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Improvising innovation in UK urban district heating: The convergence of social and environmental agendas in Aberdeen

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HIGHLIGHTS

- UK policy proposes district heating for urban low carbon heat.
- Technical and economic feasibility are insufficient to drive take-up.
- In Aberdeen convergence of social and environmental goals gave impetus to improvisation.
- The resulting non-profit ESCo has three CHP and district heat networks, supplying 34 MWh of heat pa.
- Carbon and cost savings are 45% in comparison with electric heating.

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ABSTRACT

Research on district heating has focused on technical-economic appraisal of its contribution to energy and carbon saving in urban centres. There is however lack of analysis of political and social processes which govern its actual take up. This paper examines these processes through a case study of Aberdeen, Scotland. Interviews and documentary analysis are used to examine the 2002 development of Aberdeen Heat and Power (AHP), an independent energy services company (ESCo). Technical-economic feasibility was a necessary component of appraisal, but not sufficient to govern decision-making. In the UK centralised energy market, DH investment is unattractive to commercial investors, and local authorities lack capacity and expertise in energy provision. In Aberdeen, the politics of fuel poverty converged with climate politics, creating an a-typical willingness to innovate through improvisation. The welfare priority resulted in creation of a non-profit locally-owned ESCo, using cost- rather than market-based heat tariffs. AHP has developed three combined heat and power energy centres and heat networks, supplying 34 MWh/pa of heat. Carbon savings are estimated to be 45% in comparison with electric heating, and heating costs are reduced by a similar amount. The conclusion outlines potential policy improvements.

1. Introduction

The UK Government Carbon Plan 2011 set a target for radical reduction of greenhouse gas emissions from the entire building stock: 'by 2050, all buildings will need to have an emissions footprint close to zero' (UK Department of Energy and Climate Change (DECC), 2011: 5). Forty-five per cent of these emissions are from heating, however:

> 'There has been a historic failure to get to grips with one enormous part of the energy jigsaw; the supply of low carbon heat' (Secretary of State, UK DECC, 2013: 1).

Using technical-economic modelling to assess the feasibility of low carbon options, UK government strategy concludes that heat networks or district heating (DH), using gas-fired combined heat and power (CHP) in the short run, could supply 'up to 20% of UK domestic heat demand' by 2030 (UK DECC, 2013: 45). Renewable or recovered heat sources are expected to replace gas at the end of a 12–15 year investment cycle, leaving a heat network infrastructure which is considered to be an economically viable route to meeting up to one half of anticipated 2050 low carbon heat demand. Calculations are based on energy, carbon and cost efficiencies compared with individual building heating and hot water in urban centres where demand is high and concentrated. If followed through, such provision would constitute a radical transformation of current UK practice, where DH, distributing heating and hot water[1] from shared fuel sources to multiple buildings via

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[1] Such networks may also be used to provide cooling services, using an absorption chiller linked to a CHP generator.

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insulated underground pipes, supplies only 2% of heating. Fossil fuel gas-fired individual building boilers supply the majority of heating[2] with the remainder from electric heaters, open fires or oil-fired central heating[3] (UK DECC, 2013); low carbon sources are estimated to account for only 2% (UK Committee on Climate Change (CCC), 2013). Previous UK CHP and DH support policies, also based on high level technical-economic modelling, have had limited impact (Russell, 2010), indicating that the material take up of such technologies is not solely a matter of formal efficiencies, but is governed by the political and social dynamics of retrofitting CHP and DH into a centralised energy system and established settings where it is largely absent.

In those European countries where DH is established, urban authorities have typically played a critical part in development, and UK policy also identifies local authorities as

> 'critical players in increasing the deployment of heat networks as they can create a supportive environment… and support or sponsor specific projects' (UK DECC, 2013: 50).

In the UK, however, local authorities have had no direct role in energy systems since the mid 20th century, when local and regional energy suppliers were nationalised and reorganised into vertically integrated structures. Privatisation of gas and electricity in the 1990s, and a regulatory framework geared to short-term cost efficiencies, has reinforced centralisation (Mitchell, 2008). At present a small number of large-scale corporations[4] control the majority of generation and supply. Energy-related action by local authorities has correspondingly centred on incremental efficiency gains through building insulation or use of digital energy management systems; some urban authorities have ambitious sustainable energy plans, but these remain largely aspirational and subject to unresolved questions of governance of innovation (Hawkey et al., 2014; Hodson and Marvin, 2010, 2012).

The purpose of this paper is to explore the social and political processes which shape the actual take up of such technologies in centralised energy markets, and which govern shares of costs and benefits in use. An in-depth case study of DH development in the city of Aberdeen, north-east Scotland, is used to analyse the governance process from origins to operation. Establishing the technical-economic feasibility of DH, with combined heat and power (CHP), was an essential element, but was in many ways more straightforward than the social and political dimensions of such innovation. Political confidence in legitimacy of localised energy provision, and mobilising capacity, expertise and finance were particular areas of difficulty.

The paper does not offer further technical-economic analysis of carbon and cost efficiencies of DH versus other technologies, although it does, in Section 2, summarise the features of conventional cost-benefit appraisal, before introducing the social and political dimensions of UK energy systems as context for establishment of CHP and DH. Section 3 describes methodology and data sources. Section 4 presents case study results. Section 5 discusses the Aberdeen developments in relation to the UK market and regulatory context and Section 6 concludes with suggested policy measures to improve the likelihood of sustainability benefits attributed to urban DH being secured in the UK.

[2] In 2013, 70% of all UK heating was from fossil fuel gas (UK DECC, 2013).

[3] UK DECC estimates that 10% of buildings use oil-fired central heating.

[4] Known in the UK as the 'Big 6', these are British Gas Centrica, EDF Energy, E.ON, Scottish and Southern Energy, Npower and Scottish Power. They have a 98 per cent share of the household gas and electricity markets. Five are owned by transnational entities headquartered outside the UK.

2. Urban heat networks as sustainable energy resource

2.1. Environmental, technical and economic dimensions

Technical-economic scenarios for low carbon heat for buildings in cold climates, as in UK strategy (UK DECC, 2013), are typically constituted in relation to a heat hierarchy, or ladder, of first *reducing demand* through insulation, second *efficient supply* through more efficient infrastructures, and third *use of low carbon sources*. This technically rational hierarchy is not however necessarily adhered to in practice. In the UK, although low carbon energy scenarios initially focussed on large-scale electrification of heat in highly insulated buildings, there is growing recognition of difficulties and costs of this model. Progress in insulation of a highly diverse building stock, much of which is in private ownership, has been incremental and patchy, and planned zero-carbon standards for all new developments remain uncertain (UK CCC, 2013). Building-scale electric heat pumps have also performed poorly in field trials, and there is recognition of the high costs of electricity grid reinforcement and stand-by generation capacity necessary to serve highly seasonal peak heat loads (Spiers et al., 2010; UK Committee on Climate Change, 2013).

In this context, there is increasing interest in more diversified heating solutions customised to the particular socio-economic and spatial characteristics of localities (UK DECC, 2013). In areas of high, and concentrated, heat demand, heat networks are represented as a means of efficient supply, reducing carbon emissions while contributing to security and affordability. Technical and economic modelling of European heat demand and supply also advocates DH, with improved building insulation, as a means of reducing the total cost of transition to low carbon energy by approximately 15% compared with the EU Energy Roadmap 2050 Energy Efficiency (EU-EE) scenario (Connolly et al., 2014). In the UK, any new DH development is regarded as likely to proceed from gas CHP, because of its status as a proven technology with expected source fuel conversion efficiency of 80% (http://chp.decc.gov.uk/cms/, accessed 26/09/2014). Once established, however, heat networks are seen as having long-term value due to attributed capacity to connect multiple local low carbon heat sources, which are inaccessible or uneconomic at individual building scale; these include waste heat from industry, biomass, or heat recovery from geothermal sources. UK Committee on Climate Change (2010) modelling for example concluded that DH using heat recovered from low carbon electricity generation (fossil fuel with CCS or nuclear) offered the most cost effective carbon abatement (−£110/tCO_2) measure. Formal assessments also tend to conclude that there are system-wide efficiency gains from localised DH and CHP, because heat supplied via networks means less electrification of heating, therefore reducing the cost of grid reinforcement and reducing the need for higher carbon stand-by generation. Embedded electricity generation from meso-scale CHP is also regarded as increasing energy system resilience, because it can contribute to energy storage and short-term operating reserve. This is expected to become more significant as increasing levels of intermittent wind energy are connected to the grid, while anticipated new load from electric vehicles and heat pumps increase peak demand (International Energy Agency (IEA), 2014).

There are limitations to CHP and DH as carbon saving measures. First site- and location-specific factors govern relative costs and benefits. Establishing heat networks entails significant infrastructure investment, and their effective sustainability value, relative to other options, consequently depends on long term secure, high levels of heat demand, with temporally diverse patterns of use, concentrated in a relatively small area. Large heat loads, such as hospitals or leisure centres with swimming pools, are significant to economic viability. Improving their economics is also