Developing District Heating in the UK: What Works?

David Hawkey and Janette Webb (2011)

District heating (DH), from combined heat and power (CHP), addresses social, economic and environmental objectives, by producing affordable heat, competitively priced electricity and carbon savings. Small CHP generators can perform well at local level, but also offer capacity as nodes in a distributed energy network (think of the power of distributed computing), providing grid balancing services, and reducing the need for investment in underused (higher carbon) peak electricity demand plant and network infrastructure[1]. The UK Committee on Climate Change[2] (CCC) regards district heating drawing heat from low carbon electricity generation as one of the most cost effective carbon abatement (-£110/tCO_2) measures considered. For Local Authorities, DH can contribute to economic regeneration, as well as addressing fuel poverty, energy and carbon savings targets, and social resilience[3].

However, the CCC suggests "non-financial barriers" will limit the development of DH in the UK. What *are* those barriers? We highlight the key challenges for a project developer seeking to establish a viable DH system, and show how they are being overcome.

1. District Heating General Characteristics

DH networks, wherever they are developed, share a number of characteristics with all energy networks. Upfront costs are high in relation to annual revenues, but the infrastructure and revenues last for many years. The system's financial viability relies on subscribers willing to connect and on the level and timing of their usage, all of which represent important uncertainties. A heat network is typically a monopoly supplier, which means that subscribers must trust the supply company to set a fair tariff. The supply of heat has public-good qualities, justifying public oversight of its management, although heat networks may be run for profit. Heat networks create long-term mutual interdependencies between subscribers (requiring energy services) and the network owner (seeking to recover sunk investment): return on network investment is gradual and subscribers face the costs of switching to alternative heating sources. Different kinds of energy networks in the area may compete with, or complement, each other. Resolution of these issues depends on the degree to which there is an integrated view of energy

[1] Streckiene, G and Andersen, A (2010) *Analysing the Optimal Size of a CHP Unit and Thermal Store When a German CHP Plant is Selling at the Spot Market*, MASSIG EIE/07/164/S12.467618
[2] UK Committee on Climate Change (2010) *Fourth Carbon Budget* www.theccc.org.uk
[3] Michael King (CHPA), Marina Solari (HCA), Emyr Poole (HCA), Marion Delaney (AECOM), Steve Carr (HCA) (2011) *District Heating Good Practice: Learning from the Low carbon Infrastructure Fund*. London: Home and Communities Agency www.homesandcommunities.co.uk

provision and needs in the area, and on the priorities of project developers (e.g. public welfare, carbon savings, commercial goals, etc.).

Development of DH systems is a long-term undertaking. Much planning and preparation is required to understand the complex social, institutional and physical features of an area which create the potential for heat networks, to design viable stages of network development, to draw subscribers and other stakeholders into the system, and to mobilise sufficient resources to install the system. King and Shaw[4] give an overview of an approach to the development process. Once a project moves into capital investment phase, installation of infrastructure and connections can take several years (depending on the scale of the system) and large systems (such as Bergen's heat network) can take up to a decade before creating a positive cash flow. Project management requirements (organisational, financial, expertise) evolve as the system develops.

1.1. The Role of Local Authorities

Local authorities (LAs) have usually played a crucial role in establishing significant heat networks in Europe. European LAs have historically had shared or direct control of local electricity companies. They have consequently pursued synergies and trade-offs between DH and other energy networks, and integrated energy systems with other LA developments such as housing. The context for LA involvement in DH systems in the UK is very different: nationalisation removed LA control over energy systems; the role of local government in direct service provision has reduced, shifting instead to an enabling role[5]; and economic liberalisation constrains LA activity through energy market structures, state aid rules and procurement procedures. UK LAs are nonetheless critical to the development of large-scale heat networks:

- DH is inherently local, requiring local knowledge about specific opportunities, their optimum timing, and potential for integration with other infrastructure development projects.
- DH requires an actor (or actors) with the willingness to make long term investments in a locality, and actor(s) with the organisational resources and capacities to develop and manage the social and technical systems[6].
- The statutory functions of LAs as planning authorities and service providers mean they can give strategic direction and so are key to maximising potential of DH.
- LAs have potential to act as intermediary, coordinating heat networks in partnership with other energy and utility systems;

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[4] King, M. & Shaw, R., 2010. *Community energy: planning, development and delivery*, Combined Heat and Power Association (CHPA). Available at: http://www.chpa.co.uk/media/28c4e605/Comm_Energy_PlanDevDel.pdf [Accessed November 24, 2010].

[5] Bulkeley, H. & Kern, K., 2006. Local Government and the Governing of Climate Change in Germany and the UK. *Urban Studies*, 43(12), pp.2237 - 2259.

[6] Ericsson, K., 2009. *Introduction and development of the Swedish district heating systems: Critical factors and lessons learned*, www.res-h-policy.eu/downloads/Swedish_district_heating_case-study_(D5)_final.pdf [Accessed November 8, 2010]

- They can reduce the risks of exploitative pricing by a monopoly, by ensuring transparency in calculation of tariffs, and/or non-profit business operation;
- LAs control significant heat loads;
- They have the authority to balance societal well-being against financial objectives of private sector partners, and may subsidise heat networks through integrated service planning and regeneration strategies;

However, these factors do not determine the role(s) LAs play in DH initiatives, and experience in the UK is characterised by a high degree of experimentation with different organisational forms. Nor does the role of LAs exclude other actors, including Housing Associations, Universities and commercial developers, from creating local networks. Ensuring the possibility for integration of different systems across a city is however likely to require LA involvement.

LA powers to promote well-being provide an impetus to invest in regeneration, and to tackle rising fuel poverty among public housing tenants. UK and Scottish Climate Change Acts have given LAs significant incentives to save energy and to develop low carbon supply. Financial incentives include Feed in Tariffs and the Renewable Heat Incentive. Conversely Energy Performance of Buildings directives, landfill taxes and the CRC provide the stimulus to invest in energy saving. Rising gas and electricity prices may be just as significant, if not more so.

2. Challenges of developing DH networks in the UK

The diverse challenges faced by UK DH developers can be divided into four categories: embedding the network in the social and physical terrain; building experience and capacity; managing complexity; and assembling resources. What follows is an illustration of how these challenges are manifested, though this is not an exhaustive survey.

DH networks have to be **embedded** in a landscape dominated by gas and electricity networks. This is to be understood broadly, encompassing physical installation of pipework as well as skills and expertise required for systems design and delivery and necessary supply chains. The DH developer has to engage with conventional relationships between energy suppliers and consumers, established legal and regulatory frameworks, attitudes and assumptions within local authorities about energy systems, policy approaches to sustainable energy, and the physical and institutional structures through which energy is sold. The unfamiliarity of DH, and lack of regulatory standards, create numerous challenges that local initiatives have to overcome, from establishing legitimacy within a LA to repeated contract negotiations with potential subscribers concerned about different risks .

A second set of challenges stems from lack of **experience and absence of routine procedures**. The growing number of UK DH projects demonstrates that critical momentum and capacity are developing, though these are at an early stage. Relevant knowledge can be difficult to access and contested. Developing a DH system is a relatively creative process: new structures have to be negotiated and made to work, while finding ways to fit a DH business with existing norms and institutions. Finance must also be matched to

objectives and business model. Stakeholders in DH initiatives may have limited understanding of each other's objectives or ways of working, leading to misunderstandings and delay. Technical knowledge and skills for best-practice design and engineering methodologies is relatively limited, as is commercial knowledge of CHP and DH operation in UK energy markets. Whole life cost accounting, which is key to long-term revenue projections, governance and legal frameworks (including EU procurement and state aid rules), may be unfamiliar. A lack of experience creates risks and perceptions of risk for which premiums are charged. For example, the Pöyry report[7] found that the costs of trench-work in the UK are double equivalent costs in Finland as contractors factor in risks stemming from lack of experience.

Development of DH is characterised by **complexity**, stemming from uncertainties over the level and schedules of heat demand, varying lifetimes of existing contracts for heating and energy supply to anchor loads, patterns of new development, opportunities to coordinate street breaking, land ownership patterns and underground congestion created by existing utility services (of which records are generally poor). The process of establishing a viable project is also complex. Project goals, local issues, finance, governance, business models, approaches to subscriber recruitment, risk management and legal constraints are significant in their own right, but also interact: decisions made in one area have ramifications for others. A third source of complexity stems from the coordination of a wide range of actors (subscribers, development partners, contractors, consultants, utilities, land owners, central government, etc.). No single actor can exert full control over decisions and behaviour of the others. Instead, different interests have to be aligned and maintained over the lifetime of a project, and as the system expands into new markets. The greater the number of project partners the more complex the management process. Newcastle and Nottingham City Councils[8] and Birmingham, noted the difficulties experienced in selecting a competent contractor, whilst remaining compliant with procurement rules. Even at the early market testing stage, public bodies have to avoid detailed engagement with potential contractors, because this risks subsequent legal challenge with costs to the LA. Interaction with energy markets adds another layer of complexity: UK government's approach to energy markets is evolving in response to urgent challenges confronting energy systems, with potentially significantly impact the viability of decentralised energy initiatives, though the cumulative effect (positive or negative) of emerging policies is difficult to predict.

DH systems require **significant resources** (financial, information and human). Substantial resources are required for project development (a rule of thumb is development costs around 10% of capital costs[9]). Large capital investment has to be mobilised, and sources of revenue harnessed to repay this investment over a long term. The risk this investment is placed under is a

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[7] Pöyry Energy, 2009. *The potential and costs of district heating networks: A report to the Department of Energy and Climate Change*, Oxford. Available at: http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Distributed%20Energy%20Heat/1467-potential-costs-district-heating-network.pdf [Accessed September 8, 2011].

[8] King et al. (2011) *District Heating Good Practice…*

[9] *Ibid*

key consideration, and a number of the suggestions below play a role in reducing project risks. Some benefits generated by heat networks show uncertainty in the long term (e.g. due to price uncertainty) while others (such as health impacts of reducing fuel poverty rates) may be difficult to capture and may consequently be difficult to represent in decision-making. Gathering sufficient information about an area to design a network is an important and challenging step, as is converting this information into a viable design. This is one area where LAs are likely to lack appropriate in-house skills, though outsourcing this activity to potential contractors (offering low costs in the hope of winning a resultant contract) or independent consultants (offering more impartial advice but at a higher price) is a challenge. While human resources external to the LA have to be mobilised, so too do different in-house specialisms: energy management of the LA estate, housing, planning, waste, education, leisure and economic development, as well as finance, legal and technical specialisms, are all likely to be involved to some degree. Cutting across traditional LA departmental divisions is challenging.

3. Overcoming the challenges of DH

Our research has revealed a high degree of diversity and creativity among DH developers seeking to tackle these challenges. Here we draw out some key lessons.

3.1. Adopt a strategic approach

Strategic approaches establish a vision of development in the area, and tailor short-term activities to long term goals and opportunities as they arise.

3.1.1. Coordinate across the LA

DH projects are more manageable when LA structures enable integrated energy planning. A LA in which responsibility for all energy issues is co-located (including energy procurement, energy management for housing tenants and area-wide energy infrastructure planning) will be more able to identify integrated solutions, and will have a clearer remit to pursue investigations than a LA in which these functions are divided.

Successful initiatives draw disparate LA functions together and create focused delivery teams, typically resulting in creation of a stand-alone business. Support within the LA, especially political support, is important, but is not automatic, and work has to be done to establish and maintain it. For example, devoting time to ensuring the benefits of investment in DH are clearly articulated is important to ensuring public and political support for the commitment of significant financial resources.

3.1.2. Establish a pilot project from which to build

Legitimacy for LA investment in DH and energy services is increased by awareness of the success of other LAs, and by learning from direct experience. Pilot projects create technical and organisational capacity and skills (demonstrating competence and achievement of goals), which are exploited in mobilising further resources (financial, social and political capital) for more ambitious projects. For example, the success of Woking Borough Council's in-house rolling energy efficiency fund in creating financial value while achieving efficiency and environmental goals was important in establishing

cross-council support for the establishment of Thameswey and the pursuit of more ambitious initiatives.

Strategic selection of early projects is a way of dealing with complexity. Aberdeen Heat and Power, for example, has established heat networks serving domestic subscribers (predominantly council tenants) and buildings mainly under LA control. Experience and reputation is then built before having to address the issues raised by commercial subscribers.

3.1.3. Build knowledge bases relevant to the local context.

Different kinds of knowledge, long-term and area-wide, are important for managing the inherent complexities and long timescales. Various different overviews are relevant:

An **overview of the physical and social terrain** into which the network will be built, combining formal expertise (heat mapping, energy performance of buildings, building fabric) with local knowledge (land ownership, local planning, local attitudes, economic opportunities) is crucial for designing a successful network and delivery. Heat mapping can also be an opportunity for stakeholder engagement.

An **overview of the whole-life costs and benefits** of the system enables appropriate comparisons with alternative solutions. A robust projection of financial costs and revenues is crucial to mobilising large capital investments, particularly if the alternative solutions have lower up-front costs. Inclusion of non-monetary costs and benefits can help to legitimate DH, and mobilise additional resources. For example, the waste heat initiative in Rotterdam is part financed by public subsidies of €7m, because this is the value judged to be generated by the system's pollution abatement.

An **overview of the processes involved in developing and delivering** particular DH projects, with foresight of the relationships and resources required avoids difficulties at critical moments. For example, early engagement with planning departments ensures designs (e.g. for an energy centre) meet planning requirements.[10]

An **overview of the long-term strategic development possibilities** for the network will help to avoid further development being locked-out by early decisions, and to build support for the system (see 3.1.4 below).

An **overview of the needs, interests and constraints faced by stakeholders** is important to aligning stakeholder interests, understanding the implications of different approaches (e.g. on finance), and preventing frustrations and delays caused by misunderstandings. As tensions exist between different objectives (for example, maximising revenues versus tackling fuel poverty), it is important that LAs are clear which policy objectives are being pursued.

Initiatives vary in the degree to which they have been able to establish an integrated perspective, particularly as they struggle with the challenges of getting a viable pilot project off the ground. These strategic understandings may develop once a system has begun. For example, in Bergen, the DH company initially assessed potential connections on a case-by-case basis. In

[10] King et al. (2011) *District Heating Good Practice…*

some cases, extension of the network into new areas was judged to be too expensive given that just one building would be connected. However, the municipal planning department was pursuing policies to increase urban density and prevent sprawl. By drawing these plans into assessment procedures, the DH company found that extending into some areas was financially viable even if *initial* connections would not cover the cost, because they could be confident that more connections would be forthcoming in future.

3.1.4. Understand and plan for the growth of the system

Larger DH networks benefit from economies of scale and scope. An established "backbone" system provides opportunities to build from, and small networks benefit from integration into larger ones (efficiency improves and costs reduce). A phased approach to development allows costs and revenues to be coordinated, reducing the opportunity costs (and financing costs) of investments for which benefits are deferred.

System growth is reflected in institutional capacities: DH systems recruit resources as they develop, building experience of the hardware installed and justifying expenditure on dedicated staff. These developments help bring the system under control and open up opportunities for more active engagement with gas and electricity markets.

Future-proofing early initiatives for expansion is a technical and institutional challenge. Building appropriate capacity into early networks, and establishing local technical standards, require an area-wide, long term perspective in local governance of DH, which the LA is well placed to develop. Institutional challenges of system growth arise from the ways in which early niche opportunities have been developed. For example, local authority and commercial-partner interests may be aligned around a system connecting large heat users, but diverge over expanding into residential, particularly fuel-poor, areas. Conversely, a system built to meet demand from LA-controlled buildings faces challenges of accommodating risks associated with supplying commercial subscribers.

3.2. Establish a suitable delivery vehicle and business model

The organisation of different activities within a DH system (heat generation, transport and retail) can be undertaken in different combinations by different organisations. In the UK a common approach is to establish an Energy Services Company (ESCo) to be responsible for all of these activities.

Business models include non-profit companies, such as Aberdeen Heat and Power, joint public-private ventures such as Woking's Thameswey Energy Ltd. (TEL) and private sector ESCos such as Birmingham District Energy Company (BDEC), owned by Cofely. These reflect local circumstances, values and social, entrepreneurial, or risk-related priorities. Different models vary in the ways they allocate risks, responsibilities and control; in access to finance; in access to sources of experience and expertise; in the incentive structures they create; and in the applicability of procurement and state aid rules. Each structure makes different demands on LA skills and resources. Private-sector-led models for example require LA skills in negotiating and managing long-term outcome-oriented contracts.

The organisation structure influences the level of trust felt by subscribers in relation to promised service levels, business viability and fair pricing. For commercial subscribers, a key issue is whether any project sponsor can underwrite commercial agreements. A large parent company may be able to underwrite risks, but a local authority may prefer not to take them on. Without a large organisation to fall back on, commercial subscribers require detailed agreements and insurance specifying what measures would be put in place if the DH company were to fail.

3.3. Draw subscribers into the system

Large and small DH subscribers may be recruited by attractive energy prices, "outsourcing" of boiler and system maintenance, and (for large subscribers) avoided costs imposed by environmental policies. In the UK, DH tariffs are commonly structured to give subscribers lower costs than equivalent gas supply. Supply to residents in social housing may be charged on a heat-with-rent basis, as a fixed tariff. Commercial and private domestic customers usually prefer a metered supply; costs are kept below equivalent gas supply through tariffs with a large variable element, set at a discount relative to the variable element of gas price.

Ofgem regulation of licensed electricity and gas suppliers ensures that subscribers are protected in the event of failure. UK DH customers cannot currently rely on equivalent regulatory protection, and DH developers must devote resources to establishing their own ways of addressing subscribers' concerns. A shared national resource (such as an industry code of practice) would reduce local transaction costs.

Planning systems help to build the market. Various approaches are possible, from Danish Heat Planning law where a LA can direct all buildings to be connected to a heat network, to a requirement that new development demonstrates consideration of CHP/DH. The latter helps avoid routine neglect of the option, and may reveal opportunities for an established ESCo to improve the financial attractiveness of DH for a new development. UK and devolved government planning guidance legitimates adoption of policies to promote connection of new developments to decentralised energy systems. However, in the absence of direction to LAs about the relative priority of this in comparison to other goals,[11] the guidance is ineffective as a stimulus

The planning system can help establish new networks and stabilise existing systems. Lower costs of installing pipework during development must balance against the lower heat demand of new buildings. Linking heat network development to new housing and commercial development makes viability dependent on building schedules which can change quickly. The economic slowdown of recent years has slowed the pace of new development, creating problems for a number of UK DH initiatives.

3.4. Draw appropriate resources into the system

3.4.1. Mobilise finance

Mobilising financial resources for project development and capital investment involves ingenuity, given that time scales and the size of projects are difficult

[11] Williams, J., 2010. The deployment of decentralised energy systems as part of the housing growth programme in the UK. *Energy Policy*, 38(12), pp.7604-7613.

to predict. It is advantageous to decouple development costs from capital expenditure, though recent grants have tied the two together. "Technical assistance grants" for project development are available from the EU, but must be paid back if development does not lead to a threshold level of investment.

For capital investment, initiatives draw on a range of finance streams, mixing grants, debt and equity at levels influenced by availability, risk, organisational form and goals. Availability and costs of different sources of finance evolve as projects develop, with opportunities for refinancing as well as debt repayment. As development risks give way to (lower) ongoing operational risks, the costs of finance may decrease. Different sources of finance have different tax implications, so their allocation to categories of expenditure has consequences for overall tax liability.

Grants can be crucial to financial viability, reducing the rate of return the project needs to achieve. Availability is limited and unpredictable, and grant-givers' criteria have to be met. This creates complexity if grants must be spent in a short time scale, if they are geographically limited (e.g. linked to postcode areas) or if conditions applied to grant-holders must be transferred to their partners. In the past, UK DH grant packages have created coordinated demand spikes for relevant skills and materials, leading to temporary price rises and lengthening of lead times.[12]

Loans are a common way to provide the bulk of finance, particularly when a project sponsor wishes a degree of protection from financial risks. Non-recourse project finance (secured against project assets and cash flows) may be available, but difficulties in recovering value from pipes buried in the ground complicate this option. Long term contracts between DH developers and other stakeholders may be considered assets by a project finance lender. Alternatively, project sponsors may guarantee loans.

Local authorities have access to low cost borrowing and flexibility under **Prudential Borrowing**. Public Works Loan Board (PWLB) loans can be fixed rate and long-term (up to 50 years). Central government recently raised PWLB interest rates, however, making European loans or even LA bond issues more attractive. Transaction costs of the latter mean they may only be suitable for very large projects, or joint financing of a number of projects, possibly across a number of local authorities.

3.4.2. Maximise revenues

Sale of electricity from CHP distributed generation can be crucial to financial viability of the heat network. Different options are available and the picture is evolving. Direct sale to consumers achieves the highest price, but entails the complexity of either installing (and balancing) a private wire, or negotiating a relationship with licensed companies (such as a "Licence Light" arrangement with a supplier). Sale to suppliers or aggregators is often at pre-arranged tariff levels (which may be different at different times of day), though these are generally below wholesale prices as the electricity purchaser takes on the risks of balancing supply and demand. Where appropriate skills are available, and a backlog of data allows confidence in the performance of a system

[12] Hawkey, D.J.C., 2009. *Will "district heating come to town"? Analysis of current opportunities and challenges in the UK*. Masters dissertation. University of Edinburgh.

(including forecast levels of demand), operators of CHP/DH systems engage more actively with wholesale markets, exploiting times when prices are high while taking on balancing risks. Domination of wholesale electricity by the "Big Six" utility companies means market liquidity is poor, making forecasting and financial planning difficult.[13]

Connection to public distribution systems is a significant source of uncertainty and cost for distributed generators. Distribution Network Operators (DNOs) have so far proved relatively unresponsive to calls for more transparent and accessible pricing for distributed generation, despite regulatory measures intended to overcome barriers.[14]

Arrangements for the long-term evolution of heat tariffs are important for viability (and attractiveness to subscribers). The relationship between cost structures faced by a DH company and the tariff structures the company offers can exacerbate or reduce price risks. In the UK where heat tariffs are commonly indexed against gas prices (as the alternative option), gas is an attractive input fuel. As electricity prices are also related to gas prices in the UK[15] , gas-fired CHP systems have a natural hedge against price risk. The Renewable Heat Incentive is designed to compensate the additional costs of renewable heat equipment (though not heat networks) and renewable fuels, as compared with gas prices. As RHI payments are indexed to inflation rather than gas price, DH sales indexed to gas price would bear gas price risks.

3.4.3. Use external resources judiciously and strategically

Successful approaches judiciously use external resources, recognising the limitations of in-house capacity and the value of a fresh external perspective, but matching external resources to the project as it develops. External expertise is not necessarily costly: EST, Carbon Trust, and government resources support analysis of legal, commercial and technical feasibility of projects. A number of publications and websites offer accessible guidance, and trade associations provide forums for information sharing and lobbying. Private consultants may be used for customised business models and cash flow projections, as well as systems design and engineering. Careful selection of consultants with credible track record and established relationships with relevant stakeholders in the area results in faster, more robust development.

The experience of other project developers is also a resource. In countries with extensive DH networks, sharing of information and ideas among different projects was critical to overcoming the challenges of inexperience, and to the development of shared resources including identification of poor equipment and higher technical standards.

We would greatly appreciate ***feedback from attendees of the Heat and the City Workshop for Local Authorities on this document and the workshop itself.*** *Please send comments to Dave.Hawkey@ed.ac.uk*

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[13] CHPA, 2011. *Consultation on Reform of the Electricity Market: A response from the Combined Heat and Power Association*

[14] Ofgem, 2009. *Distributed Energy - Final Proposals and Statutory Notice for Electricity Supply Licence Modification*, www.ofgem.gov.uk/Sustainability/Environment/Policy/SmallrGens/DistEng/Documents1/DE_Final_Proposals.pdf [Accessed August 9, 2011].

[15] Gas-fired power stations are usually the marginal plant on the grid