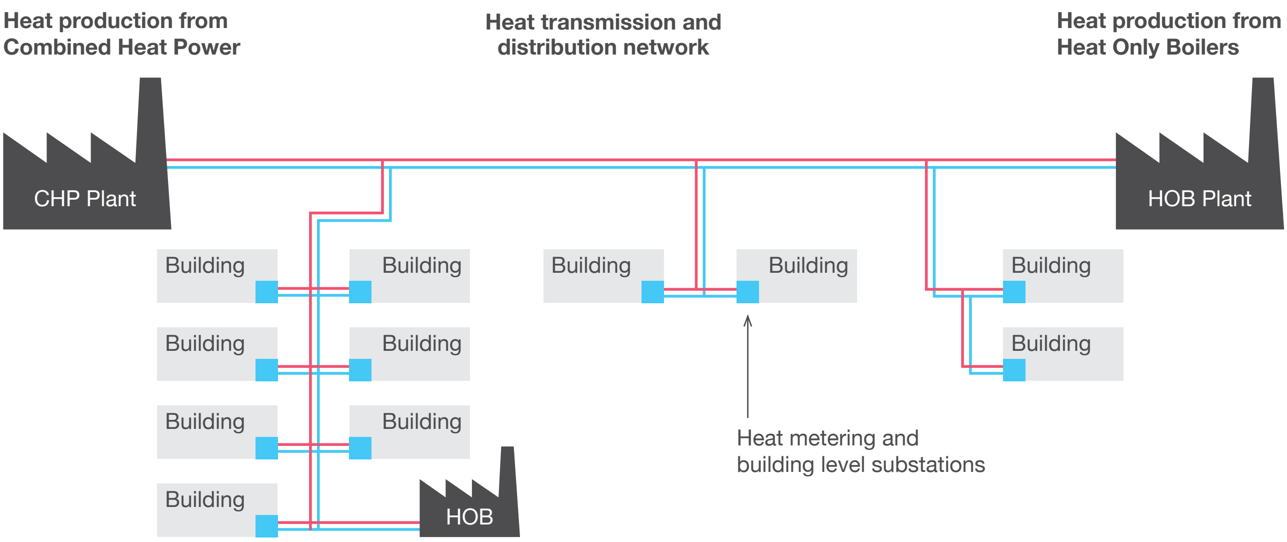

Figure 6. District Energy network overview

the consumer connections of a system will determine temperature levels, temperature differences, pressure levels and the load profiles for the entire system.

From this key design information the DH network, pumping plant and standby and top-up heating arrangements (forming the energy centre) can be designed according to the principles outlined below.

3.3 Design Life

District Heating networks form substantial pieces of infrastructure which require significant planning, design, general resource effort and cost in order to deliver effectively. This is particularly the case in dense urban environments where hard surfaces will require excavating, at significant cost. Therefore once installed to the desired standards it is reasonable to aspire to achieve life-times in excess of 50 years; a period of 20 years over the minimum to be expected. Such a design life can be achievable using pipes which adhere to industry standards including EN 253 when the network is well designed, installed and commissioned.

In practice quality control through strict installation supervision is a key step in ensuring long network lifetime. This is because a well designed network can have very long lifetimes, but when trenches are back filled any shortcomings in the installation process are hidden and are subsequently difficult and costly to locate and repair.

3.4 Principles of Operation

The main principle for the DH design in meeting the consumer requirements should be that the network hot water supply is controlled by variable flow and variable temperature to meet the consumer heat loads. This principle has been proven to give good economic performance over the lifetime of a DH system through a combination of low heat losses and good pumping energy efficiency, whilst minimising the pipe size installed across the network.

The system design peak heat demand is met with the maximum temperature and flowrate, but during normal operation as the heat demand reduces the temperature difference between flow and return and flowrates through the network are descreased to achieve further energy savings.

Variable supply temperature is normally controlled at the heat source interface, however in the case where a number of heat sources are available to the same network at different prices, lowest cost delivery can be controlled through heat source sequencing controls. (ie a more expensive high temperature heat source can be replaced with a lower cost low temperature heat). The supply temperature is typically modulated to following a pre-selected supply temperature curve linked to the outdoor temperature. The water flow rate is varied to meet the return temperature set point, ensuring pumping power costs are minimised.

The following curves in Figures 7 and 8 show the variation in flow temperature and flow rate when air outdoor temperature varies over the seasons. It should be noted that return temperature is only an estimate and is dependent on the secondary (customers) temperatures and on the design and operation of consumer substations.

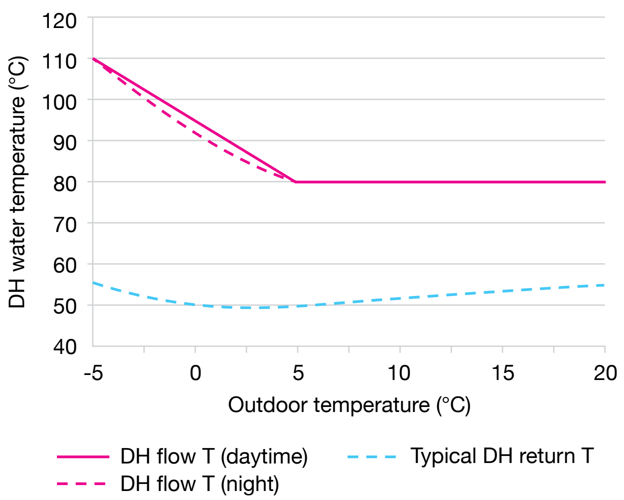

Figure 7. DH flow and return temperature variation with outdoor temperature

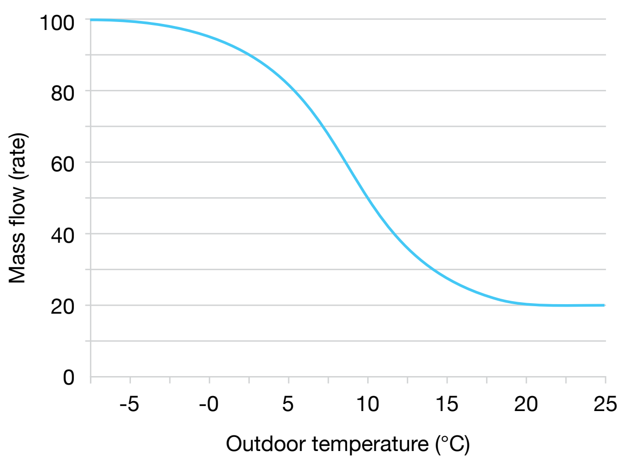

Figure 8. DH mass flowrate variation with outdoor temperature

The required DH flow is determined by consumer demand and two-port valve control in heat substations are used to match the primary flow to meet the consumer secondary temperature demand. The variable volume flow is maintained above a predetermined minimum value to ensure the full DH service is maintained across the network. This makes certain that a minimum pressure difference is maintained at a reference consumer (usually the one furthest away from the DH pumps) to provide an adequate heat supply.

3.5 District Heating Network Design

3.5.1 Heat Distribution

The energy centre or centres must ensure consumer demand is met at all times. An energy centre will normally manage the pressure, flow and temperature of hot water through the pipe network. Where there are multiple energy centres on a larger network there is a main control energy centre that load follows, with other energy centres operating at a constant output.

Figure 9 indicates the plant and main components / controls required for variable flow and variable temperature DH supply.

The key elements that must be maintained from the energy centre are pressure difference in the network at critical consumers. In addition, water quality is maintained at the energy centre to ensure long life of the network pipes.

The control of flow and temperature in the network adopts the variable temperature and flow principles described in Section 3.2 above.

Appendix 2 provides a case study of the Danish approach to the design of heat transmission systems based on the average head concept. This principal was adopted due to the many heat production units geographically separated over large distances and the need for flexibility to allow the future connections.

This extensive heat transmission network was designed and optimised around a higher operating pressure, high velocity system to enable the use of low diameter pipework to minimise construction costs. The high velocity concept is feasible where there are the long, straight sections of network but it does introduce the risk of damage due to pressure surges. This risk is managed through the ‘average head’ hydraulic concept in which the static pressure of the network is maintained at a fixed level under all flow conditions.

3.5.2 DH Network Design and Routing

The heat network design criterion is to ensure that heat can be delivered at all times to connected consumers. The key network design principles are:

- The heat network must be capable of supplying hot water to the consumers with sufficient temperature and temperature difference to meet the heat demand;
- It must be designed to minimise heat losses;
- The pressure across the entire network must not allow hot water to boil at any time;
- Pressure differences between flow and return pipes must always be sufficient to meet the required heat at all consumers;
- The network route should be designed to ensure long pipe lifetime, through minimising pipe stresses;
- The network route should be practical and distances should be minimised; and
- The pipes in the network should have sufficient capacity for all heat loads that may reasonably be expected to connect in the future.

In practice district heat network routes must be established by ensuring a route corridor can be found to all consumer points. Hydraulic modelling software is used to size pipes against the peak heat demand loads, with load profiling, heat load diversity and network phasing taken into account to determine a pipe network design. Critical consumers are identified for control of pressure, pressure difference, temperature and temperature difference from energy centre(s) at specified locations.

In DH network design, the reference consumer is identified as the consumer who would lose the required pressure differential to meet their heat demand earliest if pumping flow were too low.

Normally a pressure differential of 1 bar is used as the set point for this consumer to give a small margin given substation units are normally designed for 0.6 bar maximum pressure loss.

When preparing the mechanical design of pipe route, the pipework stress should be taken into account, especially for larger diameter pipes. This design should be carried out by experienced engineers to avoid poor pipe lifetime. Due to the nature of DH installations there are typically long straight runs of steel pipework which are subject to significant expansion forces when heated under normal operating conditions.

Techniques to compensate for thermal expansion are applied during design and installation. One technique, whereby pipework is installed under tension stress when cold, termed ‘cold pull’, allows for reduced compression stress when the system is at normal operating temperature.

3.5.3 Pipe Line Pressure Loss

The network is designed and pipe dimensions selected based on a maximum pressure loss per metre. This is normally done by simulating the whole DH network based on the designed connected heat loads and expected supply and return temperatures taking in account the topography of the proposed pipe routes.

The design trade-off associated with pressure loss per metre is the balance between heat losses and pumping losses. Designing at higher flow velocities allows smaller diameter pipes resulting in lower heat losses and pipe cost. However, this will also result in greater frictional losses and therefore higher required pumping power and costs.

Guideline pressure losses for design purposes are 100 Pa/m for main lines and 250 Pa/m for network branches. Pipe dimensions should be designed to utilise the available differential pressure combined with the recommended maximum flow velocities for hot water services for each pipe dimension.

DH mains refer to the main district heating flow and return pipes delivering bulk heat from the

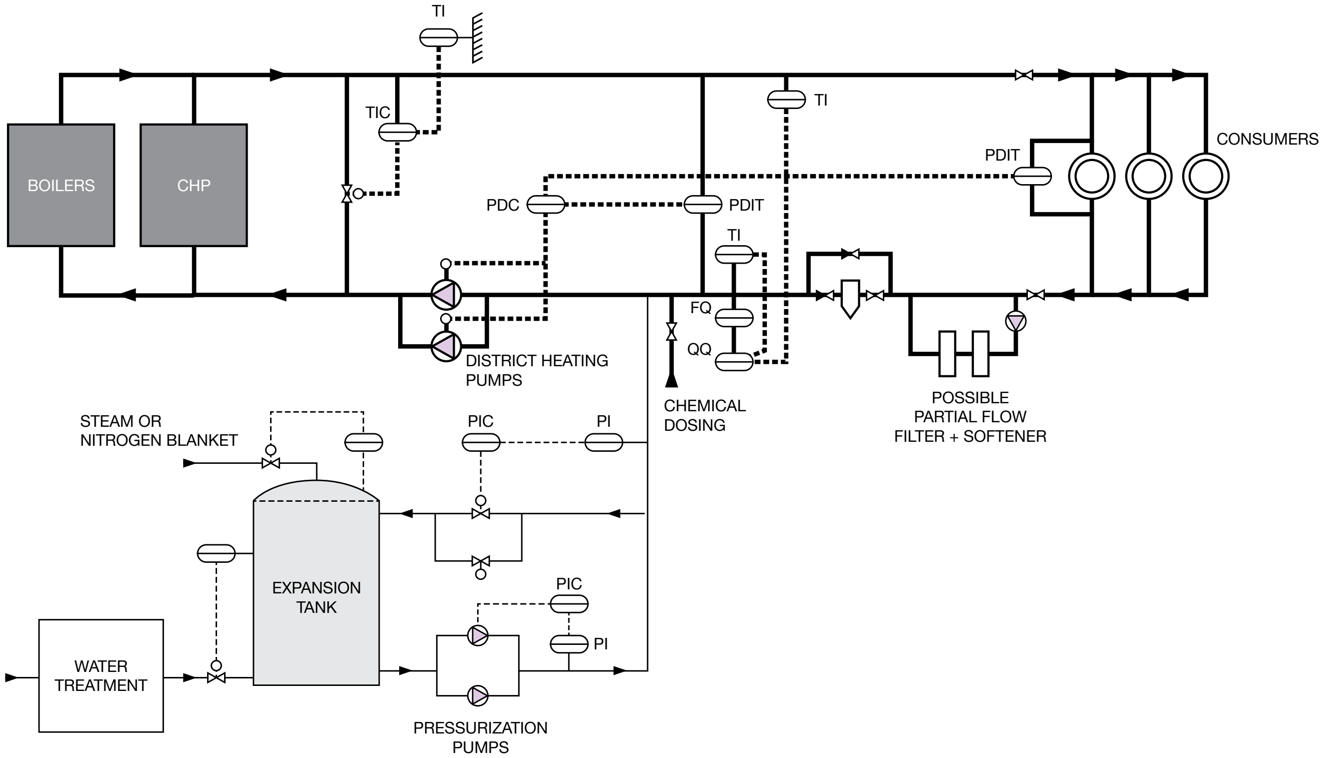

Figure 9. Typical District Heat Network Arrangement

heat source/s through the network. DH branches refer to the smaller connections off the DH mains that deliver the heat into individual consumer buildings or small subsets of consumer buildings.

3.5.4 DH Network System Components

Figure 9 indicates the plant and main components / controls required for variable flow and variable temperature DH supply, followed by other elements of the energy centre equipment.

System Pressurisation

In addition to flow and return pressure differential the network pressure must be maintained at all points to prevent steam forming within the pipe at the lowest pressure point. For this reason pressurisation pumps are essential and commonly linked to an expansion tank.

Water Treatment

Establishing a good water quality standard is key to the lifetime of a pipe network as poor water quality can erode and corrode pipe work. The installer of the network should employ a water treatment specialist to establish a comprehensive water treatment regime to protect the pipework and DH network components. The treatment regime including monitoring and maintenance should be continued throughout the life of the operation. The most important factors are correct pH value and the hardness of the DH water. A water quality specification is given in Table 6.

A basic water treatment plant should be included to manage the network water quality including chemical dosing and strainers. Filtration and other treatment such as water softening is usually carried out to part of the water flow in a bypass as outlined in Figure 9. This greatly reduces pumping requirements and should be sufficient to control water quality.

Monitoring and Maintenance - Leakage / breakage monitoring

Monitoring for leaks and breakages along the pipe network is essential to guarantee a heat supply to customers and prevent unnecessary losses. A leak detection system is therefore a key part of enabling the network to meet the key aims of energy efficiency and security.

Valves

Isolation valves should be installed on the pipe work branches and be located in a valve pit external to the consumer buildings to enable the supply to be controlled without having to enter the building.

Isolation valves improve the resilience of the network by enabling parts to be shut off should any problems with that particular section thereby minimising disruption to other consumers.

Isolation valves should be delivered as pre-insulated units and should be supplied and manufactured by the same supplier and manufacturer as the pre-insulated pipes. Insulation and outer casing material shall fulfil the same quality requirements as the pipe and which apply to all other components in the system.

3.5.5 Heat Carbon Intensity

Heat carbon intensity is used here as a measure of the carbon footprint of an energy source, in particular for establishing the relative environmental benefit of selecting one particular source over another.

The maximum carbon intensity of a heat supply for DH purposes is defined by the carbon dioxide equivalent emissions factor, on a gross CV basis, for 'Scope 1 emissions'[5] associated with natural gas used in heat only boilers with an efficiency of 85%. The maximum carbon intensity is therefore a function of the emissions factor and the energy conversion efficiency.

$$\frac{(0.184\ \mathrm{kgCO_2/kWh})}{(85\%)} = 0.216\ \mathrm{kgCO_2/kWh}$$

This represents the highest heat supply carbon intensity that should be considered for a decentralised energy scheme in London.

The heat source carbon intensity of a district heating network should be calculated inclusive of system losses (energy centre losses, connection losses and transmission losses). The system losses will be characteristic of individual systems and buildings and can be factored in during the system design.

3.5.6 Thermal Storage

Thermal stores (accumulators) can be used for balancing the daily variations of heat demand. An accumulator is normally charged when extra heat is available at low cost and discharged when heat has greater value. In this way a heat store can greatly improve the economics of a DH network.

Figure 10 on the following page shows some basic examples of accumulator operation:

The accumulator replaces peak demand capacity and allows the heat production to take place at the most economic time.

Heat storage utilisation will vary according to seasonal demand changes.

5 Direct emissions as defined by DEFRA. DEFRA, September 2009. Guidance on how to measure and report your greenhouse gas emissions. Available online at http://www.defra.gov.uk/environment/economy/business-efficiency/reporting/

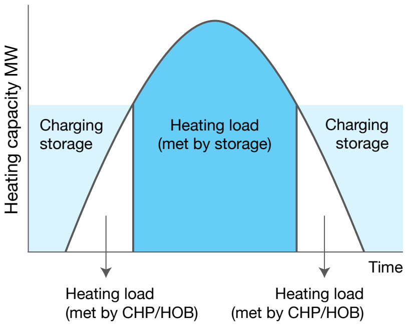

Figure 10a. Full storage

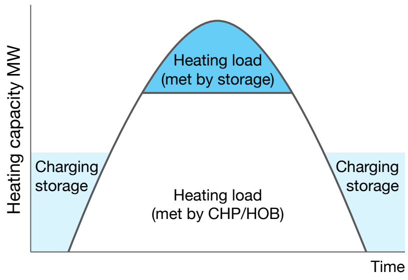

Figure 10b. Partial storage – Load levelling

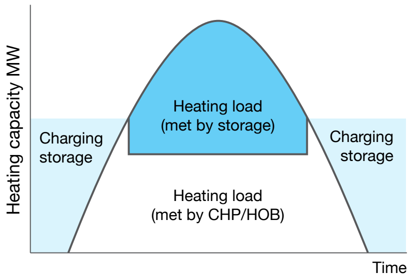

Figure 10c. Partial storage – Demand limiting

In a system where a thermal store is utilised the thermal store can take the place of the expansion tank simplifying pressurisation and heat accumulator control. Where multiple thermal stores are located on a single network then pressure control difficulties arise and all but one thermal store may need to be hydraulically isolated, which can restrict their value.

An accumulator introduces complex design and control issues and appropriate capacity and design are very much case specific, it is recommended their installation be evaluated and designed by an experienced DH designer for each installation.

The following two photographs are provided with thanks to Islington Council and show the thermal store installed at the Bunhill Energy Centre. It has a capacity over 100 m^3, measuring approximately 15 m tall and 3 m diameter.

Figure 11. Thermal storage vessel during early phase of installation

Figure 12. Thermal storage completed installation at Bunhill Energy Centre

3.5.7 Stand by and Back up Plant

Energy centres are normally built with the capability to back up the heat supply in the event of maintenance on the primary heat source equipment. In some cases this back up plant is installed remotely form the primary source; however the strategy for its operation remains the same. It is used in the event that a primary heat source of lower carbon intensity is not available.

Backup plant is installed in order that a supplier is able to maintain the service to consumers on the DH network at all times. The service is normally provided from gas fired heat only boiler plant and may be remote from the primary plant as shown in Figure 6.

3.5.8 Provision for future expansion

Where a new development commences in an area with no existing heat network but with plans for the potential for network penetration at a future date, the new development may be required to construct or at least safeguard a route to ensure that the future connection can be made with a minimum of disruption to building occupiers and retrofit of the completed development.

Where a pipe network route is to be laid but not connected as part of the main development works, the preceding sections of this chapter should be complied with. In addition, any open ends must be sealed prior to backfilling. Additional pipe weld inspections and pressure testing may be required at the time the pipe is connected to the network.

3.6 Interconnecting District Heating Networks

To facilitate the connection of existing or smaller networks there may be circumstances where plastic pipes have been used or may be specified on the basis of installation cost reduction.

Plastic pipe materials are cheaper and easier to install than steel pipework however their heat carrying performance is limited by their lower pressure and temperature ratings. Plastic pipework can be sensibly used in small area networks, especially with direct consumer connections.

Plastic pipes can be physically connected to steel pipes forming a larger area network however the consumer connections and pipes must be capable of the higher network pressures and temperatures. Alternatively, the plastic pipework can be hydraulically separated using a heat substation as illustrated in Figure 13.

Hydraulic separation of networks will negate the operational benefits therefore it is recommended where possible that pipes are rated at a 16 bar and 110 °C. This will ensure that local networks can directly connect to a larger district heating network during the lifetime of the former and realise the full economic and operational benefits.

3.7 Heat Metering

Heat needs metering accurately at any point where it is bought and sold. The metering point must be chosen to take into account heat losses, and the metering location will dictate who is financially responsible for heat losses in that part of the network. As a result heat metering is usually placed at the consumer connection.

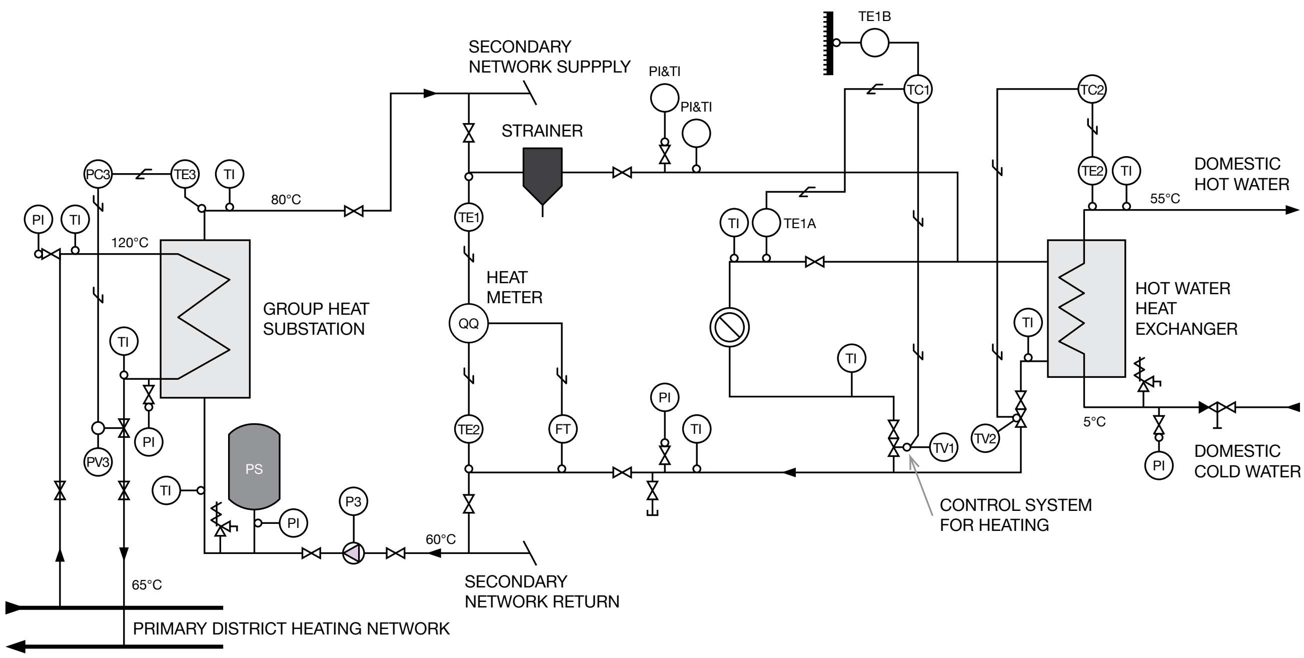

Figure 13. Group Heat Substation separating an Area Wide from a Local Network

The heat supply to a consumer may be billed at individual meters for each dwelling. An alternative approach that is common in some markets is that heat costs are shared over a block, based on a communal heat meter. This saves the capital cost of multiple heat meters, but its viability will depend on the type of housing installed and does not necessarily promote energy saving amongst individual consumers.

The components of the heat meter are: a flow meter, temperature sensors, and a heat calculator. The flow meter measures the volume of circulating district heating water. The temperature sensor pair constantly measures the temperatures feeding into and returning from the metered space. Based on the readings of the flow meter and the temperature sensor pair, the heat calculator determines the thermal energy used by the building. The calculator automatically takes into account the water density and specific heat corresponding to the temperature.

Heat meters are normally be owned, installed and maintained by the heat supplier. Meter readings may be recorded by the heat purchaser and corresponding data collected manually and sent to the supplier or an automated electronic billing system installed, depending on the heat connection arrangement and heat volume.

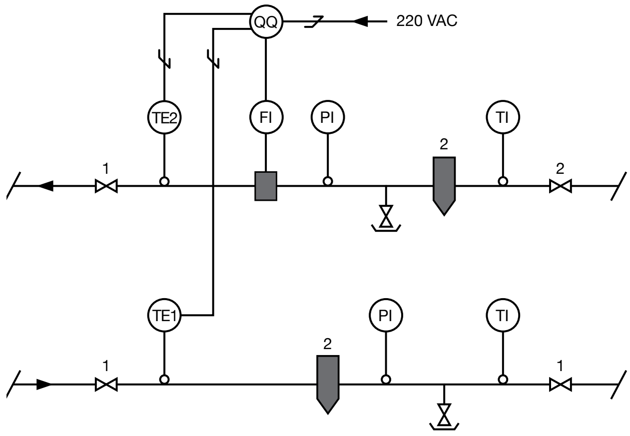

Figure 14. The general arrangement of heat metering

Key

TE1	Temperature sensor
TE2	Temperature sensor
T1	Temperature gauge
P1	Pressure gauge
FI	Flow meter
QQ	Calculator for heat energy
1	Isolation valve
2	Dirt trap

Automatic meter reading

The new generation of meters incorporate automatic meter reading (AMR) systems. AMR collects data from remote metering devices and transfers the data to a central database for billing and analysis. Meters may communicate wirelessly, via a cellular mobile radio network or over optical fibre. This reduces operational costs by obviating manual meter readings and provides detailed information on consumption patterns.

Smart Meters

Smart meters are the most advanced type of meters. The technology is still emerging and no industry standard has yet been established. Smart meters will provide more functions than AMR such as real-time or near real-time reporting, heat outage notification, and heat quality monitoring.

Conclusions

Given the significant potential for improved system efficiency and viability from better meter systems, all new district energy systems should incorporate meters with AMR as a minimum, with smart meters preferred should the advantages become clear.

In selecting a meter supplier, it is important to ensure that the data is presented by the metering system in a format usable by more than one metering and billing services provider, to avoid being tied in to a particular service provider.

The security of the system is an important consideration when selecting the communications system between the meter and the central database for billing and analysis.

3.8 Consumer Network and Heat Interface

This section considers the arrangements and options for district heating network consumer connections.

There are two key options available with respect to the connection between the DH transmission network and the consumer. Simply put these options are:

- Hydraulic separation in the form of an interfacing heat exchanger. This is the most common system in modern DH systems. This keeps primary DH water entirely separate from water in the secondary consumer building system. The arrangement of heat exchanger, valves, shunt pumps and controls is termed a heat substation and is normally installed in a plantroom in each consumer building.
- Direct connection; this allows the primary system DH network water to circulate around the secondary or consumer building system, feeding heat interface units directly within individual dwellings

All interfacing heat exchangers should be of prefabricated design rated to deliver heat at the peak heat demand expected of that particular consumer for both heating and domestic hot water.

To maximise the temperature difference between flow and return in the DH network, the interfacing heat exchangers should operate with two-port control valves. By-pass or three-port valves controls are to be avoided as these reduce the temperature difference between flow and return, reducing DH network heat supply capacity.

In the following sections Process and Instrument (PI) diagrams are described for the main options for consumer connections showing the control principle and energy metering points.

3.8.1 Instantaneous Indirect connection

Indirect connection with instantaneous heating and domestic hot water

Instantaneous indirect connections provide both heating and hot water without any need for a hot water tank, or heating only on demand from the consumer. The consumer hot water system is separated from the DH network by plate heat exchangers, hydraulically isolating both systems.

These are the most common connection types used in modern european district heating. These units have a low capital and maintenance cost and are compact, reliable, give low heat losses and offer good consumer experience.

Figure 15 below illustrates a typical configuration for this system. The hot water for space heating is supplied through one heat exchanger (HE2) and domestic hot water (DHW) through another heat exchanger (HE1). Demand is supplied instantaneously and controlled within the heat exchanger unit.

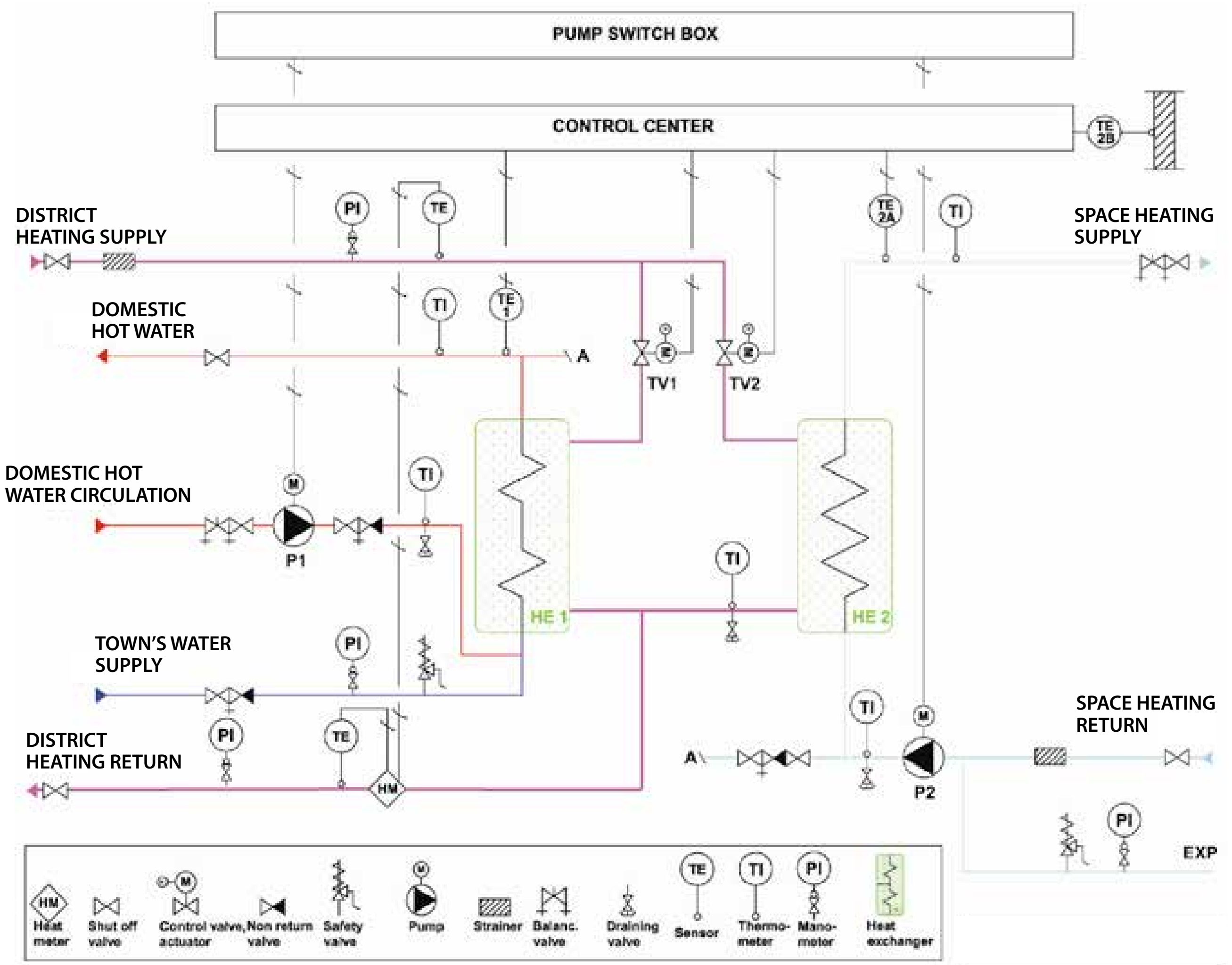

Figure 15. Heat substation - Indirect heating and domestic hot water

Indirect connection with instantaneous heating only

A similar design where heating is required but no domestic hot water is needed, or is provided by other means is shown in Figure 16.

Prefabricated substation units of both types are offered on the market with brazed plate heat exchangers and include all components from primary heat meter and isolation valves to secondary pumps, expansion system and control system with necessary alarms. All the components are installed on a steel frame to be possible to transport in to the plant room through the normal 800 mm door ways.

It is important to note that in DH, consumer circuits should not use secondary loops with a constant temperature as is normally used with a gas boiler system. This is because it would dramatically increase the primary return temperature causing a smaller temperature difference. This in turn increases the DH network heat losses and reduces the DH network heat transmission capacity.

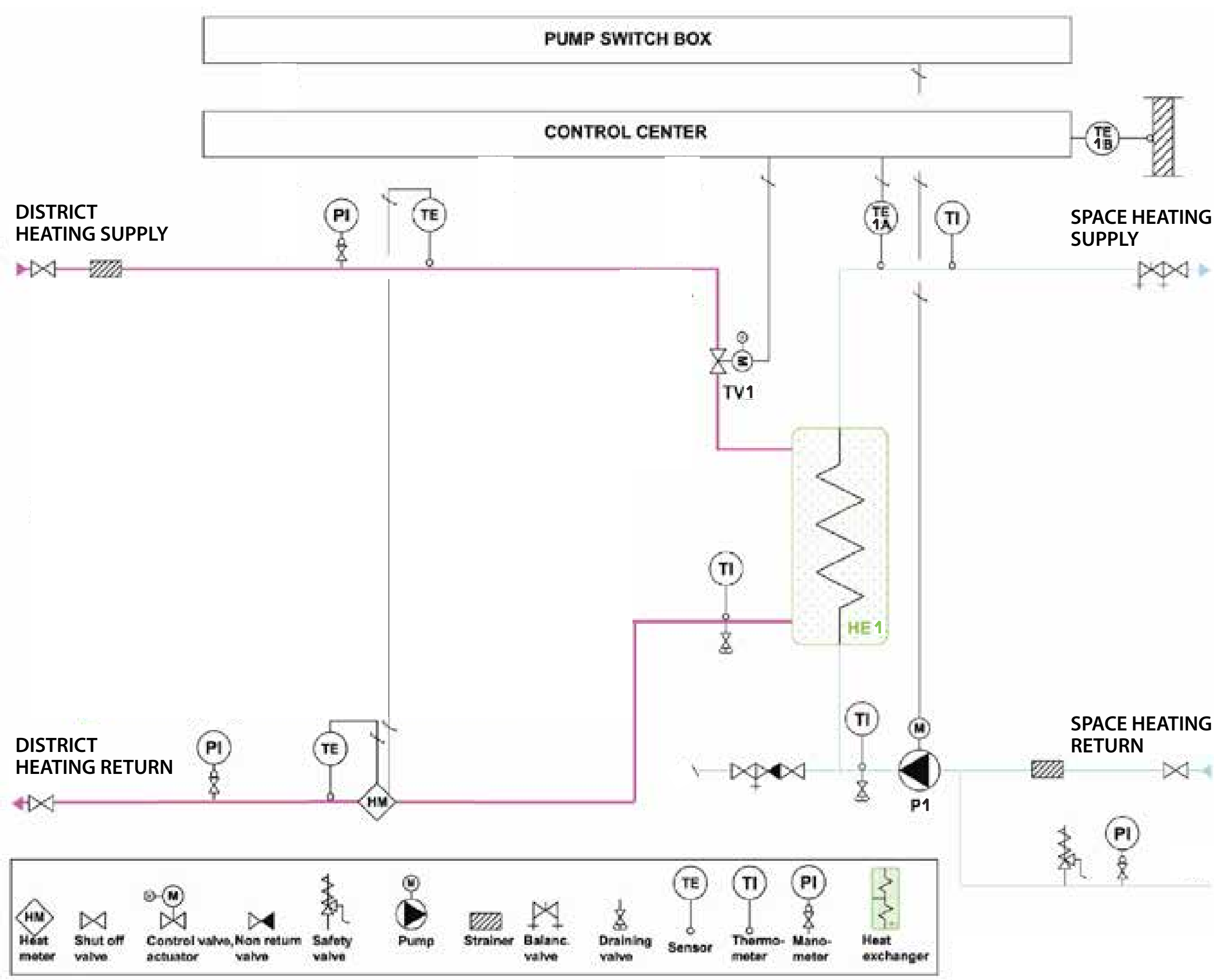

Figure 16. Heat substation - Indirect heating only

3.8.2 Domestic hot water with cylinder

Indirect connection with domestic hot water only

Some installations may consider the use of a cylinder for domestic hot water storage. Hot water storage allows domestic hot water peaks to be smoothed, potentially improving energy centre economics. They are not used for reducing space heating peak demand, this is still provided instantaneously.

Hot water storage cylinders have higher installation and operation cost (higher investment and heat loss). There is an increased risk of legionella bacteria if the hot water cylinder temperatures are not managed throughout the entire cylinder.

Figure 17 shows how a domestic hot water cylinder is recommended to be connected.

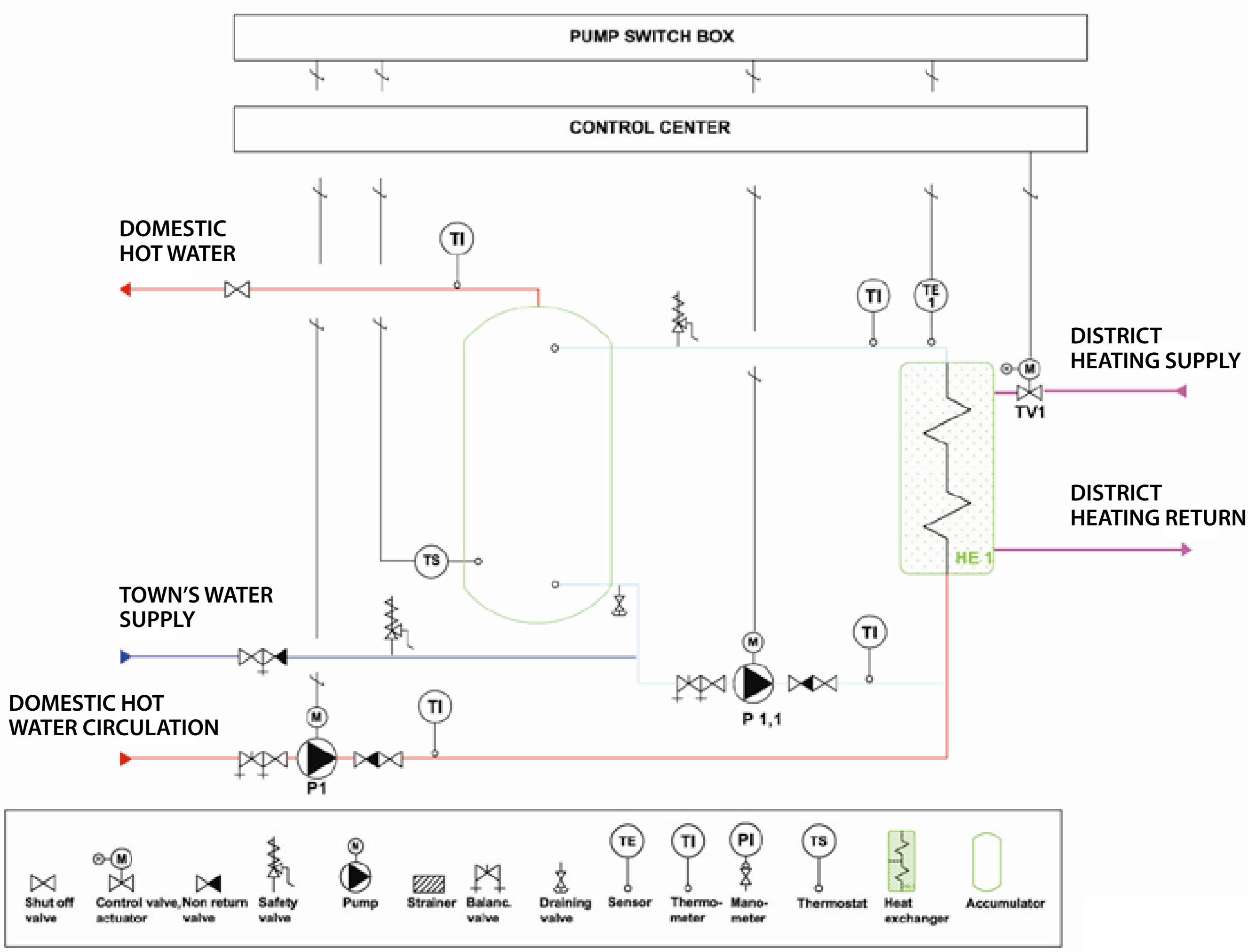

Figure 17. Heat substation - Indirect heating with Domestic hot water cylinder

Direct hot water connection for consumer space heating

Networks operating at low pressures and temperatures are suitable for domestic heating installations using a direct hot water connection to the consumer's heating system.

Figure 18 shows such a system incorporating the principle of a substation with indirect DHW production and direct heating using mixing pump control.

This unit is not common in modern DH systems and should be used only in small networks, which will not be connected directly to a larger DH system in the future. This is because the 16 bar, 110 °C hot water needed for a large DH system is not considered safe to pump directly into a consumer dwelling and consumer plumbing would need to be specially rated at this increased pressure.

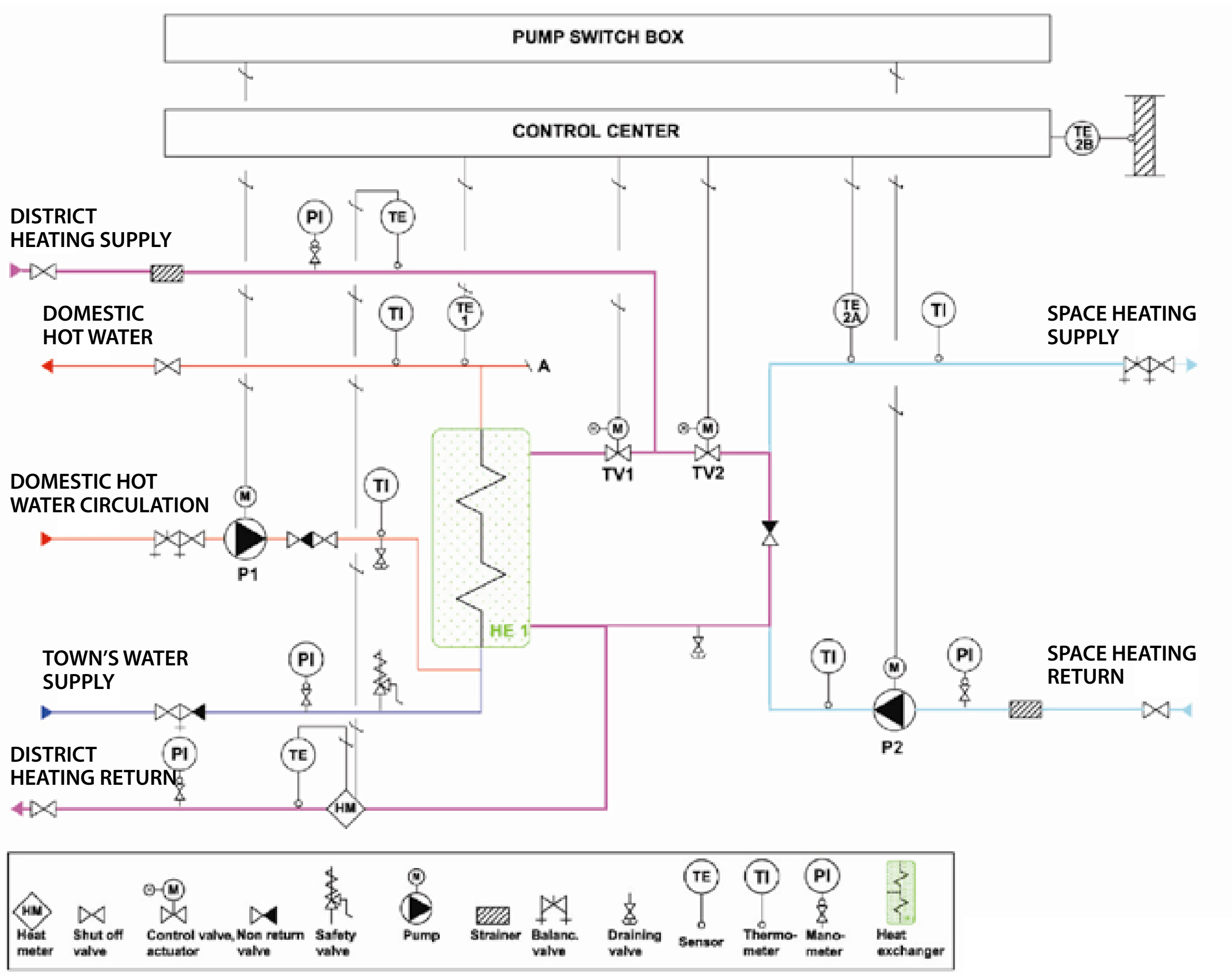

Figure 18 Heat substation - direct heating with indirect domestic hot water

3.8.3 Heat Interface Design

There are two main types of interfacing heat exchanger units which provide the heat transfer from the supply network to the consumer system. These are heat substations and heat interface units as described below.

- Heat Substations are units commonly installed in a basement plant room of a building accepting heat from the supply network and distributing the purchased heat via a communal network throughout the building. One important aspect of their design is that they are constructed with two or more heat exchangers, for example a heat substation might consist of two heat exchangers each sized at 60% of the building's peak load. In the event that one of the two heat exchange packs is in maintenance, transfer and delivery of heat to consumers on the consumer network may continue. It is not normally necessary to size the heat exchangers based on 100% redundancy. A typical example of a heat substation is shown in Figure 19a.

- Heat Interface Units (HIU) are units commonly installed in individual dwellings providing heat to meet the demands of the consumer. There are several types of HIU; some provide space heating only, while other provides both space heating and domestic hot water service.
  A typical example of a heat interface unit is shown in Figure 19b.

The same basic design and dimensioning criteria can be applied to each interface type and are normally as per Table 4.

Design Temperatures, °C	Primary side		Secondary side	
	Flow	Return	Flow	Return
Space heating • new • renovation	110- 80	55	70-80 80	40-50 60
DHW	70	max 25	55	10

Table 4. Design temperatures (Wet radiator systems and DHW)

Interfacing heat exchangers should also be designed to minimise the pressure loss through the unit to reduce pumping costs. In specifying an interfacing heat exchanger the heat exchanger's design maximum allowable pressure losses should be:

	Max pressure loss
Primary side	20 kPa
Secondary side	20 kPa
Domestic hot water (hot/cold)	20/30 kPa

Table 5. HIU pressure loss

It should be noted that these are allowed pressure losses for heat exchangers only. For the whole heat substation unit including piping, control valves etc. a 60 kPa pressure loss should be allowed for the primary side. This will give some margin when the main DH-pump pressure difference control is set to maintain the min. 1 bar (100 kPa) pressure difference at a reference consumer as is normal practice.

Heat interface units are typically specified for new developments where space can be allocated for their installation during the design and construction. For buildings which are designed or refurbished with a communal network, space for installation of the heat substation must be provided and Table 5 provides indicative space requirements. It should be noted that the heat substation is normally provided and maintained by the DH supplier and access will be required by the supplier to maintain the plant and correct any faults that occur.

Table 6 below shows indicative space requirements to accommodate heat substations within a building.

Heating capacity (space heating + ventilation) (kW)	Approximate building size (m^3)	Space required by the heating equipment (m^2)
30	1000-1500	2
200	10000-15000	4
400	20000-30000	5
800	40000-60000	6

Table 6. General indicative space requirement for heating substation equipment for building plant rooms.

Figure 19a. Typical heat substation

Figure 19b. Typical heat interface unit (HIU)

Figure 19a shows a typical example of a prefabricated heat substation incorporating plate heat exchangers, pumps, valves and necessary controls monitoring system installed on steel frame being ready to be connected mechanically and to electric supply.

Figure 19b shows a typical example of a heat interface unit as may be installed in a consumer dwelling. It incorporates many of the same components as the heat substation but on a smaller scale. Heat interface units on the market are available either as heating only or heating plus domestic hot water.

DISTRICT HEATING STANDARDS

4

These design standards have been drawn from International, European and British standards; as such they are referenced accordingly. Highlighted in the table below are those standards that are recommended for use and recommended design parameters of a heat network.

4.1 General design standards

Typically the DH network shall be designed according to following main standards including standards for bonded preinsulated steel service pipe-system and for plastic service pipe systems:

Standard number	Standard name
EN 253	Preinsulated bonded pipe systems for underground hot water networks. Pipe assembly of steel service pipes, polyurethane thermal insulation and outer casing of high-density polyethylene.
EN 448	Preinsulated bonded pipe systems for underground hot water networks. Fitting assemblies of steel service pipes, polyurethane thermal insulation and outer casing of high-density polyethylene.
EN 488	Preinsulated bonded pipe systems for underground hot water networks. Steel valve assembly for steel service pipes, polyurethane thermal insulation and outer casing of high-density polyethylene.
EN 489	Preinsulated bonded pipe systems for underground hot water networks. Joint assembly for steel service pipes polyurethane thermal insulation and outer casing of high-density polyethylene.
EN 13941	Design and installation of preinsulated bonded pipes for district heating.
DIN 16892/16893	PEX carrier pipes in heating pipes made of plastic.
EN ISO 15875-1	Plastic piping systems for hot and cold water installations. Cross-linked polyethylene (PE-X).
DIN 4726	Oxygen proof layer in carrier pipes of heating pipes made of plastic.

All the Specified material requirements should be understood as minimum requirements. Equipment suppliers should provide DH pipeline systems that meet the requirements of this specification.

4.2 Norms and standards for heat metering

- EN 1434-1:en: Heat meters.
  Part 1: General requirements
- EN 1434-2:en: Heat meters.
  Part 2: Constructional requirements
- EN 1434-3:en: Heat Meters.
  Part 3: Data exchange and interfaces
- EN 1434-4:en: Heat meters.
  Part 4: Pattern approval tests
- EN 1434-5:en: Heat meters.
  Part 5: Initial verification tests
- EN 1434-6:en: Heat Meters.
  Part 6: Installation, commissioning, operational monitoring and maintenance

Communication systems for meters and remote reading of meters:

- EN 13757-1:en: Communication system for meters and remote reading for meters.
  Part 1: Data exchange
- EN 13757-2:en: Communication system for meters and remote reading for meters.
  Part 2: Physical and link layer
- EN 13757-3:en: Communication system for meters and remote reading for meters.
  Part 3: Dedicated application layer

- EN 13757-4:en: Communication system for meters and remote reading for meters. Part 4: Wireless meter readout (Radio meter reading for operation in the 868 MHz to 870 MHz SRD band)

The following Table 7 gives recommendations for dimensioning for casing pipe giving the minimum requirement for insulation thickness in order to minimize the heat losses.

DN	Steel pipe, Do x t (mm)	Casing pipe, Do x t (mm)	Insulation thickness (mm)
20	26.9 x 2.0	90 x 2.2	27
25	33.7 x 2.3	90 x 2.2	24
32	42.4 x 2.6	110 x 2.5	29
40	48.3 x 2.6	110 x 2.5	26
50	60.3 x 2.9	125 x 2.5	27
65	76.1 x 2.9	140 x 3.0	26
80	88.9 x 3.2	160 x 3.0	29
100	114.3 x 3.6	200 x 3.2	36
125	139.7 x 3.6	225 x 3.5	36
150	168.3 x 4.0	250 x 3.9	33
200	219.1 x 4.5	315 x 4.9	39
250	273.0 x 5.0	400 x 6.3	52
300	323.9 x 5.6	450 x 7.0	50
350	355.6 x 5.6	500 x 7.8	59
400	406.4 x 6.3	520 x 8.1	42
450	457.0 x 6.3	560 x 8.8	36
500	508.0 x 6.3	630 x 9.8	45

Table 7: Recommended dimensions for casing pipe outside diameter and wall thickness (reasonable differences are allowed) for bonded steel service pipe system according to EN 253

4.3 Summary of Recommended Network Design Requirements

Table 8 summarises the network parameters outlined in this manual for DH networks that may form part of a small or large network of pre-insulated bonded DH network with steel service pipe.

For plastic pipes systems the maximum operation temperature is usually limited to 95°C and pressure to 4-6 bar (depending on pipe size and operating temperature) while design life is shorter, particularly at higher temperatures. Plastic products meeting the requirements outlined above could be considered as a direct replacement for steel pipe in area wide networks should such products become available on the market.

Network parameter			London District Energy Manual design standard	External reference
	1	Design life	Minimum of 30 years Aspiration of 50 years	IEA: District Heating and Cooling Connection Handbook, 2000 EN 253: 4.5.5.1
Pressures and temperatures	2	Pressures	16 bar g (maximum design gauge pressure)	HVAC TR/20, 2003
Pressures and temperatures	3	Temperatures	140°C (maximum design temperature) 120°C (maximum operating temperature) 110°C (recommended operating temperature)	HVAC TR/20, 2003
Pressures and temperatures	4	Temperature flow and return	110°C / 55°C but with minimum temperature difference of 50°C	
Pressures and temperatures	5	External design temperature	-5°C (design air temperature) Design ground temperature variable with ground and depth.	CIBSE Guide plus -1°C margin. CIBSE AM11 and TM48 simulation of future weather patterns
Pipework	6	Pipe work material	Steel (for primary network mains, secondary network mains, branches and consumer connections) Steel quality P235TR1 for all pipe work, or alternatively P235GH for pipe work DN300 mm and above	EN 10217-1 EN 10217-2 EN 253
Heat flow	7	Pressure loss guideline to be used in design (main and branch)	100 Pa/m for main lines 250 Pa/m for branches	
Heat flow	8	Volume supply control	Variable based on pressure difference control	
Heat flow	9	Carbon intensity of heat supply	Maximum 0.216 kgCO_2e/kWh (on a Gross CV basis for Scope 1 emissions)	DECC/Defra (www.defra.gov.uk/environment/economy/business-efficiency/reporting/)
Heat transfer	10	Supply temperature	Supply temperature shall be variable following the supply temperature curve linked to outdoor temperature.	
Heat transfer	11	Heat metering	Recommended AMR system	BS EN 1434-1:2007
Heat transfer	12	Heat interface units	Space heating (new development) Primary side flow 110°C to 80°C; return 55°C. Secondary side flow 70°C to 80°C; return 40° to 50°C. Space heating (renovation) Primary side flow 110°C to 80°C; return 55°C. Secondary side flow 80°C; return 60°C. DHW Primary side flow 70°C; return max 25°C. Secondary side flow 55°C; return 10°C.	
Monitoring and maintenance	13	Leakage detection and monitoring	Pipe network shall be provided with leak detection system, which can be connected to the remote monitoring system or can be monitored locally by local fault locators	BS EN 14419
Monitoring and maintenance	14	Water quality	pH 9-10 Alkalinity < 60 HCO3/l (mg/l) Oxygen level < 20 µg/kg Total Fe < 0.1 mg/kg Total Chloride < 50 Cl mg/l Total hardness < 0.1 dH	BS 2486:1997
Thermal storage	15	Thermal storage	Designed to optimise utilisation of low carbon heat supplies within the constraints of heat demands, heat supplies and site requirements.	

Table 8: DH Manual Design Standards

DISTRICT HEATING CONSTRUCTION

5

This chapter covers the physical works for the construction of a district heating pipe network. The reference network types are a large scale transmission network and a smaller scale distribution network comprising of insulated steel pipe sections. The standards are directed towards the typical scenario of a buried pipe network located within the carriageway of a public highway

Relevant variations for other typically encountered installation scenarios (e.g. soft dig, private land) are considered briefly at the end of this chapter.

This chapter also addresses appropriate space standards for safeguarding routes for future district heating network routes.

5.1 Installation Supervision

By experience it is known that although the DH network may be well designed and good materials selected, the most important stage in ensuring the long term economic future of a project is correct installation. This must be done under experienced and strict supervision. This is normally done so that during the construction and installation there are certain inspection points (inspected by the Engineer) which are required as accepted before the contractor can move to the next step. Examples of points that should be inspected are:

- setting out
- trench construction
- sand bedding
- pipe laying
- welding/pressure and other tests (x-ray, visual, ultrasonic, etc.)
- casing joint including alarm wires
- initial back filling
- final back filling
- surface (top soil/tarmac)
- final acceptance.

5.2 Construction principles

The safety of construction operatives and the public must be the highest priority consideration for the installation of district heating apparatus. The contractor responsible for installation must comply with and be cognisant of:

- current industry standards and specifications, including National Joint Utility Group (NJUG) standards and recommendations;
- manufacturer's design, installation and commissioning requirements and recommendations;
- relevant health and safety regulations. Contractors must provide risk assessments and method statements in accordance with the requirements of the Construction (Design and Management) Regulations 2007;
- environmental regulations, particularly in relation to the control of waste and the avoidance of local nuisance impacts including noise, dust, odour and air pollution;
- specific requirements of landowners where the route runs outside the public highway;
- specific requirements of statutory undertakers whose apparatus is affected by the works;
- specific requirements of transport organisations who may be effected by the works.
- specific requirements of those buildings along the route whose occupiers or users have special requirements with respect to access, noise, dust etc
- any licence or other consent granted under the New Roads and Street Works Act 1991, the Traffic Management Act 2004 and other relevant Highway legislation; and
- Building Regulations requirements and any conditions attached to planning conditions, where relevant.

Construction industry good practice principles for the set up and operation of worksites should be observed to ensure the safety and to avoid inconvenience to businesses, residents and other members of the public affected by the works.

5.3 Construction standards

5.3.1 Typical trenching details

Figure 20 shows a typical construction detail for a district heating network mains pipe trench in the highway, using a pair of pipes for flow and return. The minimum distance from the top of the pipes to ground level is 600 mm. The dimensions of the excavation depth (d) and width (w) and the separation distance between pipes (a) and from the excavation edge (b) depend on the size of pipe. Table 9 provides the suggested relevant trench dimensions for typical pipe diameters.

An alternative arrangement is shown in Figure 21, with both the flow and return district heating pipes enclosed in the same insulation. Such arrangements can allow a narrower trench, though are normally only feasible on smaller pipe sizes.

When the trench is located within the public highway the depth, surround, backfill and reinstatement of the trench must comply with the New Roads and Street Works 1991 (NRSWA) Specification for the reinstatement of openings in roads.

All relevant aspects of the trenching works must comply with the NRSWA. Although the pre-insulated pipes are designed to bear full road load by 400 mm soil cover (from top of pipe to the bottom of tarmac), a minimum burial depth of 600 mm is normally used according to following cross section.

Note: Initial back filling up to min. 100 mm above DH-pipes should always be done with specified, imported, screened sand and for trenching within highways the requirement is usually to use only imported backfilling materials.

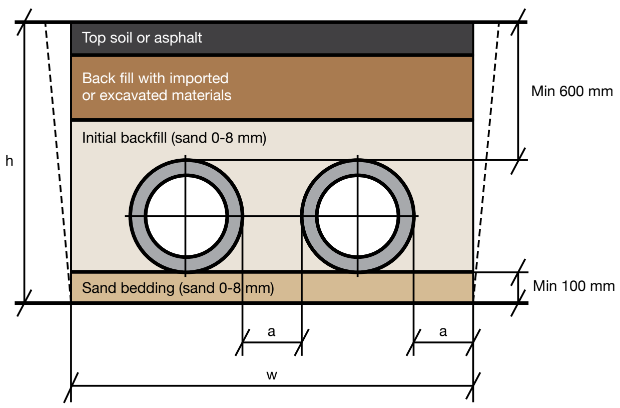

Figure 20: Typical pre-insulated flow and return pipe trench section

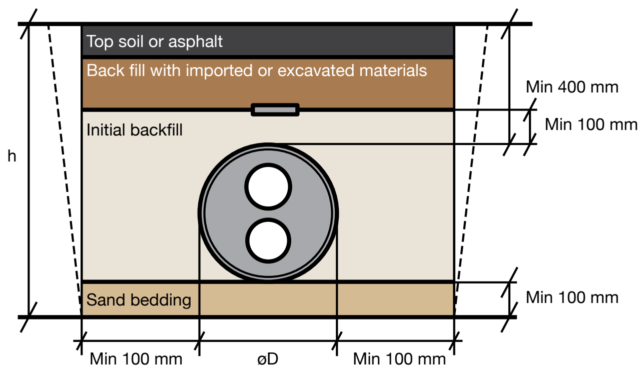

Figure 21: Typical pre-insulated twin-pipe trench section

DN (carrier/ casing)	a (mm)	b (mm)	w (mm)	h (mm)
DN80/160	150	150	770	860
DN80/160	150	150	770	860
DN100/200	150	150	850	900
DN125/225	150	150	900	925
DN150/250	150	150	950	950
DN250/400	200	200	1400	1100
DN300/450	200	200	1500	1150
DN400/560	200	200	1720	1260
DN500/630	200	250	1910	1330
DN600/800	250	300	2400	1500
DN700/900	250	300	2600	1600

Table 9: Pipe Trench minimum dimensions

It should be noted that additional space at corners and spurs will be required.

Where a district energy network is installed in proximity to other existing utility and service apparatus, the installation of the heat pipes should comply with the principles of separation from other apparatus. Separation will depend upon the congestion of the area and consultation with owners of the existing apparatus is recommended.

Where district energy is installed in new developments where no other apparatus exists the installation should comply with the principles within the National Joint Utilities Group Guidelines On The Positioning Of Underground Utilities Apparatus For New Development Sites.

5.3.2 Testing and commissioning of pipe welding

Testing of pipe work will be as detailed in EN 13941 and the relevant Project class. Typical requirements to be included in the specification are:

- All steel pipe welding is to be undertaken by certified coded welders. Certification must be in compliance with current British and European Standards. Welders may be subjected to a welding test with at least the same acceptance criteria as the criteria for the finished work, with reference to EN 25817;
- A testing regime should be established for welded joints e.g. non-destructive testing of 10% of welds as detailed in EN 13941. Visual inspection of welds is required;
- Installation pipe work should be hydrostatically pressure tested to at least 1.3 times the systems operating pressure for a period of 12 hours. For installations which meet the maximum pressure standard in this manual of 16 bar g, the appropriate pressure test standard is 21 bar g);
- Following completion of a satisfactory pressure test the site closures must be made in strict accordance with the pipe work manufacturer’s specification; and
- The leak detection system should be tested and certified.

5.3.3 Testing and commissioning of insulation welding

Typical requirements to be included in the specification are:

- Joint assemblies for the steel pipe systems, polyurethane thermal insulation and outer casing of polyethylene shall comply with BS EN 489. The joint assemblies shall be installed by specially trained personnel according to the instructions given by the manufacturer. Fusion welded insulation joints shall be implemented to join the pre-insulated steel pipe systems;
- The joint should be pressure tested with soap test to confirm it is air tight; and
- Polyethylene welders shall possess evidence of valid qualifications, which document their ability to perform reproductive welding of the quality specified.

Electrofusion welding type jointing is the preferred type of jointing. Any Contractor wishing to install alternative joints must provide evidence of equivalent performance to the preferred standard with respect to quality of installation and durability, and additional supervision and quality controls.

CONTRACT STRUCTURE AND MANAGEMENT

6

This chapter considers the forms of contract under which district energy networks are procured and operated, and shows how the selection of a particular contract structure should reflect the particular circumstances of the project and its sponsor, including the size and type of network being developed and the type of organisation to be responsible for its delivery.

The objective of the Mayor under the DE for London programme is to support the development, growth and interconnection of large-scale low-carbon networks, leading to the creation of a London-wide district energy network. Sponsors will be expected to take account of that policy objective alongside their project-specific drivers for contract structure and terms. This includes ensuring that contracts facilitate and, where possible, incentivise:

- network extension and new customer connections;
- interconnection with other networks; and
- connection of new low-carbon energy supplies.

The development of heat networks in London at the scale and in the volume envisaged in the Mayor's strategy for decentralised energy means that the retrofitting of premises and localities with district heating will become mainstream, rather than as at present the basis of new network development being more biased towards new property development

Clarity about the project-specific drivers and wider policy objectives, and the associated forms of contract to be used is essential if the costs of procurement are to be contained.

6.1 Contract structures

Which contract structure is most appropriate for a particular district energy project depends in part on the main contractual elements – works, services and property rights:

Works elements

- Design
- Construction and connection of premises
- Financing

Services elements

- Energy purchase
- Generation of heat and electricity
- Operation and maintenance
- Metering and billing
- Connection of new customers
- Supply of heat or heat and electricity to connected customers
- Customer services

Property agreements

- Sale or lease of operational land and buildings
- Easements, rights of way and access arrangements on private land and buildings
- Street works licence

District energy systems can be procured, constructed and operated in a variety of ways. The spectrum of possible structures runs from individual contracts for each of the elements listed above to a bundle of services and works procured under a comprehensive agreement. However, in practice only a few contract structures are commonly used. These are summarised in Table 8 below and developed further in the sections which follow.

Type	Description	Contracts required
Energy supply (ESCo)	An energy services company (ESCo) undertakes to supply heat to the customers, and for that purpose to build and operate the DH system. This could be set up with a defined set of consumer buildings to be connected, or to provide the service to developments within a defined area.	• Master agreement • Connection contract • Heat supply contract • Service level agreement (SLA) • Property leases
Wholesale supply of energy (DBO)	A sponsor appoints a single contractor to design, build, operate and supply wholesale heat and electricity. The sponsor sells the energy retail to consumers, and may be a consumer itself.	• DBO Contract • Wholesale heat supply contract with SLA • Connection contract • Property leases
Network delivery and operation	A sponsor (such as an owner of tenanted properties) appoints one or more contractors to design, build, operate and maintain a DH network but the sponsor remains the asset owner and contracts to supply heat and electricity to consumers. The sponsor may also purchase the fuel required.	• D&B contract • O&M contract with SLA • (Metering and billing contract) • (Connection contract)
Network operation (O&M)	An operator is contracted to run a DH system that has already been constructed, for example under a main building contract. The operator may also be contracted to undertake metering and billing and customers services, if the landlord wishes to outsource these activities.	• O&M contract with SLA • (Metering and billing contract)

Table 10. Commonly used types of contract for district energy systems

6.2 Choosing the main contract structure

The following notes provide guidance on the main considerations to help a project sponsor decide which contract arrangement is most likely to be suitable. They are intended for guidance only; a detailed assessment of objectives and options should be undertaken prior to a decision being made.

6.2.1 ESCo

Master agreement or concession:
The master agreement with an ESCo has to be long term to enable it to remunerate the investment it agrees to make. If the ESCo is expected to finance the construction of the district energy network, then provision of a demand guarantee or other means of moderating demand risk, is essential if the cost of capital is to be contained. If future demand is unpredictable, or the sponsor is unable to give a comprehensive demand guarantee, the master agreement may take the form of a concession. The concession may provide for exclusivity within a defined area and/or period of time. Concessions are mainly associated with new developments where a developer can provide exclusivity. The ESCo would then normally expect to own part or all of the assets comprising the DH scheme, albeit the assets may revert to the client upon termination of the agreement. The ESCo would take responsibility for design and construction of the assets as well, enabling a complete transfer of project risks from the sponsor.

Several variants on the concession contract can be envisaged, as alternatives to the demand guarantee or exclusivity methods of keeping the cost of capital down. The project sponsor may advance some of the initial funding required, either as advance connection charges, as a loan or loan guarantee or as an outright grant or capital contribution. Which of these options is used will depend on the expected long term profitability of the scheme.

Where the project sponsor is a developer, it might take on part of the construction activity itself and then transfer the assets to the ESCo for an agreed fee (which may not exactly match the cost incurred). The installation of HIUs and secondary networks is commonly undertaken by the developer, but this approach has on occasion been extended to include the heat sub-stations, the pipework that connects premises to the DH network and the energy centre building.

Where more than one developer or housebuilder is to connect to the DH system, the terms of connection would typically be specified in a template connection contract, which the ESCo would be obliged to adhere to. In principle, the template connection contract ensures that the terms agreed between the sponsor and the ESCo are reflected in the terms the ESCo agrees with developers and housebuilders. The connection contract effectively recapitulates the key provisions of the master agreement, and in addition sets out in detail the connection process and cost. As the ESCo has a commercial advantage within the concession area or timeframe, the charge for connection should be controlled through the template contract.

Where the connection is to existing premises and no property developer or housebuilder is involved, the ESCO's freedom to offer its own terms will depend upon the requirements contained in the Master Agreement, the counterparty party usually being a local or public authority.

Template heat supply contracts for residential and commercial customers would be drawn up as part of the ESCo agreement. These would specify the prices that could be charged and define the quality of service, so that the customers could in future deal direct with the ESCo and not need to involve the sponsor in disputes. The form and content of heat supply contracts are examined in more detail in Section 6.4. The supply agreements would also define the procedures for customer complaints and the penalties that apply in the event of failure to deliver the promised level of service. Both prices and customer services differ as between residential and commercial customers, so it is normal to draw up separate agreements for each group. Any supply agreement between landlord and tenant will need to comply with landlord and tenant legislation.

The service level agreement (SLA) works at several levels to assure a sound alignment of commercial incentives as between the project sponsor, ESCo, developers and customers. At the highest level, the sponsor and the ESCo would agree how the network as a whole is to be built and operated, including carbon performance, flow and return temperatures, reliability and downtime. At the next level, developers and the ESCo would agree about the manner in which connection is to be achieved, including lead times and compensation in the event of delay. Finally, customers and the ESCo would contract for utility-standard levels of service quality, with equivalent levels of compensation in the event of non-performance. The levels of compensation would differ significantly as between commercial and residential customers.

All these SLA provisions can be included in the master agreement or be distributed amongst the master agreement, connection contract and heat supply contracts. The advantages of a single SLA document are that consistency of performance standards can more easily be assured and that all interested parties then have access to an overview of the standards to which the DH system is to be operated. In any event, residential customers would usually need to have a plain language summary of key performance standards and their rights to compensation if these are not met.

In addition to the service level requirements, the master agreement may provide for the sponsor or a management company to have step-in rights in the event of a fundamental failure by the ESCo. Early termination may involve compensation of the ESCo for loss of profit opportunity.

Property leases

Property agreements are normally separate contracts, even when the parties are the same as in the main contract. A standard arrangement is for the buildings or spaces housing the energy centre and other equipment to be leased long term to the ESCo at nominal rents. The ESCo may also need easements and rights of access. The lease, easements and other such rights would normally be co-terminous with the master agreement.

6.2.2 Wholesale heat supply (DBO)

A design, build and operate (DBO) contract is more appropriate than a concession where the sponsor wishes to retain a direct relationship with customers. The DBO Contractor would typically supply heat wholesale to the sponsor, which would be responsible for selling it retail to customers. In this way, the DBO contractor takes on all risks associated with the provision of heat, except demand and credit risk.

As with a PFI contract, to which it bears a family resemblance, the D&B and O&M aspects of the DBO contract would normally be considered together, in order to ensure optimal life-time costs. The price at which heat will be supplied, given the required level of availability and standards of performance, is the key commercial consideration on which procurement should be focussed.

The DBO contract would normally be for at least fifteen years, to provide the long term incentive and to enable the contractor to be remunerated for funding the cost of constructing the DH scheme. In consequence, there may need to be a separate financial agreement (as with PFI contracts), although for all but the largest schemes it should be possible to require bidders to make their own financial arrangements. At the end of the contract, the assets would normally be handed over to the sponsor.

While service reliability can usually be assured through a DBO contract structure, the incentive to minimise the total cost of ownership only exists at the point where the DBO contractor is selected. Thereafter, the contractor is likely to seek opportunities to increase the D&B cost through variations, and the O&M cost through early replacement of assets and a range of other techniques. In short, getting good value through a DBO contract depends critically on the quality of contract documentation, including SLA, at the time of contract award. Procurement and getting to contract is therefore likely to take considerable time and effort.

The wholesale heat supply agreement would set out the basis for setting the price at which heat is supplied to the sponsor. The pricing formula would need to take into account the price of fuel and, usually, the revenues to be secured from the sale of electricity produced by CHP. Responsibility for the supply of fuel or the sale of electricity would be assigned to whichever party can secure best value. For a long term agreement, there should also be provision for periodic re-basing of the pricing formula to ensure that it does not get out of line with market comparators. A common error is to index-link prices over the long term without making due allowance for productivity improvements that accumulate over time and with increasing scale.

The DBO contractor would normally be responsible for connecting customers to the scheme, although the connection contract may be between the sponsor and the occupier or developer of the premises to be connected.

6.2.3 Network delivery and operation

Network delivery and operations contracts would be appropriate where demand is dominated by a limited number of class of customer, such as council-owned buildings, or social housing, or a shopping centre. The project sponsor (typically the landlord) would be responsible for pricing of heat and for the customer interface, and would normally pay for and own the assets.

In this arrangement the owner takes the majority of operating risk of the service (i.e. absorbs any losses consequential to the non-availability of the heat supply). The owner might also retain responsibility for new connections and the expansion of the network, though these functions could also be assigned to the contractor. Risk associated with appropriate design and operation of the system is carried by the supplier.

One of the strengths of this approach is that it can make the best use of a sponsor's access either to lower cost fuel supplies or lower cost capital where that is available. It also ensures the sponsor retains control over prices at which energy is sold to customers.

The contract will likely include some provision to ensure efficient operation of plant (as well as just maintenance). There are a wide range of option for the design of performance guarantees to ensure this, such as an incentive to maximise electricity output from the CHP.

In principle, the D&B contract and the O&M contract should be considered separately, because the form of the contract would be different in each case, but may be awarded together, as performance risk will be mitigated by assigning responsibility for the design, build and operations to one contractor. The D&B and O&M contracts will outline the requirements the sponsor has of the supplier, and outlines that relationship.

The D&B and O&M specifications for this contract type usually require a greater level of specificity than with concessions or wholesale heat supply because most of the risk associated with the scheme is being borne by the sponsor. The D&B contractor may lack the incentive to provide a design consistent with sponsors' drivers. Supplier can be expected to design to meet the wording of the D&B specification and to maximise O&M fees.

Methods that can be used to mitigate this risk include requiring the design proposals of D&B bidders to be more clearly outlined, appointing the O&M contractor in time for it to be able to approve the design or be involved in commissioning the network and requiring extensive warrantees from the D&B contractor for the operational efficiency of the plant installed.

In relation to O&M, one way of limiting the tendency for charges to creep up is to limit the term of the O&M contract to, say, five years and to use the opportunity to re-bid the O&M contract periodically to ensure contractors have appropriate incentives.

Connection and supply contracts, as discussed in the preceding section, will also need to be in place between the sponsor and all energy customers.

6.2.4 Operation & Maintenance

A network operation and maintenance (O&M) contract may be appropriate where an existing DH scheme is being upgraded, or where a new DH scheme is to be installed by the main building contractor. Note that in this case, the O&M contract is likely to leave virtually all risks with the asset owner, and should be of relatively short duration to retain the incentive to run the scheme efficiently.

An O&M contractor typically lacks the incentive to maximise revenues. This can be an issue where a DH network includes CHP. The merits of CHP are that it produces additional revenues from electricity sales, and secures improved carbon performance by comparison with simple boilers. From an O&M perspective, however, running CHP involves considerable additional cost and complexity. Careful attention to incentives is essential to ensure optimal running of a CHP system under an O&M contract.

Whereas an ESCo and a DBO contractor can be penalised for poor performance, an O&M contractor will not normally be willing to accept contracts with penalty clauses. The contract value is usually too small for the risk of being penalised to be covered by prospective revenues under the contract, and the assignment of responsibility for service failure is likely to be disputed.

6.3 Common contractual issues

6.3.1 Metering and billing

Unless an ESCo contract is adopted, additional contract decisions will have to be made on how to manage metering and billing, including the customer interface. A typical arrangement for local authorities or landlords is for them to retain metering and billing, revenue collection and customer services, as they are already engaged with the DH system's customers to collect rent or service charges. Several specialist firms exist who provide these services, other than accepting credit risk, typically under short term contracts; however, their charges vary widely. Metering and billing contracts are examined in more detail in Section 6.5.

6.3.2 New connections

The terms on which new connections are made will be set out in the connection contract, and these terms can be reflected in the master agreement, DBO or O&M contract. New connections can require complex contract negotiations and involve disruption to operations, putting performance standards at risk. These issues can be addressed either by sponsors retaining the new connections role for themselves or through the inclusion of new connection performance targets within the relevant contract.

However, for local authorities and other network developers or owners there is a strong policy driver to ensure the steady growth of networks once they are up and running. The extension of networks can often reduce risk associated both with heat loads and sources of heat supply and introduce economies of scale. Yet DBO and O&M contractors only have weak incentives to extend the network, and even ESCos may be reluctant or unable to commit the financial resources required to extend a network in advance of firm orders for connection that would fully remunerate the investment.

Methods of overcoming the poor incentives to extend a DH scheme include:

- requiring through planning conditions that new developments connect to an existing DH scheme if within a defined distance of the development. The net effect of this rule is to increase the density of the heat load served by the DH scheme;
- imposing an obligation on the operator to connect new customers on standard terms where the premises to be connected are within a defined distance of the existing scheme. The net effect of this rule is to spread any additional cost of new connections over all connected customers;
- providing refundable finance for the cost of a new connection.

Where the heat network is in separate ownership from the energy supplier, (the prevailing model in the UK and in Danish urban heat networks), rules are required to determine the allocation of the costs of new connection.

The underlying logic of network extension in a UK context can be most clearly illustrated in relation to the rules governing gas connections. To connect a building to existing gas infrastructure, a developer would hire the services of a UIP (utility infrastructure provider) which would charge the full cost of making the connection. If the nearest gas infrastructure were some distance away, the developer would seek out an IGT (independent gas transporter), which would invest in the necessary infrastructure and be remunerated in part by the developer and in part through future charges for gas transported over the infrastructure. With gas, the balance between these two sources of funding for network extension is determined through competitive tendering among IGTs. With heat networks, that opportunity does not exist and so will need to be determined on the basis of rules. The current absence of formal regulation of city-scale DH schemes means that the rules are required to be written into the relevant contracts each time.

6.3.3 Contract boundaries

Whatever the contract structure, it will be necessary to define the point of connection between the DH system and the customer's own heating system.

A typical arrangement with an ESCo serving residential premises would be for the ESCo to own and be responsible for the entire network up to and including the HIU, and especially the meter within it. The ESCo has the incentive to make sure that the network equipment is working properly, and has a direct contractual relationship with customers, and so logically should be responsible for maintenance, repair and replacement of all equipment used to provide service. The point of connection would then be at a valve on the customer's side of the HIU.

Alternatively, the developer may decide to own the secondary network in order to have control over all building services. The point of connection would then be at a valve on the building side of the substation serving it. The developer may still prefer the ESCo to be responsible for the HIU and heat meter, which require specialist maintenance.

DBO and O&M contractors do not have the same incentives as an ESCo and it might be more appropriate in these contracts for responsibility for HIU maintenance to belong with building management, especially if the building management also accepted responsibility for distribution of heat within the building. If that is done, then the DBO or O&M contractors would not need to be given rights of access to customers' premises.

For commercial premises, the point of connection to a DH network would normally be at a substation in the basement of the premises. Responsibility for the distribution of heat around the building would then rest with the building management. This arrangement is usually more convenient for property managers, who are responsible for building services. The point of connection to the DH system would then be at a valve on the building side of the substation.

Other contract boundaries may be more straightforward to define, but in all cases the sponsor must consider interface risks, where they should reside and how best they can be mitigated. Typically, with DBO and O&M contactors, the client will retain all interface risks between its contractors unless expressly handed over, since the contractors will not normally have a direct contractual relationship with each other.

6.3.4 Aligning contract incentives

In general, an ESCo agreement can more easily achieve a sound alignment of incentives, as it is responsible for all aspects of the delivery of heat to customers. The transfer of roles, responsibilities and risks to an ESCo also enables the terms and conditions of the contract for the DH scheme to be focussed on outputs – the quality of service to be provided and the prices to be charged – and so avoid specifying the details of design or of operating standards. The regulation of prices and of quality of service will still be necessary, as the ESCo will effectively have a monopoly position in relation to served premises. Pricing principles are examined in Chapter 7.

If the ESCo owns the assets as well as the revenues from customers, its commercial incentives should be appropriate. The ESCo is sometimes permitted only to lease the assets for the period of the concession, with an obligation to hand them back in good condition at the end of the concession. This approach can work well, at least until the termination date approaches (given the long payback period on investment in DE, the ESCo's incentive to invest in expanding the network disappears once there are fewer than about ten years left on a contract). Typically, this incentive problem is resolved by renewing the concession well before its expiry date.

Strong incentive effects can be secured by drafting and then enforcing well-defined termination clauses in the master agreement. To avoid the sponsor of the DH scheme having to take over the running of the system and to procure a new ESCo at relatively short notice, the termination clauses would need to contain detailed transition arrangements.

It would be feasible to set up an ESCo arrangement in which ownership of the assets was retained throughout by the landlord. However, in such a case, the ESCo's incentives are likely to be distorted: it could make more money if the assets were replaced more frequently, or if maintenance was skimped. In such a case, therefore, the ESCo contract will need to contain:

- A detailed asset register with expected asset lives, linked to the SLA (i.e. penalties for early replacement of critical assets)
- detailed provisions about O&M standards and procedures;
- strict record keeping requirements, and a periodic inspection regime.

Alternatively, the remuneration of the ESCo could include profit sharing; however, few DH schemes are sufficiently profitable for this to be a practical option.

Similar incentive issues arise with DBO and O&M contracts. The problem is more acute with DBO, as these are typically long term (in order to incentivise good design and build). The mitigation measures in this case are as above.

While having detailed provisions on standards and procedures, and periodic inspection, O&M contracts are usually short term (e.g. 5 years). The regular market-testing of O&M performance, with the credible threat of termination, helps to mitigate the adverse effects of these incentive issues.

6.4 Heat supply agreements

Table 11 on the following page provides an outline is provided of standard terms to be included in an agreement where heat is supplied directly by a heat provider ('ESCo') to a residential customer.

Examples of completed heat supply agreements are in the public domain. Gas and electricity supply agreements can also be referred to as a guide to the detailed provisions.

Supply agreement heading	Outline of contents
The served premises	Identification of the address to be supplied and contact details of the customer
Supply dates	Date of the agreement; date of first supply, if different; duration of the agreement.
Charges for heat	Fixed charge; variable charge; other charges that may be applied e.g. in the event of temporary disconnection.
Annual price review procedure	Description of the procedure the ESCo will follow each year to revise the charges. This will typically be a formula linked to the prevailing rate of price inflation and/or gas price inflation, and the price of a comparable boiler maintenance contract with equivalent terms (e.g. no excess).
Reading the meter	Frequency and method of meter reading; customer access to the meter and to consumption data; what to do if the meter reading is disputed, or the meter fails.
Billing procedure	Frequency of billing (not necessarily the same as for meter reading); content and format of the bill; methods of payment; time to pay; penalty for late payment; what to do if the amount owed is disputed. Where credit risk is a concern, it is important to provide some means of pre-payment, either through a pre-payment meter or a method of keeping an account in credit. The agreement would specify the conditions which would trigger a switch from payment in arrears to an in-credit arrangement. In general, pre-payment should not result in a higher charge.
Data protection	What the ESCo may do with the consumption data, with the customer's payments and with contact details.
Standards of service	The temperature of the heat to be supplied and permitted variation; permitted downtime and notification process; other performance standards; method of reporting performance; penalties for non-compliance. It is usual for standards of service and penalties for non-compliance to be set out in a separate document which can be updated without requiring all supply agreements to be revised. It is also good practice to make this information available in plain language for residential customers.
Changes to the service	Procedure for the ESCo to notify changes in the service to be provided (other than a price change). Procedure for the customer to request a change to the service to be provided, and the method for calculating any charges that may apply.
Moving house	Procedure for the customer to follow when leaving the premises and handing over the agreement to another person.
Access	Procedure for the ESCo wishing to gain access to the served premises (if necessary).
Liabilities	Listing of the liabilities of the ESCo and the customer (e.g. for death or injury, for damage to property, etc) and any limits on liability.
Suspension and termination	The reasons and procedure for suspending the agreement (e.g. due to absence from the property or failure to pay bills). The reasons and procedure for terminating the agreement (e.g. ESCo's failure to perform). Protection for vulnerable customer groups.
Annex 1 The District Energy System	Description of the district energy system and of the connection of the premises to it (e.g. capacity)
Annex 2 Residential HIU	Whether the HIU will be located inside or outside flats and houses. Whether the ESCo, the landlord or the customer will be responsible for the maintenance, repair and replacement of the HIU. Arrangements for inspection, repair and replacement of the heat meter if attached to the HIU.
Annex 3 Quality of service	• Flow temperature of heat; • Supply interruptions; • Response time to reports of supply failure; • Aspects of billing performance.

Table 11. Typical contents of heat supply agreements to residential customers

6.5 Metering and billing contracts

The costs of metering and billing exhibit economies of scale. With small DH schemes, it is usually worth considering using specialist providers of metering and billing services that can offer to share the benefits of the scale they have already achieved on other schemes. Gas and electricity suppliers that also operate DH schemes can normally integrate their billing systems and customer services, to the benefit of the DH schemes that they operate.

The charges for metering and billing heat are likely to be higher than with gas and electricity supply, since the customer base is much smaller and also because heat meters tend not to be standardised and to have a shorter life.

With an ESCo, it would normally be responsible for selecting the metering and billing system to be used. Even in this case, it is important to ensure that data is presented by the metering system in a format usable by more than one metering and billing services provider, in order to facilitate transfer on termination. Where a DBO or O&M contract structure is used, the requirement to avoid being tied in to a particular service provider is even more important (see Section 3.7. for further information on meters). Where meter procurement is the responsibility of the building contractor, these considerations should be incorporated into the specification of the building contract.

Metering and billing service contracts need not be as long as ESCo concession or DBO contracts. However, a minimum contract duration of five years is recommended, both to reduce the transaction costs of procurement and to allow the metering provider to spread its initial set-up costs related to the scheme.

Specialist metering and billing service providers will not normally accept credit risk, but contract performance standards can be used to mitigate the risk for the client. For example, follow-up phone calls can be helpful in identifying payment problems early. This must be done with care to avoid incentivising aggressive or insensitive debt recovery practices, leading to negative customer perception. Dealing with vulnerable populations in particular will require the balancing of revenue protection and customer satisfaction objectives.

6.6 Customer service

District heating is not subject to national regulation, nor are there recognised standards of service for heat providers. This means that consumer protection must be built into the specific contract under which heat is supplied to consumers. The consumer protection measures have to cover all aspects of customer service: charges for service, the quality of service provided and complaints procedures.

In practice, the way in which electricity, gas and water services are provided in this country offers a practical reference point for determining what should be required of heat providers. Most ESCos publish standardised customer charters, usually based on utility standards of service, which can be referenced for a new DH scheme. The benefit of this approach is that it assures that the standards of service for heat supply will be regularly updated in line with the generally applicable utility standards of service.

The agreed standards for customer services can be attached to the supply agreement or can form a separate contractual commitment to the project sponsor (see SLA discussion in Section 6.2.1). Other, more aspirational standards of performance, behaviour of ESCo staff and treatment of customers, tend to take the form of a Customer Charter, although the two types of document can overlap to an extent. A template customer charter is being developed by the CHPA and expected to be available in Autumn 2013. Where a new network operator is being procured, this template could be used as a benchmark to test bidders' proposed charters.

CHARGES FOR HEAT AND REVENUE MANAGEMENT

7

This chapter covers the revenue side of network operation, including the types and formulations of charges paid to the operator and the typical arrangements for metering and billing. As with the preceding chapter on contracts, this is provided as information and guidance to assist the development of well-managed, viable networks.

7.1 Types of charge

The charges levied by the heat provider typically comprise:

- Connection charge: an initial charge for connecting to the heat network, which may be paid by the developer or landlord, but is not usually payable by customers;
- Standing charge: the fixed component of the heat supply charge, normally paid by t he customer but by the landlord of rented residential premises;
- Unit charge: the price per unit of heat supplied, normally paid by the customer.

These charges can be set in several ways:

- Initially by the heat provider through competitive tender and then index-linked;
- Set expressly to recover construction and operating costs (cost-based pricing);
- Set to match the opportunity cost of the DH system (avoided cost).

Which of these principles should underlie the setting of charges for heat will depend on the type and duration of the contracts. The avoided cost approach is normally best for ESCo contracts, as it best ensures that the DH scheme will continue to provide good value for customers in the long term. Index-linking prices is liable to result in heat supply becoming uncompetitive in the longer term, as a price index such as RPI does not expressly take into account productivity improvements. Cost-based pricing, as is well-known, tends to reduce the operator's incentives to be efficient.

Basing the charges for connection to a DH scheme on avoided cost is also helpful in assuring developers that they will not incur greater costs than with a conventional heating solution. However, calculating the avoided cost of connection can be complex and not entirely objective.

7.1.1 Connection charges

Connection charges can contribute significantly to the commercial viability of district heating schemes. The developer of new premises to be served by the DH scheme would normally be willing to pay a connection fee that did not exceed the cost to provide a gas supply, inclusive of the cost of a gas boiler (for flats the cost of a central heating system), plus the cost of achieving an equivalent level of carbon reduction. As the DH system will contribute to reducing carbon emissions, the connection fee should take account of the cost of the most economical alternative method of achieving the same reduction in carbon emissions. Taken together these constitute the 'avoided cost'. The higher the carbon reduction standard to be achieved, the higher the avoided cost.

For a development that is to be built over an extended period, it may be possible to formalise the avoided cost into a formula or schedule, and then index-link or benchmark the connection fee based on this formula. Such a formula can provide both ESCo and developers with certainty, which is helpful in determining capital contribution (the ESCo's main concern) and land value (the developer's concern). Alternatively, it would be possible to re-calculate the avoided cost every few years, since the carbon performance required of new buildings is rising while cost of achieving a given level of carbon performance through adjustments in the building fabric is falling, in real terms.

7.1.2 Connection of Local Networks to City-wide Networks

Once a local DH scheme is operational, then there are several reasons for connecting it to a larger network:

- to reduce further the cost of provision of heat;
- to improve the utilisation of existing heat generating plant; or
- to avoid replacement of heat generating plant and maximise network diversity benefits;
- to spread demand risk.

The cost of connection can be compared in NPV terms with the savings in heat costs. In this case some price guarantee may be advantageous. Where the connection cost is substantial, for example a long pipe run, the cost of financing the connection may also need to be taken into account.

The calculation of the avoided cost of generation plant replacement will depend on the location of the scheme and the type of property to be connected. Where local generation plant is underutilised, it may be able to contribute heat to the larger network via the connection. That is, a replacement plant would be dimensioned in relation to the heat export opportunity presented by connection to the larger network. Alternatively it may be sensible to close it down completely. In that case, the property value that can be realised may be a significant factor.

In any event, it is likely to be impractical to standardise the charges for connection of a smaller DH scheme to a larger network.

7.1.3 Charges for heat

The pricing approach to be followed should be specified in the procurement process of any heat network.

For the reasons given in Section 7.1, prices charged for heat supplied by DH schemes are normally set by reference to the equivalent cost of gas-fired central heating (the ‘avoided cost’ or ‘gas comparator’). For most residential customers, gas-fired central heating is the most cost-effective alternative form of heating and hot water. For high-rise and ‘green’ developments, this may not be the case and an alternative benchmark may be used.

Even where the initial set of charges for heat has been derived through a competitive tender process or on the basis of costs, the annual adjustment of prices is typically made by reference to a gas comparator.

So the first step in developing a tariff for heat is to establish the gas comparator. There is no accurate way of making this comparison, as gas suppliers offer a multitude of tariffs, the take up of which is not publicly known. Gas suppliers are required to quote for an average level of consumption, specified each year by Ofgem. Almost certainly, the customers to be served by the district energy scheme will consume less than this average. The level of consumption can be estimated though it cannot be known with certainty in advance.

It should be borne in mind that energy suppliers and the gas tariffs they offer are constantly changing and for a long running contract the reference energy price should be expressed generally. For instance, the gas comparator could be stated as ‘the average gas price calculated from the cheapest gas tariffs available locally on a dual fuel basis from each of the six largest gas suppliers for a consumption of 7000 kWh per year’.

To determine the equivalent heat price, a conversion factor has to be applied to the gas price. With modern gas boilers, a 85% or 90% efficiency should be assumed.

An alternative method of calculating a gas comparator is to use the wholesale price of gas with a mark-up. The benefits of this approach are that it is more easily calculated each year and the wholesale price more closely corresponds to the actual costs of the heat provider (assuming the DH system is gas-fired). Data on wholesale gas prices are published regularly by Isis Heren[6]. For example, the year ahead NBP price of gas on 21 October 2011 was 69.925 pence per therm, which converts to 2.38p per kWh. So a mark-up of about 100% on the wholesale price would match a price derived from a retail gas comparator.

The advantages of reference to the wholesale price of gas are, firstly, that it is a single, published point of reference whereas the retail price of gas can only be determined through calculation and there is room for argument as to the data to be used in such calculation and, secondly, the wholesale price of gas is a key component of the heat provider's costs, so the ESCo may consider it a less risky approach. Conversely, because the wholesale and retail prices of gas may move in different ways, in any year there is a risk that consumers experience heat prices that are too high by comparison with retail gas. In recent years, the gap between wholesale and retail gas prices has widened so this risk has not materialised.

The heat provider typically maintains the energy system as well as supplying heat, so the price for heat should also take into account the value of this service. The value of a boiler maintenance contract can be determined by obtaining quotes. For example, in September 2011 the British Gas Homecare 100 with no excess (considered to offer a comparable service to that of heat providers) was priced for London customers at £156 a year including insurance tax.

The pricing approach to be followed should be specified in the procurement process. Where the heat provider has been selected by competitive tender, the prices offered in its tender can be reconciled with the gas comparator approach by means of just such an adjustment to the discount or mark-up.

It is not advisable to revise prices for heat simply by linking the tender heat price to an inflation index. By doing so, there is a high probability that heat prices will quickly get out of line with customers' expectations, which are based mainly on current energy prices.

It is also not advisable to base annual revisions to charges for heat directly on the actual costs of the district energy scheme, as to do so risks removing the heat provider's incentive to be efficient and, perhaps more important, provides no assurance to customers that they will continue to receive good value for money in future.

It is important that the tariff based on a gas comparator includes all charges to residential customers. As well as the fixed charge and the unit cost, heat providers may charge for late payment, for disconnection and re-connection, and for transfers when a dwelling changes hands; they may also offer a discount for paying by direct debit. All these extras should be taken into account. Tariffs should be reviewed regularly. Residential consumers dislike the frequent tariff changes to which they are exposed by gas and electricity suppliers. With a DH scheme, there is the opportunity to limit price changes to one a year. Further certainty can be provided by basing the annual tariff adjustment on a formula that is made clear to consumers (for example, by its inclusion in the heat supply contract).

In the short term the gas price may be the best comparator for a heat tariff. However, this may change in the future to reflect changes in the general nature of heat production in the UK. So the contracts should allow for a review every, say, five years to see whether the gas comparator remains appropriate.

6 ICIS HEREN energy price reporting, available online at www.icis.com.

7.1.4 Fixed charge

District energy systems typically use a tariff that comprises a fixed component and a variable component, even though most gas suppliers no longer do so. The main commercial reason for their preference for fixed charges is that heat demand is highly variable over the year and a fixed charge smoothes cash flow. Also, a high proportion of the operating costs of a DH system are fixed in the short term.

In principle the fixed element should cover regularly recurring operational and maintenance costs and the variable element should cover energy use. For residential rental tenants, the maintenance costs must be charged to the landlord and so it is particularly convenient if the fixed charge exactly matches the relevant O&M costs.

7.1.5 Variable charge

Given an overall limit on what can be charged to the customer, set by reference to a relevant external benchmark, such as retail or wholesale gas prices, then the higher the fixed charge, the lower the unit cost of consuming heat. In general, a low unit cost is not desirable as it reduces the incentive for customers to economise on heat consumption. A balance needs to be struck between the interest of the operator in a steady cashflow and preserving incentives for consumers.

For district energy systems that serve existing dwellings with a higher heat demand, it may be necessary to set more than one variable charge for heat in order to ensure that all customers benefit from the system.

7.1.6 Commercial tariffs

The same tariff principles can be applied to commercial developments. Prices for heat chargeable to commercial customers are generally lower than for residential, reflecting their much higher levels of consumption via a single connection and their reduced requirements for customer services.

The market for gas supplies to businesses is more fragmented than the retail domestic market. Many private sector firms have national agreements for gas supply and many public sector organisations participate in the 'Government Procurement Service Framework Agreement for the Supply of Natural Gas, Ancillary and Associated Services' run by Buying Solutions, or participate in the procurement service offered to local authorities by Laser Energy. These various agreements may provide a suitable benchmark for the avoided cost of gas supply.

Where reference to such agreements is not feasible, a 'gas comparator' for commercial developments can be obtained by reference to DUKES[7] , which publishes data on prices paid by industrial companies for gas.

For commercial customers, the avoided cost of maintenance can be determined by reference to quotations from specialist firms for the maintenance of central heating systems, taking care to compare like-with-like.

Similarly, the connection fee payable in respect of commercial buildings can be based on a calculation of the avoided cost of connection to gas plus the avoided cost of carbon reduction.

7.1.7 Wholesale heat tariffs

Wholesale heat tariffs will be needed where a DBO contractor is paid for heat supplied via a DH system to the local authority or landlord who retails it to customers, or where a local network is supplied with heat by means of a connection to a larger network.

7 Digest of UK Energy Statistics, published by DECC

Wholesale heat tariffs can be developed following the same principles as for commercial customers, set out above. As the scale on which heat is to be supplied wholesale is likely to be significantly higher, the avoided cost calculation is likely to produce a lower total price.

How the total wholesale price for heat is divided between fixed and variable components will depend on the capacity of the connection, and the expected total demand for heat, as this affects the commitment that the heat provider must make at the energy centre. The fixed element of the charge for heat may be constructed on a 'take-or-pay' basis.

7.2 Revenue management

As with other utilities, billing consists of reading the heat meters and collating the data into a database. Heat meters can be read in person or remotely, depending on the type of meter. Once the consumption data is collected and validated, a bill is prepared and issued to the customer. Bills can provide additional information for customers, including cumulative and average consumption and equivalent carbon emissions or carbon savings as compared with a standard benchmark for that consumer type.

The normal position for a customer with a good credit history is to bill in arrears, and not to place a deposit into the billing system. If the customer's credit rating is poor, or drops due to persistent non-payment, the billing system can be kept in credit or a deposit held while still allowing payment in arrears. Fixed monthly direct debit arrangements can be used to spread payments evenly over the course of the year (since demand will normally be high in the winter and low in the summer).

Alternatively, a formal pre-payment system can be used. Pre-payment is generally run by hardware in the HIU, and thus has a cost. However, with smart meters, pre-payment can now be achieved solely through billing system software.

7.3 Debt management and credit risk

Accurate metering and billing is essential to minimise the quantity of bad debts. A well-managed district energy system should be able to limit bad debts to about 1% of revenues, which is the typical level for electricity and gas suppliers. If so, no specific allowance for bad debt need be made, since the benchmark tariffs will already include an adequate allowance for bad debt.

Debt management is achieved primarily through an escalation procedure that combines formal reminders of amounts due, telephone contact to identify specific issues, referral to Citizens Advice or other bodies to help those with financial difficulties and, finally, suspension of service. These stages of escalation will be documented within the customer charter and, because of the potential risk to the health of the customers, suspension is only permitted as a last resort and in accordance with specified procedures (e.g. during summer). Where a heat network is being operated under contract (such as under concession or on behalf of a local authority), the contract will set out the conditions under which suspension may be made.

Pre-payment or requiring accounts to be kept in credit can be used in case of persistent payment problems. Pre-payment and credit customers should normally be charged the same prices as other customers, as arranging pre-payment does not normally entail additional costs of revenue management.

PLANNING GUIDANCE FOR DEVELOPERS

8

This chapter briefly covers the planning policy and development control issues which are likely to arise in connection with new development which could or does connect to a district heating network, and development of stand-alone DH networks themselves.

The London Plan requires that all major developments seek to achieve demanding carbon reduction targets through the application of the Energy Hierarchy (see Figure 22) to the design of the scheme. The GLA has worked with its borough partners to establish a standard of good practice for borough-level policies and development management practices to ensure widespread compliance with London Plan policy. This chapter also provides a brief introduction to the relevant planning policy and guidance on the typical requirements of local planning authorities in relation to the development of and connection to district energy networks.

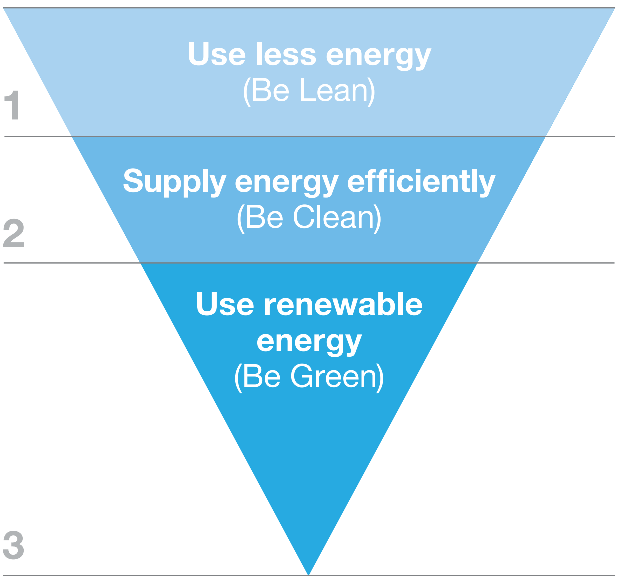

Figure 22. The energy hierarchy

8.1 Do district heating systems need planning permission?

The construction and installation of district energy networks would normally fall under the definition of 'development' under the Town and Country Planning Act 1990. Therefore such works would normally need planning permission. There are however, some cases where planning permission for such works does not need to be sought. These cases include:

- Permission as part of a wider development;
- Local authority permitted development rights;
- Electricity Undertaker permitted development rights;
- *De minimis* treatment of DH works; and
- Adoption of a Local Development Order.

Two of these cases are explained in more detail below.

8.1.1 Part 12 permitted development rights (local authorities)

One such case would be where a network is brought forward by a local authority on land in its ownership or for which it is the Local Highways Authority and can therefore be delivered using Permitted Development Rights afforded to the Local Authority in Part 12 of the Town and Country Planning (General Permitted Development) Order 1995 (as amended). Such powers are subject to maximum thresholds which state that buildings must be no more than 4m in height and the total volume of development (i.e. buildings and pipework) must be no more than 200m^3.

8.1.2 Adoption of a local development order

One alternative to conventional planning permission is to develop a Local Development Order (LDO) to secure a ‘class-based’ planning permission for the development of DH networks. LDOs can be adopted by local authorities to grant permission for a class or type of development across a whole or part of a local authority area. A development which met the description contained within the LDO would be able to commence as soon as any conditions set out in the LDO were satisfied.

8.2 The Planning Policy Framework

There is considerable policy support for the implementation of DH systems. Decentralised energy promotion is a key policy theme in the National Planning Policy Framework, which requires local authorities to identify and plan for opportunities for Decentralised energy Including district heating systems.

Local authorities are increasingly adopting targets for borough-wide carbon reduction, and this is translated into planning policy requirements related to the implementation of DH networks. Local Plans usually contain one or more over-arching policies which are supplemented with information in more detailed plan documents such as Supplementary Planning Documents (SPDs). Decentralised energy policy can take a variety of forms and the following sections set out requirements which might reasonably be expected in local planning policy.

This guidance is not intended to supersede or take precedence over adopted planning guidance. Instead, it is provided as general guidance on the issues which are likely to arise in relation to DH within and connected to new development.

Developers should always take planning advice or check with their local planning authority at an early stage in the project to ensure that they have an up-to-date understanding of relevant planning policy and statute.

8.2.1 Requirement to connect

Where there is an existing DH network, policies may require new developments to connect to the network unless it would not be feasible or viable to do so (see Section 8.3 for further details).

Such policies may set a distance threshold or designate an area within which developments are expected to connect. The requirement to connect will typically include the provision of the means to connect to that network and a requirement to bear the cost of connection

8.2.2 Concurrent planning of new development and new networks

One of the key challenges of developing a new district heating network is the timing between the delivery of the new network and the completion of new developments which would be connected to the network. If the network is delivered early, viability may be affected by delays to consumer connections. If it is delivered late, new developments may need to secure contingency supplies of heat, or they may have to commit to alternative heat supply solutions. This section provides some initial proposals of how to address this issue through planning.

There are essentially three cases to consider assuming that a new building development falls within an Energy Master Plan (EMP) that proposes a district heating DH network. These are identified below and commentary provided on options for the new development.

Where an EMP identifies the feasibility of an area-wide heat network but no firm plans exist as to who will build the network or by when:

- The development should 'future-proof' a connection assuming it has a single plant room producing hot water for space heating and domestic hot water. Future-proofing involves providing 'tees' and isolation valves in the hot water headers to facilitate the connection of an interfacing heat exchanger at a later date.
- A space reservation could be provided for the heat exchanger, or it could be planned that the heat exchanger replaces a heat-only boiler at time of making the connection to the DH network.
- Provision should be made in the building fabric to facilitate future district heating connections;
- External buried pipework routes should be safeguarded to a nearby road way or similar location where connection to the main DH network would be made.

Where there is a DH network being delivered but there is no programme to connect the development due to its distance from the network and the lack of plans for intervening sites:

- The development should be designed on the basis of its own CHP with standby boilers etc, and 'future-proofed' according to the guidelines given above;
- Allowance could be made to defer investment (installation) in the CHP plant for, say, five years to allow time for the DH to be constructed and connected to the network. Once the network connection is made, the requirement to install CHP falls away.
- If the DH network connection is not made within five years and there is no reasonable prospect of doing so, then the development should be required to install CHP. A planning obligation could be employed from the outset to ensure the CHP installation is carried out.
- During the five year period, the development will be supplied with heat from its own heat-only boilers noting that the environmental benefits will not accrue until either the DH network connection is made or CHP installed.
- The developer could be given a planning condition allowing any 'freed-up' plant space resulting from the DH connection to be used for more profitable purposes.

Where there are firm plans to connect a development to the heat network, but the network build-out will not reach the new development until some years after the development is complete:

- The development should design for a district heating connection from the outset which would entail a smaller plant room to accommodate the interfacing district heating heat exchanger and displace the requirement for heat-only boiler and CHP plant.
- Heat should be provided by temporary local heat-only boiler arrangements provided by the entity responsible for the DH network.

8.3 Feasibility and viability assessments

New development will be required to adhere to policy requirements to connect to DH networks or include future proofing measures unless it has been demonstrated that it is not feasible and viable to do so. Most local authorities will require applications to be accompanied by a feasibility and viability assessment which will be scrutinised by their officers in order to determine whether connection is reasonably practicable.

In assessing viability (cost and financial implications) and feasibility (engineering and practical constraints) local planning authorities are likely to consider the following:

- The size of the development, and the heat load and energy demands;
- The distance of the development to DH network;
- The presence of physical barriers such as major roads or railway lines;
- The cost of connection and the impact this has on financial viability;
- What efforts the applicant has made to secure agreements to create a new network through connection of nearby buildings or estates. This will be an increasingly important part of driving the development industry to take ownership of pplanning and development networks;
- The distance of the development to planned DH networks;
- The proximity of any public sector estates and buildings with communal heating systems, especially uses such as swimming pools, hospitals and large housing estates;
- Land use mix of proposed development;
- Land use mix and density of surrounding built environment.

The developer should agree the scope of a feasibility and viability assessment with the local authority early on. The local authority, or relevant Energy Service Company, may be able to provide relevant information to inform the assessment, including for example the approximate cost of connection.

Where connection is not considered possible due to feasibility or viability, developers will be expected to prepare an alternative energy strategy and submit details of this with the planning application.

8.4 Relationship with other policy requirements

In addition to specific requirements to connect to DH networks, local planning policy may require a certain level of energy performance on site, for example a requirement to achieve a certain reduction in CO_2 emissions or a Code for Sustainable Homes / BREEAM level. In some instances there may also be specific targets for the percentage of the energy demand to come from decentralised and renewable or low-carbon energy sources.

It will be for the applicant to determine the best method to achieve the target for their particular development. Connecting to a DH network is likely to make a significant contribution to on-site carbon reduction and hence the achievement of other policy targets.

Where such a policy target exists, the CO_2 reductions anticipated from connection will need to be assessed and agreed by the local planning authority. Other measures proposed to contribute to the relevant CO_2 reduction target should be complementary with network connection technologies in order to achieve maximum reasonable CO_2 reductions.

8.5 Technical specification

Local planning authorities may wish to take into account the design standards set out in the DH Manual when specifying connections or future proofing measures and in assessing planning applications. In some cases local authorities may choose to adopt the specifications contained in this guidance as an SPD.

8.6 The Planning Application Process

8.6.1 Pre application discussions

Each development site will have a unique set of circumstances and opportunities which will affect the ability to provide or connect to as DH network. It is therefore vital that discussions regarding DH connection are commenced with the local planning authority as soon as possible. Such discussions can be combined with discussions on the development more generally; however it is essential that the relevant carbon/energy officer from the local authority is in attendance.

The following topics in respect of the provision of DH might be discussed at the pre application meeting:

- Potential of the development for DH;
- Local policy requirements;
- Planning application boundary (should be drawn so as to include all local supply pipework required for the connection outside the public highway);
- Specification of DH connection/apparatus;
- The expected location and timing of connection to the network; and
- Information to be submitted with the application.

8.6.2 Information to be submitted

In preparing a planning application, the local authority's validation list should be referred to. This list, which can usually be found on the authority's website, sets out the information the local planning authority expects to be submitted with various types of application.

A DH connection is not likely to significantly increase the amount of information to be submitted as part of the planning application and is unlikely to trigger the need for additional assessments to be undertaken. Where a planning application is supported by other assessments, such as a Utility Strategy, Archaeological Assessment or Flood Risk Assessment, the DH connection or future proofing apparatus should be assessed in the same way as the rest of the development.

In respect of applications for developments which include a DH connection or future proofing measures, the following information might reasonably be expected in addition to that already required for the development:

- Plan showing the pipe route and connection point to the wider network;
- High level technical specification;
- Date of implementation and connection;
- Details of financial contributions;
- Feasibility and viability assessment; and
- Energy statement demonstrating carbon and energy savings.

8.6.3 Other consents

In addition to securing planning permission there may be other consents which must be in place before work can commence. These include the need for permits under the Environmental Permitting Regulations (EPRs) should these be required. Any works undertaken in Air Quality Management Areas may also require additional approval under the Clean Air Act (1993). In order to implement elements of a scheme that fall within the highway, it may also be necessary to secure a Street Works Licence under Section 50 of the New Roads and Street Works Act (NRSWA) 1991. Before an application can be submitted all statutory undertakers, including utilities operators, must have been consulted and confirm that they are satisfied with the proposal in respect of the protection or diversion of their apparatus. In order to determine the Street Works Licence application the local authority will also need to be satisfied that the proposed operator and contractor would meet their requirements i.e. that the operator will undertake the works in the highway in an acceptable way. Section 81 of NRSWA sets out the 'duty to maintain apparatus'; the organisation undertaking the work must demonstrate that it will be able to maintain the apparatus once it is installed. Therefore, this process will also satisfy the local authority that an operator who can demonstrate the relevant credentials will be installing and maintaining the apparatus.

8.6.4 Planning conditions and obligations

Where connection to an existing or future DH network is feasible and viable, a commitment to connection may be secured via a legal agreement; this may include provision for a financial payment to the local authority to enable connection (although a connection charge may instead be paid directly to the DH network operator). Planning conditions may also be used to ensure the connection is implemented.

Where it has been agreed that the development will connect to an existing DH network, a planning condition might be used to prohibit the development being occupied until a physical connection to the network has been installed and commissioned.

Where it has been agreed that a development will connect in the future, a legal agreement may be used to require a development to connect at any economically viable opportunity. Such an obligation is likely to state that the developer should use all reasonable endeavours to connect and should also recognise that the most suitable opportunity may arise at some point in the future, for example at the end of the economic life of a stand-alone CHP plant. Within the legal agreement a cut-off point will be defined, which will be the latest point at which a decision can be made in relation to network connection. If at this time it is not possible to agree connection to a network, due to the network being incomplete, the alternative energy strategy submitted with the planning application should be implemented (or submitted for agreement and then implemented).

8.6.5 Financial contributions

Increasingly local authorities in London are seeking to secure financial contributions to fund off site infrastructure which might include DH. There are two main routes to securing such contributions; Section 106 Agreements and the Community Infrastructure Levy (CIL).

The introduction of the CIL significantly reformed regulations governing the use of financial contributions. It is likely that the majority of local authorities will adopt a CIL Charging Schedule in the future. Once a Schedule is adopted all new development will be charged at a flat rate on a per metre squared basis, and this payment should be taken into account in viability modelling from the offset. Local authorities may choose to fund DH infrastructure using receipts from the Levy which potentially means there is a new funding stream available to deliver DH. These contributions - whether through a S106 agreement or through a CIL – would be separate and additional to the connection charge which would be made by the DH network operator to cover the reasonable cost of connection itself.

INNOVATION AND THE FUTURE OF DISTRICT ENERGY IN LONDON

9

9.1 Introduction

This section will look at the future direction of the district energy industry, in particular with regard to 'fourth generation' district heat networks.

9.2 Lowering operating temperatures of networks

Comfort heating temperatures for domestic users is typically around 21°C and hot water for kitchen use is near 55°C. If low grade heating systems were employed in designs such as larger radiators or underfloor heating then the requirement for high flow and return temperatures in a DH network is reduced. Operating at lower temperatures increases the efficiency of the system due to the smaller temperature differential between the fluid and the ground, thereby reducing transfer losses. Operating at lower temperature also offers the opportunity to exploit waste heat from sources such as process energy harvesting and solar thermal energy.

One proposed innovation in the application of low temperature systems is to connect customers to the return pipes. This would provide those customers only with low grade heat suitable for space heating, requiring an additional source of heat inside the building for DHW supply but ensuring a lower return temperature, and a higher overall system efficiency. Existing building users have a requirement for heat at 80°C, however in all connections, there is a desire to have as large a temperature differential as possible.

By reducing the operating temperatures of the DH network, the use of polymer pipework rather than steel becomes viable, thus significantly reducing the cost of materials and, with the removal of welding requirements and reduced transport costs, the cost of installation.

It is important to note that the water temperature for supply must comply with legislation for the control of Legionnaires' disease. If systems were designed to operate at a temperature below the safe Legionella operational requirements, one method of control would be to raise the temperature to a sterilisation temperature temporarily on a regular basis.

9.3 Heat storage and smaller pipes

Heat networks with a higher temperature differential require lower flow rates to deliver heat, thereby saving on heat transfer losses and pumping requirements. Pipe diameters can be reduced by lowering the heat demand in the loads through good practice energy efficiency measures. Localised hot water storage in individual buildings could be used to flatten the demand profile or buffer tanks on the primary side of the heat exchanger would have the same effect.

9.4 Developments in Electricity Market

9.4.1 License Lite

Following consultations with a working group of decentralised energy stakeholders in Febuaury 2009 Ofgem published proposed changes to the standard conditions for electricity supply licences to include a new condition, enabling licence applicants to be granted an electricity supply licence without becoming parties to the Balancing and Settlement Code, the Master Registration Agreement and other industry codes, providing certain conditions were met. The purpose is to enable smaller electricity generators/suppliers to be able to supply electricity retail, without the constraints of private wire- (see below). The main condition the applicant has to comply with is the requirement to ensure that it can obtain a range of market interface services from a fully licensed electricity supplier. Ofgem has published guidance on what services are involved.

Although Ofgem's proposals laid out the principles and a regulatory route forward, translating the proposals into an actual 'junior' electricity supply business involves a range of complex questions of implementation. However, on those being resolved, the effect will be that small players can enter the electricity supply market and supply their electricity retail to any premises connected to the public electricity distribution system, thus gaining the prospect of earning higher returns on the electricity they export. The effect should for example, be to enable CHP district heating schemes to earn greater over-all returns on their energy generation, enabling more CHP decentralised energy schemes to become viable and capable of attracting investment.

The Greater London Authority has led a project to secure the implementation of the Ofgem proposals and is currently taking steps to apply for a 'licence lite' licence itself. This will enable retail supply to be made by London boroughs and other public sector bodies in London owning electricity generating capacity.

9.4.2 Private wire

It may be worthwhile for a district energy system to supply electricity to customers over a private network, as electricity supply made under the Electricity Class Exemption Order does not have to be licensed and the burdens of licensed supply, whether to domestic or commercial consumers do not apply.

Connecting customers may entail some alteration to existing wiring, the installation of additional meters and possibly a switchboard. If a new cable has to be run down a street, it may be difficult to secure permission, since access to the public domain is normally limited to organisations serving the public interest.

To cover the additional costs associated with a private wire solution, it will normally be necessary to enter into a long term contract with the intended customers. The price at which electricity is to be supplied will then need to be benchmarked, to satisfy customers that they are obtaining good value for money.

However, it should be noted that the private wire option is not as useful as used to be thought. First, there are limits on the size of private wire scheme which can be used to supply electricity to domestic consumers. In practice that limit is 1 MW per site or set of private wires. Since DE schemes are generally getting bigger, that size limit will become more and more of a constraint and it is very unlikely that the Government will increase the allowable licence exempt scope for domestic consumers, for fear of eroding the competitive market. Second, the 'Citiworks' case of 2009 has caused changes to be made to the licence exempt arrangements for electricity supply that give all parties (domestic and commercial) who are connected to private wire systems, the right to ask for a supply through those wires from a third party supplier. The effect is that the private wire owner has lost its right to make an exclusive supply to those connected to its wires. Such rights of third party access are currently difficult to implement but it must be predicted that they will become easier, eroding the monopoly of electricity supply that private wire owners have hitherto possessed.

It is partly because of the constraints on private wire described above that the 'licence lite' alternative, having no constraints on scale and far more flexibility, is attracting increasing interest.

9.4.3 Netting off

Netting off is an option available to large energy consumers that also operate energy generation plant as a means to obtain a retail price for the energy they produce. Under this arrangement an energy supplier will reduce the total bill of the large consumer by an amount equal to the energy that the large consumer can export to the grid.

This option is available only to large energy consumers who operate generation plant since the incentive for the supplier is to secure the contract to provide the remainder of their energy by effectively offering a discount to the consumer.

9.5 Future trends in UK district heating costs

There is a significant difference in cost in district heating technology between the developed European market and emerging UK market. This is believed to be due to two factors:

Higher pipeline supply costs due to the need to import the pipework since there is no UK manufacturer. Comparisons between UK and Helsinki prices indicate the potential for a 50% price drop from the current UK price if there was the capability to manufacture the pipes in the UK.

UK contractors' lack of experience with the technology results in the need to dig wider, deeper trenches compared to other services. Since there is an inherent risk with unfamiliar technology, contingency estimates are greater than for more familiar installations[8].

9.6 District Cooling

District cooling operates on the same principles as district heating, whereby chilled water is produced centrally and distributed through a network of insulated pipes. This removes the requirement for energy intensive local cooling in buildings, thereby reducing the city's carbon output.

District cooling has been successfully incorporated into DH networks in Helsinki and Copenhagen as a complementary system, making a trigeneration scheme as outlined in the diagram below, showing how the system provides electricity, heating and cooling.

Copenhagen's scheme uses cold seawater as a source of free cooling and uses surplus heat from the DH network to drive absorption chillers to provide cooling when cold seawater cannot meet peak demand during the summer. This scheme has allowed Copenhagen to reduce the CO_2 emissions by 67% when compared to traditional cooling.

The installation of a CHP district heating network is the ideal time to install district cooling when the major groundworks are taking place to install the heating pipework.

District cooling schemes are most attractive when there is a large heat sink locally, such as the sea which can act as a free source of cooling. In direct comparison with electrical chillers, the coefficient of performance of an absorption chiller is poor. As the grid decarbonises, it is important to consider both options for cooling.

8 DECC, 2009. The Potential and Costs of District Heating Networks. Available online at https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/heat-networks

APPENDIX 1

Example of Technical Standards to enable future connection

Islington Council have developed technical standards to enable future connection to district heating networks as part of their Environmental Design Planning Guidance: Tackling fuel poverty, enhancing quality of life and environment for all. The following extract is taken from this supplementary planning guidance document and reproduced here with kind permission of Islington Council and acknowledging PB and AECOM as providing technical support for its development.

1.0.1 This section provides guidance on how the secondary heat network and systems contained within a new development should be designed to allow efficient future connection to a Decentralised Energy Network (DEN). The council already secures details of design for future connection via planning condition for major developments; by setting out clear standards in this guidance we seek to provide clarity about our requirements for all stakeholders.

1.0.2 Secondary systems shall be designed based on constant operating temperatures and variable flow rate criteria to ensure full compatibility with district primary supply systems.

1.0.3 Differential temperatures (difference between flow and return temperature) in the secondary distribution networks must be kept as large as possible to minimise pipe size, enable the supply of DEN heat from various heat sources and optimise any CHP output. To ensure that low grade waste heat, and other heat sources, can be utilised on the DENs the secondary design must focus on low return temperatures. The temperature differential at the primary / secondary interface will depend on the design of the internal building services. Therefore, all internal systems must ensure compatible designs that maintain optimum differential temperature and low secondary return temperature at the interface during all demand scenarios.

1.0.4 Key considerations for the design of building internal systems are as follows:

- The selection of low temperature operating systems such as under floor heating systems to significantly reduce return temperature.
- Low flow rate radiator circuits for buildings, complete with thermostatic control.
- Where used radiator circuits should be designed to operate satisfactorily at low temperatures with a maximum 70°C / 50-40°C flow and return (as opposed to the traditional 82°C / 71°C) without compromising the ability of the system to deliver the required level of heat. Return temperatures should be minimised and systems capable of operating at very low flow and return temperatures should be considered.
- The use of direct instantaneous hot water generation should be considered. This removes the need for hot water storage, reducing energy consumption and heat losses, reduces pipework, space and pumping costs and more importantly secures low return temperatures by adopting a heat exchanger arrangement that uses the DH return water to pre-heat the cold water makeup.
- Ensure minimum return temperature from hot water service connections, whether storage or instantaneous.
- Taking advantage of unique opportunities, like heat sinks such as swimming pools, to optimise return temperatures.

- The primary circuit will be sized for a nominal maximum pressure of 16 bar (PN16). Therefore the head loss at the primary circuit connections within the building and the plant room will be a target of 1.5 bar.

1.0.5 **Shunt Pump and Low Loss Header:** This is a common inclusion in heating systems but should **not** be used on a district heating system. This arrangement will only serve to return supply temperature water back to the heat exchanger as demand reduces on the main building sub-circuits.

1.0.6 **Two-port Control Valves and Variable Speed Pumping:** The use of two port control valves in constant temperature system applications is fundamental in ensuring that the unnecessary return of supply water temperature back to the heat exchanger is avoided. The use of variable speed pumps, in conjunction with differential pressure control valves for system balance should be considered as it provides an efficient method of delivering only the energy that is needed and when combined with the parallel pumping, provides the required turn down of the system to maintain optimum return temperatures throughout the annual demand profiles.

1.0.7 **Circuit Mixing:** Wherever possible, water returning from one heating circuit at a high temperature should be used in a second circuit. This is not always possible since one circuit may demand energy at a different time to another.

1.0.8 **Metering:** Energy meters measure volume flow rates and supply and return temperatures to provide an accurate record of energy usage. The preferred choice in a modern system is an ultrasonic device. Metering shall be installed to record flow volumes and energy delivered on the primary circuit. For residential connections, meters will also be installed on the secondary circuit where individual dwelling billing is required. The energy metering system must include a flow meter, two temperature sensors and a stand alone integrator unit complete with battery back up.

1.0.9 **Route onto and through site:** It is a requirement that there is space on site for piping connecting the point at which primary piping come onto onsite with the on site heat exchanger/ plant room/ energy centre. If the proposed site for the heat exchanger and the point at which DHN piping comes onto site are separated by an obstacle such as deep water feature, it may not be possible to connect them. Therefore proposals must demonstrate a plausible route for heat piping and demonstrate that suitable access could be gained to the piping at short notice and that the route is protected throughout all planned phases of development.

1.0.10 **Plant Layout:** New developments where the detailed connection arrangement to a DEN is unknown will require physical space to be allotted for installation of heat exchangers and any other equipment required to allow connection. The table below indicates the space required as dictated by the site heat demand.

Table 1.1 Plant room spacing requirements

Output (kW)	**250**	**500**	**800**	**1000**	**1500**	**2000**	**3000**
Number of heat exchangers	1	1	1	2	2	2	2
Length (mm)	1500	2250	2250	2750	2750	3000	3000
Width (mm)	500	750	750	1500	1500	1500	1500

Output (kW)	250	500	800	1000	1500	2000	3000
Height (mm)	2000	2500	2500	2500	2500	2500	2500
Approximate dry weight (kg)	725	1050	1300	1725	1800	1925	2000

1.0.11 The figures indicated in the table above are the packaged skid dimensions only. The sizes listed are indicative and space requirements should be considered on an individual site and system design basis. Additional space allowance for access and maintenance requirements must be considered (an allowance of at least 1m should be incorporated all around the skid to facilitate access and maintenance).

1.0.12 If the development has a plant room/energy centre it should include provision for the following requirements to ensure it can accommodate a connection to an off site area wide DHN:

Table 1.2 Provisional plant room specifications

Item	Specification requirements
ROOM ILLUMINATION	Minimum light level: 150 lux.
ELECTRICAL CONNECTION (for maintenance)	III 380 V to earth / 32 A (See Note 1 below).
ELECTRICAL SUPPLY (Control box)	220 V AC (+/- 5%), 50 Hz (+/- 3%) Thermo-magnetic protection recommended 16 A curve C (the box incorporates a thermomagnetic protection of 10 A curve C in the supply).
WATER SUPPLY	DN 25.
WATER DISCHARGE	Provide wastewater discharge line in the plant room and a sump to collect condensation from heat exchangers.
CONCRETE STANDS	Provide concrete stands for heat exchangers and pumps (if present).
VENTILATION	Mechanical and continuous, with a minimum of three air changes per hour.
HEALTH & SAFETY	Plan showing evacuation route in case of fire, located in a visible place. The plant room should not have elements of risk to health and safety (sharp metallic objects, holes in roof or floor without protection, …)
LAYOUT & DIMENSIONS	As described for the relevant packaged substation unit.

APPENDIX 2

Case Study: Danish Approach

This case study is provided courtesy of Ramboll Energy

Historical context

When studying the layout principles used in Danish district heating systems it should be noted that there is no single Danish approach. Depending on the technical conditions, each network has had its own individual characteristics, but over the years a best practice has become generally accepted. In particular the large city-wide systems like the Copenhagen system have realised the benefits of this technical approach.

The design concept of the Copenhagen district heating system is based around a transmission heat network supplying heat from the city's Combined Heat and Power plants and waste to energy to a number of both existing and new distribution heat networks serving local communities via hydraulic interface stations. Historically, this concept evolved as a result of the Danish Heat Laws introduced in the 1980's when it became mandatory to recover heat from the power stations.

The approach taken was to develop a transmission network hydraulically separated from the distribution networks that it served. In terms of system pressure, the transmission network was designed according to an average head concept and was sized for the transport of the base load capacity delivered from the main heat production facilities. This enabled it to connect many heat production units that were geographically separated over large distances across the city. It also provided sufficient flexibility to allow the future connection of new heat production facilities without impacting on design or operation of the existing system.

The local heat networks were connected to the transmission network through hydraulic interface stations, which created a hydraulic separation. Minimising construction costs was a major driver in the design as was the requirement to interconnect many existing local networks in a seamless way. In many cases these existing networks had been designed according to different thermal and hydraulic parameters and could not therefore be integrated through a direct connection to the transmission network.

As the heat network was extended to new parts of the city, new distribution networks were connected through additional hydraulic interface stations. Local peaking plants were also constructed to meet peak demand events. These were embedded within the distribution networks as an alternative to placing them at the main heat production facilities. This approach allowed the transmission network to be designed and optimized around a higher operating pressure/ high velocity concept which in turn enabled the use of low diameter pipework. At the same time, the distribution networks could be optimized for local conditions without having to meet the design requirements of the transmission network. The overall impact was a low construction cost relative to the alternative design options.

The high velocity concept was achievable in design terms due to the long, straight sections of the transmission network. However, it did increase the potential risk of damage due to pressure surges. The risk was manageable through an 'average head' hydraulic concept in which the static pressure of the network was maintained at a fixed level under all flow conditions.

Design Considerations

When a number of distribution networks are established they can be connected to one or more large central production plants through a transmission network. These distribution networks are hydraulically separated from the transmission network.

Transmission networks are in general characterised by distributing a large amount of heat over a relative long distance and thereby having high velocities in the district heating pipes. The high velocities allow pipe sizes to be minimised, thereby minimising investment but do increase the risk of water hammering in case of pump trips.

In order to minimise the risk of water hammer, a fixed average head principle is used, where the static pressure is kept at a fixed average pressure level. The principle of the average head system is illustrated in Figure 23, where a transmission line connecting two production plants is indicated.

The pressure is fixed at the cold header (e.g. the inlet of the District Heating return water to the District Heating condensers located in the energy production facility) of one the plants supplying heat to the transmission network. The concept requires District Heating flow pumps as well as District Heating return pumps, which are regulated in order to maintain a symmetrical pressure profile around the level of the average head. This is also illustrated in Figure 23, where head in both supply and return from the plant to the right are shown both for maximum and minimum load.

The District Heating pumps (both flow and return) are controlled in order to maintain an average head level in the network as well as the differential pressure in the network. Both the flow pump and the return pump may contribute to the differential pressure regulation and the average head regulation.

Figure 23 indicates a simple controller concept consisting of a differential pressure (delta p) regulator and an average head regulator. The average head regulator adjusts the ratio between the speed of the supply and return pump in order to maintain the average head level.

Figure 24 shows the result from a simple model of this controller concept. The consumption in the network is increased by increasing the KV-value of a valve (red line). This will at first decrease the differential pressure in the network (dp_cons) but this will in turn lead to an increase of the speed of the supply and return pumps (dotted lines). It is seen that the average head level (blue line) is maintained in the process.

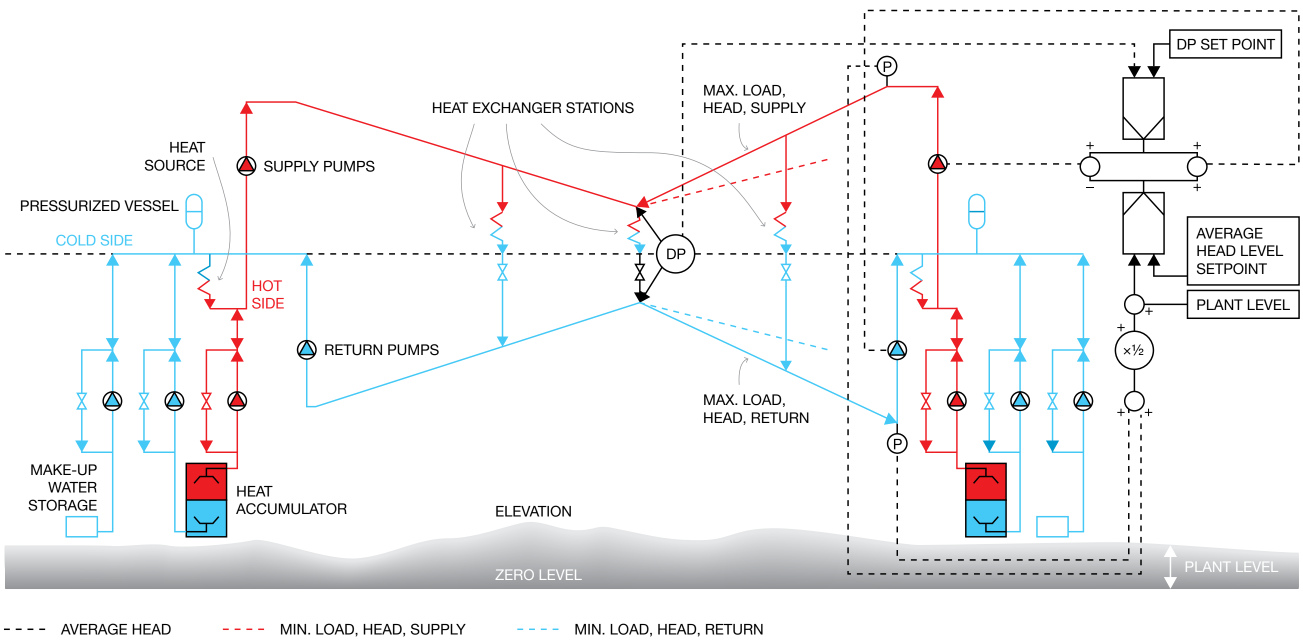

Figure 23. Principle of the fixed average head system

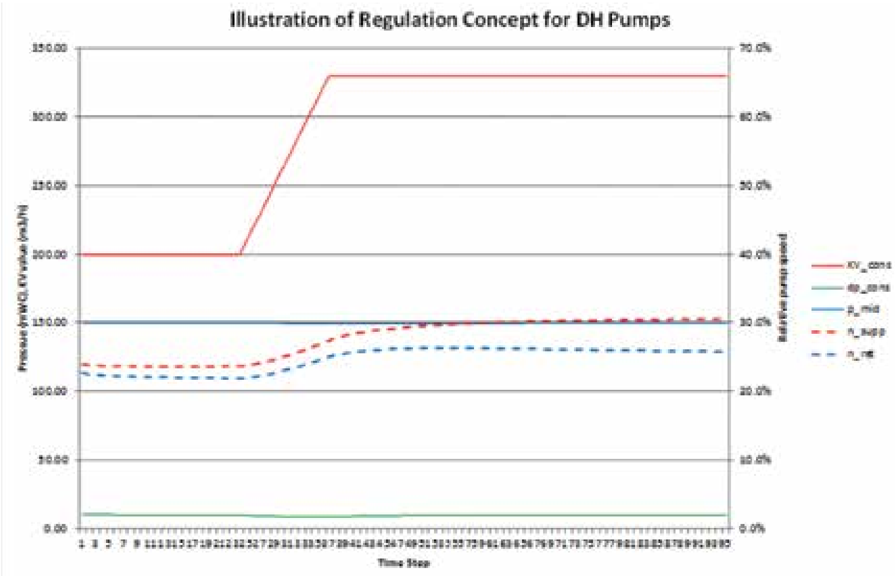

Figure 24. Illustration of results from a model of the controller concept.

One of the main advantages of the average head level concept is that pressure may be kept within acceptable limits during a pump trip, provided that the supply pumps are tripped if the return pumps are tripped and vice versa. After a pump trip the head in the supply and return pipes of the District Heating transmission system will simply gather around the average head level and thereby go into a stable situation where the pressure is within acceptable limits all over in the network.

Furthermore, the fixed average head increases the possibilities for connection of production units along the transmission line. The average head system makes it much easier to achieve favourable pressure conditions in the network regardless of the load or the production situation. Figure 25 illustrates an example of a low load situation of a system where the pressure is maintained in the return leg (in this example by a heat accumulator tank). Further down the line another production unit, for example a waste-to-energy plant, is indicated, and it is seen with this pressurisation concept the minimum pressure may be unacceptably low and can set a limit of how much of the available heat production from the second production unit can actually be utilised. This problem can be avoided by implementing the fixed average head system where it is easier to achieve favourable pressure conditions in the network regardless of load or the production situation.

All in all, networks with fixed average head are in general very safe to operate and very flexible to future expansion and connection of new production plants connected to the network.

Implications for London

The average head system used in Copenhagen follows one of a number of principles that can be used to develop wide area heat networks. Other types of system usually focus on the principle of maintaining pressure in the return leg and to have one large distribution network. There are advantages and disadvantages to each approach, depending on the context of the heat network concept being developed.

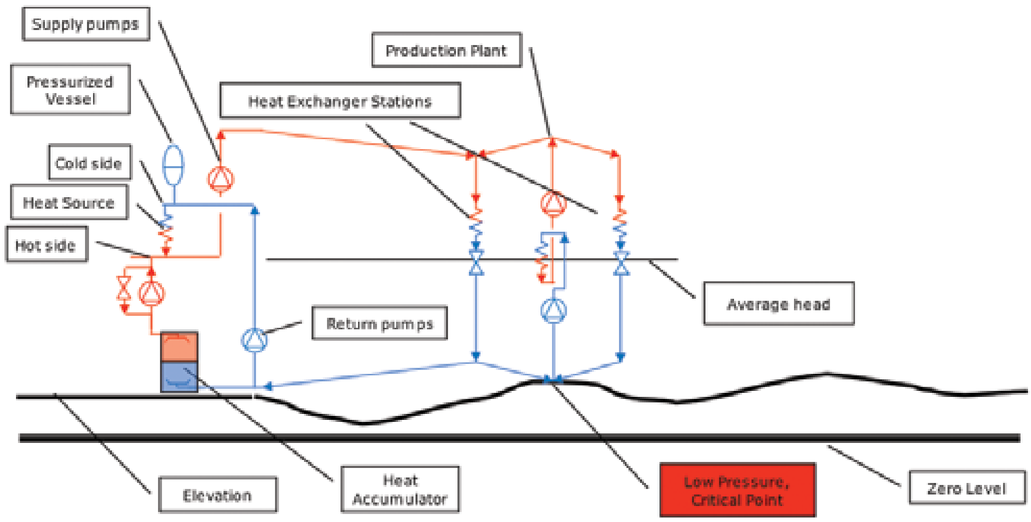

Figure 25. Illustration of a low load situation of a system where pressure is maintained in the return leg.

However, the approach taken in Copenhagen has several possible benefits in large systems and certainly in the context of London's ambitions for decentralised energy/ wide area heat networks. District heating in London is expected to develop around a series of cluster networks over the short to medium term and where the longer term aspiration is to interconnect many of these to form a wider strategic heat network connecting multiple waste to energy and/or combined heat and power stations at various locations across London. In this context it offers the following potential benefits for London:-

- Design to 25 bar reduces network diameters and reduces the need for booster pumping stations
- Allows transmission main to be sized for the baseload, with peaking plant embedded at distribution level. Hydraulic isolation of distribution networks allows them to be optimised around local conditions thereby allowing them to be designed to local pressure requirements
- Relatively low complexity of control in operation, even with multiple energy production facilities connected over large distances;
- Ease of integration of future energy production facilities of all scales and at any location with no adverse impact on existing transmission network design or operation;
- Safe transient and dynamic operation in all conditions;
- Flexibility in interim design of cluster networks so that each can be optimised around local requirements;
- Well suited to commercial model appropriate for wide area heat networks involving DH network operator.

It is noted that the approach requires hydraulic interface stations to be constructed at distribution level. This requires land and adds cost. However, energy centres constructed to serve cluster networks can become the location for these hydraulic interface stations, since they would need to be developed in any case. It should also be observed that in a large distribution network without hydraulic interface stations there is still a requirement for facilities to absorb pressure transients and there are extra costs embedded in this solution for this reason.