Ecoheat4cities

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The environmental benefits of district heating: using the new Ecoheat4cities label

Guidance for district heating companies

This report was elaborated in the framework of the Ecoheat4cities project supported by the Intelligent Energy Europe Programme.

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Project Summary

Supported by the Intelligent Energy Europe Programme (IEE), the Ecoheat4cities project promotes awareness and knowledge-based acceptance of District Heating and Cooling (DHC) systems through the establishment of a voluntary green heating and cooling label. The label will provide useful information on key energy related parameters of DHC systems to interested stakeholders throughout Europe and participating countries, including local policy makers, other DHC companies, citizens and related industries.

The three labeling criteria: **Renewability, Resource efficiency (Primary Energy Factor) and CO2 efficiency/emissions** reflect the aims of the EU 2020-targets and will thus enable stakeholders from all over Europe to see and show how District Heating and District Cooling can contribute to reaching the EU's energy targets and assess DHC as a competitive and viable option in Europe's heating and cooling market.

Project outcomes include:

- a label design tool, labeling governance and guidelines, including all details concerning the calculation methods as well as related technical and scientific background research on DH performance and best available and not available technologies;
- a tool enabling cities and municipal planners to compare different heating and cooling options;
- a guide for city planners and DHC companies to better understand the labeling process, also offering insight into how the label can provide added value and a green image.

The Ecoheat4cities label provides a way to measure sustainability and performance of DHC systems based on available and verified, local knowledge and resources.

If your organization would like to know more about the Ecoheat4cities green label, governance structure of the labeling scheme, or participate in any of its activities, please contact Euroheat & Power or its national partners. DHC companies and cities are actively invited to provide additional guidance and feedback about the on-going work by contacting us.

All information is available on the Ecoheat4cities website at
www.ecoheat4cities.eu

Project Partners

Guidance for district heating companies
Summary

Through the establishment of a voluntary green labeling scheme, EcoHeat4Cities promotes the acceptance of district heating and cooling systems by customers. As the label provides information on the energy efficiency, CO_2 emissions and use of renewables in networks, it enables local decision makers and other stakeholders to make evidence based environmental decisions when comparing heating systems.

This document provides district heating and cooling (DHC) companies with guidance on the benefits of labeling and the key parameters for achieving high performance on the labeling criteria. It promotes the label by making information available on the potential advantages to DHC companies and how labeling can be used to successfully meet their customer needs.

The early sections of the guidance start by providing information on the label itself: what the label is, how it has emerged and who it is for. The benefits of individual networks becoming labeled, such as helping connected buildings to demonstrate compliance with national building regulations, are then described. After highlighting the three adopted labeling criteria and the 7 Class rating system, the guidance then sets out how DHC companies can get started with labeling by providing information on the preparatory work required, how to engage with the labeling body and the assessment.

The guidance then outlines the fundamental factors for improving performance and discusses specific solutions that can be adopted. It then moves on to provide a series of examples detailing how particular networks have adopted specific improvements and, as a result, improved their performance in relation to the labeling criteria. The examples deal with a range of approaches including switching to low and zero carbon fuels, adding combined heat and power (CHP) and refurbishment of older networks. Networks undertaking incremental improvements to obtain middle class numbers, for example Class 4, are covered as well as those adopting the most advanced technologies and renewable fuels to achieve the highest classes e.g. 1 and 2.

Finally, the document also signposts sources of information on other aspects of quality assurance not covered by labeling criteria.

Looking to the future, DHC companies will need to seriously consider how they can decarbonise their heat networks in the same way that electricity companies are evaluating how their grids can supply electricity without continuing to use fossil fuels. The new labeling scheme has an important role to play in helping companies demonstrate that actions taken in support of this objective result in tangible improvements and reduced environmental impact. DHC companies should seriously consider the benefits of labeling and this document can help them to quantify the potential impacts.

1 Background

Ecoheat4Cities promotes the acceptance of district heating and cooling systems by customers through the establishment of a voluntary green energy labelling scheme. By establishing a label that recognizes the energy efficiency, use of renewables, and CO2 emission savings by DHC companies, the project enables local decision-makers, citizens, and interested investors to make renewable energy and energy efficiency based choices.

This document promotes the label by providing district heating and cooling (DHC) companies with guidance on the key parameters for achieving high performance on labeling criteria. This will enable DHC companies to demonstrate the environmental performance of their scheme and promote the benefits of schemes to potential users.

1.1 Where to find information in the document

Section 2 explains what the label is, how it has emerged and who it is for. Section 3 describes the benefits for DHC companies of getting their schemes labeled.

Section 4 summarizes the labeling criteria that have been adopted for the EcoHeat4Cities scheme and highlights where further information can be obtained on the methodology and procedures used for labeling schemes.

Section 5 highlights the opportunities for progressive decarbonisation of heat grids and likely future trends in district heating in relation to the EU 20-20-20 targets. This is intended to help DHC companies better understand their role and responsibilities in contributing to fulfillment of the targets.

Section 6 sets out how to get started in getting a scheme labeled.

Section 7 outlines the fundamental areas that need to be addressed in order to improve performance. Section 8 then provides strategies for improving the performance of schemes. The strategies are supported in section 9 with multiple examples setting out the improvements that schemes have made and the improvement in environmental performance that has resulted.

Section 10 considers some of the other factors in relation to quality assurance and signposts various standards which, if complied with, will help to ensure the overall high performance of a scheme.

2 The EcoHeat4Cities Energy Label

2.1 What is it?

This labelling system will allow potential customers to assess – at a glance – the energy and environmental benefits of a system. The label also allows for easy comparison with other heating and cooling options, as well as with existing and/or future district heating and cooling schemes. Using a system of ratings, the potential customer can instantly gauge the merits of this system in terms of environmental efficiency, use of renewable energy sources and comparability with other existing energy systems.

2.2 How has it emerged?

DHC systems allow users – both public and private – to enjoy efficient and environmentally friendly energy systems. However, there is a need to achieve greater municipal and public acceptance of DHC systems as, among other things, this will help support the implementation of the Renewable Energy Sources (RES) Directive.

EcoHeat4Cities aims to promote understanding and acceptance of sustainable district heating and cooling among the EU's citizens and their local representatives and authorities. It will also help to improve and establish more DHC through recognizing the use of RES and better energy efficiency (EE) in such systems. This in turn can help trigger locally integrated and increasingly cost-effective solutions for buildings, energy efficiency, renewables and infrastructures by facilitating sustainable urban planning.

2.3 Who is it for?

The label should help local politicians, potential investors and consumers to easily choose a system with the best capability in terms of energy efficiency, low CO2 emissions and use of renewable energy sources.

Ecoheat4cities also aims to encourage DHC companies to market the performance of their product from a primary resource perspective so potential customers are aware that such systems are at least equal to other primary resource systems.

3 The Benefits of labelling

3.1 *Independently demonstrating environmental credentials*

The labelling system provides DHC companies with a way of independently demonstrating the environmental credentials of the schemes they operate. Achieving a high rating can help to enhance a company's reputation and provides a means of the company being recognised for its achievements. It won't only be customers that are interested in the fact that the company is labelled; investors and current staff will want to learn what is involved.

As the label provides the non-renewable primary energy factor, carbon dioxide intensity of heat and renewability, it enables heat customers to compare the district heating and other competitor technologies. This enables the energy and emissions savings achievable by connection to a district heating network to be easily calculated.

3.2 *Help buildings demonstrate compliance with regulations*

In most countries, new buildings are required to demonstrate compliance with national building regulations. For existing buildings, energy performance certificates sometimes need to be produced, for example, when a building is sold. As part of these compliance processes the carbon intensity of heat from district heating schemes is often required and the labelling system provides this parameter which contributes to the labelling. Where a low environmental impact of heat supply can be achieved, this should help building owners and operators to demonstrate compliance.

3.3 *Shows commitment to renewable fuels/using surplus heat*

DH schemes are inherently fuel flexible, so they are capable of migrating towards lower or even zero carbon operation. Achieving a high rating under the labelling system requires schemes to use renewable fuel and/or surplus heat sources. Joining the labelling scheme, which encourages improvement through its progressive rating system, implicitly demonstrates a company's commitment to using more renewable sources of energy.

4 The labelling criteria for evaluating DH performance

A broad range of factors can influence the performance of district heating networks. As well as environmental performance these can include issues such as security of supply, customer relations and market aspects (see section 10). A range of parameters were considered according to whether they:

- were measurable,
- were not already regulated,
- had statistics available,
- were able to be compared to alternatives, and
- were understandable by target groups.

Following detailed consideration of the parameters that should be included[a] the three parameters selected for use in the labelling of schemes were:

- Non-renewable primary energy used per unit of heat delivered to the building (MWh/MWh)
- Carbon dioxide emissions per unit of heat delivered to the building (kgCO2/MWh)
- Renewable and surplus heat fraction (%)

The non-renewable primary energy consumption and carbon dioxide emission parameters are expressed relative to the amount of heat delivered to customers. The lower the non-renewable primary energy factor and carbon dioxide intensity, the better the environmental performance achieved.

Note: Within district heating schemes, there are numerous methods for calculating the carbon dioxide intensity of heat from CHP plants and these are discussed at length in the final report for work package 2 (see footnote below). The general method chosen for the Ecoheat4cities project is the power bonus method. This method provides a carbon credit for electricity generated by the CHP plant. The carbon credit is equal to the amount of carbon that would be emitted from a condensing power plant using the same fuel as the CHP plant in generating a unit of electricity.

In the case of the renewable and surplus heat fraction, this is expressed on a percentage basis compared to the total fuel use. The renewable energy sources are all non-fossil and non-nuclear and are not depleted upon extraction. Recycled fuels are defined as secondary fuels such as municipal waste, industrial surplus heat and industrial fuels. For the avoidance of doubt, by-product heat recovered from an electricity generation process is not included.

Each of the three parameters is classed on a scale of 1 to 7, with lower classes indicating better performance. The classification is determined in accordance with the procedures set out in the EcoHeat4Cities guidelines on the 'Certification of district heating systems'. The process for determining the reference values for classification are also set out in this document.

Note: The results of the labelling also vary depending on whether EU primary energy and carbon dioxide factors are used for fuels or national values are used.

[a] EcoHeat4Cities Work Package 2: Green Labelling Criteria Final Report (Apr 2011)

5 DH grids: opportunities for progressive decarbonisation

DH is increasingly recognised by decision makers as having a key role in achieving society's environmental objectives e.g. decarbonisation of energy networks. Realisation of this can give increased confidence to those considering new networks.

The text below sets out the vision for district heating in the years ahead. In the same way that it is proposed to decarbonise electricity networks, it describes approaches to progressively decarbonising heat networks. The text draws on the District Heating and Cooling Technology Platform's vision document 'A vision for 2020-2030-2050'[b].

In the years ahead, ***progressive innovation*** will lead to the use of new technology. Modern district heating and cooling systems will benefit from progressive improvements to their generation, distribution, control and customer interface systems. Innovation focused on upgrading materials, equipment and processes will lead to even higher levels of efficiency, cost-effectiveness and customer service. The label will be a potent way of recognising the benefits of these enhancements.

Some believe the future of DH is decline because of the emergence of (would be) zero carbon buildings. It is necessary, therefore, for the DH industry to demonstrate its ongoing green credentials and its intention to invest in the future. Higher efficiency, lower costs and greater overall confidence in district heating systems can extend viability over longer distances. This increases the range of heat sources that can be effectively employed. The potential to tap surplus heat sources including among others industrial waste heat, the use of which was not maximised earlier for reasons of cost-effectiveness, is increased.

Research and deployment of pilot demonstration sites will be a necessary step for approaching the large-scale implementation of innovative systems. As well as featuring state of the art technical systems, additional customer service models and communication channels with (potential) customers will also be devised.

There will be a need for ***modernization*** with the ***transfer of best practice***. Due to the difficulty of comparing district heating networks, achieving this aim will require consistent and flexible quality assessment tools and systems of best-practice transfer. Best-practice transfer will not mean full replication of existing schemes but an inventive application of the techniques and best-practices to each particular regional and local circumstance.

If the DH market is to achieve its full environmental, economic and social potential, this will need to include a significant ***expansion of existing networks***. Even though the required growth rates differ with the market situation, this applies in most EU countries.

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[b] District heating and cooling: A vision for 2020-2030-2050 DHC+ Technology Platform (May 2009)

Regulatory aspects of energy markets will be analyzed and improvements proposed to policy frameworks at European, national and municipal levels. This will be focused on ensuring that the benefits of district heating and district cooling are correctly accounted for by considering exergy as well as energy and that they assist the growth and development of innovative features. Promoting primary resource factor as the basis for evaluating the efficiency of end-user solutions, and creating a level playing field on the market are amongst the priority areas of attention. Although heat is a difficult commodity to regulate, the label can be an effective alternative.

Raising awareness of the working principles and the benefits of district heating and district cooling will be of great importance. This is true in particular for countries where the district heating market is underdeveloped and knowledge about the technology is likely to be limited. However, it is also needed in countries where district heating is well-established where even there district heating is often a largely 'invisible' solution among society at large. Communication and dialogue with customers, the wider public, national, regional and local policymakers, investors, universities, architects, builders and other stakeholders is required as a vital element of successful expansion strategies. In this regard in particular, the label has a key role to play in facilitating discussions.

Another crucial area of activity to the entire European sector will be to gain a better understanding of the trends in energy demands to help district heating providers and policy-makers pursue informed choices for the future. Customers' demand for heat may be reduced through building refurbishment and increased average temperatures. There may a corresponding increase in the demand for cooling.

Towards 2030 and beyond, greater steps will be made to move from classical district heating configurations using one main energy source to multiple source systems. Operators will feed a wide variety of sustainable heat sources into the system at different places in the network, depending on availability and need, ensuring a timely match to customer demands.

Within the energy exchange framework provided by district heating infrastructure, it is possible that ***interactive buildings*** will be connected. However, the overall energy demand of the building stock may be reduced due to more stringent efficiency requirements particularly for new buildings.

Beyond 2050, zero carbon solutions may be provided where district heating companies increasingly offer their customers entirely carbon neutral energy solutions. Energy input is all renewable or coupled to carbon capture technologies and local grids may be connected to provide networks serving entire regional areas.

6 Using the label - how to get started

Most DH networks are more energy efficient than individual heating systems and there will be benefit in getting the scheme labelled.

The flow chart on the following page explains how to get started and the different steps involved in getting the scheme labelled.

The first task is to access the EcoHeat4Cities website and read the guidelines on the certification of district heating systems. The guidelines contain the detailed procedures and processes relating to the certification of schemes including system boundary diagrams which are integral to quantifying the energy balance of a system. They also contain the equations which specify how the various performance elements of the labelling scheme should be calculated. Additionally, EU wide carbon intensity and primary energy factors for different fuels are tabulated.

The next element of the preparatory work is to collate energy input and output data for the scheme in question. This will require the metering installed at the boundary of the system to be identified and readings obtained for appropriate timing intervals e.g. at the beginning and end of an operating year. Metering will need to have been calibrated and have accuracies within industry standards for uncertainty.

After the initial preparatory work, the next step is to engage with the national certification body, get the scheme registered and an auditor appointed. This will enable the assessment process to be initiated.

The auditor will need to be provided with the information required to undertake the assessment. This will include information relating to the characteristics of the scheme, as well energy production and consumption data. Using this information the auditor will undertake the assessment and issue this to the national certification body for checking. Specifically, according to the guidelines document, the documentation of the calculation will include:

- Description and connection scheme(s) of the district heating system
- All energy input and output per energy carrier and time period
- Plausibility checks
- Conversion factors
- Explanation of assumptions and simplifications if necessary
- Pictures of the plant site
- Resulting energy performance indicators
- Date, name of suitor, confirmation of compliance with this guideline.

Finally the certification body will verify the assessment and, if correctly undertaken, issue the label/certificate. As set out in the guidelines, the certificate will include:

- Reference to a specific procedure for district heating certification
- Names of persons and institutions responsible for issuing the energy certificate
- Name and location of the district heating system
- Date on which the energy certificate was issued and its limit of validity
- The energy indicators for the scheme
- Types of indicators used
- The energy classes i.e. the class achieved in relation to each of the criteria

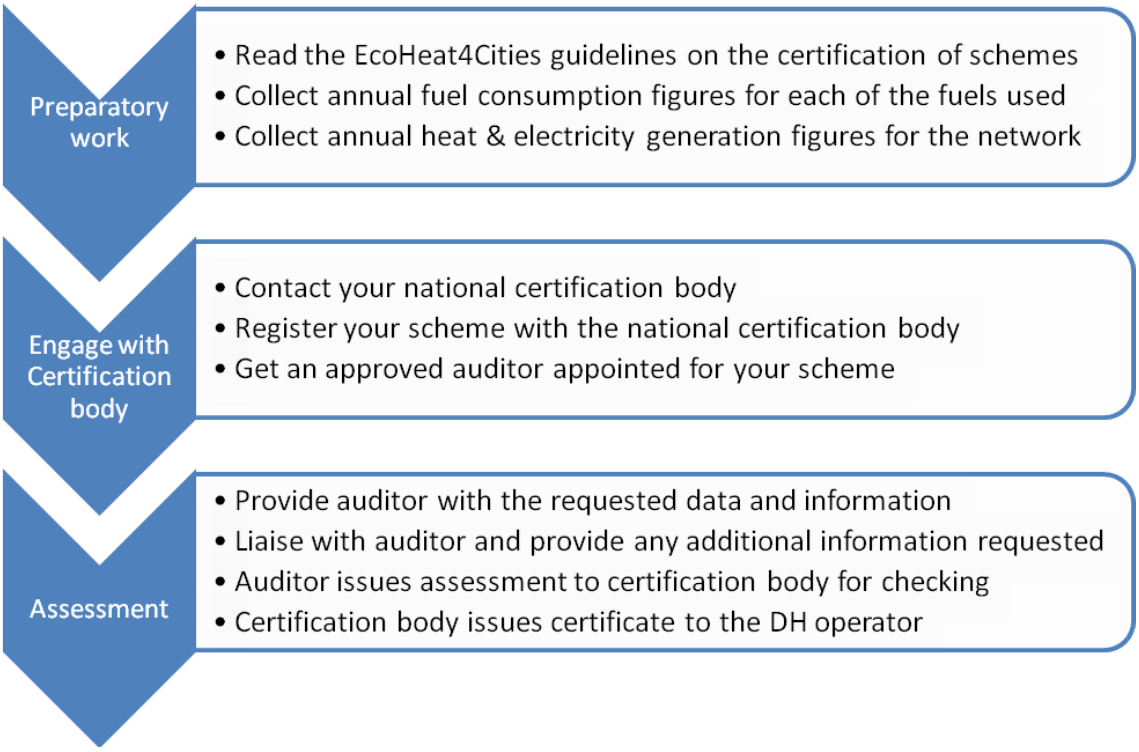

Figure 1: Flow chart showing the different steps in achieving certification

Once issued the DH operator can use the certificate to market the scheme and for various other uses including helping buildings to demonstrate regulatory compliance. The performance of the network can also be summarised using a label which represents the three criteria in the form of three flowers with different numbers of petals depending on the class achieved.

Further details describing how the labelling is being implemented in individual countries can be accessed through documentation available through the EcoHeat4Cities web site.

7 The fundamentals of improving performance

This section highlights the fundamental areas that should be targeted in order to improve the environmental performance of a scheme. Later sections of the guidance highlight more specific strategies that can be adopted and the measures that have been implemented by particular schemes to achieve high levels of labelling performance.

Essentially there are three main ways to improve the environmental performance of a scheme:

1. Reduce the heat loss from the network
2. Use renewable and other low carbon fuels
3. Install high efficiency production plant

The sub-sections below provide further information on these areas to target.

7.1 Reducing heat loss

The first fundamental step in improving the performance of the scheme is to minimise heat loss from the network. This reduces the amount of primary energy that is required to supply heat to buildings and, hence, also reduces the carbon dioxide emitted in the process, as well as expenditure on fuel. It also means that less renewable energy is used in meeting the heat demand and, hence, more renewable energy is available elsewhere.

It is not the intention of this guidance to repeat in detail the approaches to reducing heat loss that DHC companies will already be largely familiar with; they may be summarised as:

- Increasing pipe insulation thickness
- Selection of twin pipes rather a pair of single pipes
- Use of lower temperature heat distribution
- Designing for high temperature difference, with smaller diameter pipes

However, it is worth emphasising that networks adopting best practice in heat distribution can substantially reduce heat losses e.g. 30% less heat loss from twin pipes compared to single pipes[c]. Hence, there is much benefit to be gained by targeting this area.

7.2 Using renewable and other low carbon fuels

The criteria adopted in the labelling means that renewable (and surplus) heat sources score particularly well in helping to achieve a high labelling rating. As well as the renewable and surplus heat fraction being a criterion in its own right, using renewable sources also helps to reduce the non-renewable primary energy factor

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[c] Zinko et al IEA Annex VIII District Heating Distribution in Areas with Low Heat Demand Density

and the carbon dioxide intensity of the heat. As the label prioritizes renewable energy, it directly supports the objectives of the RES Directive.

A range of renewable energy sources can be used to supply district heating networks including biomass, solar and geothermal heat. As the carbon intensity of fuels varies widely (see figure 2 below) there are significant benefits to be gained from careful fuel selection. The carbon intensity of heat production will also be a function of the efficiency of the heat conversion technology. Assuming typical boiler efficiencies for different types of fuel, biomass produces heat at a carbon dioxide intensity that approaches zero but coal emits more than 400kgCO_2 per MWh of heat produced. It is clear, therefore, that prioritising renewable fuels can have a significant impact in substantially reducing carbon emissions. Where the use of fossil fuel is to be maintained, there are also significant benefits in switching to lower carbon fuels. However, resource availability needs to be taken into account as, for example, although natural gas as a fuel is approximately 40% less carbon intensive than coal its security of supply can be highly affected by political and geographic considerations.

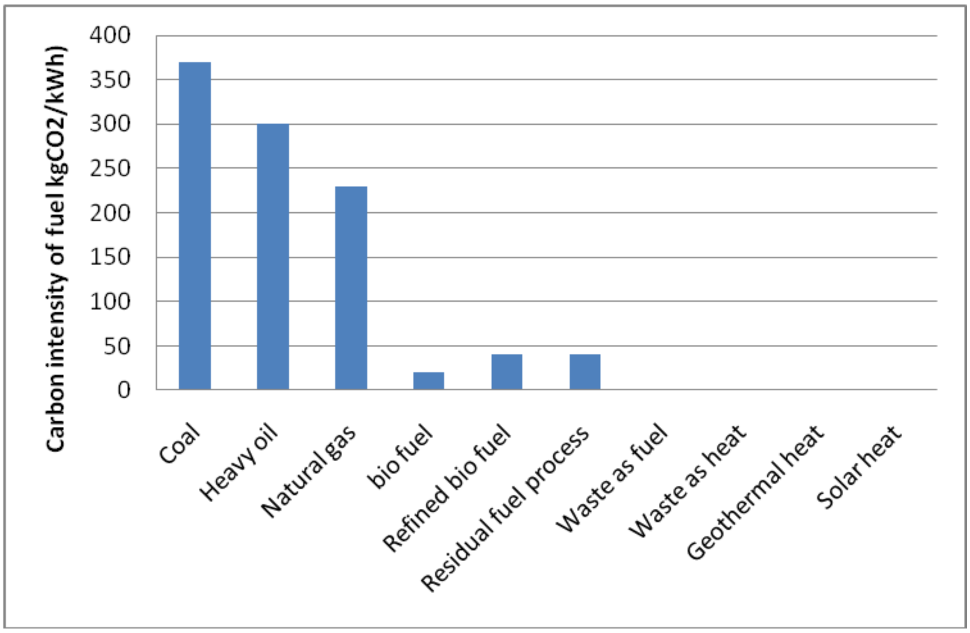

Figure 2: Carbon intensity of different fuels[d]

In the situation where boilers are to be used to provide top-up and back-up heating, it is still important to select a low carbon fuel. If this proportion of the overall heat is supplied by higher carbon fuels, for example oil, this can significantly raise the carbon intensity of a scheme, even where a very low carbon heat source is the lead heat source. For example, in a scheme where municipal waste is the primary fuel but 30% of the total fuel is supplied as oil for top up purposes, the overall combined carbon intensity of the fuel used would still be 60% of that for natural gas.

[d] Carbon emission factors taken from [input sheet of EcoHeat4Cities design tool]

7.3 Installing higher efficiency production plant

There is also considerable benefit to be gained from installing energy efficient heat production plant. Higher efficiency production plant can both reduce the non-renewable primary energy factor of a scheme and improve the carbon intensity of heat production.

The main way of improving the efficiency with which heat is generated is to use combined heat and power (CHP). CHP involves the use of a prime mover 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. As a result this can help to produce a low carbon intensity of heat production.

Figure 3 below highlights how the carbon intensity of heat production varies according to whether a particular fuel is used in CHP mode or heat only boilers. In the case of fossil fuels there is a substantial reduction in carbon dioxide intensity – the example shown in the figure shows gas engine CHP compared to central gas boilers. However, for very low carbon fuels, the carbon intensity of heat production can already be very low in heat only mode. As the methodology does not allow negative carbon dioxide intensity of heat production, the further carbon reduction benefit of CHP is not always evident; this is the case for the waste and solid bio-energy fuels shown in the graph below.

The additional benefit also varies depending on the scale and type of CHP that is used with a particular fuel and the alternative electricity only plant the CHP electricity is assumed to displace under the adopted methodology.

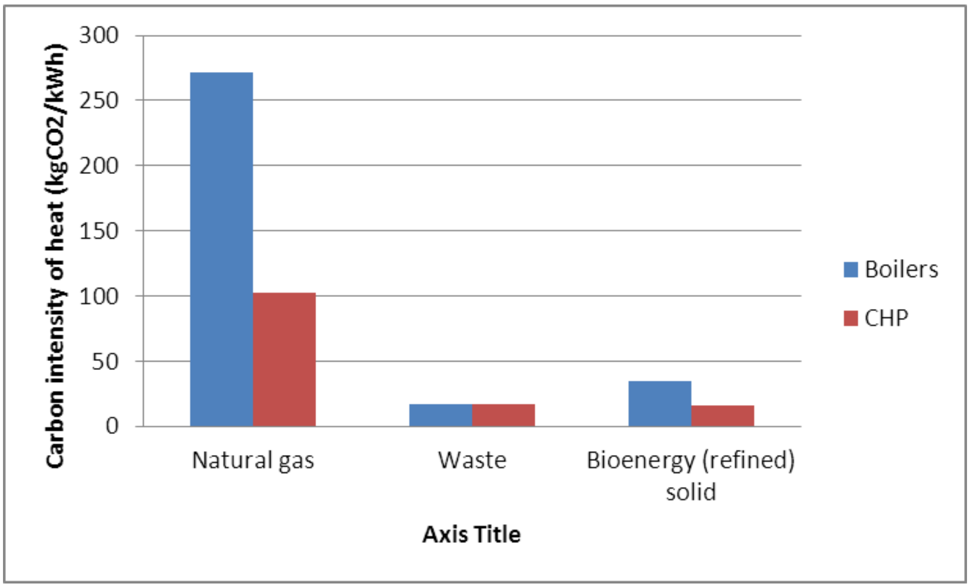

Figure 3: The carbon intensity of CHP and boilers using the same fuel

When there is a mismatch between the time at which CHP plant would be required to generate electricity and when there is a demand for heat, thermal storage can be used to store heat for use at a later time. This is a way of maintaining high overall efficiency of operation.

8 Specific solutions for improving performance

While section 7 focussed on the main areas to improve performance, the text below highlights specific strategies for improving the energy, environmental and, potentially, the economic performance of schemes. Although the approach will vary with the local circumstances in particular countries, there are underlying methods which can be applied to schemes and these form the basis of the sub-sections below.

8.1 Adopting renewable/surplus heat sources & lower carbon fuels

The carbon intensity of the heat supplied to networks can be reduced by switching to lower carbon fuels. However, whether this is economically justifiable will depend on the relative unit costs of the fuels, which in turn is influenced by local availability and security of supply considerations. Where the switch is made from fossil fuels to renewable fuels, this can also improve the renewable fraction of a scheme. The nature of the fuel switching will vary widely depending on the different fuels which are available in the locality. Examples include:

- Switching from coal to natural gas boilers
- Changing from oil to waste fired boilers
- Changing from natural gas to biomass boilers.

One fairly common situation is where existing networks have been built up using the surplus heat from the incineration of municipal waste. In these circumstances heat will have been available at low cost, enabling the initial high capital cost of the network to be financed. Example 1 provides an example of a scheme that has been developed from the outset with municipal waste as the primary fuel. These schemes can have relatively low carbon emissions as the carbon intensity of waste is far less than fossil fuels. However, their benefit can be eroded if too much fossil fuel is used as the backup heat source. Where the vast majority of heat is provided from waste the highest class can be achieved in each of the three labelling categories.

In some cases schemes will have been established using locally available solid fuels e.g. coal. In such circumstances the carbon content of the heat generated can be high and, thus, provides particular opportunities for significant environmental improvements through switching to lower carbon fuels. Example 2 describes the case of a small scheme in an emerging country which, after identifying locally available resources, achieved significant carbon dioxide and cost savings from switching from coal fired boilers to locally sourced, wood-chip; this increased the renewability by 80%. This approach can also be followed at a larger scale, although resource availability considerations become even more significant. For instance, example 3 illustrates a situation in an established district heating country where small dh networks and large buildings heated by oil were linked together in a large DH network and supplied with heat from a large scale biomass CHP installation resulting in a 81% drop in the carbon intensity of heat supply. Example 4 also shows a scheme where the carbon intensity of heat supply has been lowered by 90% though switching from natural gas to industrial waste heat.

In Central and South Eastern European countries, there may be some potential for switching medium scale schemes from coal to lower carbon intensity fuels. However, the potential for switching from, say, coal to natural gas is, in reality, limited by security of supply considerations due to a lack of national production.

In terms of labeling, there is a significant benefit in at least a proportion of the heat production being from renewable or surplus heat sources. The text below highlights where other sources of renewable energy have been successfully installed.

In cases where large amounts of roof space or areas of low cost land are available, solar thermal panels can be used to cost-effectively reduce the carbon intensity of the heat supplied and, at the same, increase the proportion of renewable heat. In Denmark, in particular, they have led the investigation and development of solar heating systems in district heating. Example 5, which is based on a Danish Scheme, illustrates a case of where a small district heating network serving low density housing has decided to install a large solar thermal field to supply a significant (80% of summer heat consumption) proportion of the total heat required.

Where low grade heat is available this can be upgraded via a heat pump for use in a district heating network. Providing the temperature differences allow a good coefficient of performance (COP) to be achieved and low carbon electricity is available to power the heat pump, low carbon intensity heat can be provided into the network. This approach has been adopted at the Katri Vala plant in Finland where 5 heat pumps have the capacity to produce 18MW of heating.

In certain locations, companies may have access to geothermal energy at a temperature that can be used in district heating networks. In most cases this will involve drilling down a significant distance in order to access the available resources.

Where industrial waste heat is already available, there may be less case for installing renewable energy generation equipment as demand can be met through using the existing heat more efficiently rather than creating more, albeit renewable, heat.

8.2 Adding CHP to a network

Fossil fuel fired schemes can improve the non-renewable primary energy factor and reduce the carbon intensity of the heat they produce through the addition of combined heat and power (CHP). The opportunities will vary depending on the specific circumstances of each individual scheme. However, more common examples include:

- Adding gas fired, reciprocating engine CHP
- Installing combined cycle gas turbine CHP

The solution adopted will vary depending on a wide range of factors including the scale of the existing network, available fuels, what the competitor individual heat generation technologies are, etc.

As an example of an emerging country, in the United Kingdom networks tend to be of relatively small scale but natural gas is widely available. Therefore, it is quite common for gas-fired, reciprocating engine CHP to be retrofitted into an existing network that previously relied upon centralised gas boilers. Example 6 describes the case of an existing, older network which, as part of a wider refurbishment, installed new gas fired CHP in its energy centre to supply the base heat load and significantly reduce its carbon emissions. In a scheme with an optimally sized gas CHP and low heat losses a high class (2) may be achieved for the non-renewable primary energy factor and carbon intensity factor, although the worst class (7) would be obtained for the renewability factor (without renewable input fuel) .

In very large schemes, there can be opportunities for adding large scale plant, such as combined cycle gas turbine CHP. These can have higher electrical efficiencies than smaller CHP, while still achieving high overall efficiency. Example 3 is an example of a large scheme which, along with other initiatives, connected to a large CHP plant to source a significant proportion of its heat. There is particular potential for adopting this type of approach in expansion countries.

8.3 Effective refurbishment

In some countries DH is a well established technology but little investment has taken place over a long time period. In these circumstances, comparison of DH systems with the most modern systems shows important differences between them.

One of the most important differences lies in the philosophy of DH system operation. In systems that have modernised the operator starts at the heat demand, with a focus on the customer and ensuring that they have effective controls to manage their demand for heat. In contrast, in un-modernised systems large amounts of the heat supplied to the network are often wasted; this situation sometimes arises where the focus is on supply and there is a perception that an endless supply of surplus heat is available.

District heating companies should prepare their own energy strategy with the aim to rehabilitate and modernise the DH system, which should be energy efficient and environmentally friendly. The owner’s policies need to recognise the need to move to demand-driven operation, thereby accessing the resource efficiency benefits of a well controlled system. This will involve a certain amount of adjustment to the network including ensuring customers have access to appropriate local controls enabling them to better manage how much heat they require and when they require it.

The new strategy should normally be set out in a mission statement that provides the foundation for strategic decisions, which move towards realising the vision.

It is essential to take a long-term view when considering DH system modernisation. High investment costs are required, resulting in a long payback period. Therefore, it is strongly recommended that financial decisions should be made on the basis of life cycle costing.

Long term heat supply planning should be based on an evaluation of local conditions and all possible solutions (available fuels, technologies and heat sources, and transmission and distribution networks). Existing and expected changes of heat demands must also be considered, as must the life cycle of equipment, and available financial resources.

One of the most important issues concerns fuel alternatives: this influences the investment and operational costs of heat generation which in turn affects heat supply costs and customer payments. A reliable fuel supply is one of the main requirements for the successful operation of a district heating system. A fuel supply monopoly can lead to interruption in the DH system operation if the fuel supply is cut off. Therefore, it can be important to have the facility to store fuel and also to establish reliable and competitive fuel alternatives, which have low environmental impact.

Example 7 describes how a scheme in Hungary was extensively refurbished and the environmental performance of the scheme was improved as a result. Example 8 highlights an example of a scheme in Lithuania that was refurbished and biofuel CHP added to improve performance.

8.4 Expanding to access multiple low carbon heat sources

Where schemes expand and interconnect they cover a wider geographic area. Increasing the scale of a district heating network can facilitate access to a broader range of heat sources. A scheme spread across all or part of a city may have access to, for example, by-product heat from power generation, energy from waste, industrial waste heat, etc. In contrast, a smaller multi-site scheme may rely on a single low carbon heat source such as gas fired CHP.

In Scandinavia there are a number of large district heating schemes that, as they have grown, have succeeded in decarbonising the heat supplied to the district heating network. This is particularly the case in Sweden where, over the last 30 years, oil and coal have been replaced by biomass and municipal waste. Sweden drastically reduced use of oil, shifting from 89% oil dependency in 1980 to 7% in 1990. By 2000 Swedish district heating systems had transitioned to 61% renewable energy sources. As of 2008, 77% of Swedish district heating came from renewable energy.

Example 3 describes how this was achieved for one particular scheme where small networks were joined together and a range of heat sources accessed. Example 9 also highlights how separate networks were joined together and new heat sources accessed. Additionally, example 10 describes how a scheme in Germany has expanded and accessed several low carbon heat sources, as shown in Figure 4 below. There is widespread potential for replicating this approach, particularly in expansion countries. Example 11 highlights a scheme that uses multiple sources including geothermal energy.

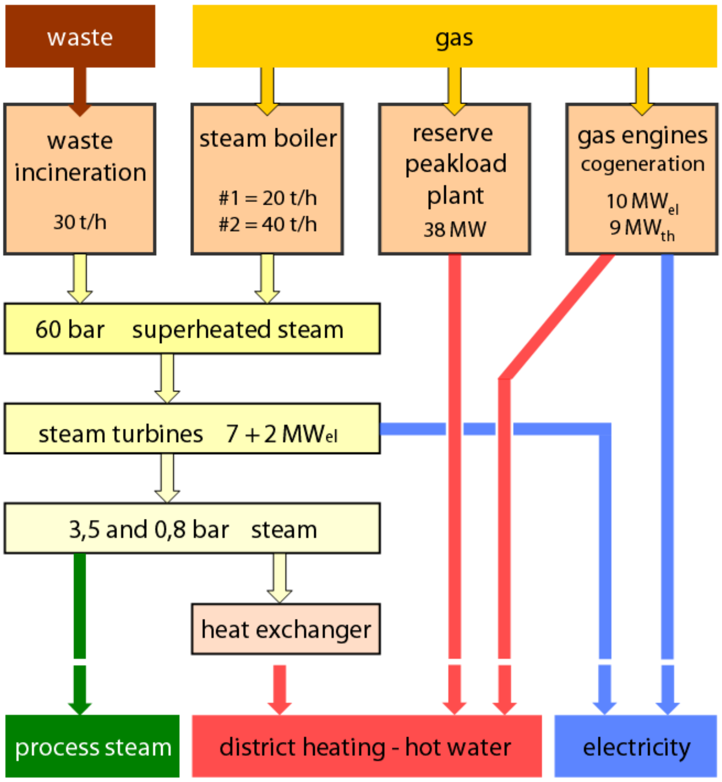

Figure 4: Example of different fuels and technologies used in an expanded scheme

Note: in the figure above t/h refers to tonnes per hour and '#' refers to number

8.5 Using low temperatures in new systems

In new district heating networks, particularly those serving new buildings, there can be major opportunities for designing low temperature networks. Research conducted under the International Energy Agency (IEA) District Heating and Cooling programme is examining the potential of lowering supply and return temperatures down to as low as 50°C and 20°C respectively.

Achieving low temperatures can substantially reduce heat loss from the network; taking into account all design features, it has been estimated that for the small Lystrup scheme in Denmark heat loss is a quarter of that which would have occurred for a conventional design[e].

Additionally, low temperatures can help to facilitate the use of low temperature heat sources. This is partly illustrated in example 5 where return temperatures of 40°C allow the use of substantial amounts of heat from a solar thermal field. Low temperatures can also help to reduce the temperature of condenser water in steam turbine CHP boosting electricity production.

[e] Danish District Heating Association: the international district energy climate awards 2011: very-low-temperature district heating for low energy buildings in small communities.

9 Examples

Using examples this section shows how a high level of environmental performance can be achieved. The examples illustrate how existing schemes have been retrofitted to improve performance, as well as how new schemes have been designed to optimise performance from the start. The effect on the labelling of schemes is also presented. The savings have been assessed in relation to Tier 1 unless otherwise stated.

Note: The examples are generally based on actual schemes; however, they have only been named where the operator has given permission to the EcoHeat4Cities project to do so.

9.1 *Example 1: The Lerwick heat from waste scheme*

CATEGORY	Emerging/expansion
EXISTING SCHEME	
Type	Multi-site, mixed use scheme
Heat sales (GWh / annum)	36GWh per annum
Output per year (GWh / a)	-
Number of dwellings	1000
Non-domestic customers	110
Primary energy source	Municipal waste
Conversion technology	Heat only boilers
Age of scheme	13 years
IMPROVEMENTS	
Overview	The network has been established around the principle of taking available waste heat and transporting it to supply consumers that were using individual oil boilers or electric heating.
Controlling heat demand and metering	Thermostatic radiator valves on radiators allow the heating water flow to reach an equilibrium avoiding fluctuations in temperature. Ultrasonic heat meters with radio cards are installed for each customer allowing meters to be read externally.
Substations and internals	Indirect heat connections have been adopted to achieve physical separation of the water in the DH and customers' circuits. Customers are encouraged to adopt lower internal heating system temperatures without compromising their internal comfort levels. Low return temperatures of 55-60°C are vital to achieving high efficiency.
Distribution network	A network of pre-insulated pipes is used to transport heat to customers across the town. A temperature difference of circa 35-40°C is achieved enabling the amount of energy transported through the network to be maximised.
Heat production	Heat is generated through a waste to energy (WtE) plant, whereby local municipal refuse is burnt. The WtE is the primary heat source supplying 80% of the heat, with oil boilers providing the remainder. Thermal storage has been added which enables heat to be stored overnight for morning peaks reducing the use of supplementary boiler plant.
Management	The scheme is operated from a control centre.
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.5 (Class 4) to 0.42 (Class 2)
CO_2 emission factor (K_{dh})	From 389 (Class 4) to 95kgCO_2 per MWh (Class 1)
Renewability (R_{dh})	From 0 (Class 7) to 89 (Class 1)
Other benefits	Customers benefit from reliable, affordable heat.

9.2 *Example 2: Conversion from fossil to renewable fuel boilers*

CATEGORY	Emerging
EXISTING SCHEME	
Type	Small residential heat network
Heat sales (GWh / annum)	2 GWh per annum
Output per year (GWh / a)	-
Number of dwellings	166
Non-domestic customers	None
Primary energy source	Switch from coal to biomass
Conversion technology	Heat only boilers
Age of scheme	Circa 45 years
IMPROVEMENTS	
Overview	As a part of a drive to reduce carbon emissions from the Local Authority's buildings, the council investigated installing biomass boilers to replace coal boilers as the lead heat source for apartments with block heating.
Controlling heat demand and metering	Prior to work on the heating system, various energy efficiency measures were adopted to reduce demand. Flats were fitted with new controls and heat meters.
Substations and internals	New heating risers were installed within each block to improve system performance and reduce heat losses within the building.
Distribution network	New pre-insulated underground mains were used to connect together the three, seven-storey blocks.
Heat production	Two new biomass boilers with a capacity of 470kW were installed in the basement plant room. A new brick wood store was constructed and local sourced wood chip is delivered via a large sizzor lift, tipping trailer drawn by a tractor. New central gas boilers were also installed as back-up to the biomass boilers and a thermal storage vessel helps to meet peak loads.
Management	-
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.6 (Class 5) to 0.60 (Class 2)
CO_2 emission factor (K_{dh})	From 502(Class 5) to 117 kgCO_2 per MWh(Class 2)
Renewability (R_{dh})	From 0 (Class 7) to 80 (Class 1)
Other benefits	The cost of heat to tenants has been approximately halved. The use of local sources of energy has also meant that value is retained within the local economy rather than being sent outside the area.

9.3 Example 3: Oil based islands linked together to Bio CHP plant

CATEGORY	Consolidation/Expansion
EXISTING SCHEME	
Type	DH system with Biomass CHP
Heat sales (GWh / annum)	145 GWh
Output per year (GWh / a)	201 GWh (fuel input)
Number of dwellings	-
Non-domestic customers	-
Primary energy source	Oil heating exchanged for biomass
Conversion technology	Biomass in CHP (60% of input)
Age of scheme	-
IMPROVEMENTS	
Overview	Almost the whole city has been converted from oil heating in block heating installations to district heating based on biomass CHP
Controlling heat demand and metering	Heat is measured at the customer level. Thermostats in the building ensure comfort and efficient use of the heat delivered.
Substations and internals	Substations are used to separate the water in the DH system from the building system. Customers are encouraged to increase the temperature drop across the substation's heat exchangers in order to improve the efficiency and also increase the electric output of the CHP unit.
Distribution network	A network of pre-insulated pipes is used to transport heat to customers across the town. A large temperature difference is used enabling the amount of energy used for pumping to be minimized.
Heat production	Before district heating was introduced the city was heated by oil from three centralized installations containing one or more oil-fired boilers. These island networks have been connected and buildings with individual oil boilers also added to the city wide DH network, with heat now supplied from biomass CHP.
Management	-
PERFORMANCE (based on Tier 2 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.56 (Class 5) to 0.37 (Class 2)
CO_2 emission factor (K_{dh})	From 369 (Class 5) to 70 kgCO_2 per MWh (Class 1)
Renewability (R_{dh})	From 2% (Class 7) to 86 % (Class 1)
Other benefits	Improved affordability of heat, DH is cheaper than oil heating. Improved security of supply, as not dependent on oil imports.

9.4 Example 4: From gas heating to DH with industrial surplus heat in Vargen, Sweden

CATEGORY	Consolidation/Expansion
EXISTING SCHEME	
Type	Industrial surplus heat
Heat sales (GWh / annum)	160 GWh
Output per year (GWh / a)	175 GWh
Number of dwellings	-
Non-domestic customers	-
Primary energy source	Industrial surplus heat
Conversion technology	Hot water from pulp mill 18 km away
Age of scheme	Started 1999
IMPROVEMENTS	
Overview	Over a period of 12 years almost the whole city has been converted from natural gas and electric heating to district heating based on surplus heat.
Controlling heat demand and metering	Heat is measured at the customer interface. Thermostats in the buildings ensure comfort levels are maintained and the heat is used efficiently.
Substations and internals	Substations are used to separate the water in the DH system from the building systems. Customers are encouraged to increase the temperature drop over the substations in order to use the surplus heat as efficiently as possible.
Distribution network	A network of pre-insulated pipes is used to transport heat to customers across the town. A large temperature difference is used to enable the amount of energy used for pumping to be minimized. Total length of the network is 18 km.
Heat production	Before 1988 all heat demand was met with electrical heat, wood fuel (pellets and briquettes), coal and oil boilers. In 1991 they started to build a small district heating systems with natural gas. The expanded network is now supplied by industrial surplus heat.
Management	-
PERFORMANCE (based on Tier 2 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.18 (Class 4) to 0.14 (Class 1)
CO_2 emission factor (K_{dh})	From 221 (Class 3) to 22 kgCO_2 per MWh (Class 1)
Renewability (R_{dh})	From 1% (Class 7) to 91% (Class 1)
Other benefits	Improved affordability of heat. Improved security of supply. Local sources with value retained in local economy.

9.5 Example 5: Installation of a solar thermal field in Denmark

CATEGORY	**Consolidation**
EXISTING SCHEME	
Type	Village-scheme, primarily single family houses
Heat sales (GWh / annum)	13.5 GWh per annum
Output per year (GWh / a)	20.5 GWh
Number of dwellings	570
Non-domestic customers	Unknown
Primary energy source	Natural gas (29.1 GWh)
Conversion technology	3 MW gas engine, 700 m^3 storage + backup boilers
Age of scheme	15 years
IMPROVEMENTS	
Overview	The district heating network was established around a small natural gas CHP plant. The business model being based on selling electricity to the grid and selling the waste heat for heating. From the beginning the heat price was relatively high compared to larger district heating schemes. In recent years this has forced the board to look for new solutions such as solar thermal (see below).
Controlling heat demand and metering	-
Substations and internals	A maintenance scheme for substations has been offered to the customers to improve operation.
Distribution network	Pre-insulated pipes (pair of pipes) are used with design temperatures of 80-40°C (flow-return). The estimated line density is less than 0.5 MWh/m. Heat distribution losses are 30-35%. As network heat losses are mainly a result of the low heat density and the standard pipe solution at the time, there are no obvious improvements.
Heat production	The board has decided to invest in 7,500 m^2 of solar thermal collectors and an additional thermal storage tank with a capacity of 2000 m^3. The investment costs will be about 2.4 million EUR, and the new production facility will be able to deliver 4 GWh heat per year or 80% of the consumption in the summer period.
Management	A facility management agreement has been made with a neighbouring DH utility to save costs.
PERFORMANCE	
Non-renewable primary energy factor (f_{dh})	From 1.1 to 0.8 (Class 2)
CO_2 emission factor (K_{dh})	From 285 to 217 $kgCO_2$ per MWh (Class 2)
Renewability (R_{dh})	From 0 to 19.5
Other benefits	Facilities are owned by consumers (cooperative).

9.6 Example 6: Retrofitting CHP to an existing smaller network

CATEGORY	Emerging
EXISTING SCHEME	
Type	Residential, led mixed use
Heat sales (GWh / annum)	20GWh per annum
Output per year (GWh / a)	-
Number of dwellings	3,000
Non-domestic customers	50
Primary energy source	Natural gas
Conversion technology	Reciprocating engine CHP plus heat only boilers
Age of scheme	60 years
IMPROVEMENTS	
Overview	The owners commissioned a feasibility study to consider the future for the scheme. As well as examining the introduction of CHP, they also wished to investigate expanding the network by connecting additional buildings. Following a positive outcome, the scheme was expanded to include two other blocks of flats.
Controlling heat demand and metering	Dwellings are fitted with thermostatic radiator valves and room thermostats. Controls at the block level ensure that the temperature for each block is controlled via a weather compensator. Dwellings are not individually metered.
Substations and internals	Each block contains a substation which provides centralised hot water and space heating.
Distribution network	Upgrades to elements of the distribution network were made as part of the improvements.
Heat production	As a result of the feasibility study referred to above, the scheme owners commissioned the installation of two 1.5MW_e gas fired CHP engines, which generate enough heat to supply the summer base heat load. Three 8MW high efficiency, boilers were also installed to meet winter peak demand and provide backup. The existing 40m high thermal store was used to smooth out the loads, enabling more heat demand to be met by the CHP.
Management	The system is monitored to ensure heat is only provided at the required time and temperature. Heating bills are based on dwelling size.
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.5 (Class 4) to 0.63 (Class 2)
CO_2 emission factor (K_{dh})	From 303(Class 3) to 188 $kgCO_2$ per MWh(Class 2)
Renewability (R_{dh})	From 0 (Class 7) to 0 (Class 7)
Other benefits	The upgrade and introduction of CHP produced cost savings which were passed to customers.

9.7 *Example 7: Refurbishment of a system adding heat sources*

CATEGORY	Modernisation
EXISTING SCHEME	
Type	Large City based scheme
Heat sales (GWh / annum)	-
Output per year (GWh / a)	-
Number of dwellings	31,000
Non-domestic customers	2,300
Primary energy source	Natural gas
Conversion technology	CHP
Age of scheme	40 years
IMPROVEMENTS	
Overview	Recognising the need to dramatically improve the performance of the ageing system in a CEE country, the philosophy of the scheme operation was changed from centrally regulated to demand driven; with a specific focus on promoting energy efficiency.
Controlling heat demand and metering	Local controls were provided and new ultrasonic based heat meters were installed at sub-stations.
Substations and internals	Substations were modernised; for example, through the installation of plate heat exchangers.
Distribution network	Out of date pipes were replaced with modern pipes substantially reducing heat losses.
Heat production	A new 90MW thermal capacity CHP was installed as the lead heat source for the heat network. One of the main advantages of large scale district heating networks is the ability to use a variety of locally available resources. In this scheme, industrial waste heat from a letter press and heat generated from landfill gas have also been added.
Management	A remote supervision system was implemented to allow system performance to be monitored, thereby improving understanding of how the system is functioning. A pricing formula has been introduced to provide transparency in pricing and billing information is now presented in a simple, easily understandable format.
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.5 to 0.38 (Class 1)
CO_2 emission factor (K_{dh})	From 337 to 133kgCO_2/MWh (Class 2)
Renewability (R_{dh})	From 0 to 40 (Class 2)
Other benefits	Customers now benefit from a flexible, uninterrupted heat supply, where costs are under control.

9.8 Example 8: Refurbishment and adding biofuel CHP in Utena

CATEGORY	Modernisation
EXISTING SCHEME	
Type	Town-scheme, covering major part of the block residential buildings, supplying steam to industrial consumers. The company supplies heat for 70% of living houses in the town.
Heat sales (GWh / annum)	140 GWh
Output per year (GWh / a)	165 GWh
Number of dwellings	309 blocks, 46 individual houses (9973 flats).
Non-domestic customers	111 public buildings and industry
Primary energy source	Natural gas 104.6 GWh, Wood chips -73.3 GWh
Conversion technology	Natural gas steam boilers, water heating boilers, wood chips boilers, flue gas condensing economizer.
Age of scheme	45 years
IMPROVEMENTS	
Overview	The first boiler house was built in 1966 for the steam and heating needs of a textile factory. Several nearby houses were connected to the boiler house. Later, with expansion of industry and erection of new block houses for workers, more and more residential buildings were connected to the boiler house, which required increased heat production capacity due to the growing heating demand. Heavy fuel oil was the main energy resource until connection to the natural gas grid. The latest modernization – installing a wood boiler and flue gas condensing economizer - increased heat generation efficiency to 0.93. Wood fuel makes up 40% of the total fuel input (2010). The business model is based on selling steam and heat for industrial and residential customers. The shares of the DH company belong to the municipality of the town. Installations in houses (substations) were modernized during the last decade and in most cases (83%) are equipped with automatic control devices regulating heating intensity according to outside temperature.
Controlling heat demand and metering	Heat demand in residential and public houses is controlled by adjusting the temperature of hot water passing to room radiators depending on the outside temperature. Metering is established at the building level. The readings of the meters are taken manually at the end of each calendar month. There are separate houses with thermostatic valves and electronic cost allocators on radiators

	for heating cost distribution between tenants in block houses.
Substations and internals	The service and maintenance problems of old substations were tackled by employing qualified persons who are in charge of permanent building heating system supervision and maintenance. Internal heating systems in houses are either separated from the DH network, or directly connected to heating pipes through a three-way regulating valve and circulator in order to maintain the required temperature in the internal loop.
Distribution network	Pre-insulated pipes with polyurethane foam insulation make up about 40% of the total network length, which is about 50 km. The rest of pipes are mineral wool insulated pipes laid in concrete ducts. The estimated line density is 2.8 MWh/m. Heat distribution losses are 15%. Supply and return temperatures are regulated according to external temperature from 70°C in summer time to 100°C when outside temperature drops to – 25°C. The return temperature varies from 60 to 40°C accordingly.
Heat production	The company is implementing a biomass CHP project. The new generation capacity is 8.6 MW of heat and 2.1 MW of electricity. The investment costs will be about 9 million EUR. The new production facility will be able to deliver 53.2GWh of heat and 13 GWh of electricity per year.
Management	Management of the company is typical for such companies in Lithuania and consists of a Direction and Supervising Board, representing the share owner i.e. the Municipality. Heat consumption is monitored by the heat supplier and heat consumption data are available for house owners and other consumers. Monitoring shows a gradual decrease of heat demand in the industrial sector and among other consumers, though the demand of residential consumers was relatively stable during the past three years.
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	From 1.0 to 0.0 (Class 1)
CO_2 emission factor (K_{dh})	From 208 to 42kgCO2 per MWh (Class 1)
Renewability (R_{dh})	From 40 to 97 (Class 1)
Other benefits	Heat prices are among the lowest in Lithuania. Prices are under the control of the National Commission for Prices and Energy.

9.9 *Example 9: Two cities link together in Sweden: Linköping and Mjölby*

CATEGORY	**Consolidation/Expansion**
EXISTING SCHEME	
Type	Link town and cities together
Heat sales (GWh / annum)	Total 820 GWh (200+620)
Output per year (GWh / a)	Total 990 GWh (235+ 750)
Number of dwellings	-
Non-domestic customers	-
Primary energy source	Biomass in CHP and HOB , energy from waste
Conversion technology	CHP and heat only boilers
Age of scheme	-
IMPROVEMENTS	
Overview	Two cities were linked and some small towns connected as well. Approximately 30 km of piping are installed. Increased use of biomass and energy from waste where possible has led to reduced use of oil and other primary fuels.
Controlling heat demand and metering	Heat is measured at the customer. Thermostats in the building ensure comfort is preserved and heat used efficiently.
Substations and internals	Substations are used to achieve separation of the water in the DH system and the building systems. Customers are encouraged to increase the temperature drop over the stations in order to improve the efficiency and increase the steam turbine CHP system's electrical output.
Distribution network	A network of pre-insulated pipes is used to transport heat to customers. A large temperature difference is used to minimize the amount of energy used for pumping.
Heat production and management	Due to the connection of two DH systems the whole system can be optimized. During the summer the energy from waste can be fully used and replace the oil boiler necessary for the low summer load (when the biomass boiler can´t be used).
PERFORMANCE (Based on Tier 2 calculations)	
Non-renewable primary energy factor (f_{dh})	0.49 (Class 2)
CO_2 emission factor (K_{dh})	141.9 kgCO_2 per MWh (Class 2)
Renewability (R_{dh})	71 % (Class 2)
Other benefits	Improved affordability of heat as DH is cheaper that oil heating. Improved security of supply as there is better redundancy when sharing boilers.

9.10 Example 10: Accessing multiple sources

CATEGORY	Expansion
EXISTING SCHEME	
Type	Mixed power supply
Heat sales (GWh / annum)	110 GWh customers supply (10 year average)
Output per year (GWh/a)	152 GWh district heat 32 GWh steam (2010) 79 GWh electricity (2010)
Number of dwellings	800
Non-domestic customers	1,000,000ft^2 of administration, business (& housing)
Primary Energy source (s)	waste and gas (and reserve oil boiler)
Conversion technology	waste incinerator gas engines cogeneration plant reserve peakload plant
Age of scheme	The district heating network has been in operation since 1955 and it has been expanded regularly with different intensity. In 2008 an expansion program for district heating was implemented with the aim to double the percentage of district heat from 15% up to 30%.
IMPROVEMENTS	
Overview	The waste-to-energy plant consists of two natural gas fired steam boilers an energy output of 20 and 40 tons per hour, one waste incineration plant with a steam output of 30t/h and a reserve/peak load boiler with a capacity of 38 MW. Additionally the utility operates a highly efficient CHP gas engine plant with an electrical output of 10 MW and a thermal power of 9 MW. For optimizing the plant's operation, especially the gas engines, a 70 MWh hot water storage tank is installed.
Controlling heat demand and metering	Thermostatic radiator valves on radiators allow the heating water flow to reach an equilibrium avoiding fluctuations in temperature. Ultrasonic heat meters are installed at each customer's premises, with readings collected via radio link.
Substations and internals	Indirect heat connections have been adopted to achieve physical separation of the water in the DH and customers' circuits. Local, building level storage is only provided where a reserve buffer is required for security of supply. Customers are encouraged to adopt lower internal heating system temperatures, enabling the DH return temperature to reduce - it is currently 55-60°C.

Distribution network	Originally the supply of end use customers with district heating was limited to the inner city, close to the location of the energy plant. However, the network has enlarged over the years. Today the district heating network covers an area of approx. 11 square kilometres, approximately 30% of the total area of the city. From 2008 until 2010 alone the length of district heating piping increased from 51 km up to 74 km, which equals a 45% expansion (2011 = 85 km).
Heat production	In 2010 nearly two thirds of the energy input to production was waste. The superheated steam from the waste incineration and the steam boilers energized the common turbines generating electricity. Part of the exhaust steam was delivered to end customers as process steam or used for generating district heat. Only 5% of the delivered heat was generated with the reserve peak load plant. The overall efficiency of the energy plant was increased to 68%. The reason the total energy efficiency is not higher is that the gas engines also operate in summer due to economical reasons.
Management	Additional gas engines of 14 MW are under construction at the moment and will be in operation by autumn 2012. The assumption for the further expansion of district heating is based on existing contracts. With the new gas engines more district heating can be generated in CHP mode such that the ratio of power generation increases further compared to the heat generation. The part supplied by the natural gas fired steam boilers will decrease going forwards because the unit will only be in use at times when the waste incineration is not available.
PERFORMANCE	
Non-renewable primary energy factor (f_{dh})	0 (Class 1)
CO_2 emission factor (K_{dh})	121 kgCO_2 per MWh (Class 2)
Renewability (R_{dh})	54% (Class 1)
Other benefits	Customers benefit from a reliable, affordable heat supply which outperforms the alternative options.

9.11 Example 11: Ferrara District Heating scheme

CATEGORY	**Modernization and consolidation**
EXISTING SCHEME	
Type	Residential and tertiary sector
Heat sales (GWh / annum)	155 GWh/y of heat delivered
Output per year (GWh)	178 GWh/y of heat supply to the network
Number of dwellings	530
Non-domestic customers	50% approximately (tertiary sector)
Primary energy source	Waste, geothermal, natural gas
Conversion technology	Waste-to-energy plant, geothermal source, boilers
Age of scheme	20 years
IMPROVEMENTS	
Overview	Recovery of heat from new waste-to-energy plant able to process 420 tonnes of waste per day while operating for 8000 hours per annum.
Controlling heat demand and metering	Not applicable (no change)
Substations and internals	Not applicable (no change)
Distribution network	Not applicable (no change to the 130km network pipe length)
Heat production	The existing District Heating scheme, based on a geothermal source, has been integrated with heat recovered from two new waste-to-energy plants in 2007 (in substitution of a previous plant built in 1993). The waste to energy plant has a thermal capacity of 29MW and an electrical capacity of 13MW. It is based on moving grate technology with a water cooling system.
Management	Not applicable (no change)
PERFORMANCE (based on Tier 1 calculations)	
Non-renewable primary energy factor (f_{dh})	0.32 (Class 1)
CO_2 emission factor (K_{dh})	65 kgCO_2 / MWh (Class 1)
Renewability (R_{dh})	81 % (Class 1)
Other benefits	The new district heating configuration avoids emission of NO_x, SO_2, as well as CO_2.

9.12 Other considerations

Monitoring strategies
Labels may vary from year to year depending on a range of factors including the mix of fuels used and the amount of heat generated by different types of plant. Day to day changes in operation will ultimately be reflected in the annual returns submitted by the district heating company to the labelling body.

Therefore, in order to provide certainty for customers, it is essential that the company operating the scheme has an effective monitoring strategy in place. This should include regular checks on the fuel mix and the amount of heat energy generated from different sources e.g. CHP relative to boilers.

Metering
The use of customer metering tends to lead to a reduction in the amount of heat energy that is supplied, as they are more aware of the quantity of energy they are consuming. As the labelling system reflects the non-renewable primary energy, carbon emissions and use of renewable and surplus heat per unit of heat supplied to the customer, reductions due to metering do not result in a direct impact on the labelling performance. However, the greater level of control of heat consumption provided by metering can lead to indirect improvements in the operation of schemes as operators have a greater understanding of system performance.

Cooling
Where heat is delivered to an absorption chiller and converted to cooling, the heat supplied to the absorption chiller is counted in the same way as if it had been directly used for heating. Given this approach to labelling, this guidance does not directly deal with the techniques to improving the performance of a downstream district cooling network.

10 Signposting standards for other quality assurance considerations

As well as the three criteria used in the labeling process other factors influence the performance of district heating networks. For example, these include security of supply, customer relations, market aspects, etc. The table below summarizes the full range of criteria that can impact on the quality of a district heating scheme.

Table 1 Examples of criteria found in each category.

Criteria category	*Examples of criteria found in sources*
Energy efficiency	COP, efficiency rates, losses etc.
Primary energy or primary resource	Primary energy/resource use in LCA perspective
Climate impact (GHG)	CO_2, GHG, methane leakage, leakage of refrigerants etc.
Environmental impact	Air quality, land use, acidification, eutrophication, biodiversity etc.
Renewable share, non-fossil share	
Fuel/energy source origin	Biogenic or fossil, prohibition of GMO:s, FSC requirements etc.
Security of supply	Reliability, age of system/lifetime, interruptions etc.
Customer relations, quality, public acceptance	Noise, smell, prices, information, eco management system
Market aspects/Financial report	investments, price information, third party access etc.
Other	fuel storage, waste plan, boiler type etc.

Other aspects of quality assurance can be achieved through the adoption of standards. This section of the guidance sign posts relevant standards in particular areas.

10.1 General quality assurance procedures

District heating companies should meet ISO standards in relation to both general quality and the environment.

ISO9000 are a family of internationally recognised standards that are employed to measure the quality management system of an organisation. While ISO 9000 set out the principles of the quality management system, ISO 9001 defines the criteria that an organisation must meet in order to gain certification.

Compliance with environmental requirements, optimization of resource consumption and minimization of environmental strains are ensured by means of an environmental management system, based on the environmental management standard ISO 14001.

10.2 Assurance of system components for improved security of supply

The level of security of supply offered by district heating networks depends to a large extent on the manufacture, design and installation of the system components. This is crucial to obtaining high levels of reliability, a long system lifetime and minimising interruptions. The subsections below signpost the industry standards adopted in relation to particular system components.

10.2.1 Substations

Substations act as the interface between each building's heating systems and the district heating system. Euroheat and Power has produced a set of guidelines relating to district heating substations. It contains recommendations focussing on planning, installation, use and maintenance of such systems. The recommendations enable the development of sub-stations that function well, providing effecting heating and domestic hot water delivery.

Svensk Fjärrvärme has also published a guide on the design and installation of District Heating Substations and the International Energy Agency (IEA) District Heating and Cooling (DHC) programme has disseminated the results of research in this area:

- 1990 R8 Guidelines for converting building heating systems for hot water district heating ISBN90-72130-12-X
- 1996: N5 Efficient Substations and Installations ISBN90-72130-88-X
- 2002: S2 Optimization of District Heating Systems by Maximising Building Heating System Temperature Difference ISBN 90-5748-022-0

10.2.1.1 Heat meters

The forthcoming Energy Efficiency Directive proposes that heat meters are installed for end consumers of heat. Heat meters should be constructed and installed in accordance with the following standards:

- EN 1434-1 Heat meters – general requirements
- EN 1434-2 Heat meters – constructional requirements
- EN 1434-3 Heat meters –data exchange and interfaces
- EN 1434-4 Heat meters – pattern approval tests
- EN 1434-5 Heat meters – initial verification tests
- EN 1434-6 Heat meters – installation, commissioning, etc

The IEA DHC programme has published research in this area:

- 2002: S7 Optimising district heating systems using remote heat meter communication and control ISBN 90-5748-027-1

10.2.2 Pipes

Good quality district heating pipes are crucial to ensuring the long term operation of networks. There are various European Standards governing the design and installation of district heating pipes.

EN 13941:2009 covers the design and installation of pre-insulated bonded pipe systems for district heating.

District heating pipes should be constructed and installed in accordance with the following European Standards:

- EN 253:2009 District heating pipes – Preinsulated bonded pipe systems for directly buried hot water networks - Pipe assembly of steel service pipe, polyurethane thermal insulation and outer casing of polyethylene

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

- EN 488:2011 District heating pipes – Preinsulated bonded pipe systems for directly buried hot water networks – Steel valve assembly for steel service pipes, polyurethane thermal insulation and outer casing of polyethylene

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

- EN 14419:2009 District heating pipes - Preinsulated bonded pipe systems for directly buried hot water networks - Surveillance systems

Where plastic pipes are to be adopted, the pipes should be constructed and installed according to the following EN Standards:

- EN 15632-1: District heating pipes. Pre-insulated flexible pipe systems. Classification, general requirements and test methods
- EN 15632-2: District heating pipes. Pre-insulated flexible pipe systems. Bonded plastic service pipes. Requirements and test methods
- EN 15632-3: District heating pipes. Pre-insulated flexible pipe systems. Non bonded system with plastic service pipes; requirements and test methods
- EN 15632-4: District heating pipes. Pre-insulated flexible pipe systems. Bonded system with metal service pipes; requirements and test methods

Using twin pipes can dramatically reduce heat loss from the network. Where steel twin pipes are adopted, they should be constructed in accordance with:

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

Compliance with standards for producing pipe systems should be assured by means of an integrated quality control system, based on the ISO 9001 quality standard. The main companies manufacturing district heating pipes have such integrated quality control systems to ensure compliance.

Additionally, within individual countries there are sometimes national standards. For example, in Germany there are about 100 AGFW guidelines and standards. The following standards, against which companies installing district heating pipework are certified, exist:

- AGFW Guidelines FW 601Qualification criteria for pipeline construction companies

- AGFW Guidelines FW 603 Joint casing application on pre-insulated bonded pipes and flexible pipes – *Guidance for fitters*

- AGFW Guideline FW 605 Qualification criteria and certification of companies that carry out joint casing application of pre-insulated bonded pipes and flexible pipes

The IEA DHC programme has also published useful research in this area:

- 1999: T3.2 Cost Effective District Heating & Cooling Networks New Ways of Installing District Heating Pipes ISBN90-5748-012-3
- 1999: T6 Plastic Pipe Systems for District Heating, Handbook for Safe and Economic Application ISBN90-5748-005-0
- 2002: S4 Pipe Laying in Combination with Horizontal Drilling Methods ISBN 90-5748-024-7
- 8DHC-05.05 Biofouling and Microbiologically Influenced Corrosion in District Heating Networks
- 8DHC-08-01New materials and constructions for improving the quality and lifetime of district heating pipes including joints – thermal, mechanical and environmental performance
- 8DHC-08-03 District Heating Distribution in Areas with Low Heat Demand Density
- 8DHC-08-05 Cost benefits and long term behaviour of new all plastic piping system

10.2.3 Energy sources

District heating networks can be served by a variety of energy sources including, most commonly, CHP and heat only boilers. The sub-sections below set out some of the standards applicable to different energy sources.

10.2.3.1 CHP

Large scale CHP installations supplying district heating networks are seldom sold as packaged units. Instead various components are assembled together to form an installation. These are normally certified by national certification bodies tasked with implementing the Cogeneration Directive. Certified schemes may then gain access to various incentives and/or use the certification to meet national regulations.

Various types of prime mover are used in installations. These include steam turbines, gas turbines and reciprocating engines. They can also sometimes be used in combination e.g. a gas turbine and steam turbine arranged in a combined cycle arrangement.

The power generation performance of different prime movers are tested against particular ISO standards e.g. ISO3046 for reciprocating internal combustion engines.

Depending on the type of heat recovery component, different ISO standards apply.

The efficiency of the whole installation will normally be certified by a national body in accordance with the performance standards set down in the EU Cogeneration Directive.

The IEA DHC programme has also published research into the use of CHP in DH:

- 1999: T2 District Cooling, Balancing the Production and Demand in CHP ISBN90-5748-009-3
- 8DHC-08-02Improved Cogeneration and Heat Utilization in DH Networks

10.2.3.2 Heat only boilers

Large boilers such as those used in district heating networks should be constructed in accordance with EN standards such as:

- EN 12952: Water tube boiler standards
- EN 12953-1: 2002 Shell boilers - general

Most DH companies will have internal procedures which ensure the quality of equipment installation within an energy centre or boiler house.

10.3 Quality assurance of 'softer' issues

The performance of district heating networks is not only affected by the hardware used to supply heat but the level of service provided to customers. This can include the provision of clear information regarding service provision, pricing and complaint procedures.

10.3.1 Ensuring high levels of customer service

A range of approaches to consumer protection are adopted across different countries. These include both regulatory and voluntary approaches.

In Denmark the heat supply act regulates a wide range of issues including how consumer complaints should be appropriately dealt with. The EcoHeat4EU website (www.ecoheat4.eu) provides further details of how this is approached in Denmark and other countries.

In the UK a Customer Heat Charter has been drafted. Among other things this voluntary charter sets out minimum standards for:

- The treatment of customers identified as vulnerable
- Maintenance response times
- Providing clear information regarding pricing, debt and disconnection
- Quality of service and complaint handling

The UK Customer Heat Charter is downloadable from the CHPA website: www.chpa.co.uk

10.3.2 Achieving transparency in pricing mechanisms

In Denmark the heat supply act regulates how consumers should be charged for heat. The Danish Energy Regulatory Authority and the Energy Supplies Complaints Board handle complaints regarding prices and conditions.

In contrast, in the UK there is no regulatory framework governing how consumers should be charged for heat. Instead, operators tend to peg the price of heat to that charged for obtaining heat from alternative heat supply sources, e.g. individual gas boilers, or simply pass through the cost of operating the network, e.g. fuel and maintenance, into the heat supply charge. Confidence is increased where an ‘open book’ approach to accounting is adopted.

11 References

EcoHeat4Cities: guideline for the certification of district heating systems

District Heating and Cooling: A vision towards 2020-2030-2050 DHC+ Technology Platform (May 2009)

EcoHeat4Cities Work Package 2: Green Labelling Criteria Final Report (April 2011)

Zinko et al IEA Annex VIII District Heating Distribution in Areas with Low Heat Demand Density

Appendix 1: Resource availability in different countries

Table A1: Summary of resource availability in individual countries

Country	Existing resource use	Available resources
United Kingdom	The dominant fuel in the UK energy market is natural gas. Approximately half of the UK electricity is generated from gas and the vast majority of UK buildings are heat by individual gas boilers. Where heat networks exist many of them also use gas, although a few of the large schemes are primarily based on municipal waste. There a small number of biomass schemes, primarily in off-gas grid areas.	In the UK municipal waste is one of the main resources that could be used to improve the environmental performance of district heating schemes. Where waste is combusted to raise steam, in the vast majority of cases this is currently used in condensing steam turbine power only plants which operate at low efficiency. If waste plants were accommodated close to customers with high heat demands, the steam turbine plant could be configured to operate in CHP mode, with the by-product heat from electricity generation being usefully used after transportation through heat distribution networks. There is some potential for biomass. The main resources are in the North and West of the country where the population densities are less. Nevertheless, there is some potential to supply smaller schemes.
Sweden	DH has half of the heat market. The other half is electricity and oil. Oil is decreasing and electricity (heat pumps) and DH increases their market shares. The total heat market is decreasing. Individual biomass is expanding but slowly. Electricity production is dominated by hydro and nuclear power, but CHP is coming mainly on natural gas and biomass.	Electricity is still cheap in Sweden and heat pumps are very attractive. One reason is that they are favored in the existing building codes. Biomass and waste is extensively used in district heating as well as industrial surplus heat. Hence, although the heat market is decreasing due to energy efficiency measures, the share of these energy sources can be increased in order to phase out fossil fuels and electricity in the DH systems. Nuclear power is still questioned and wind power is expanding fast.
Denmark	Total district heating production was 150.0PJ in 2010. According to Danish energy statistics, the fuel	In addition to traditional resources, there is a large potential of thermal solar district heating. More than 250,000 m^2 of panels are already

	used in the production of district heating in 2010 was: 46.9% renewable energy etc. (of which nonrenewable waste 6.8%, biomass 38.7% and other renewables 1.4%), natural gas 29.6%, coal 18.9% and oil 4.5%. In 2010, 77.2% of district heating was produced together with electricity.	installed and the market grows rapidly; coverage of 10% of the district heating demand is not unrealistic in the long term. Also the number of deep geothermal plants is increasing; three plants exists today but more are being investigated or in construction. Finally, Denmark expects to have 50% of its electricity consumption covered by wind power in 2020 and in the longer term renewable electricity will be used in heat pumps in the district heating systems.
Czech	Data for 2010 show that coal, especially brown coal, still prevails in the energy mix for district heat production in the CHP mode (around 70 %). In the heat-only plants natural gas plays a major role, and its share is 24 % in total heat production. Biomass is still used mainly in power plants due to the national financial support for electricity produced from biomass. The new act supporting heat production from biomass will come into force in 2012 and will enhance the share of biomass in heat production. Waste is still represented in the heat energy mix by less than 1%.	The biggest potential is seen in utilisation of waste in waste-to-energy plants. However, a higher acceptance by public for this technology is the crucial pre-condition of permissions for constructions of waste-to-energy plants. Currently, there are three waste-to-energy plants in the Czech Republic; construction of some new ones is under consideration. Replacing 12 million tonnes of brown coal combusted in CHP installations would require around 17 million tonnes of biomass which is more than 11 times its current production. The maximum production of wood chips was estimated at 1,5 -1,6 million tonnes annually, the border territories of neighbouring states included. Natural gas is available as an external imported resource but due to its fossil nature, its higher utilisation would not improve environmental performance of district heating plants.