Delta
Energy and Environment
Research, Analysis & Strategic Solutions

Report for the Sustainable Development Commission

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Community Heating CHP for Existing Housing

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Contents

Executive Summary

This report has been prepared in response to the SDC's requirement to understand:

- What is the realistic, cost-effective potential for implementing CH / CHP (CHP based Community Heating) to existing UK houses, with a focus on 'medium density' housing?
- What are the main mechanisms which can enable this potential to be realised?

The Rationale for CH / CHP

The rationale for analysing this sector is clear. CH / CHP provides one of few options for delivering substantial carbon emission reductions from existing housing given the emissions reductions that CHP brings and the clear limits that exist to delivering 'low or zero carbon' (LZC) fuel supply on a dwelling-by-dwelling basis. While we have not been able to identify an analysis of the cost of the options available for delivering carbon savings from existing housing, gas-based CH / CHP can in itself deliver some significant reduction; if the fuel supply is renewable-based, then the scale of reduction goes well beyond this, to a level that could only probably be matched by the use of zero carbon electric heating and cooling or the use of hydrogen produced from renewable resources.

What Comprises Medium Density Housing?

In essence, community heating can best serve residential areas where there is:

- An 'anchor load' – a relatively large, stable load, or collection of loads (that might include, for example, public sector buildings such as a hospital) that can form the foundation of heating network extension into residential areas.
- Mixed use – both residential and commercial buildings that have a mix of different, and complementary, thermal load profiles which together 'blend' to form a significant and stable thermal load profile. In such cases, different building types will have different thermal load profiles, including different peak load periods, that may provide sufficient stable thermal demand when combined but, in isolation, would not.
- High density housing.

The terms 'high', 'medium' and 'low' density housing have not been well-defined in the context of existing housing. For example, when it is said, as it often is, that CH / CHP can be cost-effective for high density housing, it is not clear what types of housing this covers, what density it represents and how many such dwellings there are in the UK. We recommend that detailed analysis is undertaken to clarify these questions. This report has made a general assumption that categorises the UK's 4.5m high- and low-rise flats as almost all high density; the 6.6m terraces as largely medium density, with some high and low density at each end of the range, and the 12.8m semi-detached and detached houses as mostly low density. There is considerable overlap within these loose definitions, however: for example there are likely to be zones of semi-detached housing that could qualify as high density and thus as relatively cost-effective for CH / CHP connection. For this reason, we believe that the amount of high density housing in the UK, the first target for CH / CHP development, certainly exceeds 5m and probably exceeds 6m.

The Potential for CH / CHP

Only one study, recently updated, has attempted to assess the potential for cost-effective CH / CHP development.[i] While we believe that in some respects the study might be viewed as 'generous' to CH / CHP, the key conclusions are summarised below.

In summary, on the basis of a public sector financing discount rate of 6%:

- There is 18 – 21 GWe of potential for gas-based CH / CHP that would cover both residential and non-residential loads.
- This equates to a capital cost requirement of £26.5 – 31.7 billion.
- This equates to a carbon emission reduction of 4.3 – 5.1 Mt / year. This benefit would be significantly increased through greater use of renewable-based fuel and industrial waste heat (including power station heat). However, there are clear doubts that renewable fuel supply can be anywhere near sufficient to reach the 18 – 21 GWe identified above. We estimate that it may be possible for LZC sources to provide up to half of the identified 18 – 21 GWe potential.
- This could cover 5.5 – 6.5 million homes, around one quarter of the UK housing stock.

The last number is likely to include the vast majority if not all of the 5-6m+ high density homes identified in our assumptions about housing density. In short, therefore, the proportion of medium density housing covered by the fairly optimistic financing assumptions could be low, or very low. In effect, we believe, the current cost-effective potential for medium density housing in the UK may be insignificant, unless a 3.5% discount rate is used (a rate used for public sector investments with minimal risk), and that future policy efforts could best be focussed on achieving the sizeable unmet potential for CH / CHP in high density housing. The parts of this report that address current policy context and future policy options have therefore been prepared on this basis.

The Current Policy Context

Current policy effectively ignores CH / CHP. With the closure of the Government's Community Energy Programme, there is now no significant incentive regime for community heating, rather a clutch of minor UK and EU measures that apply generally to CHP and other low carbon energy solutions and which are insufficient to overcome what remains the key challenge facing CH / CHP development – high front end cost.

Equally, there are no specific policy or regulatory barriers whose removal would unleash major new investment. There are however some profound structural challenges that face CH / CHP:

- There is a lack of central government attention to the residential heating sector, which is currently an unregulated market. A good demonstration of this is that there is no official data that indicates how much existing housing is supplied by community heating. We have seen estimates that range from 'less than 1%' to 'more than 2%'.

- Compared to the examples given in the report of the municipal commitment shown in the cities of Copenhagen and Vienna, the powers of UK local authorities in respect of community heating development are small.
- The UK energy market is characterised by the goals of delivering competitive supply and easy options for changing suppliers – a poor fit with the needs of community heating development.
- There are no significant incentive measures that link the EU's or UK's carbon commitments to incentives for CH / CHP.

Policy Mechanisms and Solutions

Given the gulf between current CH / CHP development in the UK (we believe that no more than 1% of homes are served by community heating, and only a small proportion of these are supplied by CHP) and the potential (5.5m homes), we believe that 'tweaks' to existing policies, strategies and measures will be insufficient. Achieving the goal will require major policy intervention of a transformational nature, for which some options are:

- Carbon policy linkage. This can be achieved by closely linking the market mechanisms that will be implemented to deliver the UK's climate commitments, probably emissions trading, to incentives for CH / CHP.
- Penalising energy waste. Around 40% of UK primary energy supply to the heat and power sectors is lost through heat dumping, electricity network losses and conversion losses. A penalty for energy waste from new fossil-based power stations and from existing plants located near heat loads (the penalty for the former being higher) could be designed to directly incentivise CH / CHP.
- Incentivising private sector involvement. We believe that future scale development of CH / CHP cannot go forward without major private sector commitment, likely to include the UK's major energy supply companies. Their investment hurdle rates preclude involvement in community heating and future commitment will depend either on major change to regulatory approaches, for example the inclusion of community heating network as part of utility regulated asset base (requiring intervention by DTI and Ofgem), and / or the introduction of significant carbon or energy waste related incentives indicated above.
- Obliging buildings (or perhaps certain types of buildings) to connect to community heating schemes.

There are a series of other measures that have some opportunity to stimulate investment in CH / CHP. These, in part, stem from the clear experience so far, both in the UK and other countries, that community heating development can be most cost-effective when designed to serve a mix of both commercial and residential zones, and to be based on high heat demand **anchor loads**, typically hospitals, commercial developments, prisons, universities and, in some cases, schools – that can be extended to existing housing. There are several measures that have the potential to incentivise anchor load development, including:

- Effective enforcement of existing Planning Policy Statements (PPS) in England, Scottish Planning Policy (SPP) in Scotland, Technical Advice Notes (TAN) in Wales and Treasury guidelines on public procurement.
- Effective exploitation of public building development programmes to create anchor loads, for example new hospital buildings.

Recommendations and New Research

To achieve the potential for CH / CHP identified in this report, major policy change is required. To justify this, the benefits of scale investment in CH / CHP will need to be much better understood than they are at present, in particular the carbon benefits. In addition to the policy recommendations contained in the report, some of which are included above, we therefore also recommend that:

- Further detailed research is undertaken to identify the potential for development of CH / CHP for different housing densities, perhaps focusing on 3 – 4 conceptual schemes linking anchor loads to different densities of housing.

- Further detailed research is undertaken to identify the relative costs of carbon emission reduction arising from CH / CHP in comparison with other carbon mitigation options.
- Analysis is undertaken to identify the practical potential for use of power station and industrial waste heat, biomass and energy-from-waste plants for supply to new community heating systems.
- If existing owner-occupied housing is to be a focus of CH / CHP policy, research and ideally pilot projects to assess critical issues such as connection rates.

Introduction

This report has been prepared in response to the SDC's requirement to better understand the potential opportunity for, and benefits of, the use of community heating CHP (CH / CHP) systems in existing housing. It is an evidence-based report that assesses existing research and has not involved any significant new research.

This report therefore has sought to present answers to two key questions:

- What is the realistic, cost-effective potential for implementing CH / CHP to existing UK houses?
- What are the main mechanisms which can enable this potential to be realised?

The Question of Housing Density

A core focus of the brief was to consider the potential and mechanisms for implementing CH / CHP in owner occupied homes (around 70% of existing stock) in 'medium density' communities. There is no clear analysis that provides guidance on what density of existing housing represents a break between high and medium densities. In relation to cost-effectiveness of CH / CHP for new housing, the following guidance has been provided by the EST and Carbon Trust:[ii]

> *Assuming that most new build will be via private developers (with project lifetime of 20 years and a discount rate of 12%) new developments of 55 dwellings per hectare and above are likely to be cost effective.*

There is no data that indicates what the viable density would be for existing housing under similar conditions. For existing, older housing, heat demand per dwelling is higher even where energy efficiency measures have been implemented and thus the threshold might be smaller. However, the cost of retrofitting community heating to existing homes is higher, perhaps pushing the viable density threshold significantly higher than 55 / ha.

In any event, there is currently no data that classifies UK dwellings by density and it is thus unclear as to how many homes fall into the 'medium density' classification. Postcode heat density analysis, available on the EST website, provides some indication but does not take into account the impact on density of open spaces, streets and other non heat consuming zones.

In summary, it is currently hard to justify the use of a given existing housing density on which to base the analysis in this report. In our view, further work could usefully be done to identify the density of existing housing more precisely.

The challenge remains, however, to pin down the housing group that falls between flats on the one hand, of which there are around 4.5m in the UK and for which there is likely to be most cost-effective potential for CH / CHP, and detached and semi-detached housing on the other, of which there are around 12.8 million and for which micro-CHP, according to 'The 40% House' report, is likely to be a more cost-effective means of delivering carbon emission reductions. The group in between these two extremes, around 6.6m terraced houses, whose average density is unknown but in many cases will certainly exceed 55 dwellings / ha, is probably the most likely candidate for labelling as ‘medium density’ for the purposes of this report, although in reality, some of these properties will also be found in both high and low density zones.

Why CH / CHP?

CH / CHP has long been considered a high capital cost means of delivering heat to Britain’s homes and one which can only attract significant investment if grants or other incentives are available. Compared to current alternatives, this is certainly the case. However, it is also the case that CH / CHP based on natural gas provides a means to deliver some potentially significant emission reductions from existing housing.

In addition, CH / CHP based on renewable fuel provides one of very few means to deliver *very substantial* reductions. The delivery of biomass or other renewable fuels fuel to individual households on sufficient scale to displace all fossil fuel-based heating is almost certainly unviable. CH / CHP, in contrast, presents an opportunity of bringing about not only a large-scale housing fuel switch from fossil to non-fossil fuels, but also new options for the use of multiple fuels (CH / CHP schemes can be designed to use different fuels at different times).

1. Current Status

Little detailed information is available about the amount of community heating and CH / CHP supplying low / medium density housing in the UK. The 1998 BRE study, 'Nationwide Survey of Community Heating'[iii] is the only significant study available and it does not break data down according to housing density.

Ofgem used to keep a database containing details of all CHP plant in the UK, but no longer does so.[iv]. The last version has been used here to determine the existing status of CH / CHP but, again, there is no information about housing density.

There is a very small number of community heating (heat only) systems based on biomass, including Aviemore and Glenshellach in Scotland.

1.1 The 1998 BRE Survey

In essence, this survey involved interview with a sample of community heating plant owners and operators in order to derive a nationwide view of UK community heating. The survey focused on determining the floor space of various categories of building supplied by community heating and the overall thermal demand. The data is not presented in a way that enables the number of dwellings supplied by community heating to be derived. We have attempted to interpret the data in order to derive an approximation.

Number of Dwellings supplied by Community Heating

The Survey provides data on the domestic floor space supplied by community heating in the various sectors (there is no data for large multi-user schemes or private housing). Table 1 below summarises this data and provides an estimate of total dwellings served based on an average floor space of $70m^2$. Note that a proportion of local authority community heating supply is likely to be non-residential.

TABLE 1
PUBLIC SECTOR DWELLINGS SUPPLIED BY COMMUNITY HEATING

Sector	Sector floor area in the UK (km^2)	Proportion of floor area with CH	CH floor area (km^2)	Number of dwellings with CH
Housing Associations	49	0.3%	0.1	1,463
London Local Authorities	58	20%	11.6	165,714
Other Local Authorities	288	0.6%	1.7	24,286
Total	**350**	**3.8%**	**13.4**	**191,463**

To this estimate of almost 200,000 homes should be added dwellings that the Survey includes with 'large multi-use schemes'. According to the Survey, the total amount of community heating heat supply (excluding nursing homes and sheltered housing) is shown in Table 2.

TABLE 2
COMMUNITY HEATING ENERGY SUPPLY IN THE UK

Sector	UK CH energy consumption (GWh/year)
Housing Associations	21
Local Authorities	3,112
Private housing	167
Large multi use schemes	793
Total	**4,093**

The share of residential housing in the multi-use schemes is unknown but given the heat supply data above, the number of such dwellings will be significantly less than local authority housing, but enough to send the total number of dwellings above 200,000, around 1% of UK dwellings.

This is certainly in the same order of magnitude as other findings:

- The report 'The 40% House'v states that less than 1% of all housing stock in the UK is supplied by community heating, but does not state the basis for this estimate.
- The EST uses a figure of 1%, again not giving the basis of its estimate.
- Dalkia[vi] (an energy services company) states that over 450,000 homes are supplied by community heating.

Fuel Supply

Table 3 summarises the Survey findings on fuel supply to existing community heating systems and indicates the majority share of natural gas, but also the large minority share of other fuels, indicating the overall age of many community heating systems.

TABLE 3
FUEL USE IN UK CH SYSTEMS

Fuel	Fuel share %	UK CH fuel use (GWh)
Natural Gas	54%	23,305
Fuel Oil	20%	8,568
Coal	17%	7,283
Heat bought from 3rd	5%	2,142

parties		
Household waste	2%	623
Gas Oil	1%	461
Other	1%	461
Total	–	**42,843**

The Survey does specifically suggest that many of the schemes are old and / or inefficient:

> "The energy consumption of community heating schemes seems to be, on average, higher than that for their sectors as a whole. This is probably due to:
>
> - The age of the schemes – in most sectors this is 20 years or more
> - The low level of controls on community heating schemes"

Potentially significant carbon savings could be achieved by the refurbishment of some of these schemes. The level of saving will depend greatly on the specific features of the scheme, but could be based on one or more of the following:

- The conversion of heat only community heating to CHP.
- The installation of more efficient heat pipes.
- The installation / upgrade of user controls.

1.2 Ofgem data on CH / CHP Use

Tables 4 and 5 below summarise data from the Ofgem CHP database, which has data on natural gas based schemes only as of 2005. The data suggests how small is the current contribution made by CH / CHP to UK energy supply, and the overall very small size of most schemes.

TABLE 4

CH / CHP SCHEMES – ELECTRICAL AND THERMAL CAPACITY

No of Systems	Total Electrical Capacity (MWe)	Total Thermal Capacity (MWth)
37	59	108

TABLE 5

CH / CHP SCHEMES – SIZE RANGE

0 – 100 kWe	100 kW – 1 MWe	1 – 5 MWe	5 MWe+
8	26	1	2

Conclusions

There are three principal conclusions to be drawn:

- The quality of data is poor and / or outdated.

- Only a very small proportion of dwellings, probably no more than 1% of UK housing, is served by community heating. The Ofgem data suggests that the share of energy supply by CH / CHP is tiny.
- Many existing schemes are old and / or inefficient.

2. The Potential for CH / CHP

2.1 Defining Potential

The vast majority of households in the UK could, technically, be connected to a community heating scheme. The economic potential identifies the subset of this technical potential that would give acceptable returns on investment, and is the focus of this section. We draw primarily on work carried out by PB Power Energy Services in 2002[vii] ('The UK Potential for Community Heating with Combined Heat & Power', referred to as the 2002 Study), and updated/expanded upon (for DEFRA) in late 2005 / early 2006[viii] (referred to as the 2006 Study), which has not yet been published. While this examines potential for all community heating, it is possible to draw out some analysis looking specifically at potential in low and medium density existing housing.

The economic potential is hugely dependent on two factors: discount rates and energy price. For example the 2006 Study shows, for all community heating:

- An economic potential for 22 GW of CHP capacity serving community heating (at a 6% discount rate, typical for some public sector financing). This rises to 29 GW if electricity prices are assumed to be 20% higher than the base case. But if they are 20% lower, the potential falls substantially to just 5 GW.
- 22 GW of CHP capacity, at a 6% discount rate, almost disappears to just 0.08 GW at a 9% discount rate.

The community heating potential discussed in this section should therefore be used with caution. It is based on natural gas fuelled CHP plant supplying heat, the current regulatory environment, and energy price projections made in 2001/2005. If, as in countries such as Denmark, policies were introduced that tilt the playing field towards community heating (for example by taxing non-CH heating more highly), the potential might be significantly larger. Or, if gas prices increase and electricity prices fall, the potential (along with other gas-fired generation) will almost disappear.

Identifying potential is also dependent on a large number of other assumptions. An example, where considerable uncertainty exists, is connection rates. The potential in the above studies is based upon 40% of all buildings connecting to a community heating scheme in its first year of the scheme's operation, rising to 80% in year 8 of operation. Culturally, is this likely or possible for owner-occupied low and medium density housing in the UK – the vast majority of whom will have individual gas boilers? There is no significant UK experience on which to base such an assumption. These softer issues have a major impact on what some describe as the socio-cultural potential, a subset again of economic potential.

Other assumptions that have to be made in order to identify potential include:

- The price of heat (partly a function of energy prices).

- The cost of installing community heating infrastructure (which includes both the cost of pipes and the cost of digging trenches for the pipes).
- The cost of connecting properties to the community heating scheme (and whether any internal costs – such as installing or renewing a 'wet' heating system inside the property are included).
- The size, type and operation of CHP plant supplying heat to the community heating scheme).
- The cost of operating the community heating scheme (both maintenance cost and billing customers for heat).

2.2 Community Heating Potential for All Building Types

The two recent examinations of UK community heating potential identify potentials as shown in Table 6 (note that in our view, there are some aspects of the potential studies that could be deemed as 'generous' to CH / CHP). Both relate to all building types, not just houses and flats.

TABLE 6

COMMUNITY HEATING POTENTIAL AS IDENTIFIED BY THE 2002 AND 2006 STUDIES

		Discount rate			
	Units	3.5%	6%	9%	12%
Total CHP in CH potential – 2002 Study (2006 Study in bracket)	MW electric	NA (33,125)	18,300 (21,500)	2,289 (75)	787 (0)
Capital cost	£ billion		26.5	2.7	1.3
Carbon emissions savings (average grid mix)	Mt carbon per annum		4.3	0.7	0.4

Notes:

1. CHP electricity is assumed to displace grid electricity with emissions of 117g/kWh.
2. The 2006 Study did not provide figures for capital cost and carbon emissions savings. If the cost and emissions savings from the 2002 Study are assumed to be directly proportional to the installed CHP capacity, the 2006 potential – at a 6% discount rate – comes with a capital cost of £31.7 billion and carbon savings of 5.1 million tonnes.

The key findings are as follow.

- At discounts rates of 6% there is very large potential, equivalent to nearly one quarter of all UK power generation capacity. This increases substantially for a 3.5% discount rate (a rate used for public sector investments with minimal risk).
- The 18.3 GW potential for a 6% discount rate encompasses some 5.5 million households, a quarter of the current housing stock. This correlates to areas with heat demand greater than 2 MW per square kilometre, which takes in large swathes of suburban areas such as much of south-east London, Birmingham and Glasgow.[ix]
- When using discount rates commonly used by the private sector (12%) the potential is minimal (<1 GW) at best. A 9% discount rate (public-private partnerships might use a discount rate of 6 to 9%, depending on the level of risk and structure of the partnership) results in little potential when based on 2006 energy price projections.

Realising the 18 – 21 GW potential (for a 6% discount rate) requires **capital investment of £26.5 – £31.7 billion, yielding annual carbon savings of 4.3 – 5.1 million tonnes a year** (based on displacing the grid electricity with a carbon content of 117g / kWh).

The cost of carbon emission reduction amounts to £247 / tC based on a lifetime of 25 years. This is much higher than, for example, the £112 / tC quoted by the EST as the typical cost effectiveness for the Community Energy Programme, although there is significant variation around this average, which is likely to be dominated by high-density schemes [x]. Most of the 18-21 GW potential likely involves substantially greater community heating infrastructure investment (as the schemes will be new, not refurbishments of existing schemes) than under the Community Energy Programme.

The annual carbon savings arising from CH / CHP for each dwelling type are:

1. Around 65% if all savings are compared to the emissions associated with the previous supply of heating and hot water. (If the individual boiler were instead replaced with a 90% condensing boiler, then emissions would be reduced by 28% – although there is some evidence that individual household condensing boilers struggle to reach a seasonal efficiency of 90% in many UK homes).
2. Around 34% if all savings are compared to the sum of the emissions associated with previous heat / hot water supply and the displaced grid emissions.
3. Around 6% if only those savings associated with the production of heat and electricity *consumed by each dwelling* (as opposed to the total grid electricity displaced) are compared to the sum of heat and displaced grid emissions. This level of saving does not take into account the additional and significant savings arising from the CHP electricity that is not allocated to meet the electricity demand in each dwelling.

(See the endnote for the assumptions underlying this conclusion[xi]).

How the Potential was Identified

A summary of the methodology used by PB Power studies follows. For the detailed methodology, please see the 2002 PB Power report.

- The number of potential customers and their heat demand is estimated (on a postcode sector basis).
- The capital cost of a heat distribution network to serve these customers is estimated.
- The cost of supplying heat is estimated using a natural gas CHP plant (taking into account revenue from electricity sales). The heat price is fixed at 15% below (2002 study) / equivalent to (2006 study) the typical lifecycle cost of heat from a conventional heating system. These translate, for the 2006 Study, into heat prices of 3.45p / kWh for a detached house, rising to 5.27p / kWh for a terraced house (higher because the cost of an individual boiler is spread over fewer kilowatt hours of heat).
- The income from heat sales is estimated, based on an initial 40% of customers connecting to the system, rising to 80% of customers eight years later.

Other key assumptions used in the Study are:

- A connection cost to the network of £950 (plus an additional £510 for heat distribution within blocks of flats). This is at bottom of the EST estimate of £900 – £3,300 per dwelling, with the high end likely based upon installing a 'wet' heating system within the dwelling. The Study assumes that the community heating scheme does not bear the cost of installing such a system.
- Gas prices (for the CH / CHP / boiler plant) gradually decrease through to 2010, with the 2002 study assuming a 2010 price of 0.78p / kWh (0.82p / kWh for the 2006 Study). Residential gas prices for 2010 were assumed at 1.33p / kWh and 1.29p / kWh respectively. These prices are substantially below early 2007 prices; for comparison, RWE npower's residential gas tariff is 2.5p / kWh (excluding VAT).
- The price paid for CHP produced electricity was assumed, for the 2002 study, to gradually increase to 3.08p / kWh in 2010, settling around this price. The 2006 study assumed a slightly higher price of 3.25p / kWh (including Climate Change Levy and embedded benefits).
- Residential heat demand was calculated using fossil fuel consumption for space and water heating, together with a boiler with seasonal efficiency of 65%. This equates to thermal demands of 16,800 kWh for a detached house, falling to 11,000 kWh for a terraced house and 5,900 kWh for flats.

Other studies noting potential for community heating include:

- 'The 40% House'[xii], which refers to 4.4 million existing homes and 2.1 new homes having community heating by 2050, comprising some 4.9 GW of energy supply. This would supply 22% of all dwellings.
- The Royal Commission on Environmental Pollution ('Energy – the Changing Climate'[xiii]) estimated that 7.9 GW of heat could be supplied by community heating.

2.3 Implications for Community Heating Potential for Low and Medium Density Housing

The lack of consistent data and definitions for low and medium density housing means that identifying the part of the overall community heating potential for such housing relies on judgements, estimates and inferences. Straightforward data is not available, for example, that breaks down the 5.5 million homes (identified in the 2002 Study with economic potential for community heating at a 6% discount rate) by housing density or even housing type.

Indeed housing density itself is only an indicator of the economic potential for community heating. Heat density is a better indicator (the heat demand per unit land area), but the most relevant metric for community heating potential is the linear heat density, defined as the heat sales per metre of pipe (explained further on page 11). To understand this metric, a row of narrow houses with very long (deep) gardens may not have a particularly high heat density, but might have a relatively high linear heat density as the length of pipe per house would be relatively low. Below we examine ways of understanding the housing types and densities that comprise this potential.

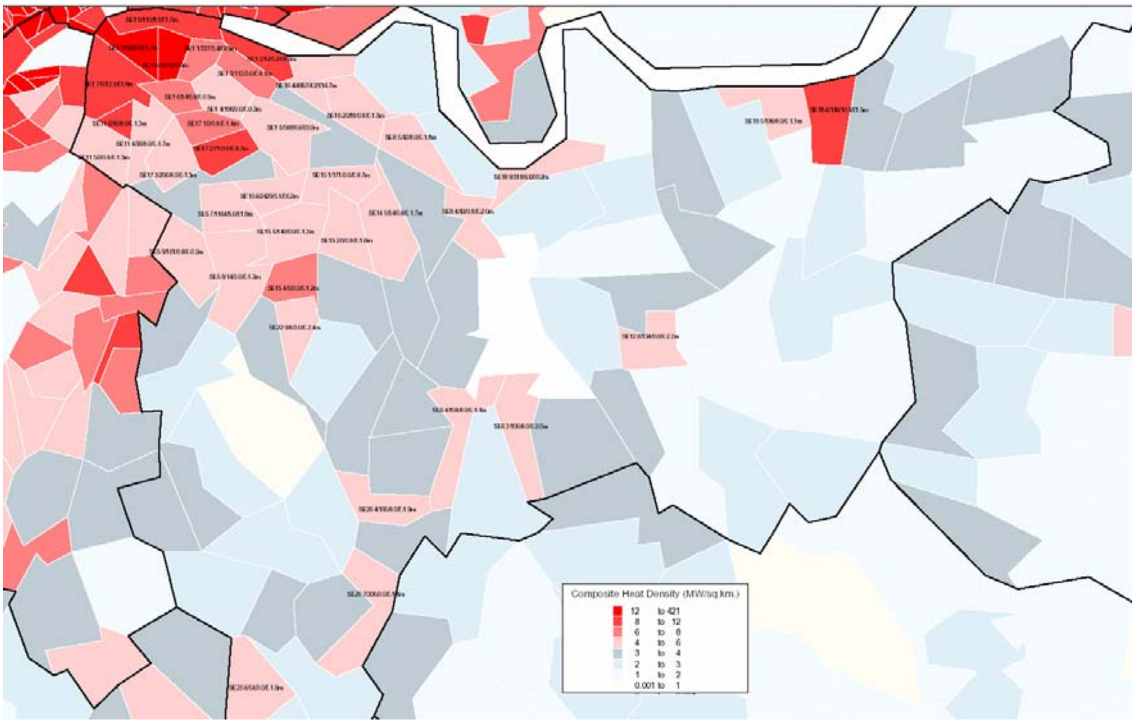
Heat densities

The 18 GW potential identified for a 6% discount rate equates, according to the 2002 Study, to areas with "heat demand density greater than 2.0 MW / km^2". This heat demand density encompasses large parts of many urban areas.

A heat density map for SE London, covering areas such as Greenwich and Charlton in the north, Catford in the south, Dulwich and Sydenham in the west, and Woolwich in the east (most of these areas are typical of suburban London) (see Figure 1), shows that that many of these areas have a heat demand density greater than 2 MW / km^2 and therefore have cost-effective potential for CH / CHP, according to the 2002 Study and the assumptions made.

FIGURE 1

HEAT DENSITY MAP FOR SOUTH-EAST LONDON



WWW.EST.ORG.UK

The detailed make-up of houses in these suburban areas is not clear, but certainly encompasses more than tower blocks and high rise accommodation, but unlikely to extend to large areas of semi-detached housing. In crude terms, this potential will *likely* correlate with high and some medium density housing, characterised by flats, terraces and possibly some dense semi-detached housing. Further work is required to provide greater clarity

One shortcoming of the Study is that it considers heat demand by postcode sector area (a postcode sector is a sub-area of a normal postcode area – for example the London postcode SE1 is split into 9 postcode sectors). Therefore a mixture of very high density housing (such as tower blocks or dense commercial buildings) together with low / medium density housing (such as semi-detached houses) in a postcode sector area may give an average heat density >2 MW / km^2, with all properties earmarked as having community heating potential.

In practice a community heating scheme might focus on the higher density housing and commercial property, and not spread to the lower density housing. This may mean that the 2002 / 2006 Study over-estimates the number of houses with potential in some postcode sector areas. It could also underestimate potential when there is a small amount of high density housing in areas of otherwise very low density housing (as the average heat density across the postcode sector will be low).

The result of this shortcoming suggests that the Studies are likely, if anything, to overestimate the amount of medium density housing and underestimate the amount of high density housing.

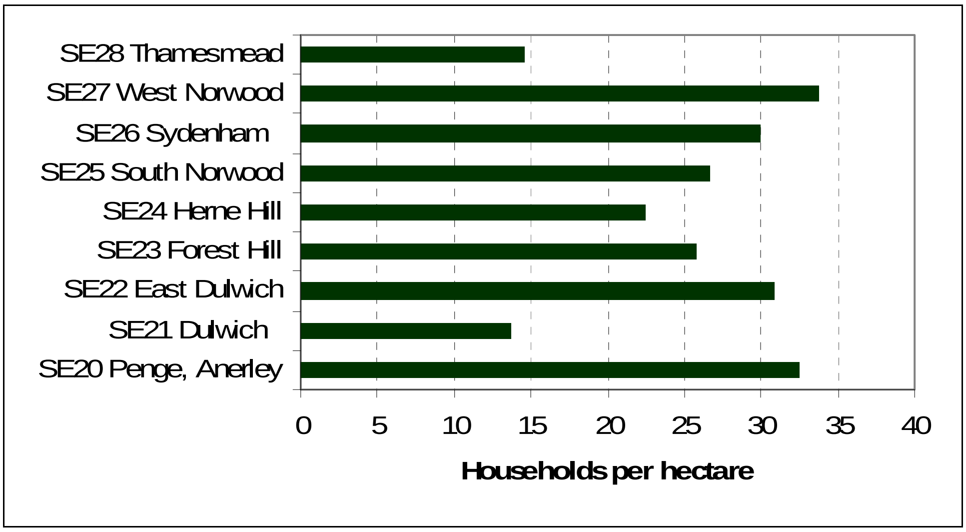
Housing Density

We now examine how the heat density assessments summarised above might translate to housing density. In the UK a threshold of around 50 houses per hectare is used as a rule of thumb by some organisations, including the EST, when considering the viability of community heating. The origins of this go back to a study conducted by Susan Owens in the 1980s[xiv], when the energy landscape differed radically to that of today.

Figure 1 showed heat densities, mapped by postcode, for SE London. Much of suburban south-east London has heat densities mostly greater than 2.0 MW / km^2, and so would be ripe for CH / CHP if a 6% discount rate is used. This area has a housing density typically around 20-30 dwellings per hectare as shown in Figure 2 (based on assessment of density of areas that include parks, open spaces and commercial buildings), indicating that CH / CHP appears to be cost effective at relatively low housing densities when *averaged across relatively large areas*. In practice, the specific zones where CH / CHP will be most viable are likely to have significantly higher density. This highlights the difficult in assessing the potential based on heat density analysis on a postcode basis.

FIGURE 2

HOUSING DENSITIES FOR SUBURBAN PARTS OF SOUTH-EASTERN LONDON



UK CENSUS 2001. NATIONAL STATISTICS OFFICE

House Types

The 2002 Study identifies 5.5 million dwelling (possibly as high as 6.5 million dwellings if the higher potential identified in the 2006 Study correlates directly with an increased number of dwellings[xv]) as having community heating potential with a 6% discount rate. The house types are not identified.

The make up of UK housing stock is shown in Table 7. Note that the vast majority of flats are low-rise (3.6 million).

TABLE 7
COMPOSITION OF UK HOUSING

	Flat	Terraced	Semi-detached	Bungalow	Detached
Number of dwellings (millions)	4.5	6.6	7.0	2.1	3.7
Proportion of owner occupiers (%)	29%	66%	75%	82%	96%

BRE DOMESTIC ENERGY FACT FILE 2000

It is reasonable to estimate that the great majority of flats are likely to be included within the Study's 5.5 (6.5) million high density homes. Some may be omitted as they occur in areas of otherwise low density housing that does not reach the ~2 MW / km^2 heat density criteria resulting in economic community heating potential. The Study's 5.5 (6.5) million homes may, therefore, include some 3 – 4.5 million flats, and 1 – 3.5 (4.5) million terraced, with a very few dense semi-detached homes.

Our inference is that, under current market conditions and with the assumptions made in the Study, the majority of flats have community heating potential, some terraced housing (likely less than half, possibly significantly less) and a very small number of dense semi-detached housing may have potential.

'The 40% House' report identifies 4 million existing high density homes that are likely to be suitable for community heating. The source of this is unclear, but appears to correlate approximately with the 4.5 million flats identified above. The '40% House' analysis therefore may only assume that community heating is applicable to flats, and not to terraced or semi-detached housing.

Community Heating and Low and Medium Density Housing in Sweden

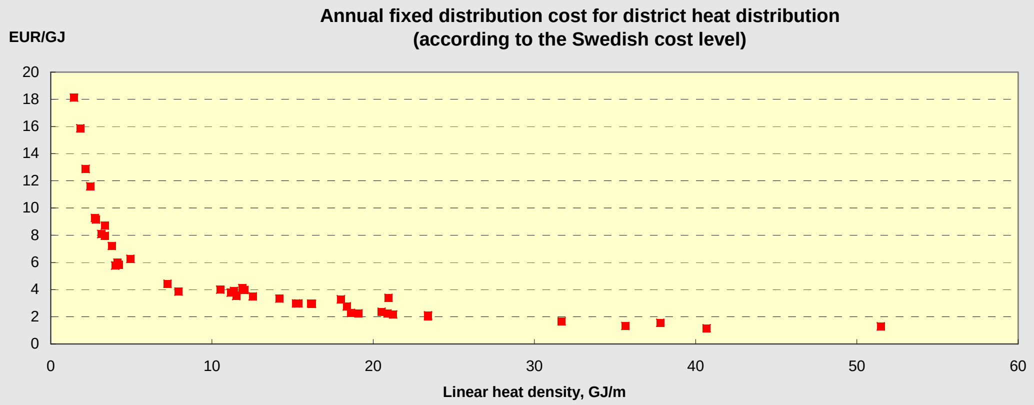
FVB District Energy, a Swedish community heating consulting firm, uses a further useful metric for evaluating the density at which community heating schemes are viable, the annualised annual capital cost for heat distribution. This is dependent on the **linear heat density**, defined as the heat sold per metre of pipe (dense areas will have a high level of connections per unit length of pipe and so high heat sales per metre of pipe – low and medium density areas will have the opposite).

Sven Werner at FVB has examined how the capital cost (annualised), expressed in cost per unit of heating capacity of the plant, varies according to different linear heat densities (the amount of heat sold per unit of pipe) in Swedish district heating schemes. The results are shown in Figure 3. Of interest is the fact that the fixed infrastructure cost rises rapidly at a linear heat density around 5 -7 GJ / metre. According to Werner, this linear heat density represents areas with semi-detached and detached houses, whereas city centres will typically have densities over 20-30 GJ / metre.

The implication for this is that, in Sweden, community heating can be viable in areas with semi-detached and some detached housing. Although there is some community heating in areas with a high proportion of detached housing in Sweden, this is far from commonplace – indeed some schemes focusing on these areas have failed. And this in a country where the playing field is firmly tilted toward community heating. A recent four year research study in Sweden was dedicated to this topic.

Direct translation to the UK is difficult due to the very different environment, but it is clear that the UK environment for community heating is more challenging than Sweden. The Swedish experience should make the UK cautious about the potential for community heating in areas with detached housing.

FIGURE 3
HOW (ANNUALISED) FIXED INFRASTRUCTURE COST VARIES WITH LINEAR HEAT DENSITY IN SWEDEN



2.4 Overview Community Heating Potential for Low and Medium Density Housing

Overall, the studies we refer to suggest some, but not much, potential for community heating in medium density housing if discounts rates of 6% or lower are considered. We believe that a critical concept to consider is 'linear heat density', as assessed in the box above based on experience in Sweden. Streets with closely packed houses, even if these houses have long, narrow gardens, may offer potential as the amount of heat sold per length of community heating pipe will be high. As gaps between houses become larger, linear heat density falls and the economics will become much more challenging.

The two UK CH / CHP potential studies identify a potential for some 5.5 million up to 6.5 million homes when a 6% discount rate is considered. The majority of these are likely to comprise flats (high rise and low rise), with some 1 – 4.5 million terraced and semi-detached housing included (the range depends on how many flats are not included in the potential and the differences in the two potentials. This matches fairly well with the scenario derived in 'The 40% House' which estimates around 4 million of current UK housing connected to community heating in 2050.

We can summarise by suggesting that there is economic potential for *some* medium density housing to be captured by community heating, but almost probably no low density housing. Certainly the vast majority of housing (as opposed to flats) *cannot* be economically captured by community heating – unless a 3.5% discount rate is used. At higher discount rates there is minimal potential for community heating potential in housing, with the little potential likely to be exclusively focussed on very high density housing such as tower blocks and multi-story flats.

Finally, it is necessary to emphasise that the assumptions under-pinning the potentials discussed may not be the same as assumptions used by community heating scheme developers. Two specific factors that stand out are:

- Connection rates – with almost no experience of 'pushing' community heating out to existing owner occupied housing in the UK, there would be significant risk attached to assuming 40% connection rates in year 1, rising to 80% connection rates in year 8.
- Heat sales price – the methodology used in the studies of the levelised cost of heat (effectively spreading the cost of the boiler over the number of kilowatt hours of heat generated) is unlikely to be used in homeowner decision making processes. The more likely comparison with community heating-supplied heat will be the operating cost of supplying heat – the cost of fuel (gas) and the ongoing maintenance cost. This could lead to a much lower price of community heating-supplied heat and lower potentials. Again, there is minimal experience in the UK on which a community heating operator could set heat prices.

2.5 Low and Zero Carbon District Heating Potential

The studies cited in this section consider that all community heating will be powered by natural gas CHP. There are a number of sources of lower carbon heat that could be utilised, primarily heat recovered from the following sources (if sited relatively close to community heating schemes):

- *Energy from waste plants* – for example from the SELCHP plant in south-east London (which currently dumps the waste heat produced as a result of the power generation process); community heating schemes in Nottingham and Sheffield both use heat from waste plants.
- *Large power plants* – for example the Barking CCGT plant in East London, which currently dumps the waste heat, and the power plant at the Grangemouth refinery near to Falkirk, which again dumps significant quantities of heat.
- *Biomass fuelled heat and CHP plants*, for example the biofuelled CHP plant being developed to supply a new community heating scheme in Southampton.

- *Industrial waste heat.*
- *Geothermal sources*, such as the source that supplies the existing Southampton community heating scheme, or large-scale supply from heat pumps.

There are also a small number of examples where solar thermal is used to supply (typically only a small proportion of supply) community heating schemes.

It is difficult to generalise about the cost of heat from these sources. In some cases the heat will already be produced but not utilised, so the only additional cost is that of heat recovery equipment, plus the fee charged by the power station / industry generating the waste heat. In these cases, the heat supply may well be competitive with that from new natural gas fuelled CHP plants.

The cost of biomass heat supply will typically be higher than that from natural gas, with three main cost influencers. Biomass equipment and operation and maintenance cost will always be higher than for natural gas. Fuel supply cost comparison depends on future changes in natural gas prices and UK/global supply of and demand for biomass – biomass fuel is typical more expensive than natural gas at present. Finally, incentives for renewables help biomass compete against natural gas.

The amount of heat sold according to the community heating potentials identified in the studies is shown in Table 8 below and is shown in order to provide an assessment of the degree to which waste heat available from LZC sources could supply community heating schemes.

TABLE 8

HEAT SUPPLIED ACCORDING TO CH / CHP POTENTIAL ANALYSES

		Discount rate			
	Units	3.5%	6%	9%	12%
Total CHP in CH potential – 2002 Study (2006 Study in bracket)	MWe	33,125	18,300 (21,500)	2,289 (75)	787 (0)
Amount of heat sold (2006 Study in brackets)	GWh per annum	(230,400)	114,300 (149,700)	19,400 (600)	11,500

Energy from Waste Plants

The future development of energy from waste (EfW) plants in the UK is uncertain. Two recent reports[xvi] have examined the potential for new plants in the UK. These identify a possible thermal capacity of 1.8 GW by 2020, although this would rise to 7.8 GW according to the Renewable Energy Association if all waste is sent to EfW plants (although in reality this figure would be lower as much of the waste would likely have to be combusted in large power plants where heat recovery may not be viable). On the basis of the lower figure and an assumed load factor[xvii] of 70% around 11,000 GWh of heat could be supplied per year from EfW plants in 2020.

The Biomass Task Force includes municipal solid waste (energy from waste) in the potential for biomass heat supply, identifying a potential of 14,000 to 18,000 GWh of heat supply.

The two estimates equate to some around 10 – 16% of the total heat sold by the 18,300 MW of CHP potential identified for a 6% discount rate in the 2002 Potential Study.

However, it is likely that some EfW plants will be sited too far from community heating schemes to make heat recovery and transportation economic. If half the EfW plants are suitable for heat recovery to supply community heating schemes, this reduces the contribution of EfW to 5 – 8%.

Recovering Heat from Large Power Plants

The Community Heating Development Study for London[xviii] estimated that 230 MW of heat could be recovered from the Barking Power plant in east London, plus an additional 100 MW if the plant is expanded as planned. This would supply 1,650 GWh of heat (assuming a load factor of 57%). If the equivalent of five other large CCGTs are assumed to be sited relatively to close to areas with large community heating potential (there are a total of 35 CCGT power plants in the UK), heat recovery from existing CCGTs could comprise around 10,000 GWh, or around 9% of the community heating heat supplied as identified in the 2002 Study.

Industrial Waste Heat

The Carbon Trust estimates[xix] that 40,000 GWh of industrial waste heat could be utilised (we have assumed these are from industrial processes rather than large power plants). It is unclear how much of this could be utilised in community heating schemes, but if a figure of 50% is assumed, this gives 20,000 GWh of what is currently effectively zero carbon heat, around 18% of the community heating heat supplied as identified in the 2002 Study.

Biomass

Biomass fuel can be sourced both from within the UK and from international markets. UK biomass resource is discussed below, but resource from outside of the UK is virtually unlimited in terms of meeting demand from community heating schemes. The additional cost and space required (for storage and handling of the biomass fuel) for biomass heating is perhaps a more relevant constraint to its potential contribution.

The technical potential for biomass fuel supply in the UK has been identified in a Future Energy Solutions Study for the DTI[xx] as 42,000 GWh / year, made up of energy crops, straw and forest / wood industry waste. The study estimates that by 2020, biomass could contribute 13,000 GWh of heat supply, the majority in the industrial sector.

The Biomass Task Force[xxi] identifies a range of 29,000 – 33,000 GWh / year (with an additional 4,000 – 5,000 GWh from “wet” biomass) from existing biomass resource (biomass that is both currently exploited and not currently exploited). The Task Force identifies a further 24,000 GWh of heat supply that may come from future development of energy crops. The Royal Commission on Environmental Pollution’s report, ‘Biomass as a Renewable Energy Source’,[xxii] identifies a substantially larger contribution that biomass could make (based on a very high contribution from energy crops).

It is difficult to make generalisations about the potential scale of biomass fuelled community heating, as the biomass resource could be used for heat only or CHP applications, and used in community heating plants or in industrial or building applications. Further, large scale biomass heating / CHP plants require considerable space, and may not always be applicable to CH / CHP schemes

We assume that the contribution of biomass by 2020 is unlikely to rise much above 10,000 GWh (around 9% of the total heat sold by the 18,300 MW of CHP potential) and may be more than an order of magnitude less. In the long term, there is sufficient resource to make higher contributions. A figure of 40,000 GWh / year is possible, although this includes the contribution of energy from waste, assumes that virtually all potential biomass resource is exploited (including the future potential for energy crops) and that around three quarters of this would be used for community heating (possibly at the expense of other applications). This would comprise 35% of community heating heat supply.

Geothermal

We have found no evidence for a significant contribution of geothermal heat for community heating in the UK. Contributions may be possible from heat pumps, although we have not found any data quantifying this potential.

Solar Energy[xxiii]

District heating and cooling systems can be made solar and combined with some form of thermal energy storage. At least eight solar-assisted district heating systems have been constructed in Germany. Other such systems exist in Sweden, Denmark, the Netherlands and Austria. The largest of these, in Denmark, includes 1,300 houses, a 70,000 m^3 gravel-pit for storage and a 30% solar fraction.

Summary

In summary, the potential contributions from LZC sources of heat based on our assumptions are shown in Table 9. It should be recognised that these figures will probably be extremely challenging to meet (current heat supply from such sources is minimal) and could come at the expense of using these resources to supply industry or other sectors.

However, according to the assumptions, LZC sources of heat could supply close to half or more of the 18 GW of CH / CHP potential identified in the 2002 Study, although this will be exceedingly challenging to achieve.

TABLE 9

POSSIBLE CONTRIBUTIONS TO COMMUNITY HEATING HEAT SUPPLY FROM LOW/ZERO CARBON HEAT SOURCES

Source	Potential heat supply (GWh)	% of heat sold for CH equivalent to 18.3 GW of CHP
Energy from waste	7,000 to 9,000[a]	5 – 8%
Heat recovery from large power plants	10,000	9%
Industrial waste heat	20,000	19%
Biomass[1]	10,000 – 40,000	9 – 35%
Total	**49,000 – 79,000**	**42 – 71%**

Notes

1. Biomass resource outside the UK could lead to larger contributions from biomass.

3. Case-studies

This section presents short summaries of seven community heating case-studies that include medium density housing and which provide some experience and lessons for potential future CH / CHP development in the UK.

3.1 Lerwick, Shetland

Background

Shetland has no access to natural gas and has historically relied upon oil fired heating. The Lerwick community heating scheme was set up to reduce the cost of heating and the outward flow of money from the islands economy through the need to import oil.[xxiv]

The Shetland Heat Energy & Power Ltd scheme commenced operation in November 1998 using backup oil fired boilers. In November 1999 the 7 MW waste-to-energy plant run by Shetland Islands Council became operational, leaving the boiler plant as standby and to meet peak loads.

The scheme serves commercial, industrial and public buildings as well as housing. Currently 700 low/medium density houses are connected to the scheme, 300 hundred of these being municipally owned and 400 private.

Financing

The scheme has been financed by the Shetland Islands Council Charitable Trust (a body funded from the oil industry activity in Shetland), with assistance from the European Regional Development Fund under the Highland & Islands Objective 1 Partnership and the EU Thermie Fund. The development of the scheme has been viewed as an investment in the Shetland economy.

All major installation and maintenance work is contracted to private companies, whilst the council, through the company, retains overall ownership of the project.

Project Performance

To date the project has been deemed successful by the manager of the company, Neville Martin. With a turnover of £1m per year from the sale of heat, it is estimated that some £2m remains in the Shetland economy that would otherwise be spent on imported oil. There are plans to expand the scheme to allow connection of new housing.

Critical Success Factors

- The availability of Trust and EU funding has been a significant factor, as has the related feature of the project, that it is not required to make a commercial return.
- It was crucial to get residents to buy in to the scheme; this was achieved by getting plumbers to back the scheme – now effectively acting as a sales force.
- The potential for reduced capital costs, space saving and reduced heating costs were highlighted to managers of public, commercial and industrial buildings.
- Grants are supplied to domestic households for connection to the scheme, reducing the cost of connection to the same level as installing an oil fired boiler (around £400 – £500).

Relevant Transferable Lessons

- The importance of persuading residents and the Council of the benefits of the scheme.
- The value of a 'project champion' with real enthusiasm and determination.

3.2 Tower Hamlets, London

Background

The Tower Hamlets community heating scheme was first conceived by the Council's Energy Efficiency Unit in the early 1990s whilst the Barkantine Estate was being modernised. Funded through a PFI arrangement with EDF Energy (originally London Power Company, a fully owned subsidiary of EDF Energy) the system came online in 2001. The scheme utilises a 1.4 MWe gas fired CHP plant with supplementary boilers. The scheme was sized to supply the peak winter heat load and uses large storage tanks so that electricity can be generated when there is greatest demand for it and it has most value. Local residents are offered a dual heat and electricity tariff, with heat prices based upon the gas price used to fire the gas engine and boilers. Electricity prices are guaranteed to be 20% lower than the average tariff offered by the cheapest 10% of suppliers. The scheme reduces CO2 emissions by 30.4% (based upon 2001 levels), or 2,500 tonnes annually.[xxv]

Ownership & Financing

The scheme is owned and operated by EDF Energy but will become the property of the Tower Hamlets local Authority after 25 years. The project received £6 million from DEFRA as a National Pathfinder scheme under PFI.

Project Development Model

Under the PFI agreement EDF Energy was required to build, own and operate the plant and infrastructure and to take responsibility for billing. In return, the Council pays an annual 'mortgage' fee for the system that allows EDF Energy to make a 12% profit and additional profit from electricity sales to National Grid, with the Council ultimately taking ownership.

Project Performance

The project has been hailed as a successful use of PFI, although it has been argued that tax payers are effectively subsidising the provision of cheap heat and electricity to the residents. There are plans to double the project size, with three private developers keen to connect new build housing to the system. The scheme won the 'Best Use of Gas' category in the 2000 Energy Awards.

Critical Success Factors

- Sizing the plant to meet the peak winter demand and utilising heat storage tanks allows the project to operate flexibly and maximise the value of electricity produced.
- The use of PFI allowed Tower Hamlets to develop the project without having to raise money or take financial risk.

- Local residents were brought onside by the appointment of a ‘Tenants’ Friend’, an enthusiastic expert in energy efficiency, who argued the project’s case. A three day energy efficiency exhibition was held to provide additional information to residents, followed by a residents’ vote on the scheme.
- Tower Hamlets were extremely tenacious, pushing hard for the scheme to be a success

Relevant Transferable Lessons

- PFI is a suitable mechanism to allow community heating schemes to be developed without local authorities having to take significant financial risk.
- It is important for energy managers interested in community heating to fully research what is possible, including trips to existing community heating schemes in the UK and abroad.
- It is essential for personnel of suitable experience to be brought in as early as possible.

3.3 Southampton

Background

Southampton has a history of community heating, with much of the city centre's office and commercial space supplied by a CHP and geothermal scheme.

A new biomass fuelled scheme is currently in the development phase. This new scheme will be based around a 50 MW vegetable oil fired CHP plant (likely, at first, to be imported palm oil) with natural gas fired backup boilers. The scheme will be connected to 3,000 mostly low / medium density council houses, 8 schools and 9 other council buildings. Other private households will also be encouraged to join.[xxvi]

Ownership

Solent Sustainable Energy Limited (SSEL), a not for profit company, has been setup by the local council to deliver the project. The generating plant and other infrastructure will be provided though an ESCO contract which has currently been put out to tender – a partner had been found, however they have pulled out. As the CHP plant will be located near and supplied by the local port, Associated British Ports is also involved in the project.

Financing and Project Development

The cost of installing the generating plant and infrastructure will be borne by the ESCO contractor. The project will greatly reduce fuel poverty by offering low price heat to all those connected. Initial connection will have to be paid for but grants are available from the South East of England Development Agency and the EST (while there are currently few grants to cover fuel costs, there are a number for energy efficiency improvement to homes).

It is planned that the connection of homes to the community heating infrastructure will be contracted out to private installers.

The project will receive ROCs from its status as a biomass plant, with SSEL receiving heat for free from the CHP operator. Payments made by residents will go towards the infrastructure costs.

Critical Success Factors

- The renewable energy basis of the project, enabling ROC generation.
- The use of grants available for energy saving home improvement to connect homes to the scheme.
- A number of anchor loads are being used to provide a foundation for the scheme (including the schools, council buildings and council houses). The system will then be expanded to supply private housing. The council owned loads include: 9 schools, 8 social service properties (including residential

homes for the elderly), 3,440 council houses. Overall, the anchor load will account for 50% of the scheme's capacity and cover the cost of infrastructure development.

- The use of a mixed load - made up of housing and non-residential building types levels out the load profile, improving system economics and efficiency.

Relevant Transferable Lessons

- It is necessary for the project manager of a community heating scheme to be tenacious; there are many hurdles to be overcome especially if CHP is to be used; these include convincing the council and residents, and management of partners and contractors.
- Ensure that the right people are involved. It is necessary to have the correct experience available and, where not available locally, this has been brought in from outside.

3.4 Sheffield

Background

Sheffield's community heating scheme supplies a number of commercial and public sector buildings in the city centre. The scheme produces heat which is sold to local customers and power which is sold to National Grid using Sheffield's energy from waste facility as an energy source.

Although the supply of heat to a local council estate made up much of the schemes initial load, domestic heating now represents only 15% of the schemes heating load. There is currently no medium density housing connected to the scheme; Veolia (the owner), believes that without significant government incentive, the use of community heating for medium density housing cannot be economic.[xxvii]

Ownership

The scheme was initially developed and operated by Sheffield Heat and Power, a private company partly owned by Sheffield City Council. The scheme is now owned and operated by Veolia Environmental Services.

Financing & Project Development Model

Sheffield City Council established Sheffield Heat and Power Ltd during the 1980s. The council worked with private partner EKONO-Oy, a District Heating specialist based in Finland, and developed the project under PFI.

Project Performance

The project is considered a success and has been used as an example of best practice by the Carbon Trust.

Critical Success Factors

- The support of Sheffield City Council was essential. It provided the key first contract for Sheffield Heat and Power. This provided a platform that could be built on to secure new customers and thus further tranches of finance.
- The system was developed within a small area surrounded by a number of large energy users, making it financially feasible.
- The product is not 'pushed' at potential customers; rather it is left to sell itself based upon its technical and financial merits.

Relevant Transferable Lessons

- Project return is viewed over a long time-frame - typically 20 years.

- It is important to get the right staff; they must have a good understanding of energy and engineering matters since most initial contact with new customers is through energy managers or consulting engineers.

3.5 Copenhagen, Denmark

Background

The task of connecting the whole city and the outlying suburbs to the scheme has been underway since 1986, and is due for completion in 2009. When it is complete, 275,000 households, 0.75m people, will be served by the system, including medium density zones. To achieve this goal, a 34 mile primary heat main and many more miles of neighbourhood piping have been laid and equipped with 26 heat exchanger stations, three booster pump stations, 14 peak load units and a computerised control, monitoring and regulation installation. The main sources of heat are a number of CHP plants and the city incinerators. Peak load units provide additional thermal capacity at times of maximum heat demand.

The system consists of a primary heat network that transmits bulk heat at high temperature and pressure, which is then transferred to secondary neighbourhood networks via heat exchangers. These secondary networks carry heat at much lower temperature and pressure, allowing cheaper pipe to be used.[xxviii]

Ownership

Copenhagen's community heating scheme is owned and operated by the Metropolitan Copenhagen Heating Transmission Company (CTR). The company purchases heat from CHP and incineration plants and transports it, together with heat from CTR's own peak load units, to delivery points in the municipalities involved.

Financing

Community heating schemes in Denmark have benefited from significant financing support from the Government.

Project Performance

The project has been successful to date, an international model, with Copenhagen's energy consumption / m^2 falling by more than 50% since the 1970s. The project saves around 290,000 tonnes of oil per year.

Critical Success Factors

- Development of the Copenhagen community heating scheme has relied upon strong government support at national and municipal level with strong financial support from energy taxes and tough legislation supporting community heating enacted. All new buildings and existing buildings with a heating requirement greater than 250 kW must be connected to Copenhagen's community heating system. Some of the municipalities making up the city's community heating partnership have gone further and also require domestic buildings to be connected to the network. A connection rate of 90-98% within the community heating area is expected when system expansion is completed in 2009.

- The system's large size allows it to be operated in a flexible and economically efficient manner.

Relevant Transferable Lesson

- It is clear that the development of district heating on this scale relies upon strong government support at all levels and a clear, coherent long-term strategy. The success of the scheme rests greatly upon the requirement to connect and the availability of public financial support derived from high energy taxation.

3.6 Vienna, Austria

Background

The community heating network of Vienna supplies around 240,000 dwellings (including areas of medium density housing) and 5,000 industrial customers. Waste and CHP plants provide 97% of the heat supply. Starting in 1969, the system has been expanded in various stages over the last 3 decades and is now fed by 10 individual plants with an installed capacity of 2,500 MWth providing 35% of the city's heating requirement.[xxix]

Ownership

Fernwaerme Wien is wholly owned by the municipality. It was established in 1969 to operate and maintain the system.

Financing

The project has mostly been funded by the municipal government.

Project Performance

The system is considered a success with a tradition of efficient operation and customer satisfaction. There are currently plans to expand the system by a further 276 MWth. It is anticipated that 50% of Vienna's heating requirements will come from community heating by 2020.

Critical Success Factors

- Considerable emphasis is placed on ensuring that new buildings are connected to the heating network. This is achieved by maintaining strong relationships with developers and ensuring that community heating is considered at the outset of the development planning.
- Subsidies have been provided to home owners and businesses to cover the cost of connection to the scheme.
- Long term contracts with the CHP plants that supply the heat enable the scheme to offer competitive heat price rates in return.
- The use of primary and secondary networks has allowed cost effective system expansion, with pipes in the latter having a lower specification.

Relevant Transferable Lessons

- Community heating system operators must ensure reasonable prices for customers and good reliability. Consumers are however more sensitive to supply quality issues than price fluctuation.

- Energy policy at national and local government levels must be supportive of community heating network development and expansion. There must be a clear political will within the city or community heating would not succeed.

3.7 Highlights of International CH / CHP Policy

Denmark

- Major government support for community heating came with the oil shock of the 1970s. Since then, Denmark's energy policy has focussed upon reducing reliance on foreign oil through the development of community heating and natural gas networks.
- Three main policies have represented the platform for community heating development in the 1970s and 1980s:
    - All new electricity plant had to be CHP.
    - Each municipality was required to develop a coherent energy strategy that included the efficient supply of heat. This led to use of a zoning strategy, whereby planners assigned areas as either natural gas zones or community heating zones based upon the heat density.
    - Within community heating zones, customers are required to connect to the system.
- The community heating and gas infrastructure development occurred in parallel, allowing efficient cost benefit decisions between the two sources of heat to be made. This contrasts with the UK where the focus has been on natural gas availability.

Austria

- Austrian energy policy since the 1950s has had a strong emphasis upon the use of renewables and energy efficiency. This policy context has been particularly supportive of CHP and industrial waste heat community heating systems.
- The development of the Vienna Climate Protection Programme (KIIP) has been a key driver of recent expansion of Vienna's community heating system. KIIP was launched by the city in 1996 as a cross institutional initiative involving the city's environment and buildings departments, the Austrian Energy Agency and local universities. A number of measures were highlighted by KIIP that could reduce Vienna's environmental impact, with one of the key goals of the programme being to identify projects that could succeed in the short term. As such, expansion of the community heating system in Vienna was one of the core recommendations of KIIP. In effect, Vienna was responding to the challenge of climate change by promoting CH / CHP more than ten years ago.

4. Policy Landscape & Key Barriers

4.1 Current Policy Landscape

With the early closure of the government's Community Energy Programme, policy support for the development of CH / CHP to existing housing is virtually non-existent. Indeed, we have been able to identify only two measures specifically targeted at CH / CHP:

- Its inclusion among the range of measures that comprise the Energy Efficiency Commitment. Energy suppliers may include connection of a dwelling to a community heating network to qualify; if the network is part of a CHP scheme, and thus deemed 'innovative, the benefit is uplifted by 50%.
- Connection to community heating is included in all UK fuel poverty programmes, including Warm Front in England.

What other few measures there are apply also to other forms of CHP or low carbon generation, and include:

- Renewables Obligation Certificate (ROC) benefits for renewable based schemes, including the planned Southampton scheme for which this benefit has enabled the scheme to proceed. The RO is the Government's main support mechanism for the expansion of renewable electricity. It obliges electricity suppliers to source a rising percentage of electricity from renewable sources. The level of the obligation was 6.7% in 2006/07. It is planned to rise annually to 15.4% in 2015/16. In order to meet their obligation, energy suppliers must prove they have purchased energy from renewable sources by presenting ROCs or, alternatively, by making a fixed financial payment (a 'buyout price'), or some combination of the two.
- A limited benefit through the allocation arrangements for Phase I of the EU ETS. In the UK National Allocation Plan for Phase I, a reserve of allowances was ring-fenced for new entrant CHP projects. Apart from this, CHP projects were treated no differently from other installations in the same industrial sector. For Phase 2 of the scheme, beginning in 2008, the UK has proposed different arrangements that include a new CHP-only sector which would receive a fuller allocation than non-CHP plants.
- The December 2006 announcement by DTI that requires power plant developers to consider opportunities for heat recovery. The new guidance states that "Government believes it is highly preferable, from a climate change and fuel efficiency perspective, for the waste heat from large power stations to be put to beneficial use where possible. It expects developers to explore opportunities to use CHP fully, including community heating, when developing proposals for new power stations. However, it does recognise that

in some cases CHP will not always be an economic option." There is no obligation associated with this measure and so is unlikely to have material impact.

- Exemption from the Climate Change Levy (CCL) for qualifying CHP fuel inputs and electricity outputs, provided that the electricity is used on site or sold direct to other users. For electricity sold via a licensed supplier, that licensed supplier had to collect the levy, subject to any reliefs that applied, when it was sold on to a consumer. In cases where CHP operators are themselves licensed suppliers, direct sales of Good Quality CHP electricity are levy exempt.
- There are 100% first year capital allowances (Enhanced Capital Allowances, ECAs) on investments in certain energy-saving plant and equipment, including CH / CHP energy plants. However, in the case of heat pipes used for CH / CHP schemes, the ECA applies only to pipe insulation, not the pipes themselves. This is based on the fact that a category exists for conventional 'wrap-around' insulation material but not for pre-insulated heat pipes such as those used in CH / CHP schemes.

- There is little EU legislation that will have a significant impact on the market. The two main measures are:
    - The CHP Directive requires member states to identify the potential for CHP, including CH / CHP, and so should highlight a market opportunity to policymakers. Governments will be expected to report on progress towards these targets on an annual basis and may therefore feel some pressure to take measures to move towards these targets, although severe sanction from the Commission is unlikely. The Directive also enables certain incentive regimes to be introduced which would otherwise infringe state aid rules.
    - Article 5 of the Energy Performance in Buildings Directive requires that new buildings above 1,000m^2 be considered for CHP, community heating and/or cooling, or decentralised renewable energy systems. This will have no direct impact on existing housing but may stimulate the development of anchor loads.

There is a growing range of measures that relate to planning guidelines and financing of public sector projects. While these have no direct impact on existing private housing, there are potential indirect benefits through the stimulus they may provide for the creation of anchor heat loads that can, in turn, extend into private housing areas:

- Planning Policy Statements, including PPS1 (Delivering Sustainable Development) and PPS3 (Housing). While these measures could be seen to encourage the development of new CH / CHP anchor loads, they are unlikely to do so in practice unless accompanying guidance gives a specific push.
- The January 2007 Treasury paper, 'Transforming Government Procurement', makes it clear that whole life costing should be fully taken into account in public procurement and investment. This should favour in particular energy systems that have relatively high front end costs but lower ongoing costs, with CH / CHP being a typical example. This could have significant impact on the development of CH / CHP in the public sector, if it turns out to be effectively enforced. There is no sign yet that it will be.

4.2 Core Barriers

There are no specific policy or regulatory barriers to CH / CHP that, if removed, would lead to any significant development of the market, whether in high density areas or in medium / low density areas. The most fundamental barrier remains the high front end cost and the absence, as we have seen above, of any sign of an incentive regime to compensate for this.

This absence of policy attention stems largely from the following:

- There is almost a complete absence of central government attention to the residential heating sector, which is an unregulated market, and thus no real debate geared towards bringing about the most suitable heat supply solutions for that sector which might focus greater attention on community heating. This is based largely on the historical development of a national gas network that extends into the majority of UK residential dwellings. The community-based alternative would currently be a poor cultural fit with how customers expect their heat to be supplied, a situation quite unlike several other European countries. One of the many consequences of this is that there is generally poor data on existing community heating development, and insufficient analysis on the real opportunity for future growth.
- The UK energy market is characterised by the goals of delivering competitive supply and easy options for changing suppliers. Again, this is a very poor fit with the needs of community heating development with its relatively high capital costs and need for long-term customer commitment. While there are already examples of schemes where connection rates have been fast, we believe that much more information is need to identify real customer attitudes to community heating connection in the UK, and the rates at which they can be expected to connect to new schemes. Given that a significant proportion of householders probably have no idea what community heating is, encouraging connection will be a challenge.
- One of the most important benefits that CH / CHP can bring is the significant reduction in carbon emissions from existing UK housing. Yet there are no significant incentive measures that are linked to this benefit. As the next section argues, it is highly unlikely that there will be any further major development of the market unless such an incentive regime is introduced.
- Compared to the examples of the municipal commitment of the cities of Copenhagen and Vienna given in the report, the powers of UK local authorities in respect of community heating development are small.
- There has been inadequate follow up by Government to commitments to alleviate fuel poverty through community heating and, as a consequence, targets will be missed by some distance.
- The sector continues to be tarnished, though not significantly, by its poor track record in the 1960s and 1970s. There are emerging signs that this image is changing – in some recent schemes, householders have been keen to connect.

5. Policy Mechanisms & Solutions

This section summarises potential policy mechanisms that could be applied in order to secure the potential for CH / CHP identified in section 2.

Initially, it was our goal to identify as a priority changes to existing mechanisms, since this was felt to be more politically feasible than new dedicated mechanisms. However, given the chasm that exists between current CH / CHP status and ranges for potential identified in section 2, we believe strongly that adjustments to existing measures will be insufficient for delivery.

Accomplishment of the goal of connecting 20-25% of UK housing to low carbon community heating systems will require major policy intervention of a transformational nature. It will also result in increasing costs, either directly or indirectly applied, to energy consumers. There is precedent for such a scale of change. In the 1970s, state-owned British Gas undertook a major public programme to convert gas burning appliances in every building in the UK from town gas to natural gas. It also launched a campaign to increase the take up of gas-fired central heating. While this was in train, investment in social housing, and community heating maintenance along with it, was cut.

5.1 Options for Major Policy Intervention

A National Heat Strategy

The previous section highlighted that there is little significant central government focus on heat supply and that heat supply itself is not regulated. Given the relatively high proportion of UK carbon emissions that is associated with domestic heating and hot water supply, we believe that there is a good case to be made for the development of a national heating strategy that is charged with:

- Identifying in greater detail the potential for CH / CHP based on a clear understanding of housing densities across the UK.
- Providing a better understanding of the least cost options for reducing emissions in existing owner-occupied households.

Carbon Linkage

Given that the prime reason for bringing about the extensive development of CH / CHP across the UK is to secure substantial carbon emission reductions from existing housing that cannot otherwise be achieved through other technical measures, then policy linkage to overall UK carbon policy is a logical place to start.

There is a clear momentum in both the EU and the UK towards the use of emissions trading as the leading instrument to deliver emissions reduction. The EST has estimated that the investment cost per tonne of CO_2 for CH / CHP is at least £40-80

/ t or more. This is substantially above levels that have been seen so far in the EU ETS, but may even be below the range required to deliver the scale of reductions that are being discussed.

However, experience with the ETS and the UK NAP process suggests that emissions trading theory and practice are quite different, and that a price for carbon does not necessarily deliver significant emission reductions, either through penalising emissions or incentivising emissions reduction. For the ETS to deliver substantial new investment in CH / CHP in the UK, two things must happen:

- The carbon price should relate directly to switches in fossil fuel power station investments from conventional low efficiency plant, in particular CCGT plants that do not recover heat, to high efficiency CH / CHP and other types of CHP. Experience so far indicates that despite carbon pricing in the power sector, CCGT plants remain the investment of choice for most UK generators.
- The UK NAPs for future ETS phases should be designed to specifically target favoured energy supply solutions. This can be done, for example, by ensuring an allocation for new entrant CH / CHP schemes of a certain efficiency that reflects the emissions displaced from the equivalent separate generation of heat and power.

At the customer level, there is an emerging consideration of the opportunity for personal carbon allowances and trading. Given the critical importance of high connection rates in ensuring the viability of community heating schemes, there may well be scope for designing any new allowance system in a way that incentivises high levels of connection.

Another option is the establishment of 'Zero Carbon Zones' – similar to the smokeless zones of 1950s – where owners of public and commercial buildings are required, among other things, to connect to a CH / CHP network. These would also provide anchor loads that enable network extension into residential areas.

Penalising Energy Waste

Around 40% of UK primary energy supply to the total heat and power sectors is lost from UK power plants through heat dumping and electricity network losses. Recovery of substantial amounts of this energy through the development of, for example, CH / CHP, would help to bring about several energy and environmental policy goals.

One important option to achieve this (the recent DTI guidance for plant developers to consider CHP is largely toothless) would be through the introduction of a penalty for energy waste from new fossil-based power stations and from existing plants located near heat loads (the penalty for the former being higher).[xxx] The level of the penalty could be easily linked to the difference between the operational efficiency of the station and a typical CH / CHP or industrial CHP plant. The proceeds of the penalty could be recycled to the energy poor or to catalyse investment in CH / CHP plants.

Stimulating Targeted Public / Private Initiatives

Experience from a number of the UK case-studies highlighted in section 3 suggests strongly that private / public partnership of some form is a pre-requisite for CH / CHP sector expansion. This would require significant carrot / stick incentives both for the private sector, mainly energy companies, and for local authorities. Energy companies must be involved if the target is existing private housing, and local authorities must be involved if there is a requirement for anchor loads from which CH / CHP can be extended into zones of existing housing.

Energy companies could be incentivised by the measures suggested above, while local authorities could be incentivised most effectively by linking their access to central government support to their performance in delivering emissions reduction. If, at the same time, the CH / CHP measures that potentially exist in the government's PPSs and the new Treasury procurement guidelines were enforced, then a substantial local authority participation in low emission projects could be enabled.

A Danish Approach

Given the transformational nature of the proposed changes, the UK government could take some value from an assessment of what the Danes achieved and how they went about it. As section 3 illustrates, however, the approach was based on non-market oriented central and local government intervention and edict – a strategy that is fundamentally inconsistent with current UK energy market operation.

5.2 Options for Change to Existing Mechanisms

We have indicated that major intervention is a necessity given the scale of the challenge, and of the opportunity. This is not to say that 'fine-tuning' of existing measures should be ignored. There are several opportunities for this as a means of tackling existing owner-occupied housing, and they include:

Energy Efficiency Commitments

EEC2 already includes some scope for incentivising CH / CHP but it is fair to say that this has made no discernible impact on market growth. However, the mechanism exists and is a potentially potent means of stimulating the market if the measure is prioritised as part of EEC3 or subsequent phases. Currently, however, it is not clear that any specific priority is given to CH / CHP at all in the EEC3 proposals and thus it is unlikely that there is time to influence the final shape of that phase. Should there be an EEC4, however, then it will be important to ensure that the focus on community heating should be increased.

Energy Supply Regulation

Given the high, or very high, capital cost requirement of community heating systems and the consequent low returns, energy companies have little interest to invest given the ways in which their revenues are regulated. If, however, investment in the community heating network could be included as a part of the regulated asset base (RAB; there is a growing shift towards inclusion of investment as a part of the RAB in order to cover increasing requirements for, for example, sustainable investment) then the whole picture changes.

There is no obvious reason why such a mechanism, which is analogous in some respects to the basis on which communication networks are financed, could not work well. However, securing such a change would require the intervention of DTI and Ofgem, and a convincing case that CH / CHP is able to deliver lower cost carbon emission reductions to the existing housing stock than others measure, and would also presumably involve a financial structure that did not leave the gas supply industry at significant disadvantage.

House Purchase Taxation

The existing arrangements for Stamp Duty present an opportunity to apply tax to house purchases at differing levels that reflect the degree to which the property incorporates low emission measures. If, for example, the house were connected to a high efficiency CH / CHP scheme, this would qualify for a certain level of relief on Stamp Duty, effectively reducing the price of the property for the new purchaser, and facilitating the sale for the vendor.

Other Measures

There is a series of other measures that have some opportunity to stimulate investment in CH / CHP. These, in part, stem from the clear experience so far, both in the UK and other countries, that community heating development can be most cost-effective when designed to serve a mix of both commercial and residential zones, and to be based on high heat demand anchor loads, typically hospitals, commercial buildings, prisons, large leisure centres and, in some cases, schools and universities.

A 2004 Review of the Community Energy Programme[xxxi] highlighted the importance of exploiting mixed anchor loads, as shown in Table 10.

TABLE 10

COMPARISON OF HOUSING-BASED AND MIXED CH SYSTEMS UNDER THE CEP

	Cost Effectiveness of carbon savings	Cost Effectiveness of carbon savings	Cost Effectiveness of CHP	Cost Savings
	Carbon Savings over 25 years relative to Electricity at 0.117kgC/kWh using alternative (usually gas boilers) if appropriate (£/tC)	Carbon Savings over 25 years relative to Electricity at 0.18kgC/kWh and using existing system (£/tC)	£ of grant per kWe CHP (£/kWe)	Whole life cost savings over 25 years, discounted at 3.5% (£ per £ grant funding)
Housing only	112 (25 to 315)	60 (14 to 170)	296 to 3500	1.11 to 4.80
Mixed schemes: universities, hospitals and other public buildings.	57 (8 to 216)	31 (4 to 117)	163 to 487	0.94 to 5.60

These other measures therefore include:

- Enforcement of existing PPS and Treasury guidelines. Section 4 has referred to existing Planning Policy Statements and the new Treasury guidance on public procurement that both create clear opportunity for targeted support for CH / CHP. The responsible departments, DCLG and the Treasury, need to be made aware that follow-up guidance should highlight this opportunity.
- Effective exploitation of public building development programmes as anchor loads. National school, prison and hospital building programmes offer some potential for the creation of mixed use anchor loads that can be extended into residential zones. In general, hospitals offer a much more feasible opportunity for this than schools and university campuses given their higher energy load factors. Up to now, however, the guidance for sustainable development to be taken into account within PFI investment appears to be weak. The 2002 paper, 'Green Public Private Partnerships' is the most up-to-date guidance available and while it cites a relevant 2002 BRE report that applies to community heating ('Energy Services PFI Projects for Community Heating - New Practice Profile 123'), it has not proved possible to access it on the internet. In short, there is great scope for strengthening the

requirements for consideration to be given to the opportunity for CH / CHP as new hospitals are considered.

- Communities England initiatives. This new agency also has the potential to deliver CH / CHP based on anchor load development. CE is a single housing and regeneration agency that combines the functions of the former Housing Corporation and English Partnerships. The government intends that, in England, it will "be tasked with embedding new and innovative approaches to regenerating strategic sites".
- Recognising the potential of ESCOs. There is no UK national standard definition for ESCOs, nor a clear regime for incentivising their creation. However, there are now several examples (including Aberdeen, Southampton and Tower Hamlets) of ESCOs that have been used as the central vehicle for CH / CHP development. It is probable that their wider establishment, based on public-private partnership, will be a pre-requisite for accelerated project investment. The development of a UK standard ESCO structure, together with accompanying financial or regulatory incentives, is one means for achieving this.[xxxii]

6. Conclusions & Recommendations

The key findings of this report, in particular focussing on sections 3 (Case-studies), 4 (the Policy Landscape) and 5 (Policy Mechanisms and Solutions) are summarised below:

Case-Studies

- To a significant degree, most CH / CHP schemes developed to date have depended on securing grant or incentive support. This confirms the view that, in the current market environment and based on current financing models, CH / CHP investment does not appear to be viable.
- The use of non-residential anchor loads, for example in Southampton, Lerwick and Copenhagen, is critical.
- The existence of a committed and persistent community heating enthusiast who is able to see the project through and overcome an array of obstacles, is important.
- The examples of Tower Hamlets and Southampton demonstrate that public-private partnerships are both possible and, potentially, necessary.
- In both Copenhagen and Vienna, policy focus on heat supply, together with significant local authority power and financing capability, enabled community heating investment to be taken forward on a scale which has so far proved impossible in the UK.

The Current Policy Landscape

- With the demise of the Community Energy Programme, there is now no significant policy framework for CH / CHP development that is sufficient to overcome the capital cost hurdles.
- There are also no significant policy or regulatory barriers, the removal of which would stimulate major new investment. Instead, it is the fact that heat itself is not the subject of sufficient specific policy focus by either government or Ofgem that has led to neglect in wider energy policy.

Recommendations - Policy Mechanisms

- Given the very great gap between current installed community heating and the identified potential, we believe that only major policy intervention by central government can bring about the necessary transformation. ‘Tweaking’ of current measures is unlikely to be sufficient to bring about any significant change.
- There are a number of options that the report identifies, including a specific and direct linkage between the use of market mechanisms designed to

achieve climate targets and CH / CHP; and the introduction of significant penalties for energy waste from power stations.

Further Research

To achieve the potential for CH / CHP identified in this report, major policy change is required. To justify this, the benefits of scale investment in CH / CHP will need to be much better understood than they are at present, in particular the carbon benefits. In addition to the policy recommendations contained in the report, some of which are included above, we therefore also recommend that:

- Further detailed research is undertaken to identify the potential for development of CH / CHP for different housing densities, perhaps focusing on 3 – 4 conceptual schemes linking anchor loads to different densities of housing.
- Further detailed research is undertaken to identify the relative costs of carbon emission reduction arising from CH / CHP in comparison with other carbon mitigation options.
- Analysis is undertaken to identify the practical potential for use of power station and industrial waste heat, biomass and energy-from-waste plants for supply to new community heating systems.
- If existing owner occupied housing is to be a focus of CH / CHP policy, research and ideally pilot projects to assess critical issues such as those issues that will determine connection rates, for example customer attitudes towards switching from conventional to community heating supply.

Glossary

BRE	Buildings Research Establishment
CCGT	Combined Cycle Gas Turbine
CH / CHP	CHP based Community Heating
CHP	Combined Heat and Power
CTR	Metropolitan Copenhagen Heating Transmission Company
DCLG	Department of Communities and Local Government
DEFRA	Department of Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EDF	Electricité de France
EEC	Energy Efficiency Commitment
EfW	Energy from Waste
ESCO	Energy Services Company
EST	Energy Saving Trust
ETS	Emissions Trading Scheme
KIIP	Vienna Climate Protection Programme
LZC	Low and Zero Carbon
PFI	Private Finance Initiative
PPS	Planning Policy Statement
ROC	Renewable Obligation Certificate
SDC	Sustainable Development Commission

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[v] The University of Oxford Environmental Change Institute. 2004. *The 40% House.*

[vi] Dalkia website, http://www.dalkia.co.uk/content.asp?page=88.

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[xi] In the pre-community heating / CHP base case scenario, a heat-only boiler with a seasonal efficiency of 65% is assumed to supply heat to the dwelling. We assume grid emissions to be 117g / kWh (DUKES uses 124g / kWh). For the CHP scenario, the 2006 Study assumes use of a CHP gas engine with electrical efficiency 38% and thermal efficiency 42% (these and other efficiency values are gross calorific value). We have assumed that this supplies two thirds of the heat to the dwelling (which is identified by the 2002 Study as requiring 5,906 kWh, 11,004 kWh and 12,487 kWh of heat for a flat, terrace and semi-detached dwelling respectively), with a 90% condensing central boiler supplying the balance. No value is attributed to the CHP plant avoiding grid losses, and no discount is used for losses in the community heating network. The methodology used in the calculations is as follows:

> The net emissions saving NES = A + B – C where:
>
> A is the level of emissions associated with grid-based electricity generation that is displaced by the CHP plant.
>
> B is the level of emissions associated with heating the dwelling, before CHP, with a 65% efficient boiler in the dwelling.
>
> C is the level of emissions associated with heating the dwelling with a mixture of two thirds CHP heat and one third central boiler plant heat. (Note that B exceeds C because the fuel consumed by the CHP plant exceeds that used by the individual boiler; this is more than offset by the savings made through displacement of grid-based emissions (A) by the CHP system).

The share of the base case boiler emissions represented by the emission saving (NES / B) is around 65% (case 1 in the main report), while the share of the sum of base case separate boiler and grid-based emissions represented by the saving (NES / (A+B)) is around 34% (case 2). The former allocates all the carbon savings to the provision of the same amount of heat to the dwelling and, we believe, is the more relevant comparison in this analysis. For case 3, factor A is decreased to the level of emissions associated with the supply of electricity to the dwelling, a reduction of 62% compared to the level of grid emissions displaced by the CHP plant.

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