CREATING THE CONDITIONS THAT FACILITATE THE DEVELOPMENT OF EQUITABLE, LOW CARBON COMMUNITIES IN SCOTLAND

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Increasingly, 'Sustainable Communities' are defined in terms of being low carbon and as vehicles for delivering well-being and equity for users and residents. However, a focus on 'low-carbon' alone could result in limited focus being given to current inequities (i.e. those who are given less) and potentially exacerbate the issues. In this paper we present the results of comparison with two Scandinavian case studies (Denmark and Finland) to draw lessons for the UK in general and Scotland in particular, in terms of specific low carbon 'community approaches' to providing heat. Presented are the fundamental drivers, issues and constraints associated with providing community level heat via decentralized District Heating Networks (DHNs) as a key element of equitable, low carbon communities. The approaches adopted in a number of European countries have delivered tangible outcomes, but what has proven to be a successful route in one country may not be the case in another. The development of heating systems has many implications, in terms of the density of design required, and the impacts on fuel poverty and winter mortality. Stakeholders have an opportunity to consider a range of innovative policy, planning and public private partnership approaches from across Europe to guide future decision-making processes.

Keywords: low carbon communities, district heating, combined heat and power.

INTRODUCTION

The UK Department for Environment, Food and Rural Affairs (DEFRA) defines how sustainable communities should embody the principles of sustainable development, that they should be well-run, have due regard for the needs of future generations and minimize climate change (DEFRA, 2005). In terms of climate change the Royal Commission on Environmental Pollution (RCEP) describes how the built environment has a significant impact, with buildings responsible for more than 45% of total UK CO2 emissions (RCEP, 2007). Domestic dwellings account for 27% of the total emitted and with a view to future impacts, more than two-thirds of the domestic dwellings that will be standing in 2050 have already been built.

Positive action to upgrade the existing stock of homes is therefore needed, representing a major challenge, but one which if successfully addressed has the potential to significantly influence how the UK and Scottish targets of 80% reductions in CO2 emissions by 2050 can be met. As Figure 1 shows, unaltered CO2 emissions

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from existing stock dwarfs those that will be generated from new build. In this context, the RCEP emphasizes the importance of reducing energy demand and CO2 emissions by improving insulation and supplying the residual energy demand from renewable sources.

This research therefore considers the experiences of two north European countries (Denmark and Finland) with respect to providing low carbon heating, in particular to residential properties. It considers development densities, District Heating Networks (DHNs) and explores issues related to equity, comparing these to the UK in general and Scotland in particular. The importance of local authorities is examined, for example the policies and development densities being permitted (in particular for housing). Such densities can provide a fundamental barrier or opportunity for the incorporation of DHNs and there is the possibility that current design/planning approaches (philosophies and policies) in some parts of Scotland and the UK are compromising the potential to install these now and in the future.

Combined Heat and Power (CHP) technologies can be efficient ways of generating heat from low carbon, renewable fuels, with economies of scale realized for larger developments (for example those associated with DHNs), making them more attractive investment propositions. The residual energy demand to be met by such systems is driven by the insulation characteristics of buildings, and this is considered from an equity perspective, specifically focussing on winter mortality rates in north European countries and fuel poverty in Scotland.

Local authorities again have a potentially important role to play, to support and facilitate the development of CHP DHNs, and a number of mechanisms to facilitate their involvement are described.

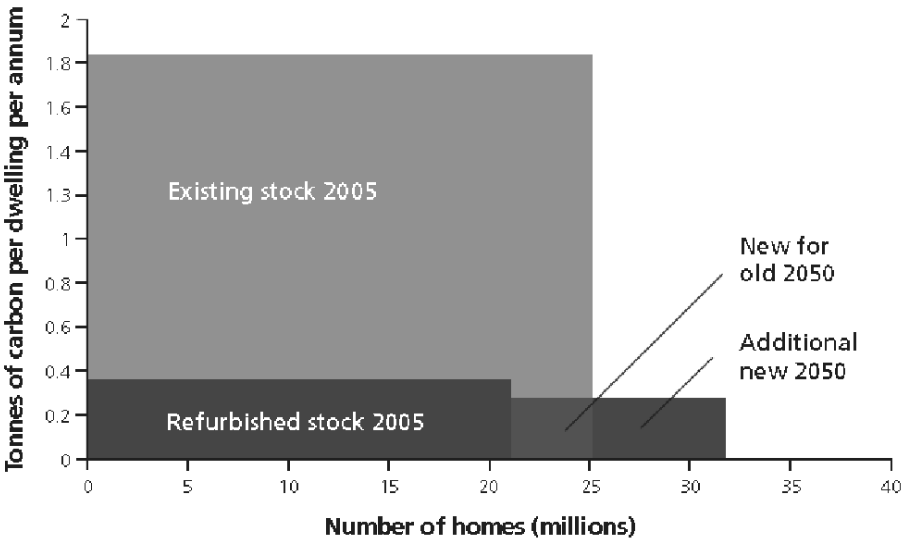

Figure 1. CO2 emissions from refurbished and new-build housing in a scenario achieving 75% CO2 reductions by 2050 (source: RCEP, 2007).

DEVELOPMENT DENSITIES AND THEIR IMPACTS ON THE POTENTIAL TO CREATE LOW CARBON COMMUNITIES

A comparison of densities for specific case studies is provided in Table 1 (adapted from CABE, 2005). The Table incorporates two well known sustainable community case studies of Hammarby Sjöstad (Stockholm) and Vauban (Freiburg), with 145 and 90-100 DPH respectively. These are often referred to as good practice, low carbon case studies, both incorporating DHNs. The UK projects shown have lower DPHs, but with the exception of Milton Keynes, are still higher than those recommended by the RCEP to make DHNs viable and demonstrate that delivering the required densities does not involve undertakings which are unusual in a UK context.

Table 1: Summary of development densities for different types of community

Development	Units/Ha	Persons/Ha
Milton Keynes average, 1990	17	68
Average net density, London	42	168
Sustainable urban density	69	275
Victorian Edwardian terraces – Hertfordshire	80	320
Vauban, Freiburg (http://www.vauban.de)	90-100	360-400
Hammarby Sjöstad, Stockholm	145	580

Net densities of 100 people per hectare (or about 40-50 dwellings per hectare) have been recommended as minimum densities for CHP district heating (RCEP, 2007) with their use more viable in high density urban areas than in low density suburban or rural areas. In terms of wider UK guidance on density, Planning Policy Statement 3 (Housing) for England states that 30 dwellings per hectare (DPH) should be used as a national indicative minimum to guide policy development and decision-making, until local density policies are in place.

In Scotland, the country's most populous local authority, Glasgow City Council's (GCC's) policy on residential density (RES 1) states that higher density development may be appropriate to the city centre and inner urban areas, with a range of 30 DPH minimum to a maximum of 100 DPH. Higher densities (more than 75 DPH) may apply to some outer urban areas as well. However, generally, lower densities are described as being more appropriate to outer urban areas, up to a maximum of 50 DPH for a base level of accessibility and in the range 20 to 75 DPH for higher accessibility areas.

GCC's policy on densities was not established with DHNs as a core objective. However, understanding the potential is important in particular if future policy shifts in favour of CHP DHNs, as currently set out in the "Sustainable Glasgow" plans (GCC, 2010). Glasgow suffered from a post Second World War development programme of high density housing estates, in particular developed in the suburbs. Many of these developments which became known as problem estates meant that policy moved towards different kinds of ownership and rental models at lower densities. However, schemes such as the critically acclaimed Crown Street development in the Gorbals area recreated the original urban grid pattern (prior to regeneration projects of the 1950s and 1960s) and achieved relatively high densities of 110 DPH. The emphasis of the new scheme has been described as high quality design and good maintenance (James, 2007). Research in this area has shown that there is no correlation between urban quality and density (Llewleyn-Davies, 2005):

"The recommended approach is design-led, concentrating on sustainable urban quality. Market considerations influence many of the housing forms and this, together with the design-led approach, makes density a measure of the product, not a determinant of it."

Llewllyn-Davies produced a summary of average DPH densities, based on a number of case studies, which were recommended as a guide for future development. These excluded the development of detached and linked housing in central and urban locations, with DPHs of such units varying from 30-65. For terraced housing this increased significantly, with the highest range being 55-175 DPH for an urban setting. For flats the highest DPH was 240-435 in a central setting.

DISTRICT HEATING NETWORKS IN EUROPE

Finland

Overall, one-fifth of the country's power generated is used to heat buildings and in the cities about 80% of buildings are connected to DHNs (Powergen, 2010). In Helsinki Powergen describe the situation as one which is now approaching saturation point, with 93% of buildings connected to a DHN. In Finland, DHNs are installed in almost all towns and population centres (Energiateollisuus, 2010), providing heat to 2.6 million people. In the largest towns, district heating accounts for a market share in excess of 90% and accounts for 50% of the total heating market. 95% of apartment buildings and most public and commercial buildings are connected. However, for detached houses, just over 6% of heat energy comes from these networks. According to Energiateollisuus (energy supply company) the more densely built the area and the larger the buildings, the more economical district heating is.

Helsinki Energy produces over 90% of the city's heat demand using CHP units, with more than 93% of buildings connected to the DHN (C40, 2010). Electricity generated from these CHP units exceeds the city's demand, with the result that excess energy is sold into the Nordic market, generating revenue for the City council. In the summer Helsinki temperatures reach an average of 21°C in the afternoon, and for the other half of the year daytime temperatures are less than 10°C. The need to heat buildings is therefore described by Helsinki Energy as being almost a year-round activity, making the city, like the rest of Finland, a viable location for CHP DHNs. In 2007, CHP provided 29.7% (26.8 TWh) of the country's electricity demand, more than half of that (14.4 TWh) associated with DHNs. This is a situation which has helped the country to reduce its dependency on imported fuel. Thirty years ago 90% of the heat produced by district heating and CHP plants was generated by burning coal and oil. Today these fuels are less than 40% of the feedstock, having been largely replaced by lower carbon options such as peat, wood and natural gas.

Denmark

In the 1970s Denmark, along with Japan, was one of the two developed countries most dependent on imports of fossil fuels in the world. The oil shortages of that era had a significant impact on the country, to such an extent that it developed policies to ensure that it moved towards increasing energy self-sufficiency in particular up to the period 2000. Danish Energy policy development goals (including security of supply) have, since the 1970s, focused on reducing import levels of fuels; and on reducing environmental impacts, including CO2 levels (Christensen, 2009).

Through the development of the Heat Law in 1979 (a Heat Supply Act) the objective was set of raising district heating market share to 60% of demand (by 2000). Central government issued guidance, supervised the planning process and approved plans. Local authorities were given responsibility for the heat planning process and together with the energy utilities and supply chain began work on the development of a new infrastructure, initially targeting natural gas. Soon after the focus moved to decentralized, co-generated heat and electricity systems using biomass and wastes as a fuel source. This was supported, in 1988 by bans on the installation of electric heating systems in new buildings, followed in 1994 by a ban on the installation of electric heating systems in existing buildings with water-based central heating systems.

The results of Denmark's heat planning initiatives have been transformational, with the country spending $5.2 billion (US dollars) in 1981 on imported fuel stocks, compared to raising $6.1 billion in revenues from exporting oil, natural gas and a small amount of electricity in 2006 (Christensen, 2009). This is in the context of Denmark's economy growing 80% in the same period (in terms of Gross Domestic Product), with a virtually unchanged level of energy consumption. Denmark has moved from being 98% dependent on imported fuel, to being the only country in the EU self-sufficient in energy. District heating schemes were installed to supply the majority of Danish households, meeting the 60% target mentioned above, and with almost half of all electricity supply being generated by CHP. The contribution of biomass and wastes as a feedstock for district heating schemes has increased by 300% to a total share of approximately 46%.

EQUITY IMPLICATIONS

Heating and mortality rates

The UK has 25,000-40,000 more deaths in winter than the summer months (UK Parliament, Environment, Food and Rural Affairs Committee, 2009), higher than for a number of other European countries with similar or even colder climates. Excess winter mortality is defined as the number of additional deaths during the winter season (December to March inclusive) compared with the average for non-winter seasons (Healy, 2003). In England, mortality rates are 19% higher in the winter than in the summer and 16% higher in Scotland. Healy compares this with other countries, where the percentages are 13% in Finland, 12% in Sweden and 12% in Denmark. The necessity (for survival) to ensure effective insulation in Scandinavian climates which are repeatedly, year on year, colder than other parts of Europe, appears to ensure that lower winter mortality rates result. The UK Parliamentary Committee comments that low energy efficiency levels of many English homes is a factor in the situation there. Healy considers data on domestic thermal efficiency to identify if there is an empirical relationship between variations in seasonal mortality and different housing standards across a range of EU countries. The results are summarized in Table 2.

Table 2: Coefficient of seasonal variation mortality (CSVM) and domestic thermal efficiency in European countries.

Country	CSVM	Cavity wall insulation (% houses)	Roof insulation (% houses)	Floor insulation (% houses)	Double glazing (% houses)
Denmark	0.12	65	76	63	91
Finland	0.13	100	100	100	100
Ireland	0.21	42	72	22	33
Portugal	0.28	6	6	2	3
Sweden	0.12	100	100	100	100
UK	0.18	25	90	4	61

The Table shows that the percentage of dwellings in Sweden and Finland with cavity, roof and floor insulation, along with double glazing significantly exceeds that in countries such as the UK, Ireland and Portugal (Denmark also performs well in most categories). A correlation between housing standards and mortality rates does therefore appear to be a possibility on the basis of this data.

Fuel poverty in Scotland

A person is in fuel poverty if they need to spend more than 10% of their income to afford adequate energy services – a warm and well-lit home being an example of this.

Extreme Fuel Poverty can be defined as a household having to spend more than 20% of its income on fuel. Based on data from the 2009 Scottish House Condition Survey, in 2004/05, 18% of households (419,000) were in Fuel Poverty in Scotland, a figure which increased in 2005/6, 2007 and again in 2008. 27% of households (618,000) were in fuel poverty in 2008.

The number of households living in extreme fuel poverty also increased over the period 2002 to 2008. In 2002, 3% of households (71,000) were living in extreme fuel poverty, a figure which rose to 8% (182,000) in 2008. Table 3 summarizes the situation, doing so by showing the number of fuel poor households in terms of the type of heating used. This shows that almost 27% of households are living in fuel poverty, with the majority using gas fuelled, central heating systems. The survey also indicated that people living in tenements are least likely to be in fuel poverty, with those living in low density, detached housing most likely. A third of households in detached houses are fuel poor compared with 23% of tenement dwelling households. The figure is approximately 25% of households living in semi detached, terraced and other flats. Households heated by electricity are, according to the data in the Table, almost twice as likely to be in fuel poverty as those using gas. In addition, significant improvements to the energy efficiency of the existing social housing stock has meant that Fuel Poverty is now more prevalent in the private sector than in the social rented sector (GCC, 2009).

The options for improving equity in Scotland, by reducing fuel poverty, require further research to establish the extent to which improved insulation programmes could address this, and to what extent sustainable heating systems should then supply residual heating demand. This research would identify the most appropriate low carbon, equitable solutions for existing dwellings (e.g. in terms of providing biogas, CHP DHNs, individual household systems etc., considering how new development could complement this, for example by providing more viable DPHs which make investment in DHNs more viable (as discussed in Section 2).

Table3: 2008 Fuel poverty by heating fuel characteristics (000s)

	Not Fuel Poor		**Fuel Poor**		**Extreme Fuel Poor**		**Total Sample**	
Heating Fuel	**000s**	**%**	**000s**	**%**	**000s**	**%**	**000s**	**%**
Gas	1,389	59.6%	285	12.2%	117	5.0%	1,791	76.8%
Oil	73	3.1%	35	1.5%	19	0.8%	127	5.4%
Electric	220	9.4%	107	4.6%	38	1.6%	365	15.7%
Other fuels	30	1.3%	11	0.5%	8	0.3%	49	2.1%
Total	1,712	73.4%	438	18.8%	182	7.8%	2,332	100.0%

District heating costs and fuel poverty: European comparison

It is difficult to reach conclusions on the contribution of DHNs in other European countries, in terms of either alleviating or exacerbating fuel poverty, with very limited data available in this area. Many of Denmark’s DHNs are still fuelled by natural gas, although the country is increasingly working to reduce gas consumption with more sustainable, low carbon options. The prices of gas per kWh (annual consumption of 15,000kWh/year) for domestic customers (including tax and duties) in a number of EU countries (4th May 2010 prices, in Euros per kWh), are summarized below (Source: Europe’s Energy Portal):

- Denmark: €0.117
- Finland: €0.108

- Sweden: €0.120
- United Kingdom: €0.041

These prices indicate that consumers in the UK are currently paying one-third the price paid by a number of Scandinavian countries for natural gas. In Denmark DHN consumer prices average €2,000 for the consumption of 18.1 MWh/year, which amounts to €0.11 per kWh and is approximately 3% of average household incomes (Christensen, December 2009). It should be noted that this compares to a lower annual gas consumption in Scotland of 15MWh/year (BERR, 2007).

District heating schemes in countries such as Denmark are described as providing cost savings compared to individual boilers e.g. on average DHN consumers in the larger cities pay approximately half the price paid by consumers using individual boiler or electric systems (Christensen, 2009). More widely across the country, it is commented that DHNs produce a lower cost option for 98% of Danish consumers. In terms of comparison with individual heating systems this can be summarized:

- 97% of all district heating consumers pay less for their heat compared to heat from household-based oil stoves.
- 87% of DH customers pay less than the cost of heat from individual natural gas boilers (Jan.-Sep. 2008).

However, the charging structure for DHNs indicate that there is a higher unit charge for energy (gas and district heating) in Denmark compared to the UK. The impact this has in terms of a comparison on fuel poverty is not clear. Winter mortality rates, as discussed earlier, are lower in Denmark, but this may be a result of the improved levels of insulation described.

POTENTIAL MODELS FOR FACILITATING EQUITABLE LOW CARBON COMMUNITIES

Decentralized, CHP installations and DHNs are not as widespread in Scotland and the UK as they are in countries such as Denmark and Finland and a lack of experience in such installations has been identified as a key barrier to future investment in the UK (Pöyry, 2009). A comparison highlights that estimated cost of UK civils works are more than double those in other EU countries with more experience. The barrier is further heightened by what would anyway be relatively large, up-front investments to install CHP DHNs (with significant financing implications and risk). Local authorities are identified as particularly strategic partners, able to assist developers to construct lower-risk DHN business models by:

- Providing the relevant planning powers and ability to coordinate between developers and consumers.
- Enabling relationships with controllers of large heat loads (e.g. social housing groups, NHS Trusts, public buildings etc.

There are currently no similar legislative developments to the Danish Heat Law planned, nor are there regional planning initiatives being considered as part of a strategic analysis approach to planning decentralized CHP DHNs in Scotland. GCC, with the "Sustainable Glasgow" initiative, has gone further in this respect (a strategic planning perspective) than any other city or town in Scotland. One of the proposals made by the Council (GCC, 2010) to both the UK and Scottish Governments is that legal powers for district heating zones should be strengthened to include:

- Power for local authorities to compel connection to a DHN in a designated zone.
- Power for local authorities to compel large commercial and industrial concerns to sell waste heat to DHNs, with the creation of an entity (potentially a public private partnership) to raise capital, develop, own and regulate DHNs.
- Removal of legal restrictions on local authorities to act as energy companies.

Following the Local Government Act 2003 local authorities were enabled to use powers which assisted them in delivering well-being in their communities. The Energy Savings Trust (EST) in a briefing paper for England described how similar leglization means that Councils there should regard this as a “Power of First Resort” (EST, 2006). In effect the aim is that rather than searching for a specific power in the statutes, in order to take a particular action, councils can instead look to their well-being powers. This is described as giving local authorities the power to (but is not limited to) give financial assistance as well as to enter into arrangement or agreements.

This power is described as providing an opportunity for certain local authorities to enter into trading agreements or arrangements with any person for the provision of services on a commercial basis if the purpose is to promote well-being. It would seem reasonable to include fuel poverty and winter mortality as important aspects of this. Woking Borough Council (http://www.woking.gov.uk) describes how energy efficiency is the key to its Climate Change Strategy and how using energy more carefully will reduce C02 emissions and promote sustainable development and well-being. Woking Town Centre CHP station is a commercially operating energy station, the first project of Thameswey Energy Limited, a joint venture company of Thameswey Limited (a company wholly owned by the Council) and Xergi Limited.

SCOTLAND AND FUTURE INFLUENCES

In March 2007, the then Scottish Executive published ‘Achieving a Low Carbon Building Standards Strategy for Scotland’ (the Sullivan Report), setting out the first Energy Efficiency and micro-generation Strategy. The targets described were that net zero carbon new buildings (i.e. space and water heating, lighting and ventilation) should be built by 2016/2017, if practical. This is supported by changes to the Building Standards, which mean that from late 2010 new buildings will be required to emit 30% less CO_2 than required by 2007 standards. The 2013 standards will then require 60% savings compared to 2007 standards, with the ambition of total-life zero carbon buildings by 2030. For existing buildings the Sullivan Report recommended:

- There should be consideration of developing practical performance standards aligned with the Energy Performance Certificates.
- The building regulations should continue to set the minimum standards that apply to new work on existing housing stock.

Individual households (rather than flats) outwith social housing programmes are the most heavily impacted by fuel poverty and winter mortality. However, Scandinavian countries have shown a way forward, in terms of the importance of insulation levels which can overcome winter mortality, if not fuel poverty. One of the potential, future policy initiatives which will support innovation is the proposed UK Renewable Heat Incentive (RHI) scheme, which at the time of writing is undergoing consultation, with a potential implementation date of April 2011. The RHI will result in payments being made for a wide range of renewable heat installations, depending on the type and scale of technologies involved. One aspect of this which requires further research is the extent to which the RHI will incentivize the installation of individual household approaches to low carbon heating, compared to larger scale DHNs.

CONCLUSIONS

Scotland can learn from the actions taken in neighbouring countries, to deliver equitable, low carbon communities. However, this is not to say that the approaches taken elsewhere should be replicated. Countries such as Denmark and Finland have provided heat infrastructure for their communities using DHNs for a number of decades, while Scotland has gone down a different route. The retrofitting costs for existing communities, to install DHNs widely across the country would be significant, as well as potentially unpopular if communities were not key stakeholders in the process. Future research should broaden the comparisons, by considering a wider range of countries in terms of their socio-economic positions, for example from Central Europe, to explore how efforts to achieve greater sustainability with lower levels of GDP are performing.

Raising the finance to invest in DHNs, in the current fiscal climate, where pressure will increase on public bodies to make cuts in spending may mean that the timing is right to increasingly consider innovative public-private partnerships to deliver equitable, low carbon heating solutions to communities. Developing these solutions, and understanding the strengths and weaknesses of competing options requires research into appropriate organizational structures, funding mechanisms and appropriate actions, including technology identification, for site specific circumstances.

High density housing improves the viability of DHNs as a low carbon heating option and an area for future research could be to establish if synergies can be developed which allow this type of development to support the introduction of CHP DHNs to existing low density housing, for example those with fuel poverty issues. The situation of more than a quarter of Scotland's households being in fuel poverty, coupled with it being amongst a group of countries with the highest levels of winter mortality rates in Europe, should require that equity considerations underpin future housing development in the country.

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