Local Energy Assessment Fund

Community Heating Study

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Contents

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Executive Summary

Purpose of this Study

This work has been commissioned by the Carbon Coop as part of their ongoing work with their members and the wider community to encourage low carbon energy interventions. Potential financial returns from low carbon energy generation are a key concern, since the Carbon Coop's model for financing of Whole House Retrofit relies in part on cross-subsidy as well as 'Pay as You Save' financing to achieve the full 80% reduction by 2050 retrofit target (17 $kgCO_2/m^2.a$ and 120 $KwH/m^2.a.$).

The purpose of this study is to understand whether sufficient financial returns could be made from the retrofitting of community heating systems to help cross-subsidise low carbon retrofit measures. This was prompted by informal industry reports of double-figure returns on district heating following the introduction of the Renewable Heat Incentive (RHI). The aim was also to develop a methodology to assess the viability of retrofit community heating schemes in primarily residential contexts, so that the Carbon Coop could use this as part of future work on carbon reduction in neighbourhoods across Greater Manchester and beyond.

However, the Carbon Coop do not see financial returns from the Renewable Heat Incentive as a priority that excludes consideration of fuel poverty, improved energy efficiency and overall reduced carbon emissions. This report therefore considers the implications of community heating networks for these issues too, so that the Carbon Coop and others can make a more informed decision when considering investment in community heating networks.

Using real-life case study examples, the potential for retrofitted community heating networks has been explored in different contexts; a relatively recent high density mixed use development, high density mid-20th century apartment blocks, small terraces and larger suburban semi-detached housing.

Key Findings

- The RHI is structured so that the maximum returns can be gained from the lowest level of the pricing 'tier'. This encourages the development of schemes which meet this criteria, but which may not necessarily be the most effective approach in terms of energy efficiency, capital cost and reduced carbon dioxide emissions.
- The RHI appears to pay for investment in new heat production where distribution infrastructure already exists and management is simple. It doesn't seem to pay for retrofit of new distribution infrastructure and management in existing urban areas at its current rate.
- Heat demand has a significant influence on returns. As the energy efficiency of buildings improves, thereby reducing heat demand, the returns from the RHI reduce.
- There is an inherent conflict between community renewable heat schemes, which must maximise energy use to improve returns and system efficiency, and the building retrofit agenda, which aims to reduce primary energy demand whilst also improving thermal comfort and mitigating issues of fuel poverty.

- Were the financial conflict between the needs of community heating systems and whole house retrofit to be overcome, there would still be a fundamental energy problem in that as heat demand reduces the parasitic losses of a system increase.
- New investment in solar thermal systems appears to be supported by the RHI, provided it is sized adequately to match an appropriate level of demand. If only providing hot water, this has the advantage of not being in conflict with any energy efficiency improvements to the built fabric.
- The capital costs of community energy schemes, especially distribution networks and the heat interface units for each property, can be high. This may be an area for further investigation and returns on the RHI may improve as capital costs reduce and the market develops.
- There is a need for community and management buy-in in all cases. This can be much more difficult when ownership and management is dispersed. For example in a mixed-tenure neighbourhood the implementation of a scheme may require negotiations with owner occupiers, private landlords and tenants, social landlords, the local authority and utilities companies. It is unlikely that this process will be worthwhile where returns on investment in terms of finance, carbon and energy are marginal.

Carbon Coop

The findings of this study suggests that there is little room in the returns from the RHI on community energy schemes in existing residential areas to cross-subsidise whole house retrofit. In addition there is an inherent conflict in both financial and carbon and energy use reduction terms between community heating and whole house retrofit. With the primary aim of the Carbon Coop being to help its members reduce their carbon emissions, whilst helping to fund whole house retrofit, this suggests that the retrofitting of community heating systems should only be pursued by the Carbon Coop in very particular circumstances - where distribution infrastructure is already in place and implementation and management is straightforward.

As an organisation which also aims to improve the health and social wellbeing of its members, the implications of maximising returns from community heating for fuel poverty and thermal comfort should also be considered. Given the findings of the parallel study on whole house retrofit that many people are already under-heating their homes, resulting in problems with damp and condensation, this is potentially a major issue for members. Under-heating of homes would also reduce financial returns for any scheme, as heat demand is reduced from that predicted at the scheme planning stage.

Community energy schemes seem to provide more promising returns in areas of high density where there is a relatively simple management structure. Given that the Carbon Coop so far has mainly focused on individual residents of single homes or apartments, it may require a change of approach for the Carbon Coop to get involved in this area.

Where the Carbon Coop can perhaps make the biggest contribution to worthwhile community energy schemes is in the engagement, education and pre- and post-completion support and monitoring that will be required to make these schemes a success, as a trusted organisation with expertise in this area.

Introduction

Why community heating?

With the release of the national Heat Strategy and Heat Mapping for the UK, district and community heating is currently being promoted as an approach with significant potential to contribute to the de-carbonisation of heat in buildings[1]. This means moving away from the current model of heating buildings, in which fuel, most commonly natural gas, is burnt on site to create heat. Instead, as is common in many towns and cities across northern Europe, heat production takes place at a community level, with heat piped to individual buildings. Though still uncommon in the UK, this has become a more popular solution in new build developments with high environmental ambitions, particularly when coupled with a lower-carbon fuel such as biomass (wood).

A major driver in this move to district and community heating is the introduction of the Renewable Heat Incentive. This mechanism was launched for commercial and community projects in 2011 and is similar to the 'Feed in Tariff' for low carbon electricity. Generators of 'renewable heat' from sources such as solar thermal and biomass are paid for each kilowatt hour of energy they produce. Different rates apply for different technologies and sizes of system. This payment is set to help overcome some of the financial barriers to developing such schemes.

For community heating systems to be worthwhile, there needs to be sufficient demand for the heat that they produce to justify the costs of the infrastructure required to distribute this heat. This is commonly referred to as heat density. The greatest levels of heat density are usually found where building density is also high, or where there are many large and poorly insulated buildings or uses such as swimming pools which require continuous heat.

There is an inherent tension between heat density and building fabric energy efficiency retrofit measures. As the energy performance of a given set of buildings improves, the demand for heat, and therefore the heat density, also reduces. This means that for the same or similar level of investment in infrastructure, to pipe the heat to each of these buildings, the return on this investment is likely to be reduced. The best returns on investment would be achieved in poorly insulated buildings, but this would conflict with a desire to improve the internal environment and thermal comfort and, depending on the cost of fuel, also with the potential to combat fuel poverty. This has implications for the Carbon Coop business model, which proposes a financial mechanism for whole house retrofit based on a Pay as You Save model with any shortfall topped up by cross-subsidies from low carbon energy generation - in this case the Renewable Heat Incentive.

The fuel source for these projects must also be considered. To qualify for the Renewable Heat Incentive, a low carbon fuel such as biomass or solar thermal must be used. Whilst solar thermal can make a contribution to hot water energy demand and some space heating demand in spring, summer and autumn, an auxiliary heating source is still required in the winter months. This study has therefore focused on biomass as a potential fuel source, with solar thermal as a potential secondary source. The biomass fuel supply chain in the UK is still under-developed, though has improved dramatically in recent years. However, the supply will always ultimately be constrained by the amount of land available for growing fuel crops. The UK's entire heating demand could never bet met with biomass sources alone, and for this reason the choice of biomass as a fuel should be carefully considered. The potential impact of burning fuels on air quality in urban areas should also be considered, with NOx emissions from biomass burning plant a particular issue.

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[1] DECC (2012) 'The Future of Heating: A strategic framework for low carbon heat in the UK' available at http://www.decc.gov.uk/uk/en/content/meeting_energy/heat_strategy/heat_strategy.aspx

In addition to these technical and financial considerations, community heating networks can be difficult to implement due to organisational, managerial and ownership issues. On a street of houses, a system will operate most effectively if all of the householders sign up to be supplied with heat, so that the use of the infrastructure is maximised. There are also ongoing costs for billing and maintenance, which must be shared amongst the users. This is a new way of doing things for many people in the UK, and it is likely that it will take time for it to be accepted.

The Carbon Co-op

The Carbon Coop is a Manchester based community benefit cooperative, which brings its members together to explore how they can best improve their environmental impact and promote the development of carbon reduction measures. They are currently building on the idea of a 'Community Green Deal', developing an approach to whole house retrofit that is community led. They have taken the 2050 carbon reduction goal as tan absolute target for these retrofits (17kgCO_2/m^2.a and 120kwh/m^2.a primary energy), as used in the Technology Strategy Board Retrofit for the Future programme and adopted in the Greater Manchester Retrofit Strategy. This is both seen as more equitable, meaning each household arrives at the same point no matter what their starting point, and means that reductions made in the residential sector are in line with the UK's overall commitments in the Climate Change Act 2008 [2]

As a mutual model it benefits from being controlled by those it provides services and advice to - thereby helping to overcome the trust issues so often cited as a reason for people to mistrust advice given on home improvements. This structure also helps to facilitate a peer-learning process among its members. For example in whole house retrofit those 'pioneers' are able to share knowledge about what measures work best, and what the process involves with those who follow-on. In addition, if members are able to work together to increase their purchasing power they can bring down the costs on products such as wall insulation, solar panels, or highly efficient appliances. The Carbon Coop has a sister organisation in the 'Carbon Re-Investment Society' (CRIS). This will provide financing services for low carbon investment in energy efficiency and renewable energy. As a mutual with no shareholders to satisfy, this should provide trusted and low cost finance. Financial modelling has shown that funding retrofits which achieve the above target solely through a 'pay as you save' mechanism compliant with the 'golden rule' that loan repayments come to less than the savings on utility bills will not suffice. The Carbon Coop is therefore investigating other ways of making a return to cross-subsidise this, whilst also furthering the development of a low carbon economy.

This report seeks to determine whether and in what circumstances a suitable return can be made through investment in community and district heating networks through the Renewable Heat Incentive, and in doing so develops a model for assessing the viability of community energy schemes. However, financial returns are not the sole consideration - the energy and carbon emissions implications of schemes, and the effect on the well-being of households and communities, are also considered.


Renewable Heat: Biomass (woodpellets) and solar thermal collectors.

[2] available at http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx

Methodology

Case Study Selection

A case study approach was taken, so that the sometimes abstract modelling of heat demand and returns could be grounded in a concrete reality. Four case separate case studies were chosen to examine the potential for community heating. These were all within Greater Manchester, in neighbourhoods which the Carbon Coop have either already worked with or where there are active potential partner organisations to the Carbon Coop. They were chosen to examine a range of built forms, ages and densities of residential development. The case study sites include a recent high-density mixed use development, a set of walk-up inner urban apartment blocks, an area of small and dense terraced housing, and an area of larger semi-detached housing on a suburban layout. These are all quite common and representative forms of development in Manchester and across the UK as a whole, and so whilst the findings of this study are particular to these case studies, they should have relevance to many other neighbourhoods.

Site Visit

A site visit was carried out to examine the physical condition and wider context of each of the case studies. This real-world context mitigated the 'optimism bias' sometimes present in solely desk-top studies, as the complexities and implications of siting and routes for the infrastructure associated with community heating could be more fully understood.

Heat Demand

Current heat demand in the apartment block, terraced housing and semi-detached housing was taken from SAP calculations carried out for homes in the areas as part of a parallel study on whole house retrofit assessment. Where appropriate in each of the case studies, a series of different heat demand scenarios were tested. Starting with the base-case existing condition, different levels of energy efficient retrofit were tested. From a 'light retrofit' to comply with Part L 2006 to full PassivHaus. Different combinations of technology - solar and biomass - were also examined where appropriate. This was felt to be important because of the conflict noted above between energy efficiency, returns from district heating and system efficiency.

Cost and Payment Data

Cost Data was provided by a quantity surveyor with experience of district and community heating and checked where available against other published data. Fuel costs were assumed and the latest version of the payments under the Renewable Heat Incentive was used. (This is the area in which it proved hardest to find consistent data, probably due to the small size of the market in for district heating in the UK at present).

Model Development

An initial feasibility model was built to establish the broad returns available and the scheme parameters which would present best value. In almost all cases it was found that the boiler should be sized to obtain RHI from the first 'tier' of the pricing structure. This is equivalent to a maximum boiler size of 200kWth. This finding influenced the modelling for each of the individual cases, and scenarios were built to take advantage of this. This model was then built into a set of scheme specific case studies based on the above data. The models included scheme specific data for capital and operational costs, system efficiency and parasitic energy demand. General assumptions were made on fuel costs and inflation which remained consistent throughout all variations. A set of graphs were produced to illustrate the findings of the model for each case where different scenarios were tested.

Modelling assumptions:

Equipment		
Biomass boiler efficiency	90%	
Baseline boiler efficiency	92%	
Fuel cost		
Biomass	£0.035	
Gas	£0.040	
Electricity	£0.011	
Inflation		
Retail Price Index	2.0%	
Fuel price inflation (common to all fuels)	5.0%	
Maintenance cost inflation	2.0%	
Costs		
Admin, billing and bad debt	11%	of fuel costs
professional fees	5%	of installation costs

Community Engagement

The early findings of each of the case study models was presented at community engagement events in each of the neighbourhoods in March 2012. As well as raising awareness about the Carbon Coop and the potential for low carbon initiatives, these events meant the team could get a feel for the level of understanding and likely level of 'buy-in' for community heating in each neighbourhood. This is important given the need to maximise connections to maximise the efficiency and effectiveness of any system.

Above: One of the several community engagement events held as part of this study.

Case Study One: 'The Yellowbricks'

Description and Context

Homes for Change and Work for Change occupy a building which was built in two phases as part of the Hulme redevelopment in the mid and late 1990s. It consists of ground and first floor workspaces to the north of the block, with residential accommodation above this to six stories. The southern part of the block, 'phase two', is four-stories of residential development with as yet undeveloped workspace on the ground floor facing Old Birley Street. They were constructed to exceed the regulations on energy efficiency in force at the time, with 100mm of cavity insulation and high performance windows. The residential accommodation is served by high efficiency individual gas boilers. The workspace is on a communal heating system with a single boiler which is coming to the end of its useful life. The building was developed by a housing cooperative in partnership with a larger housing association. It is now managed by two fully mutual cooperatives: 'Work for Change' covers the workspace element, and 'Homes for Change' manages the residential accommodation.

Location: Old Birley Street, Hulme, Manchester

Description: mixed-use development

Number of dwellings: 75

Dwelling Size: varies

Density: 125 dwellings per hectare

Area of workspace: 15,000 sq.ft.

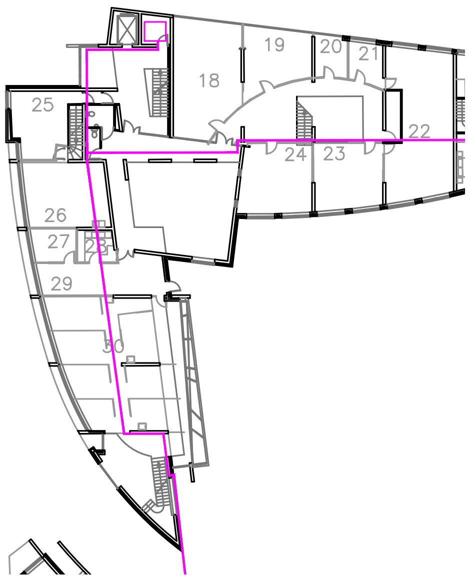
Aerial Photo showing the courtyard block form of Homes for Change. The workspaces of Work for Change are in the north-west corner

Technical Assessment

The building was originally constructed to a high level of energy efficiency, far beyond what was required at the time by the regulations. Therefore, despite the high residential density of the development, its heat density is relatively low. The layout of the building is relatively complex, with irregularly stacked forms and roof terraces. The residential apartments that form the bulk of this building were built to have individual heating systems. There are very few existing ducts or service runs in the residential parts of the building that would be able to accommodate the infrastructure associated with a community heating system. The shape of the building, arranged around a central courtyard, also means that the runs of any new infrastructure would be lengthy. In contrast, the workspaces are already on a centralised system, with a mains gas boiler that is coming to the end of its serviceable life. They are all located in a relatively compact area of the building, on the ground and first floors of the north-west corner of the block. There is also an unused bin store in which the new boiler and a hopper for the biomass fuel could be housed.

The plan to the left shows the layout of the whole of the block, and the length of network that would be needed to connect it.

The plan to the right shows the more compact work for change only scheme.



Social and Management Assessment

The building is managed by two separate cooperatives, one for the workspace and one for the residential units. At present there is very little overlap between these two organisations. The residential occupiers each have their own account with a gas supply company to provide fuel to the boilers which heat their homes. It is uncertain whether many residents would be willing to change from this arrangement, as only one of the residential occupiers of the building attended the community engagement event. A social landlord would probably have some difficulty engaging their residents in this, and the situation is perhaps more difficult when the landlord is made up of its tenants. In addition, the ability of social landlords to carry out this kind of work depends on their access to finance and their ability to raise repayments through a non housing benefit qualifying service charge which creates a higher arrears risk. There is an annual cost to the co-operative in getting boiler safety certificates and time spent organising access for these, which would be reduced if a communal system was installed - but this may not provide enough of an incentive to move to an unfamiliar technology. In contrast, the workspace energy use is all overseen by the workspace manager. Tenants of the offices and workspace are not metered, with energy charges instead included in the overall rental costs and service charge pro-rata on the space they occupy. If the source of heating for this space were changed, it is unlikely that the tenants would even notice. The Renewable Heat Incentive in this case would also provide an income stream for this low-cost managed workspace, which is mainly tenanted by community and voluntary organisations and SMEs.

Modelling

Due to the complexity of the building, its low heat density, and the seeming reluctance of some residents to engage with the idea of a communal heating system, it was decided that a retrofitted community heating system would be inappropriate for the residential elements of the building.

However, the workspace, with its existing infrastructure and simple management structure would appear to be an ideal candidate for a simple boiler replacement scheme. We therefore modelled this in more detail to test the returns and efficiencies available. Given the age and overall specification of the building, only one scenario was modelled, as it was not felt that retrofitting of the building fabric would be necessary or appropriate.

The existing heat distribution system and central heat plant allows for a cost effective swap out of the current gas boiler for a RHI eligible Wood Pellet boiler. The scheme has the added benefit of being due for a boiler replacement and having existing arrangements for maintenance and billing on a communal basis. Overall the installation of a wood pellet boiler comes at low additional capital and operational cost, based on the stated assumptions and initial cost estimates this allows for an ROI over a 20 year term of 29.8%.

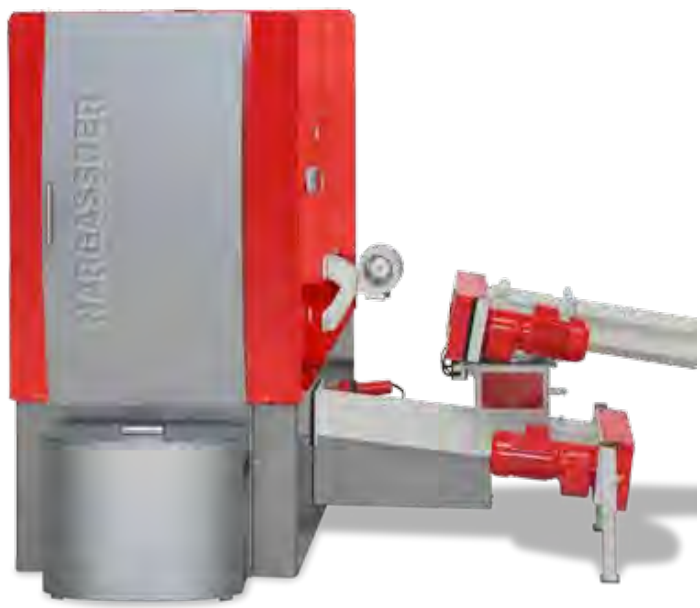
In addition to the financial return the installation of a new high efficiency wood pellet boiler in place of an older gas boiler and utilisation of the existing heat distribution network will offer some reduction in primary energy demand whilst reducing the workspace's CO_2 emissions by 41 tonnes per year.

Inputs, outputs, assumptions:

System description	Replacement of existing communal gas boiler with wood pellet boiler and fuel store utilising existing heat distribution system
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	90 kWp
Capital Cost	£43,470
Annual heat demand	223,332 kWh
Annual CO2 reduction	41,177 kg
ROI	29.8%

Next Steps

With such healthy rates of return it seems sensible to recommend that the existing ageing boiler is replaced with a new biomass boiler. The workspace manager is already gathering quotes, and this work is likely to be carried out within the next 12 months. Any additional monitoring or understanding of energy use that could be developed in the meantime to ensure the most effective sizing of plant may be useful.



A biomass boiler (wood-chip or wood-pellets)

Key Learning Points

The above case study highlights the importance of both physical and social infrastructure in community heating schemes. The boiler replacement scheme for the workspace is viable because the physical and management infrastructure is already in place. The lack of need for separate billing means that the management costs are very low. The existing infrastructure and the compact arrangement of the workspace means that infrastructure costs and heat losses are kept to a minimum.

This stands in stark contrast to the residential element of the scheme, where despite a high residential density, the complexity and layout of the building and the low heat demand makes a community heating scheme inappropriate. The lack of interest from the residents also means that even if it were technically viable, it would be unlikely to ever proceed, as it would need their agreement. This demonstrates both the technical and managerial difficulties present in any attempt to retrofit a community heating system.

Case Study Two: The 'Redbricks'

Description and Context

The apartments known locally as 'The Redbricks' are located at the northern end of Hulme. They are arranged in six long narrow blocks along three streets. They are all three storey 'walk-ups', with six flats arranged around a staircase, each with a balcony or garden space. There is lots communal green space between the flats, some of which is used in community gardening projects by residents. The apartments were built either side of the second world war and originally had coal fires for heating. They were built as council housing, and subsequently transferred to a specially created housing association. They have a quite active tenants and residents association. Many of the properties have been the subject of right to buy purchases.

Location: Hulme, Manchester

Description: walk-up apartment blocks

Number of dwellings: 40/45 per block, 250 in total

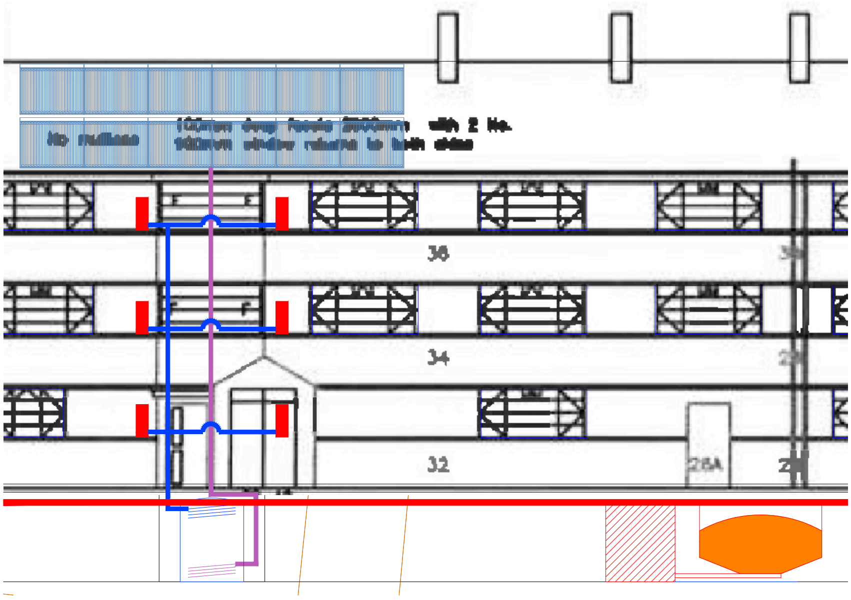
Size: 70 sq m per flat

Density: 85 dwellings per hectare

Aerial Photo showing the six blocks of the 'Redbricks' next to the Mancunian Way.

Technical Assessment

The simple layout of the blocks and their relatively high density means that they appear to be an ideal candidate for community heating. The heating system has been upgraded from the original coal fires, so that each apartment now has an energy efficient gas boiler and independent central heating system. In a communal heating system this boiler would need to be replaced with a heat exchange unit and heat meter to allow for individual billing. They also have double glazed windows, some loft insulation and cavity wall insulation. Despite this the flats can still be expensive to heat and some of the apartments have issues with condensation, damp and mould growth, suggesting that there is still room for improvement in the fabric performance of the buildings. The properties have a full basement, in most cases running the full length of the blocks and they all have pitched roofs with considerable loft space. There is also an existing ducting system connecting the flats which used to serve the larder cupboards with cold air from the basement which it should be possible to reuse, and there is space beneath each of the stairwells which could house boilers, thermal stores and the other plant required. The blocks are aligned on north-west/south-east axis, so may also prove suitable for solar thermal.



Diagrams to the left and on the following page showing the potential distribution network for each of the blocks within the Redbricks, which uses the existing stairwells and allows for one boiler per block.

Social and Management Assessment

The flat blocks are owned and managed by a local housing association, with many householders having purchased leaseholds within them.This means there is a single body responsible for their maintenance and upkeep, and this should therefore simplify implementation, although negotiations would be needed with the leaseholders. The Tenants and Residents Association is very active and will need to be persuaded of any change to current systems. The residents of the 'Redbricks' have been involved in a large number of community based environmental actions over the years. These have included food growing schemes, environmental direct actions and the production of a 'Green Zone Toolkit' which is shared online so that others can see how to take green actions for themselves. It is therefore quite likely that many residents would be open to projects which improve the environmental performance of their homes, especially if this also makes their homes cheaper to run.

Modelling

As there is room for improvement in the thermal performance of the built fabric of the blocks, and there is potential for both solar thermal and biomass to be connected to a communal system, several scenarios have been modelled. Initially solar thermal and biomass systems were looked at in isolation and a final iteration looked at a combined system. Several versions of retrofit measures were modelled, to test the point at which the level of fabric retrofit reduces the returns from the Renewable Heat Incentive so that a communal scheme is no longer viable. All of these scenarios are 'per block',

Scenario One (A): Solar thermal for hot water only

System description	New communal Solar thermal system providing 50% of hot water demand
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	36 kWth
Capital Cost	£64,113
Annual heat demand met	32,871 kWh
Annual CO2 reduction	5,736 kg
ROI	5.06%

Scenario One (B): Solar thermal for hot water and heating demand

System description	New communal Solar thermal system providing 85% of hot water demand and 15% of space heating
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	128 kWth
Capital Cost	£231,175
Annual heat demand met	118,523 kWh
Annual CO2 reduction	15,934 kg
ROI	**4.2%**

The models demonstrated that a return of around 5% could be expected for a solar thermal system achieving a solar fraction of 50%. The cost effectiveness of such a system reduced once the solar fraction increased over the 50% mark and over generation was expected during the summer months

Scenario Two: Communal biomass and existing built fabric

System description	New communal biomass heating system and associated heat distribution
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	200 kWp
Capital Cost	£252,630
Annual heat demand met	318,323 kWh
Annual CO2 reduction*	38,071 kg
ROI	**3.73%**

Scenario Three: Communal biomass and retrofit to AECB Silver standard

System description	New communal biomass heating system and associated heat distribution
Associated works (costs not included)	Building Fabric upgraded to achieve AECB Silver Standard - 40 kWh/m^2/yr
Rated Capacity	<200 kWp
Capital Cost	£252,630
Annual heat demand met	217,523 kWh
Annual CO2 reduction*	22,118 kg
ROI	**-0.55%**

Scenario Four: Communal biomass and EnerPHit

System description	New communal biomass heating system and associated heat distribution
Associated works (costs not included)	Building Fabric upgraded to achieve EnerPHit Standard
Rated Capacity	<200 kWp
Capital Cost	£252,630
Annual heat demand met	174,443 kWh
Annual CO2 reduction*	15,301kg
ROI	**-4.67%**

Scenario Five: Communal biomass and PassivHaus Retrofit

System description	New communal biomass heating system and associated heat distribution
Associated works (costs not included)	Building Fabric upgraded to achieve Passivhaus Standard
Rated Capacity	<200 kWp
Capital Cost	£252,630
Annual heat demand met	98,960 kWh
Annual CO2 reduction*	3,355kg
ROI	**N/A (loss outside of model parameters)**

(The CO2 reduction figure given here only considers the reduction given by the use of an RHI compliant heating system vs a standard gas boiler. It excludes the CO2 reductions that will be achieved by the fabric works. For each of these scenarios the overall CO2 reductions would be much greater if the fabric works were also taken into account. However, as the aim of this study was to assess the benefits of different heating systems, this has been excluded from the tables above and below).*

A communal biomass boiler could offer returns of up to 3.72% if no other building fabric works were carried out. If a communal boiler were to be installed in conjunction with works to reduce the primary energy demand then the return is also reduced. Not including the cost or carbon savings of the fabric efficiency retrofit works the additional cases analysed looked at progressively deeper levels of retrofit and reduction of primary energy demand, and presented progressively lower rates of return. This is due to the lower heat density and associated higher heat distribution costs (both financial and energy in system heat loss) per unit of heat delivered.

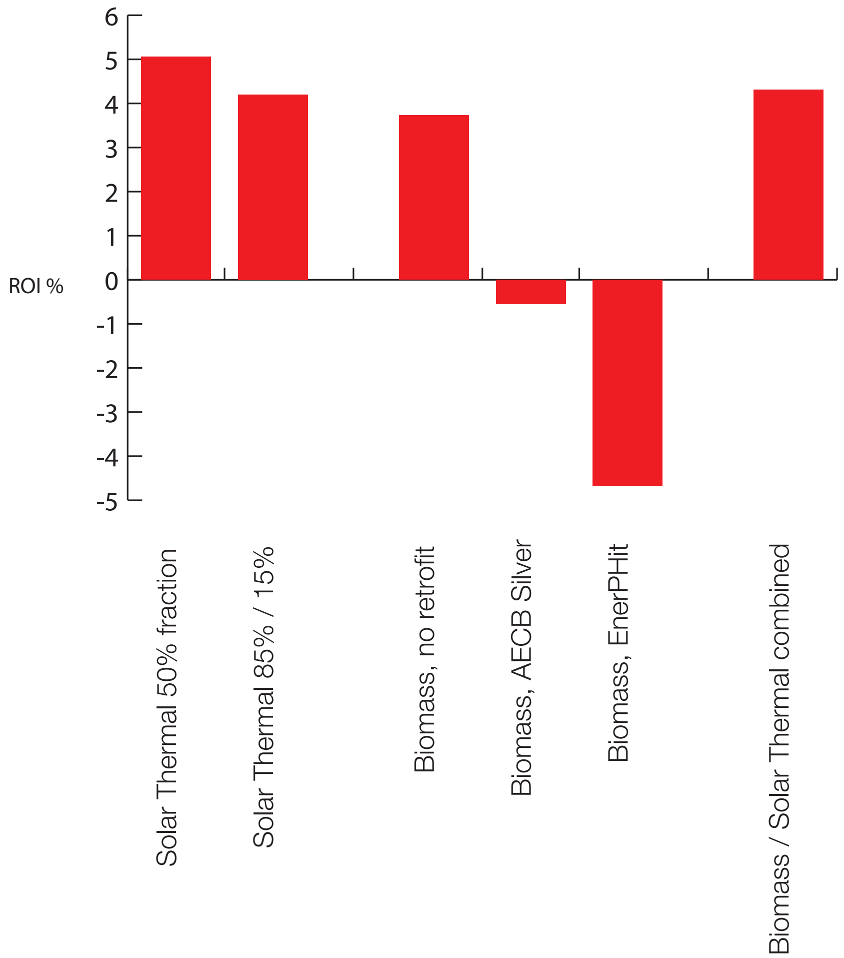
Scenario Six: Combined biomass and solar thermal system

System description	New combined solar thermal and communal biomass heating system and associated heat distribution
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	200 kWp
Capital Cost	£281,043
Annual heat demand met	326,167 kWh
Annual CO2 reduction*	33,831 kg
ROI	**4.31%**

The model demonstrated that whilst combining systems reduces the primary energy demand the rate of return is reduced. This is due to the increased capital cost for two sets of equipment that are able to meet the same demand.

The models also demonstrate the effect of additional parasitic energy loss associated with the change from distributed heat plant to community heating. Allowances have been made for the main heat plant power consumption, the pump energy required to distribute the heat around the scheme and heat loss from the distribution pipework. Although there is some minor variation in the amount of parasitic energy loss as end user demand varies, it is a fairly constant figure for a given scheme with a given length of distribution. Therefore as we have analysed progressively more effective levels of fabric refurbishment, the amount of parasitic energy use becomes a higher proportion of the overall primary energy demand. For the baseline scheme losses account for around 16% of the total heat demand, this rises to 36% for a scheme retrofitted to a Passivhaus standard. This ‘wasted’ energy means that as end user demand falls the overall cost effectiveness of the schemes also falls.

Comparison of Return on Investment of different scenarios:



Overall it can be considered that whilst a change to renewable community heating may reduce carbon and, in some cases, be affordable, it initially increases primary energy demand and may presents a disincentive for future demand reduction works to the built fabric which themselves would have other wider benefits to the health, comfort and well being of occupants.

Left: Heat exchanger unit that would replace individual boilers in a communal scheme. Most residents would not notice a major difference within their homes.

Next Steps

The modelling demonstrates that a full biomass system cannot be supported by the RHI at current prices if any retrofit works to the building are undertaken. This is because these works would reduce primary energy demand, which whilst beneficial for the residents as it reduces fuel costs and improves thermal comfort, also increases the proportion of parasitic energy losses.

However, a solar thermal system that provides for some of the hot water needs of the residents does appear to be worthwhile. This could be investigated by the tenants association and the landlord as part of a wider programme of retrofit works to improve the energy performance of the blocks.

One of the findings from modelling the system is that the parasitic heat losses are considerable. Further investigation should perhaps take place to see if it is possible to design distribution system in such a way that the losses can be directed into the properties to become useful heat and therefore improve the viability of the system. For example, it may be possible to use the duct system as part of a passive stack ventilation system so that fresh air drawn into the properties would be partially pre-warmed by the losses from the pipework. This improvement in the ventilation of the buildings would also improve comfort and air quality in the properties.

Key Learning

This case study demonstrates that whilst the RHI does not appear to be sufficient to support a new centralised biomass heating system at present, because of the costs of the infrastructure, it does help to make solar thermal viable as a means mainly of supplying hot water and reducing primary energy use. Unlike the biomass system, this would be complimentary to rather than in conflict with the need to carry out improvements to the fabric efficiency of the buildings.

Case Study Three: Moss Side

Description and Context

Moss Side is an area of tightly packed red-brick terraces in a lower income area of south Manchester where fuel poverty is an issue for many residents.This form of housing is common across Manchester and the North of England generally, so the findings from this study are relevant to many other neighbourhoods. The houses are arranged in long narrow blocks, opening directly onto the pavement at the front and with small yards and back alleys to the rear. The majority were built in the late 19th Century and the early years of the 20th Century. Though some houses have been improved with new windows, doors and loft insulation, they generally have a high level of heat demand.

Location: Moss Side, Manchester

Description: terraced houses

Dwelling Size: 70-85 sq m each

Number of dwellings: 20 - 55

Density: 80 dwellings per hectare (approx)

Above: The narrow blocks of streets in Moss Side.

Technical Assessment

The density of the houses and their high level of heat demand makes Moss Side an apparently ideal candidate for community heating. The most efficient route for the distribution network is likely to be through the attic spaces of the houses, as in many cases these are continuous and accessible. If this was not possible, the distribution network would need to be buried in the public highway or the back alleys. This would cause additional technical and project management difficulties, because of the need to coordinate with other services and utilities already present and seek permissions from the local authority if carrying out works to adopted highways . Plant and storage tanks would need to be accommodated in new build 'containerised' buildings located on some of the small areas of left over space at the ends of blocks or between blocks, and this would require careful planning.

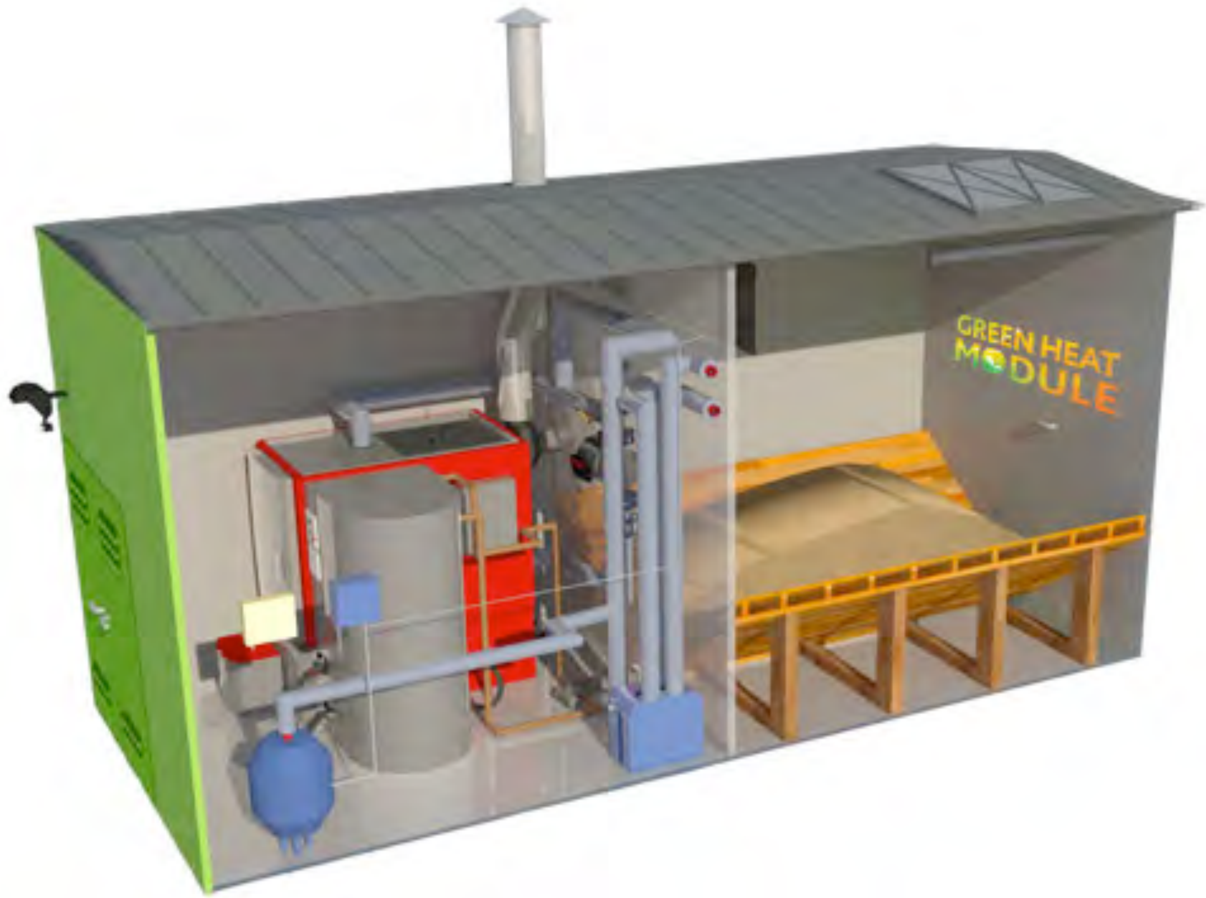
Social and Management Assessment

Fuel poverty is an issue for many residents. In the parallel study on whole house retrofit we found that many people were under-heating their homes, and as a result were suffering from poor thermal comfort. Many properties had problems with damp and condensation. Any community heating system would have to also reduce fuel costs, otherwise it is likely that these problems would persist. This may also have consequences for the returns and efficiency of the system. If people reduce their household demand for heating in an effort to reduce costs, the returns to the community heating system will be less than projected and the system will run less efficiently.

The properties here are a mix of tenures, including private rented, social housing and owner occupiers. A community engagement event was held in March 2012 at which questions were raised about the financial, legal and ownership implications of a community heat network. The diversity of tenures and social circumstances of those living in the area were felt to be a barrier to the implementation of any scheme. It was agreed that it would take a lot of work - in education, engagement and legal and mortgage advice - before a majority of occupiers and owners in the area would agree to take part in any scheme. Some residents are already active in local environmental groups, many of whom came to the event, and work has been done by the Carbon Coop and others on raising environmental awareness. This at least means that some of the social structures are already in place for this work.

Left: A containerised biomass plant room being lowered into place in a residential development by font energy - www.fontenergy.com

Below: Green Heat Module by Wood Energy - http://www.woodenergy.com



Modelling

Modelling was carried out for six of progressively more intensive built fabric retrofit scenarios. As with the Redbricks, this was so we could explore the impact of fabric retrofit works, which have benefits for reduced fuel poverty and improved comfort, on the returns from investment in a community heating scheme.

Scenario One: Existing Built Fabric

System description	New communal biomass boiler
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	200 kWp (supplying 20 units)
Capital Cost	£224,595
Annual heat demand met	348,288 kWh
Annual CO2 reduction*	42,376 kg
ROI	**5.39%**

Scenario Two: Light Retrofit

System description	New communal biomass boiler
Associated works (costs not included)	Light retrofit to achieve space heating demand of 110 kWh / m2 / yr
Rated Capacity	200 kWp (supplying 25 units)
Capital Cost	£248,573
Annual heat demand met	343,783 kWh
Annual CO2 reduction*	39,365 kg
ROI	**3.79%**

Scenario Three: Mid Retrofit

System description	New communal biomass boiler
Associated works (costs not included)	Mid retrofit to achieve space heating demand of 75 kWh / m2 / yr
Rated Capacity	200 kWp (supplying 31 units)
Capital Cost	£281,043
Annual heat demand met	326,167 kWh
Annual CO2 reduction*	33,831 kg
ROI	**1.76%**

Scenario Four: Retrofit to AECB Silver Standard

System description	New communal biomass boiler
Associated works (costs not included)	Retrofit to achieve AECB Silver standard of 40 kWh/ m2/ yr
Rated Capacity	200 kWp (supplying 40 units)
Capital Cost	£324,135
Annual heat demand met	291,869 kWh
Annual CO2 reduction*	24,284 kg
ROI	**-0.93%**

Scenario Five: Retrofit to EnerPHit Standard

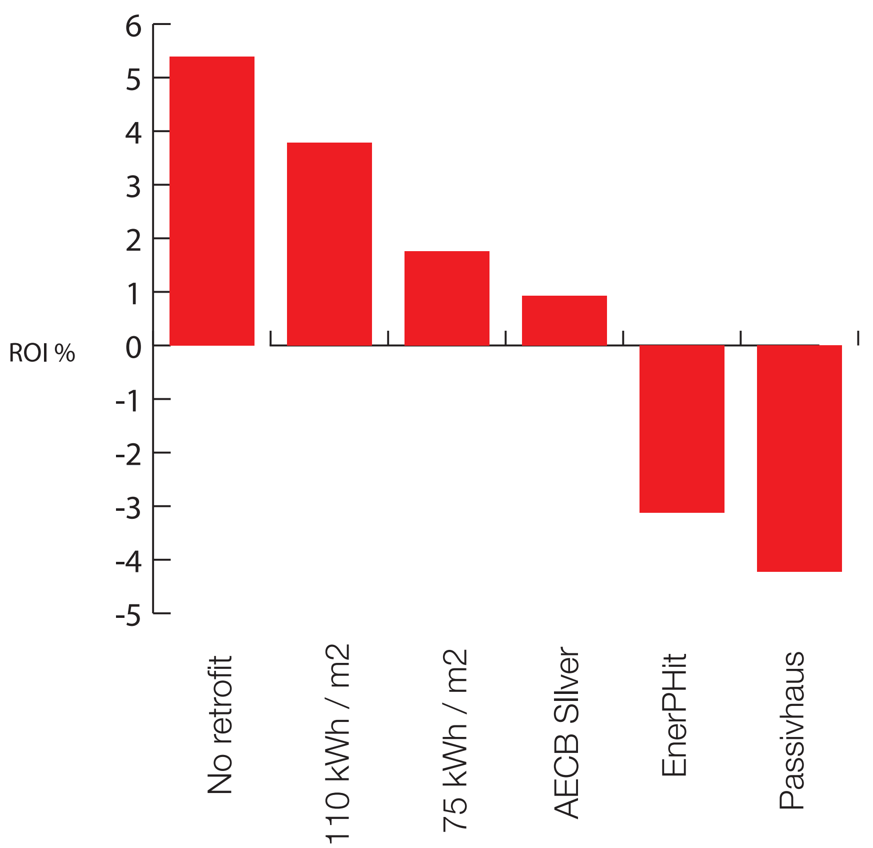
System description	New communal biomass boiler
Associated works (costs not included)	Retrofit to achieve EnerPHit standard - 25 kWh/m2/yr
Rated Capacity	200 kWp (supplying 50 units)
Capital Cost	£375,795
Annual heat demand met	294,759 kWh
Annual CO2 reduction*	20,164 kg
ROI	**-3.12%**

Scenario Six: Retrofit to PassivHaus Standard

System description	New communal biomass boiler
Associated works (costs not included)	Retrofit to achieve Passivhaus standard - 15 kWh/m2/ yr
Rated Capacity	200 kWp (supplying 55 units)
Capital Cost	£385,560
Annual heat demand met	273,705 kWh
Annual CO2 reduction*	14,544kg
ROI	**-4.23%**

(The CO2 reduction figures given here only considers the reduction given by the use of an RHI compliant heating system vs a standard gas boiler. It excludes the CO2 reductions that will be achieved by the fabric works. For each of these scenarios the overall CO2 reductions would be much greater if the fabric works were also taken into account. However, as the aim of this study was to assess the benefits of different heating systems, this has been excluded).*

Comparison of return on investment of different scenarios:



As with the Red Bricks the modelling showed that whilst a return of over 5% may be achievable for retrofitting onto the existing building without modifying the fabric, the rate of return reduces as it is combined with measures aimed at reducing primary energy demand and parasitic losses approach 40%.

In each case modelled it was more cost effective to assume that the maximum amount of properties possible would be served by each system. This ensures that costs per property are minimised and the system is operated to its maximum capacity. This also highlighted the costs associated with installing not only a new heat distribution system but also replacing existing gas boilers in each property with a Hydraulic Interface Unit (HIU) resulting in high capital costs. Although HIU costs may be reduced by waiting for boiler replacement to be required the overall scheme requires a high early adoption rate to work and if the early adopters were widely spread the additional heat distribution costs would more than compensate for any cost saving.

Next Steps

Given that even in the base case non-retrofit scenario the returns from the RHI is marginal, it seems we must accept that a retrofitted community heating system in this context is probably unviable at present. It may be worth investigating some of the cost data, to see whether reductions could be made in this area. We have found it quite difficult to source accurate and reliable cost data on the heat distribution elements of the system in particular, possibly due to the current under-developed and small scale of the market for this technology in the UK. However, without improvements in the technology which may not even be possible, this will not address the fundamental conflict between returns and fabric energy efficiency in homes.

Key Learning Points

Evidence from the parallel study on whole house retrofit suggests that some residents are under-heating their homes compared with the results from SAP[3]. If this were to continue and was common amongst residents in this area, returns would be lower even in the base case with uninsulated houses. This approach would also not address fuel poverty or thermal comfort issues to as great a degree as retrofitting the houses.

The returns and the value for money in both energy and carbon savings reduces as the energy efficiency of the properties is improved. Even on a ‘light retrofit’ to achieve the equivalent of Part L 2006, the scheme becomes unviable. As the level of retrofit increases, the ratio of useful energy to distribution losses approaches 50%. Whilst it may be possible to improve the financial returns from the scheme if the costs of the infrastructure can be reduced as the market for district heating in the UK matures, this fundamental issue of energy losses cannot be avoided.

Financial returns may also be improved if management costs could be reduced, for example by billing on a fixed basis, by floor area or occupancy, rather than by metering. This is unlikely to be a satisfactory situation for residents who will be used to paying their heating bills independently and may feel it is unfair if they seem to use less energy than others in a similar situation. This would also run counter to any efforts to increase awareness of energy use and thereby reduce it.

In all of these cases the assumption is that all the houses on the route of a scheme will sign up. If this is not the case, it will further affect the viability of the scheme. It seems therefore that this is not a context in which community heating works well or would be worth the investment at present - financially, environmentally or socially.

This case study demonstrates the importance of concentrated heat demand and a simple system, and that if other factors are a concern - such as fuel poverty and thermal comfort - so that some retrofit work is also likely to be undertaken, it will affect the viability of a scheme.

[3] See ‘Whole House Assessment Method’ report to Carbon Coop by URBED for DECC, April 2012.

Case Study Four: The Heatons

Description and Context

The Heatons is an area of Stockport with large semi-detached houses on a suburban layout. The houses have front gardens and driveways, and generous back gardens. The majority of the housing in this areas was built in the mid-20th century, and some have undergone improvements such as double-glazing and top up loft insulation. Most homes appear to have gas boilers and central heating systems. The vast majority of people living here are owner occupiers.

Location: Stockport, Greater Manchester

Description: large semi-detached houses

Number of dwellings: 20 (base case)

Density: 30-40 dwellings per hectare (approx)

Technical Assessment

Despite the low density layout, due to the size of the houses and their age and general level of improvements, heat density is still likely to be quite high at present. However, many homeowners have undertaken improvements, and as fuel prices continue to rise this is likely to continue and perhaps even accelerate, reducing demand for heat. The installation of a community heat network would require the replacement of independent boilers in each of the houses with heat exchange units, despite the fact that some may have only recently been fitted with highly efficient condensing boiler systems.

Unlike any of the other buildings in this study, it is not possible to run the distribution network for a community heating system either inside or fixed to the buildings. The distribution network must be buried in the gardens, driveways and most likely also on the public highway. This will mean excavation work which can be expensive and will require legal permissions. Many services are already carried in the public footpaths and pavements - electricity, gas, telephony. Adding a heat distribution network would require careful coordination with and investigation of what is already in place. Whilst there may be opportunities to 'piggy-back' on other services, such as the laying of fibre-optic cables, this adds a layer of complication to the management of the project. There are few 'left-over' spaces available in the area for the location of the central plant, even compact containerised systems. The affect of these on the appearance of the area would have to be acceptable to local residents.

Excavation for a district heating system taking place in Sweden, showing the insulated to be installed in a trench beneath the hard surface covering. From Technical Research Institute of Sweden - www.sp.se/en/index/research/mechanicallifesafety/functionalpipeline/Sidor/default.aspx

Social and Management Assessment

For a community heating system to work in an area like this take up amongst residents would need to be maximised. Residents who are used to individual contracts with the mainstream energy companies for their gas may be reluctant to change to this system. If only a few households agreed to sign up it would seriously damage the viability of any scheme. As with the homes in Moss Side, management and billing costs could be reduced if the system was simplified and no heat meters were used, but this is likely to meet even sterner opposition here.

As early modelling demonstrated that the technical case for community heating in this neighbourhood was marginal, no community engagement event was held here. Whilst there are active environmental community level groups in this neighbourhood, it wasn't felt that this would be a good use of their valuable time and energy.

Modelling

A single case with 20 units per system was modelled, with no improvements to the existing building fabric. As this case was found to provide only marginal returns, this was taken no further.

System description	New communal biomass boiler
Associated works (costs not included)	N/A Existing building fabric retained
Rated Capacity	200 kWp
Capital Cost	£298,620
Annual heat demand met	431,494 kWh
Annual CO2 reduction	49,725 kg
ROI	2.6%

Next Steps

As with the homes in Moss Side it seems that this suburban area is not a suitable candidate for a community heating network. This is both because the financial returns, even with the RHI, are poor, but also because the amount of energy lost in the distribution system is disproportionate. The social and management implications of a community heating scheme in this area would also be considerable. In this case in both energy and financial terms independent heating systems for each household would seem the most appropriate approach.

Key Learning Points

This case study illustrates the significance of the costs of infrastructure in any community heating scheme. In this case it means that even in the base case of current energy demand with few energy efficiency improvements, a scheme is financially unviable. However, even if these costs were brought down by improvements in technology or as the market for district heating in the UK matures, the energy lost in the distribution of heat would be significant, making it a less energy efficient solution than individual heating systems for each home. As the energy efficiency of the built fabric of these homes is improved, the case for a community heating system is further weakened. The additional level of complication in this case study because of the need to bury the distribution infrastructure within the public highway, and the need to negotiate with utilities providers and the local authority to achieve this is probably not worth the investment of time, money and effort in this case.

Conclusions

Summary

The case studies outlined above have enabled an investigation of the potential for the Renewable Heat Incentive to support investment in community heating networks across a range of different contexts and scenarios. There are several useful conclusions that can be drawn from this work:

- The RHI is structured so that the maximum returns can be gained from the lowest level of the pricing 'tier'. This encourages the development of schemes which meet this criteria. This may distort project objectives to a degree, forcing a consideration of matters when sizing schemes which are not directly related to practical matters of implementation, energy demand and engineering.
- The RHI appears to pay for investment in new heat production where distribution infrastructure already exists and management is simple (e.g. Work for Change). It doesn't seem to pay for retrofit of new distribution infrastructure and management in existing urban areas in many contexts at its current rate.
- Heat demand has a significant influence on returns. As the energy efficiency of buildings improves, returns on the community heating system reduce. This points to the fact that there is an inherent conflict between community renewable heat schemes, which must maximise energy use to improve returns and system efficiency, and the building retrofit agenda, which aims to reduce primary energy demand whilst also improving thermal comfort and mitigating issues of fuel poverty.
- Were the financial conflict between the needs of community heating systems and whole house retrofit to be overcome, there would still be a fundamental energy problem in that as heat demand reduces, the parasitic losses of a system increase. In some of the case studies above this has approached 40% of total primary energy use - and is clearly not sustainable if our overall aim is to reduce carbon emissions through efficient use of energy.
- New investment in solar thermal systems appears to be supported by the RHI, provided it is sized adequately to match an appropriate level of demand. If only providing hot water, this has the advantage of not being in conflict with any energy efficiency improvements to the built fabric.
- The capital costs of community energy schemes, especially distribution networks and the heat interface units for each property, can be high. This is especially the case where properties are less close to each other or where some households do not wish to use the community heating system. This may be an area for further investigation and returns on the RHI may improve as capital costs reduce and the market develops.
- Management costs for maintenance and billing and the risk of bad debts should be considered in the appraisal of any scheme, as this can affect its viability.
- There is a need for community and management buy-in in all cases. This can be much more difficult when ownership and management is dispersed. For example in a mixed tenure neighbourhood the implementation of a scheme may require negotiations with owner occupiers, private landlords and tenants, social landlords, the local authority and utilities companies. It is unlikely that this process will be worthwhile in the cases above where returns on investment in terms of finances, carbon and energy are marginal.
- All schemes rely on a high level of take-up. If only a small proportion of the residents in an area agreed to take part a scheme may become unviable.

Carbon Coop

The findings of this study suggest that there is little room in the returns from the RHI on community energy schemes in existing residential areas to cross-subsidise whole house retrofit. In addition there is an inherent conflict in financial, carbon emissions and energy use reduction terms between community heating and whole house retrofit. With the primary aim of the Carbon Coop being to help its members reduce their carbon emissions, whilst helping to fund whole house retrofit, this suggests that the retrofitting of community heating systems should only be pursued by the Carbon Coop in very particular circumstances.

As an organisation which also aims to improve the health and social wellbeing of its members, the implications of maximising returns from community heating for fuel poverty and thermal comfort should also be considered. Given the findings of the parallel study on whole house retrofit that many people are already under-heating their homes, resulting in problems with damp and condensation, this is potentially a major issue for members. Under-heating of homes would also reduce financial returns for any scheme.

Community energy schemes seem to provide more promising returns in areas of high density where there is a relatively simple management structure. Given that the Carbon Coop so far has mainly focused on individual residents of single homes or apartments, it would require a change of approach for the Carbon Coop to get involved in this area.

Where the Carbon Coop can perhaps make the biggest contribution to worthwhile community energy schemes is in the engagement, education and pre- and post-completion support and monitoring that will be required to make these schemes a success, as a trusted organisation with expertise in this area.

Other Risks to RHI Returns

The Renewable Heat Incentive is the first scheme of its kind in the world - launched as a bold and pioneering policy initiative. However, policy risks should be considered by anyone currently considering investing in projects which generate a return through the Renewable Heat Incentive. Government action in reducing the ‘Feed in Tariff’ rates for renewable electricity generation has made many people in the industry nervous about relying on similar measures to pay for renewable heat. A consultation document published in March 2012 suggests that as with the FIT the Government intends to place an absolute cap on the amount of money paid out through the Renewable Heat Incentive as a first step in 2012, with future reductions in the rates paid out to be calculated using a form yet to be agreed in 2013 and beyond[4]. This may have a serious effect on the confidence of anyone planning to invest in renewable heat on the basis of returns from the Renewable Heat Incentive alone.

A second significant risk to returns from the RHI is the prevalence of under-heating of homes that was discovered as part of a parallel study on the ‘Whole House Assessment Method’ for the Carbon Coop. The heat demand assumed in this study was based on assessments of actual homes in each of the case studies carried out as part of this other study. However, when these results for the existing condition were compared with resident’s actual fuel bills, there was often a large discrepancy. Many of the residents were using much less energy for heating than predicted by SAP, possibly due to a mixture of fuel poverty and energy cost concerns and a degree of environmental awareness that meant they were very frugal with energy use. If this is the case in an area with a community heating network, and heat use is lower than predicted as a result, this could seriously affect the financial returns and the overall energy efficiency of any scheme. This issues needs to be investigated more thoroughly generally, and in any proposed scheme in particular.

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[4] DECC, (2012) ‘The Renewable Heat Incentive: Consultation on Interim Cost Control’ available at http://www.decc.gov.uk/en/content/cms/consultations/rhi_cost/rhi_cost.aspx