Community heating and combined heat and power

NHBC Foundation

Housing research & development in partnership with BRE Trust

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LOGSTOR A/S: Figure 4 (page 8) Cross section of modern pipes (plastic, steel and aluminium) with the leak detection wires shown.

Utilicom Limited: Figure 8 Comet Square, Hatfield; Figure 9 Combined heat and power engine and heat storage; Figure 10 Gas-fired boilers (all page 20).

Vital Energi: Section opening photograph on page 17, Figure 11 (page 21) The Tachbrook Triangle; Figure 12 (page 21) Hydraulic interface unit; Figure 13 (page 21) Wireless meter reading.

Göteborg Energi AB: Figure 14 (page 22) The Gothenburg City community heating scheme's newest production plant built in 2006.

Aberdeen City Council: Figure 15 (page 25) Heating pipes being installed in a trench.

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FOREWORD

Community heating is not new to the UK as there was a major expansion of such systems during the council house building boom of the 1950s to 1970s. However, these were often poorly installed and maintained and problems regularly arose with water penetration and corroded pipes. Lessons have been learned and modern systems do not suffer in this way due to better design of both systems and components.

Some European countries already fully utilise community heating, while only a handful of UK cities currently possess large-scale community heating networks. However, there are significant environmental benefits from this approach that could help us to deliver sustainable communities of the future. The introduction of the Code for Sustainable Homes and future energy efficiency targets mean that low carbon solutions, such as community heating, will increasingly need to be considered.

Housebuilders and the environment could both potentially benefit from the increased uptake of these systems, but, there will also be benefits for consumers. With very few exceptions, the occupant or owner will notice little difference between a home heated conventionally and one that is heated by a community system except for the fact that they will generally be paying lower heating bills. Also, the absence of external flues significantly reduces the potential risk of carbon monoxide poisoning or a gas explosion.

This guide provides an introduction to community heating and combined heat and power systems and highlights where they may most effectively be used. The main focus is on new housing developments but the guide also considers how the systems could serve existing communities and mixed use developments. A number of case studies also highlight developments where community heating has already been adopted.

I hope you find this guide useful and it helps you understand the increasing role these systems could play in helping us achieve our environmental goals.

Rt. Hon. Nick Raynsford MP

Chairman, NHBC Foundation

ABOUT THE NHBC FOUNDATION

The NHBC Foundation was established in 2006 by NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and housebuilders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

Further details on the latest output from the NHBC Foundation can be found at www.nhbcfoundation.org.

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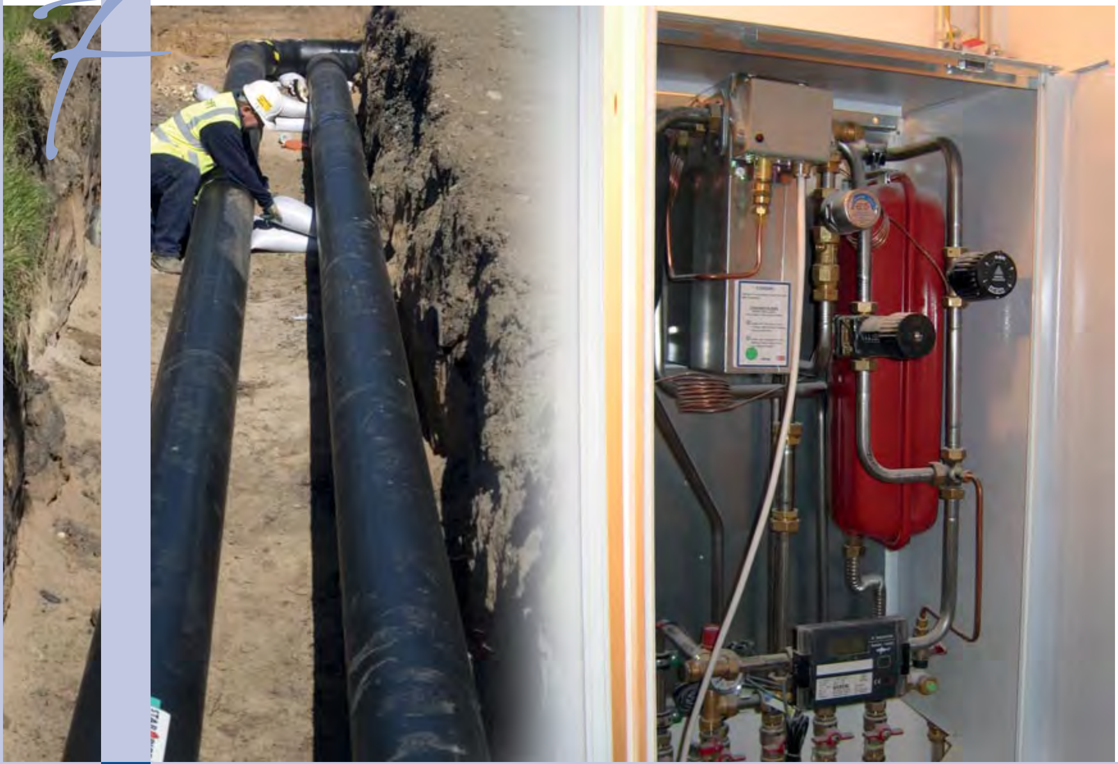
GLOSSARY

Anchor load	A relatively large heat load that requires heat more or less continuously. It helps to run the system in a less transient way.
CHP	Combined heat and power.
CSH	The Code for Sustainable Homes.
Community heating or district heating	More than one building connected through a heat distribution network. Community heating is generally the term used in the UK but in countries outside the UK it is usually called district heating.
ESCO	Energy services company.
HIU	Hydraulic interface unit, separates water networks hydraulically.
Moisture detection system	A system to detect moisture in the pipe insulation material.



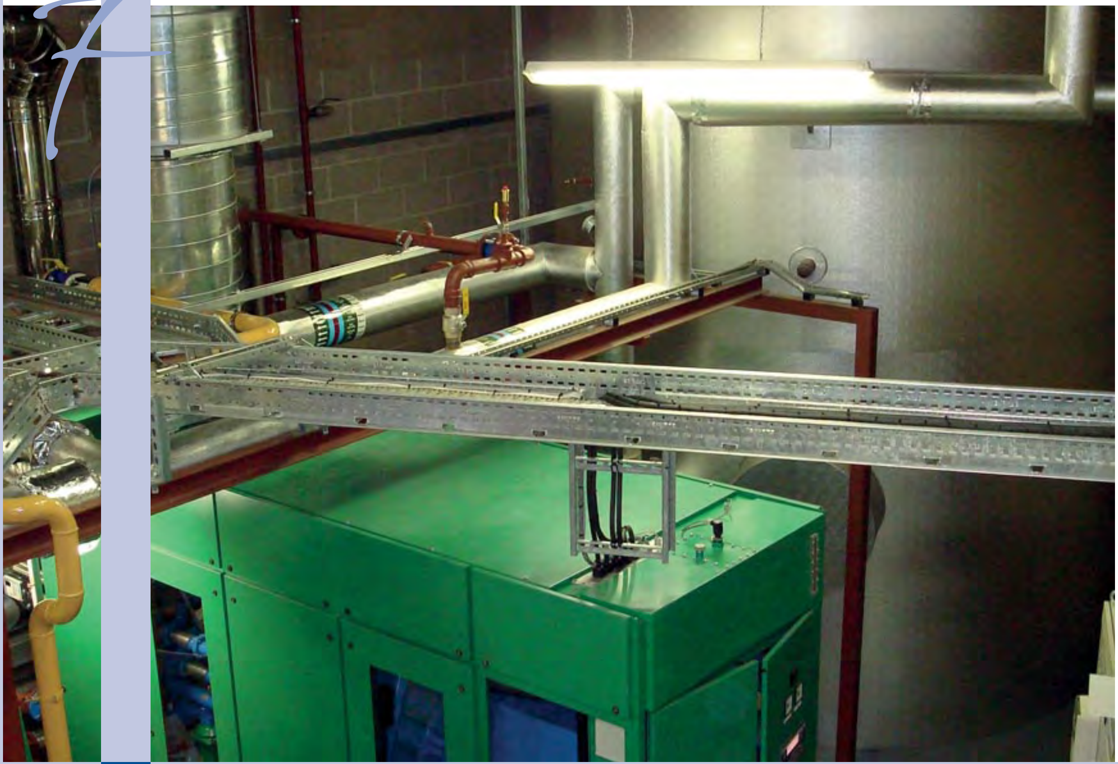
1 Introduction

Community or district heating, where buildings are collectively served by the same central heating plant, is widely developed in continental towns and cities. Although historically not widely implemented in the UK, it is now seen as a part of the solution for delivering sustainable communities for the future. There are powerful environmental drivers for this approach principally because it enables the integration of combined heat and power (CHP) and renewable energy generation.

This guide aims to introduce the reader to the concept of community heating and CHP and to provide a straightforward introduction on its applicability. The focus is principally on new housing developments, but the possibilities for serving a mixture of both new and existing buildings as well as mixed use developments is also described.

The guide is written principally for developers and housebuilders. The advent of the Code for Sustainable Homes (CSH) means that low carbon solutions, such as community heating, are a key consideration for new developments.

Community heating and CHP schemes involve a wide range of stakeholders from masterplanners through to financiers. While the guide does not attempt to address all the issues in sufficient detail for these audiences, they may also find it of interest.



2 What is community heating?

Community heating is an infrastructure for delivering heat to multiple buildings from a central heat source (Fig. 1). There are three basic parts to such a scheme:

- an energy centre containing the heat source(s)
- heat exchangers in the buildings that are being served
- a network of pipes to connect them.

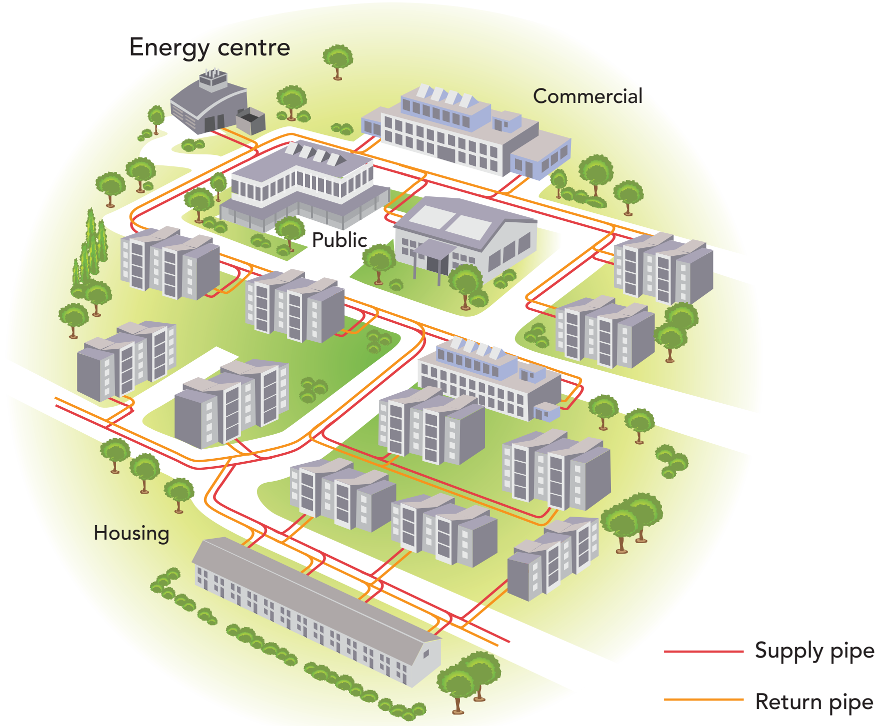


Figure 1 The principles of community heating showing the key elements.

The energy centre houses the heating plant which can include a range of technologies and fuels eg gas, biomass boilers and CHP. Hot water from the energy centre is pumped through the pipe network to the individual buildings. In each dwelling, heat is conveyed via a hydraulic interface unit (HIU) to the central heating radiators and to the hot water taps. See Appendix 2 *Community heating scheme elements* for more information.

Both the space heating system and the domestic hot water system within each dwelling are exactly the same as for dwellings with individual gas boilers. This means that the occupants in dwellings served by community heating have just as much control over their heating systems. Systems are also more responsive because hot water is immediately available.

Any building can be connected including dwellings, commercial and institutional buildings, retail premises and industrial applications. The community heating scheme can:

- be integrated within a single building, such as a block of flats (sometimes referred to as block heating)
- serve a number of buildings on a single site (such as a university campus) or in close proximity eg several blocks of flats
- serve a whole community, town or city centre.

In some countries, there is already a high utilisation of this technology. Most of the towns and cities of Denmark and Sweden are heated in this way and German cities like Berlin and Hamburg have some of the biggest networks in the world. These very large examples of community heating enable the integration of any source of available waste heat, including from power generation, and industrial and waste processing. They also readily enable the integration of heat from renewable energy sources such as solar thermal and biomass.

Some UK cities also possess substantial community heating networks, notably Sheffield, Nottingham, Southampton and Birmingham, and schemes like Citigen in London that serve the Barbican. For new developments close to such schemes, the best solution is almost certainly to negotiate a connection to the existing network.

In Scandinavia, villages often also have a small network normally served by a biomass boiler or gas-fired CHP engine.

2.1 Community heating in new developments

For new build housing developments, a network would ideally be devised to serve all the buildings on that site (Fig. 2). However, where there is a large development with zones of high and low density, it is more likely to be restricted to the high-density areas.

The issue of density is an important one when considering whether or not community heating is a suitable option for a given site. The pipes themselves are expensive and the key parameter is the heat demand density, which depends on the heat demand of the buildings and how close together they are. The issue of heat demand density is dealt with in more detail in section 4.

There is a significant amount of international research currently being carried out, principally to lower the cost of the pipe infrastructure in order to improve the economics for community heating in lower density areas and also for high efficiency dwellings.

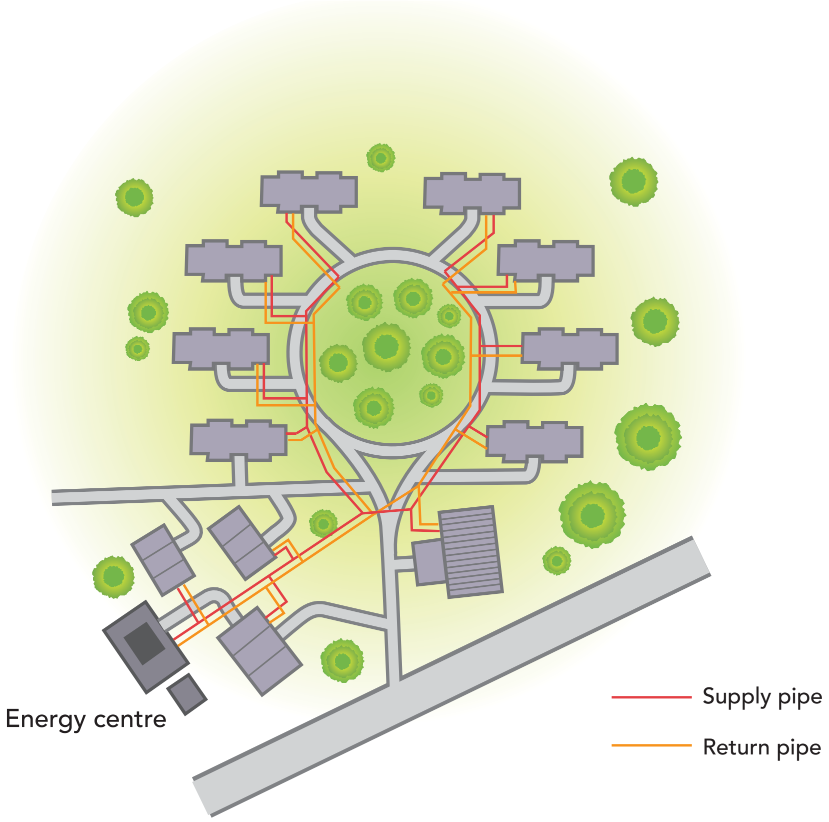


Figure 2 A site-wide scheme plan.

2.2 Energy linking

When considering community heating for a given development, it may be possible to also connect adjacent existing buildings. Although this would clearly be a more complex scheme, its economics may well be improved, especially when this increases the variety of different types of users connected. Some public sector users, such as leisure centres with swimming pools, are particularly attractive as they can act as anchor loads and possibly host the energy centre.

Services for new developments, eg telephone, electricity and water, are invariably provided using connections from local, area-wide distribution networks. Similarly, if the new housing development is close to an existing community heating scheme, it is well worth investigating the possibility of connecting to it; investment in local heat generation equipment may therefore be avoided and further carbon dioxide reductions may be achieved.

2.3 How is community heating different compared with a conventional supply system?

With very few exceptions, the occupant or owner will notice little difference between a home heated conventionally and one that is heated by community heating. Noticeable differences are:

- reduced maintenance for the individual heating system as there is no boiler to safety check and maintain
- the HIU that takes the place of the boiler is smaller than a traditional wall-hung boiler (Fig. 3)
- no hot water storage cylinder (also the case for combi boilers)
- immediately available, unlimited hot water supply
- using electricity for cooking, as there would be no gas supply

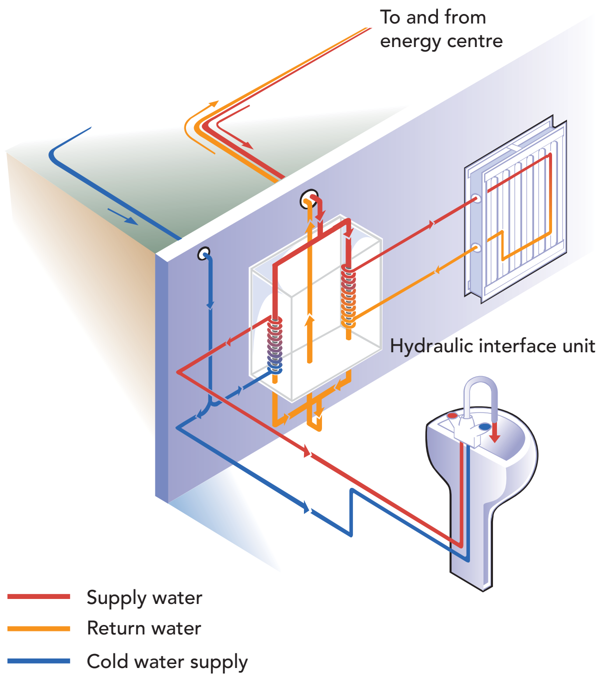


Figure 3 The hydraulic interface unit.

- consumer choice for heating is more restricted ie a customer connected to a community heating scheme cannot change supplier in the way that a gas or electricity consumer can switch from one supplier to another
- payment made for heat supplied instead of gas consumed.

If the community heating option is being considered, it should be part of an initial energy analysis to be carried out at the design/masterplanning stage. This enables an informed choice to be made based on the consideration of all aspects of a development.

Most developers are accustomed to fitting gas boilers or electric panels and these become the responsibility of the occupant or landlord. With community heating, an HIU is fitted in each dwelling and the plant itself is located in an energy centre.

This means that:

- accommodation must be provided onsite for the energy centre. This may be purpose-built or within one of the buildings, eg the basement of a block
- arrangements must be made regarding ownership, operation and administration of this local energy supply system.

Ownership probably involves the formation of a special purpose vehicle or energy services company (ESCO) – this is discussed further in section 6. Administration involves fuel purchase, electricity and heat sales and a service agreement for customers.

Operation involves ensuring that all equipment up to the customer interface is operating effectively. This comprises an automated system that oversees plant operation and network surveillance, together with a full maintenance schedule. For biomass plant, visual checks are additionally recommended.

The fuel supply for the energy centre may be the gas supply. If, however, biomass is being considered then enough space must be allowed for storage, delivery and process. The size of storage space required will vary widely depending on, amongst other things, the size of scheme, the proportion of heat supplied by biomass and the type of fuel being used.

A pipe network must be installed in trenches so that a connection can be provided to each building that is to receive the community heating supply. This should be considered alongside the other service connections that will be provided to each home as economies can be achieved with the civil engineering.

The dwelling internal system is most likely to be the same as a conventional wet system with radiators, timer, temperature controls and thermostatic radiator valves. However, radiators may be larger in size than usual because the optimum efficiency for a community heating system requires a larger temperature difference between supply and return.

A gas supply would probably be needed for the plant in the energy centre, as even biomass schemes rarely rely solely on biomass fuel due to the difficulties involved in using a base load technology to meet peak loads. However, the gas supply would not need to be extended to each individual home. This has the advantage of avoiding the need for external venting as well as potential safety advantages, but it also implies that cooking requirements would be met by electricity. The developer would need to take into consideration this restriction of customer choice, and also the effect on overall dwelling carbon emissions.

Consumer choice

Nowadays consumers expect to have a choice in who supplies their energy. Most networks are natural monopolies so that domestic customers do not have a choice over the gas or electricity network to which they are connected, but they are accustomed to being able to choose from a range of suppliers. However, the supplier and network operator of community heating are generally the same company.

To allay concerns of any abuse of a monopoly by community heating companies, they benchmark their heat prices against a selection of alternative energy prices and contractually commit to the customer to provide heat at a lower price. This has, however, become more difficult with the proliferation and complexity of tariffs. Any disputes are subject to normal trading legislation. Some scheme operators have established codes of conduct and as the market develops, regulatory aspects are likely to change in order to improve customer confidence.

Scheme operators are also exposed to the full wholesale cost of fuel which is more volatile than domestic gas prices. So when prices are rising, the increase is likely to be sharper for community heating. Nevertheless, when maintenance for individual boilers is factored in together with the higher efficiencies for centralised heat boilers and/or CHP, the cost is likely to remain less for community heating.

Metering the heat

Whether or not to meter heat has, historically, been the subject of a great deal of debate. In the context of affordable housing community heating, traditionally flat rate charges were often applied according to the size of the dwelling.

Nowadays the desire for individual accountability and the presence of an incentive to conserve energy has tilted the argument in favour of heat meters, particularly in new dwellings where the capital cost of the meter can be included in the purchase cost of the dwelling. Heat, electricity and water metering can be integrated and read remotely via mains or fibre optic cables.

2.4 History of community heating

There was a major expansion of community heating in the UK during the 1950 to 1970s council house building boom. When they were working well, these schemes provided an economical heat supply at a predictable price for tenants, who generally paid a heat-with-rent price.

However, these schemes were often poorly installed and maintained. Problems arose with backfill material including sharp stones damaging the insulation wrapped around the steel community heating pipes. Water then penetrated, soaking the insulation material leading to high heat losses. Also, corrosion of the pipes duly followed. At that time there was no way to detect such problems until there was a major leak. Failing to provide an adequate service, many of these systems were decommissioned.

Despite an overall poor track record for these older systems, there are examples that demonstrate the potential longevity of community heating infrastructure. The Pimlico District Heating Undertaking (PDHU) has been operational since the early 1950s. When it was recently upgraded with the addition of CHP, 50-year-old pipes were found to still be in good condition. The scheme is now expanding to serve private new-build developments.

Modern systems do not suffer in this way (Fig. 4). Pipes are manufactured as bonded layered systems to minimise expansion and contraction due to temperature changes. The insulation material is an integral part of the manufactured pipe which, sealed with a hard plastic jacket, has a lifetime of at least 30 years. The pipes are laid in trenches and backfilled with sand, which supports the pipe but allows good drainage, preventing the build-up of moisture.

Finally, the pipe incorporates a leak detection system that is able to pinpoint the presence and position of moisture as soon as it appears. Wires embedded in the insulation layer run the entire length of the pipe network back to the energy centre. Moisture alters the resistance of the wire raising an alarm so that scheme operators can rectify the matter before a leak occurs and end users experience a loss of service.

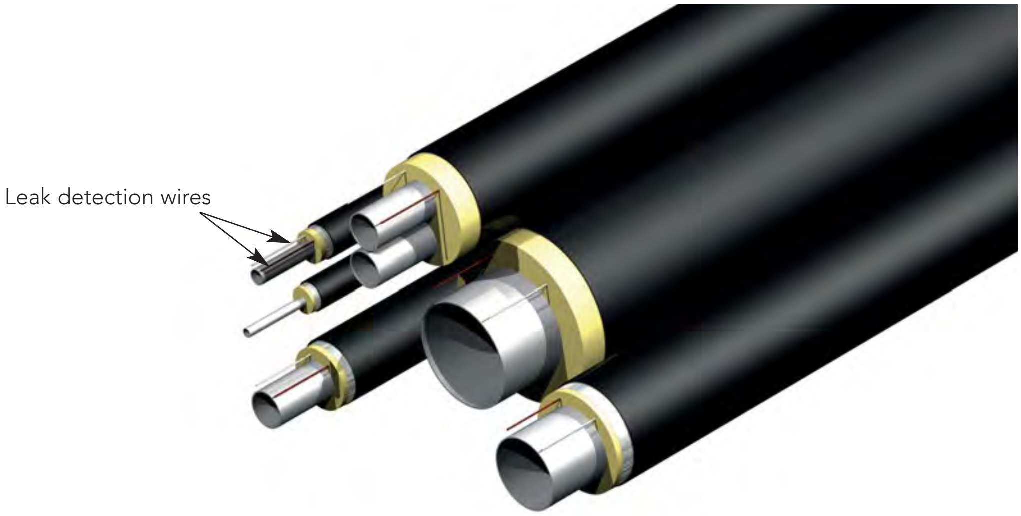


Figure 4 Cross section of modern pipes (plastic, steel and aluminium) with the leak detection wires shown.

3 The benefits

Community heating offers a number of benefits.

3.1 For users

Running costs

Customers of modern community heating schemes will generally be paying less for their heat than those with gas boilers or electrical heating. Systems with CHP derive revenue from both heat and electricity by burning fuel, and they operate with a significantly higher overall efficiency than conventional alternatives. In addition, the aggregated demand enables the operator to take advantage of the highly competitive (and hence cheaper) commercial fuel markets in a way the individual householder cannot. Consequently, the heat price can be pitched at a very competitive rate.

Safety

As the plant is external, there is no necessity for external flues from the individual dwellings. Removing the necessity for gas-fired equipment within dwellings also removes any potential risk of carbon monoxide poisoning or gas explosion.

More space

The HIU that interfaces between the primary distribution network and internal central heating systems is smaller than wall-hung boilers. Additionally, there is no need for stored domestic hot water. These features contribute to space saving within the dwelling.

The avoidance of the need for external flues from internal boilers also provides greater flexibility in the design of buildings.

3.2 For registered social landlords

Less plant

The conventional heating solution is that each home has its own boiler which must be sized for maximum demand on the coldest winter day. In the case of community heating, demand for heat is aggregated. Consumers behave differently so the statistical probability of their demand peaks all coinciding is reduced. Demand is consequently spread more evenly and total plant size is reduced.

The smoothing of the demand profile is enhanced even further where different types of buildings and consumers are connected to the system.

Easier maintenance

Legislation requires landlords to undertake an annual safety inspection of boilers within dwellings. This requires access to all dwellings (which can be time consuming and occasionally difficult) as well as the actual servicing of the boilers. By comparison for community heating, the plant is located in one energy centre making planned maintenance straightforward. Plant is also monitored automatically so its operation can be proactively maintained at a high level of performance.

Customer security of supply

The typical arrangement of a series of in-line boilers within the energy centre, usually with CHP acting as the lead boiler, provides security of heat supply to consumers because the supply is not dependent on one single item of plant.

Where CHP is used to supply electricity locally, it is necessary to have in place a 'top-up and spill' agreement with an energy supplier. This provides additional electricity for those occasions when demand onsite exceeds generation capacity and conversely exports it when onsite generation exceeds demand. Because the local system is connected to the grid in this way, security of electricity supply to consumers is improved.

Finally, security is also enhanced where more than one fuel source is used. This could be biomass and natural gas providing for a heat-only system or biofuel/diesel and natural gas for a CHP engine. This will also provide a buffer against price volatility in the market for the traditional fuels.

3.3 Nationally

Environmental benefits

In a community heating scheme, hot water is distributed from the energy centre to all the connected buildings. The water could be heated from a variety of sources including CHP, renewable energy sources such as biomass, and in the case of larger networks, heat from waste or industrial processes. In each of these cases, a low carbon source is being used so that community heating is an environmental energy option.

It should also be noted, however, that while overall emissions are likely to be reduced by installing community heating, focusing all the emissions at the energy centre means that a chimney stack will be necessary. The design of the chimney will need to follow Environment Agency regulations and comply with the Clean Air Act 1993. The Her Majesty's Inspectorate of Pollution (HMIP) Technical Guidance Note D1[1] gives guidance relating to requirements on exhaust discharge. This is particularly important for biomass schemes as they can generally incur more air pollution than gas installations. Ultimately, the local authority will need to assess and approve the planned installation.

Future proofing

Community heating enables whole communities to be switched to new and emerging technologies with ease. For example, a gas-fired CHP engine could be replaced in the plant room by a new higher efficiency model or a hydrogen fuel cell at some stage in the future with no disruption to residents.

Low carbon fuels

Community heating pipes simply transport hot water from the energy centre to consumers. The heat source(s) could be almost any fuel. In particular, this includes heat from CHP (see section 5), but it can also include waste heat from adjacent sites where commercial or industrial activities may be dumping heat and/or heat from renewable sources such as biomass, geothermal, solar thermal and heat pumps.

4 Where and when to use community heating

Community heating is defined as where two or more buildings or dwellings are connected together by sharing a common source of heating. Theoretically, all but the most isolated of buildings can be connected to community heating networks. Indeed small villages and low density suburban housing in European countries such as Austria and Denmark are served by such networks; however, there are a number of factors that will enhance their financial viability.

4.1 Density

Installing a community heating scheme is a major capital investment. The cost per dwelling depends on how close together the dwellings are; the pipe length per dwelling is least when flats are being built. If community heating is considered for individual houses, the relative cost per dwelling will be substantially increased.

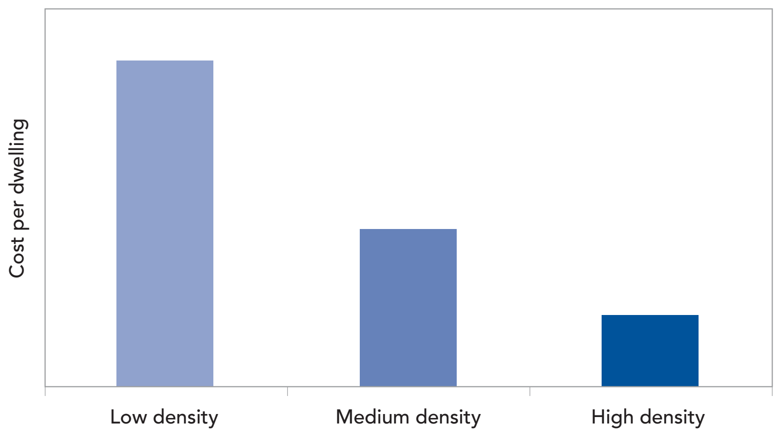


Figure 5 Indication of investment cost per dwelling for dwelling densities.

The key parameter is the heat demand density; this is reduced not only when the dwellings are spaced further apart but also when the dwelling is better insulated. New dwellings will be significantly better insulated and the effects of this on heat demand are illustrated in terms of different levels of the CSH shown in Figure 6. It can be seen how the monthly heat consumption for a CSH level 6 flat is significantly lower than a Building Regulations-compliant 2006 flat during the winter months.

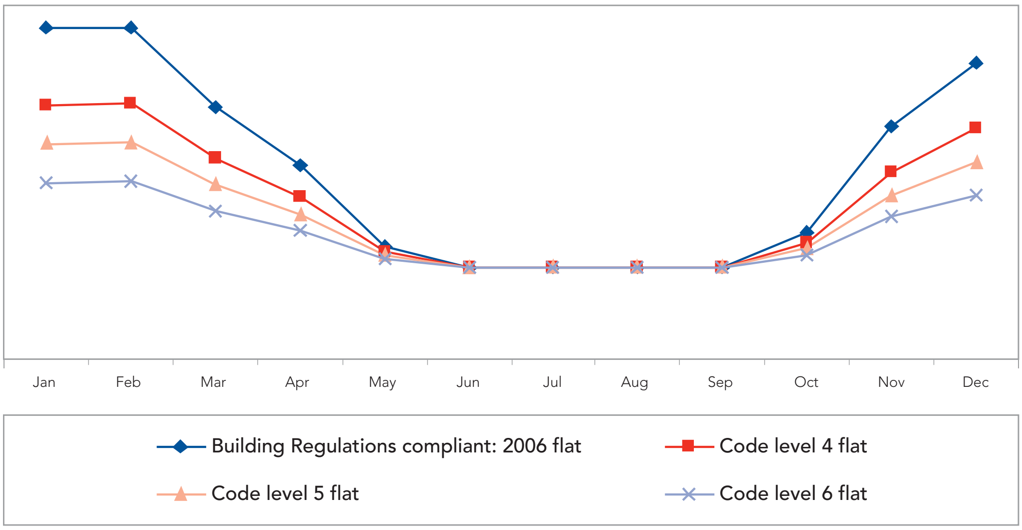


Figure 6 Estimated heat demand for different levels of the Code for Sustainable Homes.

Another important factor to be aware of is that distribution losses expressed as a percentage of the heat demand increase with lower dwelling density. This is a particularly important issue to take account of where developers are considering the use of a community heating system to supply individual houses in order to meet carbon reduction targets eg the higher levels of the CSH.

There is no set rule on when community heating will be the preferable solution as a number of factors will need to be considered. Rising fuel prices and the comparative cost of devising solutions for meeting the requirements of increasingly stringent planning guidance and legislation, all need to be taken into account. As a general rule of thumb, community heating often emerges as the best solution for new flats, whilst other approaches regularly emerge as the superior option for individual houses.

Careful consideration of the need for heating infrastructure at the masterplanning stage can optimise the contribution that the layout can make and reduce the cost of infrastructure without necessarily 'cramming' a site. The key aspect at the masterplanning stage is to ensure sufficient space has been allocated for an energy centre, either as a separate building or contained within another building.

4.2 Mixed use

While this guide is primarily concerned with housing developments, it is always worth determining whether there are other loads nearby that could also be connected to a community heating network. This applies both to new and existing buildings. Public sector users, such as leisure centres with swimming pools, are particularly attractive as they can act as 'anchor loads' and possibly host the plant room.

Different building types have different characteristic heat demand profiles. While for a domestic user peak demands might be expected between 7 to 9am and 5 to 10pm, commercial and public buildings are more likely to peak between 9 to 5pm. There are also buildings which have consistent round-the-clock demand such as hospitals.

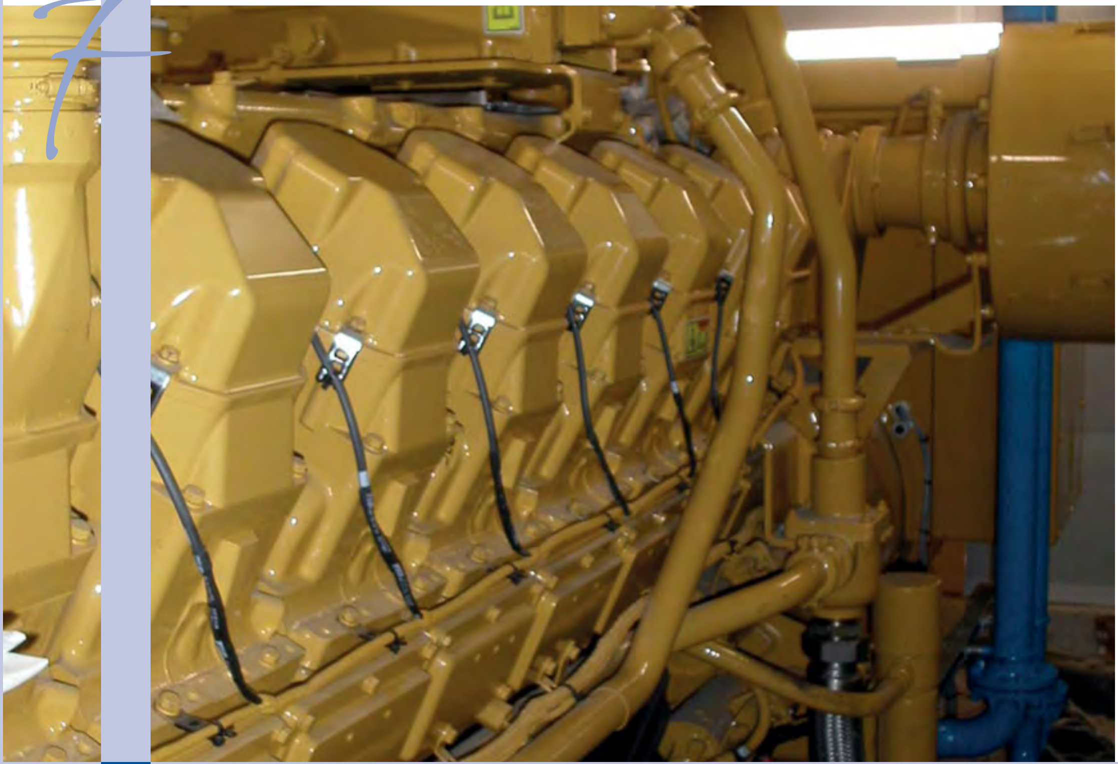
Connecting such different users produces an aggregate demand that is smoother than individual ones meaning that heating plant can run continuously for much of the time. This is quite unlike the erratic or spiky demand on an individual boiler in a single house, and leads to better plant performance, less overall plant capacity to be installed and consequently, improved financial viability.

4.3 New and existing buildings

The critical issue in the factors above is the extent of the heat demand. New buildings have considerably reduced heat loads due to progressive tightening of Building Regulations, whereas older buildings have poor levels of thermal insulation and consequently relatively high heat loads.

On the other hand, services infrastructure is more easily installed in new developments than retro-fitted in existing buildings. Furthermore, the cost of heating pipes is roughly 25% of the full installation, with the remaining costs being for trenching etc. So economies can be secured by installing all services simultaneously.

Consequently, a scheme that serves both new and existing buildings is the most attractive option.



5 Where and when to use combined heat and power

CHP involves the use of a heat engine to simultaneously generate both electricity and useful heat. Conventional power plants emit the heat created as a by-product of electricity generation into the environment through cooling towers, flue gas, or by other means. CHP captures the by-product heat for distribution through pipes to local users. While CHP can act as the lead heat source for a community-heating network, in reality there are factors that limit its suitability.

Small-scale CHP engines are available for small blocks of as few as six units. However, the complexities involved in overseeing the operation of the CHP and, in particular, managing the sale of electricity mean that for most developments, CHP only becomes a practical option where a commercial ESCO is engaged in the scheme.

Such companies require a sufficiently large development to make a return on capital. Currently, they are interested in developments of more than 300 to 500 residential units but this may be lower depending on matters such as mix of uses and presence of an 'anchor' customer. Further information on ESCO models is contained in section 6.

Most CHP systems currently supplying community heating schemes use natural gas as the fuel source. Such systems have the potential to reduce emissions to a level where CSH level 4 can be achieved, see Appendix 3 *Achieving Code for Sustainable Homes level 4 with gas-fired CHP* for more information.

With government plans for zero carbon homes by 2016, the concept of CHP fuelled by renewable fuels is receiving increasing attention. CHP engines can be run on biofuels (eg vegetable oils, used cooking oil and bio diesel), methane from landfill sites, coalmines or the anaerobic digestion of organic waste and biomass including energy crops.

Renewable CHP is a largely unproven concept in the UK, however, new systems are starting to emerge, eg gasification of wood chip with the synthetic gas burned in an engine and burning wood chips with the hot gases driving an air turbine.

While these technologies may be part of a solution to achieve zero carbon homes, developers need to be aware of the technical and operational risks that accompany such advances.

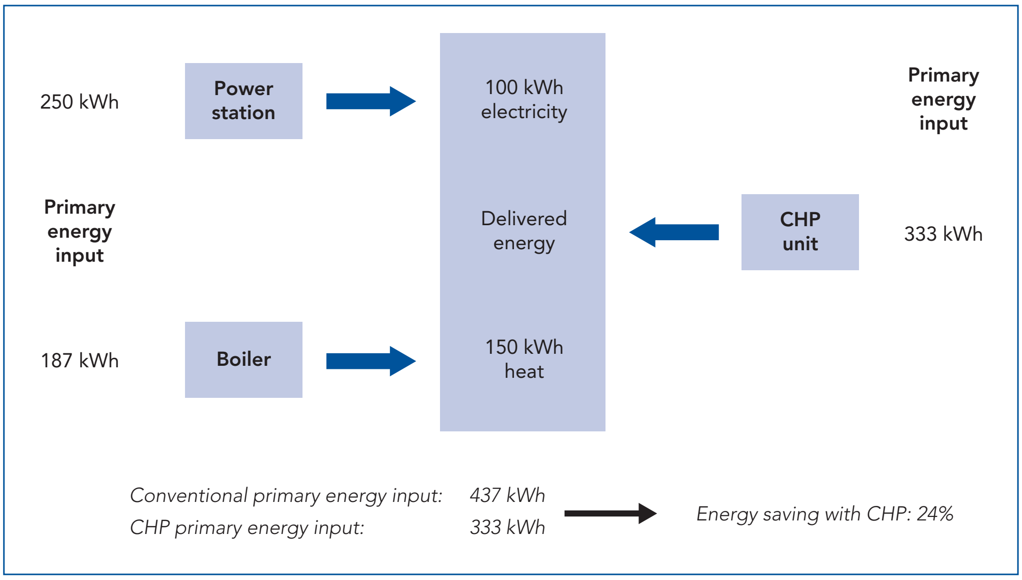


Figure 7 Comparison of conventional heat and power production with combined heat and power production.

6 How to implement community heating

6.1 Options appraisal

In developing an energy strategy for a development, it is necessary to collate as much data as possible about the predicted energy use, loads and profiles for the site. This can be fed into an 'options appraisal' that will consider which mix of technologies is most appropriate for the development to meet its energy requirements. It is important to establish at the outset what objectives the energy strategy must meet. These can include:

- capital cost
- cost to eventual users
- security of supply
- meeting the demands of the Building Regulations and the CSH
- any onsite or near-site requirements by local planning policies.

Options appraisals should be conducted on a whole life costing basis, including maintenance and replacement costs, over a fixed term typically set at 25 years. Net present value methodology should be used to ensure options are compared on a like-for-like basis. The options to be compared can include a variety of technologies. These may be:

- gas condensing boilers
- a mix of renewable energy technologies, possibly including solar thermal panels, micro-wind turbines, ground source heat pumps and photovoltaic panels
- community heating, perhaps with CHP and/or renewable energy.

The preferred solution should then be examined through a technical feasibility study. This may include business modelling although this may be undertaken as a separate exercise.

6.2 Business plan modelling

Assuming that the selected technology is feasible, the business modelling will identify the expected capital cost and revenue stream (most importantly for the sale of heat and, if CHP is included, electricity), and any fixed charge for system costs. It will also calculate whether the revenues will support the capital investment required. The cost of the alternative 'business as usual' approach should be allowed for as a baseline, ie the cost of installing gas mains and an individual gas condensing boiler.

The ongoing operation and maintenance of the system once the development is completed should also be considered. This will include metering, billing and revenue collection. These services can be provided by an ESCO, of which there are various types:

- Utilities – some major energy companies have formed energy services divisions of their businesses targeting the new build market.
- Specialist private companies operating in a niche market offering energy service packages.
- Special purpose vehicles established on a bespoke basis for individual developments. This may be under some form of community ownership such as a cooperative, a leaseholder company which owns the freehold of the property, or be owned by a private sector company developed in partnership with the developer.
- Municipal-initiated ESCOs – a number of local authorities (including Woking Borough Council and the London Climate Change Agency) are developing community heating schemes and have established ESCOs to operate them.

The ESCO generally takes on ownership of the scheme and all that this entails. This may be in perpetuity or for a fixed term franchise. Alternatively, if ownership is retained by the host organisation, then the energy services management, including operation and maintenance, can be contracted out in a manner similar to facilities management or estate management. An ESCO can invest capital, or arrange financing, for the scheme. Typically, its investment is for the additional costs, over and above the conventional energy solution. Some ESCOs have incorporated other services into their packages including water and waste management, cable television, telecoms and data services.

A variety of different trades, suppliers and contractors are needed to build a community heating scheme. Utilities and specialist ESCOs can also manage its development and construction through a turn-key contract, whether they are the eventual owners or not. Alternatively, a specialist engineering consultant can be retained to manage this process and engage with the various contractors and suppliers.

Steps to take when selecting a commercial ESCO

- Engage a consultant to prepare tender documentation eg invitation to negotiate.
- Run a pre-qualification exercise for prospective private sector partners (the goal of this is to produce a list of potential companies for the tendering exercise).
- Initiate the tender period including site visits and review meetings (for the companies to collect relevant information for their proposals).
- Evaluate the bids and select preferred bidder.
- Negotiate with the preferred bidder to financial close.

7 Case studies

Comet Square, Hatfield, Hertfordshire

This new housing development officially opened in July 2008 and comprises 270 residential dwellings in four blocks (Fig. 8). A key element of the energy strategy was the implementation of community heating with CHP. In order to effectively utilise the CHP, the heat distribution scheme was extended to include an adjacent 100-bed nursing home. This increased the heat load and flattened the profile, making the scheme more viable.

A large heat storage tank located in the energy centre also enhances the output, enabling heat from the CHP to be stored when it cannot be used in the community-heating network. This means that CHP provides over 65% of the total energy demand for the development. Additional heat and electricity is supplied by gas-fired top-up/back-up boilers and the national electricity grid.

Heat and electricity production is managed by the external ESCO, Utilicom Limited. The ESCO's charges are set to deliver a 10% reduction for residents compared with alternative energy costs. Heat is delivered through HIUs and is metered and billed individually.

The ESCO funded installation of the CHP, boilers and heat storage unit, and the housing developer funded the energy networks. The estimated carbon dioxide reduction compared with alternative individual condensing gas boilers is 230 tonnes per annum.

Technical data

CHP electrical output	185 kW
CHP heat output	280 kW
Heat storage	43 000 litres
Top-up boilers	3 x 700 kW

Management arrangements

The ESCO has contracted with the developer to supply heat and electricity for 20 years through private networks. This contract is transferred to the managing agent and charges are levied via the managing agent.

Figure 8 Comet Square, Hatfield.

Figure 9 Combined heat and power engine and heat storage.

Figure 10 Gas-fired boilers.

The Tachbrook Triangle, London

The Tachbrook Triangle comprises a number of newly built private and affordable apartments and restored grade II listed townhouses in London SW1, along with some commercial office space for the Westminster Primary Care Trust. The apartments are connected to an existing community heating scheme via an internal pipework connection from the Pimlico District Heating Undertaking (PDHU), the UK's oldest community heating scheme. Heat is generated at PDHU via a central boilerhouse which already provides heat and hot water to over 3000 homes and commercial buildings. The energy centre at PDHU facilitates CHP and gas boilers.

An internal distribution pipework was installed in the Tachbrook development along with HIUs providing heating and hot water to each individual apartment. The scope of the work was extended to include the installation of an HIU for the Westminster Primary Care Trust to provide hot water to a doctor's surgery.

The scheme incorporates a meter reading solution with a radio communications module which accurately measures heat consumption inside the dwellings. Data is collected from each meter by 'touring' the premises with a wireless Bluetooth receiver and handheld computer to receive real-time on-demand data. This is more cost effective than other data collection methods because there is no need to knock on doors to read meters.

The pipework and HIU installation were carried out by Vital Energi.

Figure 11 The Tachbrook Triangle.

Figure 12 Hydraulic interface unit.

Figure 13 Wireless meter reading.

The Gothenburg City community heating scheme

Around 500 000 people live in Gothenburg, Sweden. The community heating scheme supplies approximately 90% of the residents in the city via a large pipe system made up of over 1000 km of supply and return pipes. The heat supply units comprise a variety of production technologies and are spread out around the city. The base load plants include:

- a new natural gas-fired CHP plant producing about 30% of the annual load (Fig.14)
- an energy from waste CHP plant producing 25% of the annual load
- waste heat from distant oil refinery industry
- two biomass boiler plants
- four large-scale heat pumps.

There are also some CHP units that again, are spread out; some using sewage gas from a water treatment plant and others using natural gas. In addition, there are some back-up oil/gas-fired boilers throughout the city which are able to provide heat if required. The scheme is connected to two nearby communities enabling the import and export of heat as and when necessary and is soon to be connected to a third.

There are all types of buildings connected to the system, from housing and hospitals to commercial, public and industrial buildings. All are metered and invoiced depending on capacity and energy used. In blocks of flats, the building owner decides how to charge the tenants. Most tend to allocate costs based on floor area as flats typically have their heating supplied from different stems which makes it difficult to measure individually.

In addition to the heat load, there are also absorption chillers at various locations which provide cooling for commercial buildings and hospitals.

Technical data, installed capacity

CHP electrical output	300 MW
CHP heat output	400 MW
Heat only output	1500 MW

Figure 14 The Gothenburg City community heating scheme's newest production plant built in 2006, combined cycle gas turbine combined heat and power.

APPENDIX 1

Policy framework

Government energy policy is set out in the Energy White Paper,[2] which sets the UK on a path to reduce carbon dioxide emissions by 60% by 2050 as one of the key goals. Principal policy areas affecting community heating for new build developments are outlined below.

- The 2008 Budget introduced an exemption on Stamp Duty on new build homes that are zero carbon. More information and details of compliance are available on the HM Revenue & Customs website at www.hmrc.gov.uk.
- Government measures to reduce carbon emissions for new dwellings to zero by 2016. The minimum energy efficiency requirements in Part L of the Building Regulations[3] is one of the mechanisms through which these reductions are to be achieved. Building Regulations will be progressively tightened in stages in 2010, 2013 and 2016. Until 2013, standards are likely to continue to be set with reference to space heating, water heating and lighting and to offer the option of adopting low and zero carbon technologies. The move towards zero carbon in 2016 is likely to include emissions from other sources (principally electrical appliances). In Scotland the zero carbon requirement is likely to initially exclude emissions from other sources.
- Alongside the Building Regulations, CLG has introduced the CSH. The CSH measures the sustainability of a new home against nine categories of sustainable design, rating the 'whole home' as a complete package. The CSH uses a 1 to 6 star rating system setting minimum standards for energy at each level. At present, all new affordable housing must be built to CSH level 3, equivalent to the Building Regulations for 2010. Where the building density is high, one of the effective ways to help meet the carbon dioxide reduction requirements of the CSH is via community heating with CHP and/or renewables.
- The 2007 Supplement to Planning Policy Statement 1 (PPS1)[4] on *Planning and climate change* recognises that climate change considerations need to be integrated into the planning system with new developments configured to limit carbon emissions and integrate low carbon technologies.
- The PPS provides powers for local planners to oblige new developments to connect to existing or planned sustainable energy networks.
- Electricity trading arrangements for decentralised generation are under scrutiny by Ofgem.[5]
- The government has announced its intention to produce a heat strategy for the UK in the late spring of 2009. This will consider issues such as consumer protection and the need for market regulation of heat markets in general.

Regional planning

The supplement to PPS1 creates the framework for local and regional planning authorities to create regional spatial strategies and local development frameworks. As an example at regional level, the London Plan[6] (the Mayor of London's spacial development strategy) has set out a hierarchical approach to:

- ensure the building is as energy efficient as possible
- ensure energy required is supplied as efficiently as possible
- secure a set percentage of the residual load from onsite renewable sources.

Local development frameworks or core strategies set the overall vision and requirements at a local level. A good example is Southampton City Council which has stipulated that:

> *All developments, either new build or conversion, with a floor space of 500 m^2, or one or more residential units (based on the size of the final development footprint), will be required to incorporate decentralized and renewable or low-carbon energy equipment to reduce predicted CO_2 emissions by at least the percentage values for each type of development stated in the 'Requirements for reductions in CO_2 emissions' table.*
>
> *Where specific opportunities exist, development will be required to connect to existing Combined Heat and Power (CHP) systems or make equivalent CO_2 savings through other onsite renewable or low-carbon energy measures. Proposals that are not in accordance with this policy will be refused.*

APPENDIX 2

Community heating scheme elements

Pipes

A network of pipes (Fig. 15) carries the heated water from the plant in the energy centre to each connected building and/or dwelling HIU. It is this network that really characterises community heating; therefore, the quality of the pipes is crucial. Modern pre-insulated pipes are of very high quality and have an integrated surveillance system to detect the first sign of moisture ingress or leakage.

Figure 15 Heating pipes being installed in a trench.

The energy centre

The plant room or energy centre typically has an arrangement of in-line boilers. The lead boiler provides for summer base load – generally domestic hot water services for washing and bathing. Most modern schemes will include a CHP engine acting as the lead boiler. As demand for heat rises, other boilers will come on-line as required. A computerised buildings energy management system (BEMS) monitors performance and controls the plant sequencing, and logs any alarm from the moisture detection system. The BEMS provides automated control but is usually monitored remotely. Energy centres can be located in the basement plant rooms of larger buildings or may be in purpose built boiler houses (Fig. 16).

Figure 16 Seaton community heating energy centre, Aberdeen.

Consumer interface

Within the dwelling is an HIU which takes the heat from the main heating network and transfers it to the dwelling central heating system and domestic hot water supply through a plate heat exchanger. The dwelling central heating system can be directly connected to the community heating system through the HIU – in this case, the water from the community heating flows through the dwelling circuit. Alternatively, an indirect connection can be used, which means that the dwelling's heating system is a separate secondary circuit heated by an additional heat exchanger inside the HIU.

Figure 17 HIU installed on open wall.

The HIU, which also contains other equipment such as controls and metering equipment (and in the case of indirect connection, a small pump to push the water around the secondary system), is approximately the size of a wall-hung gas boiler albeit flatter. There is no need for domestic hot water storage tanks as hot water can be obtained instantaneously from the heat exchanger 24 hours a day. Otherwise, there is little difference from a typical central heating arrangement with radiators, timers and controls. Some consideration has to be given to the sizing of the radiators to ensure an adequate drop between flow and return temperatures; increasing the temperature drop means a smaller diameter and, hence, lower cost pipe can be installed, as well as pipe heat loss being reduced.

Thermal storage

Peak demand periods for electricity and heat do not always coincide, therefore, the inclusion of a thermal store within the design of a community heating system enables the operator to cope with this. CHP plant can be run at times of peak electricity demand, regardless of heat demand, in order to maximise revenues from electricity sales. Surplus heat can be dumped into the thermal store and drawn off later as required.

APPENDIX 3

Achieving Code for Sustainable Homes level 4 with gas-fired CHP

For the analysis presented below, a gas-fired reciprocating engine CHP has been assumed. The CHP performance parameters used for the calculations are representative of a 200 to 300 kWe CHP engine.* Such an engine would be able to supply a residential development of around of 300 to 600 new apartments. Supplementary heat would be provided by top-up gas boilers. Carbon dioxide calculations have been undertaken using SAP 2005.

Figure 18 takes as its baseline dwellings that are compliant with the Building Regulations 2000 Part L 2006.[3] It can be seen in the second bar how the carbon dioxide emissions per m^2 can be substantially reduced through the application of energy efficiency measures alone.** However, Figure 18 also shows how further substantial reductions in carbon dioxide emissions can be achieved by the application of CHP. Indeed, the combined effect of energy efficiency measures and CHP enables CO_2 emissions to be reduced by around 50%, thereby enabling the CSH level 4 to be achieved.

All of the calculations undertaken have considered a flat of 60.9 m^2 floor area.

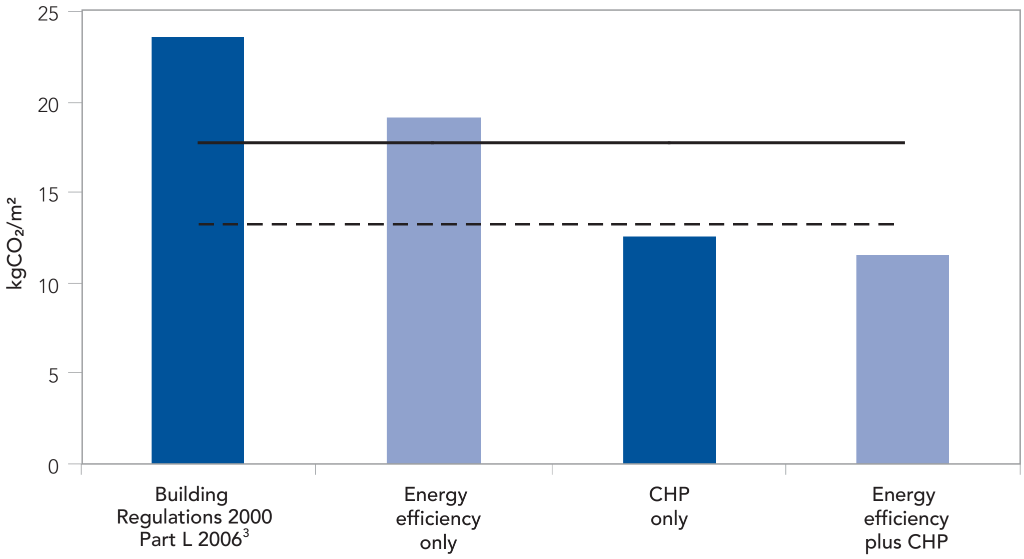


Figure 18 Example modelling of carbon dioxide emissions with energy efficiency and CHP.

* Power efficiency 32% and heat efficiency 43%. 60% of heat supplied with CHP.

** Fabric parameters used are: U-values (W/m^2K): walls 0.25, roof 0.13, windows 1.2 (g=0.5), y-value (W/m^2K) of 0.04. Air tightness of 3 m^3/hm^2. MVHR 85% efficient and 1W/l.s specific fan power.

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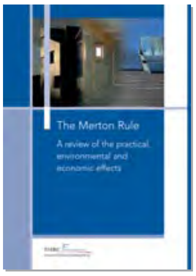

The Merton Rule

A review of the practical, environmental and economic effects

Since its introduction in 2003, the Merton Rule has been a focus of controversy. While some call it 'ground-breaking', and view it as having a positive impact on the renewables industry, others believe that it encourages a 'bolt-on' approach to energy efficiency and can be a financial burden on developers.

The review also looks at how the Merton Rule has been interpreted, the effect it has had on reductions in CO_2 emissions and how developers have been impacted financially in complying with its requirements. **NF11**, January 2009

The use of lime-based mortars in new build

This guide provides a general introduction to using lime-based mortars and is aimed at those who may have little knowledge of this material but who want to apply best practice when used in new build construction projects. It describes a range of mortar types concentrating on natural hydraulic limes.

A Draft for Development Standard is also included which provides replacement and new clauses for incorporation into BS 5628-1:2005 *Code of practice for the use of masonry – Part 1: Structural use of unreinforced masonry.* **NF12**, December 2008

NHBC Foundation publications in preparation

- Code for Sustainable Homes – simply explained
- Water efficiency guidelines
- Sustainable drainage systems for housing

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Community heating and combined heat and power

The advent of the Code for Sustainable Homes means that low carbon solutions, such as community heating, are a key consideration for new developments. There are powerful environmental drivers for this approach principally because it enables the integration of combined heat and power and renewables.

This guide aims to introduce the reader to the concept of community heating and combined heat and power and how they can be applied. The focus is principally on new housing developments, but the possibilities for serving a mixture of both new and existing buildings, as well as mixed use developments, is also described.

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The NHBC Foundation has been established by NHBC in partnership with the BRE Trust. It facilitates research and development, technology and knowledge sharing, and the capture of industry best practice. The NHBC Foundation promotes best practice to help builders, developers and the industry as it responds to the country's wider housing needs. The NHBC Foundation carries out practical, high quality research where it is needed most, particularly in areas such as building standards and processes. It also supports house builders in developing strong relationships with their customers.

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