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**Multi-level Governance of Socio-Technical
Innovation:
the Case of District Heating in the UK**

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Abstract

While urban heat networks are established components of energy systems in several European countries, district heating (DH) serves only around 1% of the UK's space and hot water heat demand. Many of the factors relevant to Scandinavian 20th century development of DH (resource efficiency, affordable heat, regeneration, local revenue generation) inform contemporary UK plans, but climate protection policies are giving new impetus to low carbon energy innovation. A number of municipal authorities are actively developing DH projects, though in a context which differs significantly from those which supported earlier extensive innovation in Europe. Key differences include limited local authority powers, resources, and capacities; limited supportive institutions; and tensions between local initiatives and the global scale of key energy actors. Therefore, in spite of the maturity of DH technologies, and some supportive UK and Scottish governance measures, deployment of DH in the UK (and several other countries) represents a significant collective action problem. Using new qualitative data on UK, Dutch and Norwegian DH cases, we examine the local governance solutions and the prospects for effective governance of UK heat networks.

Key Words Governance, district energy, district heating, low carbon energy, cities, sustainability, socio-technical innovation.

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Multi-level Governance of Socio-Technical Innovation: the Case of District Heating in the UK

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1. Introduction and Research Themes: Energy Systems and Concepts of Governance

Accelerating global demand for energy, anxieties about security and cost, and scientific evidence of the damaging impacts of fossil fuel combustion, are placing innovation in socio-technical infrastructure² at the heart of public debate. place particular emphasis on system-wide innovation. This requires renewal not just of energy technologies, but of governance arrangements for supply chains, investment and ownership, regulatory frameworks and consumption. The design and coordination of adequate policy and resource frameworks, under time constraints, is extremely challenging. State, market and civil society actors face unanswered questions about governance, including the credibility and legitimacy of priorities for investment, and the share of responsibility for costs and benefits. The definition of the ‘problem’ of energy system change, and its potential solutions, are not surprisingly subject to uncertainty, and marked by anxiety over risks of market and government failures, which in turn have material consequences for the cost of capital, and the resulting energy systems.

This paper examines some of the situated practices of governance and innovation in distributed energy (DE), particularly that involving heat networks (‘district heating’ DH). It aims to give insight into the interactions between local (municipal government), energy market, and state government actors in the UK, contextualised with reference to European examples from the Netherlands and Norway. Using new qualitative data, we examine project development and governance in five localities. We draw on the functional Technological Innovation Systems (TIS) model, and the multi-level perspective (MLP) on socio-technical transitions, to identify factors which account for particular practices of energy governance.

The main political divide over proposed solutions for low carbon energy systems development continues to centre on arguments about the relative effectiveness of market mechanisms vs government-led ‘command and control’ planning measures. In practice, European institutional arrangements for energy infrastructure are highly diverse, ranging from ‘centralised state provision through ministries and state-owned companies, local municipalities and private provision’ (Helm, 2010: 9). The variety of provision is equaled by variety in financial arrangements, from public to private finance, and from franchises to direct asset ownership. A mixed ‘planning and markets’ approach is typically used: competition in European energy markets is pursued in tandem with policy measures intended to enhance security of supply and low carbon transition; market-mechanisms (liberalisation / ‘unbundling’, the EU ETS, and variants of carbon incentives and taxes) exist alongside centralised control and planning (energy efficiency standards, infrastructure planning and capacity mechanisms).

¹ We wish to thank Dr Mark Winskel for his contribution to early drafts and discussions about case study interpretation.

² Socio-technical infrastructure is defined here as a combination of knowledge and expertise, material technologies, equity and investments.

Empirical social science has also long established that the organisation of production and consumption is not in practice characterised by a simple dichotomy between ‘markets’ and ‘hierarchies’, just as it has repeatedly shown the inadequacies of a model of organisational conduct derived from the tenets of rational-economic individualism (Fligstein and Dauter, 2007; Goffman, 1983; Granovetter, 1985; Ostrom, 1990; 2009; Powell, 1990; Sen, 1977; Simon, 1955; Stark, 2009). In this context, the concept of governance, although often used only loosely and sometimes implicitly, promises an analytical device for bridging between the stark dualism of market or hierarchical solutions. Use of the term governance opens up to more deliberate and reflexive enquiry the variety of potential solutions to major collective action problems, in different political-economic contexts, and at different scales, from local to global. When applied to local energy systems innovation, the concept of governance places questions of organisational control, distribution of costs and benefits, risk and responsibility, explicitly on the agenda for negotiation. It creates potential for recognition, and analyses of, the role of diversity, complexity and different political values in addressing collective action dilemmas, and the likely range of planning and markets, and public and private agents and resources involved. Perhaps above all, it enables recognition of the socially- and historically-situated qualities of solutions to innovation. Evidence from practice demonstrates that circumstances shape actors’ proposed solutions to address complex issues of finance and resource allocation, and concerns over accountability, legitimacy, credibility and equity (Kern, 2011; Ostrom, 2007).

Privatised energy markets, which have developed alongside finance capitalism over the last 20-30 years, have decisively shaped the political-economic circumstances for such systems innovation. With the aim of assuring reliable rates of return through controlling risk, and hence lowering the cost of capital, global financial market actors have devised increasingly standardised risk assessment instruments to govern investments. In seeking to reduce financial risk, such instruments work to decontextualise and delocalise investment decisions for systems innovation. Local, customised, energy systems, which do not fit dominant system ‘templates’ are marked out as riskier, making a ‘business case’ for infrastructure investment hard to establish. Given the local and contingent qualities of DH, with high upfront investment, long-term payback, and risks regarded as hard to mitigate through standard means, the resulting increase in capital costs will limit the financial viability of projects. Bridging the gap between rationalised finance models and local political and economic interests in DE projects requires considerable governance capacity, which will have high transaction costs for organisations with limited resources. Inter-organisational governance of the kind often entailed in DH systems is particularly challenging and prone to recurring crises, with notable disadvantages including ‘management complexities, financial and organizational risks, the risk of becoming dependent on the partner or power imbalance, partial loss of decision autonomy, and culture clashes’ (Sundberg and Sjodin, 2003: 492). New DH networks may be increasingly disadvantaged, relative to other energy investments, unless the cost-benefit calculus is changed by introduction of supportive regulatory measures.

2. Applying Theories of Innovation Governance to DH

Innovation systems and transition theories have been informed by sociological analyses of science and technology, and actor network theory, as well as having foundations in evolutionary and environmental economics. The MLP established in

the 1990s (Kemp et al, 1998; Geels, 2004) sought to address criticisms of transition theory as inappropriately ‘micro-social’ in focus. It conceives of system transition as taking place in relation to a nested innovation hierarchy of niche, regime and landscape (Geels and Schot, 2007). The regime represents the meso-level of institutions and organisations, where ‘normal’ means of organising societal functions such as provision of energy are established; it is regarded as changing incrementally and in path-dependent ways. The regime represents the accumulated knowledge, investments, public and private infrastructures and norms constituting established practice (Smith et al, 2010). In common with other recent innovation systems theories, the MLP conceives of radical change as most likely to arise from niche innovations, which must gain sufficient momentum to displace an established regime. Both niches and regimes are treated as situated in a macro-level landscape of societal and physical processes, encompassing environmental and financial resources, as well as social movements, politics, global economic organisation, scientific knowledge, demography, and so on.

The MLP is powerful in providing a means of conceptualising and ordering complexity, and in providing an analytical means of tracing alternative pathways to transition, but there are also questions about its explanatory power. One of these concerns the extent to which insight into innovation governance for socio-technically embedded and coupled systems such as DH requires analysis of the relevance of particularities of place and spatial scale. Hodson and Marvin (2010) argue that place has frequently remained implicit in research drawing on the MLP, with the background assumption that regimes operate at the scale of a country or geographical region. The specificity of place, given different resources, histories and cultures, forces researchers into interaction with the multiple levels of governance practice, and power relations, and their variable geometry. It highlights concerns about capacity and capability to manage system innovation and questions of purpose, intent and motivation. Smith et al (2010) argue that ‘places bring meaningful historical and social narratives into the realisation of abstract goals. They generate regionally relevant visions whose symbolism and specificity carry greater moral authority as a result’ (p. 444).

An alternative perspective is provided by Winskel (2011) who suggests that the MLP has been overly-influenced by normative concerns with advancing radical sustainable technologies, which are expected to thrive predominantly in protected niches, before becoming a motor for meso-level regime change. The ‘niche’ has been treated, predominantly, as situated at the micro-level of interaction. He regards the social constructivist analysis of systemic innovation as resulting in over-emphasis on micro-social niches as engines of system change. This risks a ‘one best way’ account of innovation as a necessarily disruptive process, entailing the break-up of incumbent regime authority. Consequently the potential for regime reform to produce radical transformation has been downplayed. This has resulted in less recognition of, and insight into, the roles of the incumbent regime in innovation, and of non-radical innovation i.e. based on recombinations of existing technologies, or of incremental innovations which may exert considerable cumulative effect over time (Smith et al, 2005; Winskel, 2011). Given high economic and political stakes, Winskel implies that claims about the moral and symbolic power of associations with place are similarly flawed by social constructivist assumptions, and are unlikely to outweigh concerns about energy affordability and supply security, framed by the cost-benefit calculus of a dominant regime. In addition it might be argued that, during periods of major

political economic uncertainty, as at present, the concept of a singular stable and self-perpetuating regime under-recognises the tensions and sources of schism within and among regime institutions, or the potential for a plurality of ‘partial’ regimes to be in operation, with different goals and assumptions. Such tensions may work as catalysts to socio-technical innovation at a range of scales, as suggested by economic sociology analyses of the productivity of intra- and inter-organisational dissonance and discrepancy in assumptions and understandings (Boltanski and Thevenot, 2006; Stark, 2009).

Hence we aim, as advocated by Smith et al (2010), to analyse some of the inter-linkages between ‘actors and institutions of markets, technology and societal demand with those of market regulation, innovation policy and environmental governance’ (p.446). We seek however to avoid the pitfalls of ex-ante pathway prototypes. We treat the concepts of micro, meso and macro levels as analytically useful distinctions, which may however inadvertently obscure the interlocking and shifting qualities of relationships between actors, many of whom have a number of identities in, for example, localities, business, government, research and campaigning. Such a perspective does not imply an inevitable focus on micro-level or niche-led action as the major means of system innovation. Analyses of the Dutch energy transition project, designed initially as a democratically-informed and participative platform for innovation, for example, have provided insight into structural dynamics of power relations. Incumbent actors played a dominant part in setting direction and framing the evaluation of costs and benefits of technologies (Hendriks, 2008; Kemp, Rotmans et al 2007; Kern and Smith, 2008). Governance of innovation is irreducibly political (Meadowcroft, 2009); it is not designed in a social vacuum and its agents are complex entities, not atomistic individuals; it proceeds from current policies, ‘sunk investments’ and incumbent interests.

3. Using the TIS Model to Structure Data Collection

For data collection purposes, the functional Technology Innovation Systems model (TIS) (Bergek et al, 2008; Hekkert et al., 2007; Jacobsson and Bergek, 2011) was adapted to the socio-technical DH network. TIS categories provide a means of identifying project development problems, and the resources, institutions and actors which can be recruited to solve those problems. Adapting the TIS categories to DH projects requires recognition that DH is locally bounded by area-based heat demand, and the technology is spatially anchored in evolving patterns of demand. Systems rely on long-term interdependencies between developers and subscribers, and local authorities typically play a critical role. Second, DH is a relatively well-established technology; hence our focus is on deployment and organisational innovation rather than technological innovation per se. Third the concept of “Entrepreneurial Experimentation” is flexibly interpreted. Rather than the “point source” model of innovation implied by the term “entrepreneurial”, suggesting individuals or organisations making high risk investments in the hope of extraordinary returns, we emphasise the socio-technical “experimentation” aspect of the category. The need to coordinate a wide range of stakeholders, particularly subscribers who make a long-term commitment to the system (either through long term contracts and/or due to the cost barrier associated with switching to another energy supply) and forego access to retail competition, means that developing a DH network is rarely comprehensible in the context of conventional entrepreneurship, or undermining incumbent interests. While new DH networks present a series of risks to those involved in their

development (financial, political, technological, etc.) they are rarely undertaken because the risk profile is matched by large financial returns. However, the space available for new activities (generating new forms of knowledge and other externalities which expand that space) is an important consideration. Fourth, rather than a macro-scale interpretation of the search processes which structure the selection environment for different investment opportunities, and hence technologies (Hekkert et al., 2007), we find the function a useful category for exploring factors influencing the “search” carried out by local actors and decisions (including investment decisions) at a local level. In part, this is because DH is a mature technology and so falls outside the purview of investors searching for opportunities to establish a strong position in an evolving energy system.

4. DH Governance Arrangements in European Context: Case Studies in Norway, Netherlands and UK.

District heating (DH) is a well-established technology in a number of European countries, but serves only around 1% of the UK’s space heating and hot water demand. Historically in the UK it has been marginalised by a relatively cheap, plentiful and secure supply of North Sea gas, combined with a short-term least cost calculus in price-competitive electricity markets, resulting in the ‘dash for gas’ in electricity generation and reliance on individual building heating systems. Gas-fired CHP has not been prioritised, despite recognised energy saving, and social and environmental, benefits (Kelly and Pollitt, 2010). The absence of a state body with direct responsibility for heat supply, which could for example identify zones for DH, and regulate and license suppliers, has added to relative disadvantage for both CHP and DH (Hawkey, 2011; Russell, 1993).

In western European countries (notably Denmark, Finland, Germany, The Netherlands, Norway, Spain and Sweden), DH has developed under a variety of institutional arrangements, but two factors - the scope and power of local authorities (LAs), including budgetary control, and significant public sector control over energy - have been particularly important historically. The dominant governance model has centred on locally-owned energy companies, where the municipal authority is at least a significant shareholder, if not sole owner (Ericson, 2009; EuroHeat & Power, 2009). LAs have played a critical role by virtue of:

- their capacity (as municipal agents) to map the distribution of heat demand and supply in an area and to plan energy (heat and power) supply to optimise fuel and infrastructure efficiency;
- their capacity to coordinate the development of heat networks with other energy and utility systems;
- the significant heat loads controlled;
- the perceived reduction in risks of subscription to DH, associated with lock-in to a monopoly heat supplier;
- their responsibility to balance societal well-being, including affordable warmth, against financial costs, including cross-subsidisation of heat networks through income from other public services.

The broadly-based social-democratic welfare consensus established in significant parts of post-war western Europe supported equitable access to integrated, and in some instances cross-subsidised, public services including energy. In the last 20-30

years however on-going liberalisation of energy markets, combined with rising public debt, has resulted in some dismantling of locally-controlled energy services and increasing concentration of ownership by transnational utilities. In countries such as Sweden, this has brought greater fragmentation of services and evidence of rising heating costs (Rutherford, 2008). Whether shaped by political economy, or plentiful supply of resources, or their interaction, goals in a privatised energy system are necessarily defined in commercial terms; social obligations are limited, and political coordination over energy efficiency, security and affordability must be structured around the institutions of private-public partnerships, which have become a defining feature of neo-liberal governance.

4.1 BERGEN, Norway: from corporate experiments to multi-level governance and municipal leadership.

The form and governance of DH development in Bergen can be traced to state instruments requiring recovery of minimum levels of energy from waste, allied to corporate strategic interests in energy system development. Early local level governance was weak, and the scheme relied on commercial partnership between an electricity utility and a waste management company. Limited state-level regulation meant that the development pathway had to be newly devised. More recent proactive local governance has been driven by state and international climate protection measures, and the perceived success and momentum of the scheme.

The DH network is a joint venture between BKK (Norway's second largest electric utility) and BIR (the waste management company). The local authority (LA), Bergen Kommune, does however own shares in both companies, but under the Norwegian model of energy market liberalisation LAs do not use share ownership to pursue social goals. In 1996 BIR obtained a license to construct and operate a waste incinerator roughly 12km from central Bergen. The license stipulated that a minimum of 50% of recoverable energy must be used. Although BIR considered options for industrial use of the heat, a DH application proved more economically attractive. The joint venture, BKK Varme, was established to construct and operate a DH network, purchasing heat from BIR's waste incinerator and retailing it to consumers. From BKK's perspective, DH drew on their energy retail expertise, but also complemented 'regime' electricity market structures by relieving strain on electricity networks caused by new electric heating developments. The understanding of DH as improving network resilience and limiting costs is common among electricity suppliers. Indeed Norsk Fjernvarme (the Norwegian District Heating Association) was initially made up predominantly of electricity companies. Reflecting BKK's interests and retail expertise, BKK Varme was established to give BKK overall control through a 51% shareholding.

Other local circumstances facilitating development of the DH network included the construction of a motorway running into the city and passing near the incinerator, allowing BKK Varme to coordinate DH planning with transport infrastructure permissions already granted. Bergen's built form also allowed easy identification of buildings likely to be suitable for DH connection (pre-1960s buildings predate the general electrification of heating in Norway, and so usually have water-borne, oil-fired heating).

In a context where climate protection policy has gained increasing prominence, state governance, which seeks to integrate social, economic and environmental and criteria for energy systems, has proved supportive of locally-devised solutions for DH. State licensing of DH systems above 10MW regularises development by imposing data requirements, appraisal methodologies, heat tariff limits and service reliability and consumer protection measures. Project developers submit detailed plans, including evidence of subscriber commitment to connect, before a license is granted. Combined environmental and socioeconomic indicators (using open calculations and assumptions) are used to judge whether the development is “socially rational and environmentally acceptable” relative to other heat solutions (NVE, 2009). In TIS terms, the framework constrains the scope of DH governance models, without being overly-determining, and mitigates local problems by increasing legitimacy among stakeholders and subscribers. Development of DH in Bergen predated even more supportive state governance. Significant new resources have been made available, including advanced technical support from the Norwegian Water Resources and Energy Directorate, state funded grants covering up to 20% of capital costs for DH, commercial lenders willing to finance heat networks, and a competitive market in specialist consultancies and contractors.

While the municipal authority played a relatively passive role in early development of the system, the state was crucial to the initiative’s success. Licensing reduced the importance of a pro-active local authority, and opened up space for the establishment of the initiative; it worked to establish legitimate relationships with the local authority through planning consent procedures, and the inclusion of a requirement to connect to DH in local planning policy. Subsequently, growing interest within Bergen Kommune (reflecting growing interest in climate and urban development issues, and recognition of local benefits produced by DH) has led to closer collaboration between the DH company and municipal authority. The authority now assists BKK Varme to identify sites for new energy centres and is committing municipal buildings to the network (including retrofitting water borne heating to buildings including the City Hall). The heat network has been integrated into the city’s strategic development plan, which is aiming to increase urban population density, and to make long-term development of heat demand more visible to BKK Varme. Several factors contribute to this change. Since around 2007, climate change has become more prominent in Norwegian politics, and political interest in urban development in Bergen has also grown. In addition, the rapid development of a relatively large DH network is seen as a significant achievement, and the success of the system attracts support from subscribers and the Bergen Chamber of Commerce.

In this case, state governance frameworks have regularised DH technology; commercial goals tallied with investment in DH, and enabled gains for private energy companies in line with their objectives. At the same time, prominent new measures for climate protection meant a supportive local authority, gradually creating a ‘virtuous circle’ of development.

4.2 ROTTERDAM, Netherlands: from informal knowledge exchange networks to private public partnerships via crisis and reform.

Rotterdam DH development is characterised by hesitant beginnings in the 1970s and 1980s, when government attempts to encourage DH largely failed (sixteen of fifty feasibility studies succeeded) (Raven and Verbong, 2007). This activity, combined

with use of DH in an expanded national housing programme in the mid 1990s, however, created relevant experience and skills. Energy market liberalisation, and consolidation of regional electricity companies (which developed most DH networks), in the 1990s stimulated efforts at informal trust-based governance in the early 2000s. Finally, after crisis in the late 2000s, a combination of climate change imperatives and an influential state heat law (2009) has led to establishment of a formal institutional and organisational model, based on public-private partnership. State powers to cap heat tariffs, on the basis of alternative heating cost and on the basis of reasonable returns on infrastructure investment, mitigate both investment and consumer risks of DH development in a liberalised energy economy.

While the Rotterdam Warmtebedrijf initiative is able to draw on established Dutch DH praxis, uncertainties over heat sources, costs and necessary expertise have precipitated a number of crises and a reconfiguration of the project. The initiative aims to bring waste heat from the industrial harbour area into the city. The organisational form is complex: there is separation between heat producers, a transmission infrastructure operator, a wholesale company which uses the transmission infrastructure, and two commercial distribution and retail companies (Nuon and Eneco), recruited for their established expertise, and responsible for developing the retail market. The municipal authority in turn supports their activity, for example through planning powers requiring connection of buildings in DH zones. The involvement of Nuon and Eneco, both large companies, is also an important factor in mobilising financial resources. The infrastructure is financed by a 70/30 split between equity and debt, and commercial lenders were willing originally (prior to changes in the initiative discussed below) to lend on the strength of take-or-pay contracts with Nuon and Eneco (PVW, 2005).

Explorations of the use of waste heat date back to industrial ecology programmes in the 1990s, and the evolution of the project illustrates the fluidity of governance, which has evolved in line with emerging state governance of energy to find a viable local model for an embedded DH. Horizontally-structured industrial ecology programmes were established initially as industry/academia collaborations, but over time drew in regulators, local and regional government and NGOs. The objective was to reframe environmental issues as joint problems, rather than sites of antagonism between industry and regulators (Baas, 2008). This consensual governance model built trust between participants, encouraging plant managers to share operational data which underpinned feasibility studies into the use of waste heat. However, as investigations coalesced around a model of urban (as opposed to industrial) heat demand, the municipal authority began to take a more directive role, for example, requiring that open procurement procedures be used to gather competitive bids from industry for the supply of heat (Visser, 2008). This may reflect the LA's role in minimising cost of heat to consumers and standard requirements for best value procurement. In addition, as in Bergen, climate change mitigation was becoming a prominent political topic as Rotterdam joined the C40 cities initiative. The virtues of greater municipal control over governance are contested, with some accusations that the trust built among participants in the Industrial Ecology programmes was undermined, and that the bureaucratic procedures required by the municipal authority slowed the pace of development. Nevertheless, as the project progressed, the role of the municipal authority has become increasingly central. Two developments precipitated a major overhaul of governance.

A single publicly-owned company had been planned to develop and operate the transmission system, and handle transactions. However, the costs of installing equipment at a refinery to allow continued operation in any break in heat network business were significantly underestimated. Connection of the refinery was abandoned. Separate developments, resulting from overcapacity in Dutch waste management infrastructure, led to the relocation of a waste incinerator and considerable increases in capital costs, further undermining the plant's business model. Instead, Rotterdam's municipal waste would be burned in a more distant CHP incinerator, and a longer transmission system was required to bring the heat to the city centre.

The municipal authority paused the initiative in 2007 while investigations into a new business model were undertaken. There were political divisions as to whether the initiative should be abandoned, with arguments centring on the balance between losing sunk investments and risks of pressing ahead. The process of developing a new business model was therefore subject to considerable political scrutiny. The new model drew E.On in as a shareholder, allowing the Warmtebedrijf to exploit E.On's expertise in energy dispatching. E.On sought to shield itself from the risks of infrastructure development and operation. The original single heat transmission company model was replaced with a two company (infrastructure and commercial operations) structure. The new model adopted an innovative approach to heat sales: Warmtebedrijf heat is fed into networks previously supplied by E.On's own (fossil) CHP generators. A complex set of calculations governs the process, which is designed to make the arrangement profit-neutral to E.On while providing Warmtebedrijf with revenue. Although E.On's involvement is crucial to the new business case, the role of the municipal authority has also become central, particularly in mobilising financial resources. The municipal authority's equity investment has risen from €9m to €38m, and it now guarantees the commercial loans to the initiative (which have risen from €58m to €149.5m, Warmtebedrijf, 2010). The redesigned business model will ultimately recover these additional costs from the waste management company through lower heat tariffs, but the financial resources and creditworthiness of the local authority are crucial.

The new arrangements for use of industrial waste heat illustrate two general features of DH governance: responding to local circumstances and opportunities requires innovative organisational and commercial forms; as a consequence, governance may entail complex arrangements intended to balance the objectives of the different parties. Like the Bergen case, the Warmtebedrijf project illustrates the role of state governments in regularising the context for supply and sale of heat via DH. However, DH projects continue to require locally-innovative solutions, and technical and financial constraints remain significant. In Rotterdam the question of waste heat capture from the refinery remains unresolved, although other heat capture opportunities have been created through the secure establishment of heat mains infrastructure. State, local and private sector interests had to be aligned through lengthy negotiation to achieve this outcome.

4.3 UK

4.3.1 Energy Policy and Market Context

Since the late twentieth century successive UK governments have acted on neo-liberal arguments that privatisation and private finance would reduce public expenditure and improve efficiency, without degrading public infrastructure, even at a higher cost of (commercial rather than public) capital. Higher borrowing cost, it was argued, would be more than recovered by resulting lower total expenditure and improved performance incentives (Flyvbjerg, 2003; Helm, 2010). Consequently UK energy systems and infrastructure are owned and financed largely by the private sector, with the UK government acting as market regulator (Helm, 2010). Devolved governments in Scotland, Wales and Northern Ireland can promote energy efficiency and renewables through advice and investment, and have some discretion over the banding of UK renewable energy incentive payments, but are otherwise bound into centrally-regulated markets.

After a decade of laissez-faire government attitudes to energy planning, top-down policy-making returned prominently to the government agendas, prompted by crisis over failure to maintain the infrastructure asset base, and by Climate Change legislation with ambitious decarbonisation and renewable energy deployment targets. It is recognised that transition to a low carbon, secure and affordable energy system is unlikely to be manageable under current energy market structures. One of the elements in renewed debate over energy planning concerns the potential contribution of CHP and DH. Urban heat networks are under consideration as part of a portfolio of low carbon energy technologies intended to reduce the risk of over-reliance on any single solution, and thus improving competition, innovation and cost saving (DECC, 2011; HMT National Infrastructure Plan 2011; UK Carbon Plan, 2011). Forthcoming Electricity Market Reform (EMR) measures, for low carbon incentive and carbon emissions tax payments, set out in the EMR White Paper (UK Government, 2011) will however shape economic feasibility and hence the extent of implementation. EMR focuses largely on centralised reform of generation and supply, but acknowledges that these measures alone are unlikely to be sufficient to produce system-wide transition. Distributed energy (DE), with more variety in business ownership and investment (PPPs, community interest companies, ESCos set up as trading arms of LAs and so on) is envisaged as playing a greater role in what is currently a market dominated by six integrated utility companies, which comprise a powerful lobbying force in relation to government policy (Mitchell, 2010). DE businesses could be developed alongside the 'Big 6' as small scale, stand-alone community enterprises, with the incumbent 'regime' remaining largely unaffected, or they may take a range of forms, including joint ventures between utilities, LAs and/or other social and commercial enterprises. The EMR White Paper identifies the benefits of a greater role for DE as reduced costs, more diverse, and localised control over, supply and potentially a more resilient and secure energy system. There is however no settled means to meeting these desired outcomes or generating the anticipated investments, and it is unclear to what extent, and how, aspirations to a greater contribution from DE will be brought about. This uncertainty is not restricted to DE, but reflects a wider lack of clarity regarding the means by which highly ambitious policy targets are to be realised in risk-averse and capital constrained times. The major focus of policy continues to be low carbon electricity supply, which puts in question the strength of commitment to urban heat networks, as opposed to

electrification of heat, and there are unresolved issues about the compatibility of these different facets of policy. Hence there remain many questions about whether outline policy supportive of DH will result in significant change in practice. In contrast with the Netherlands and Norway, where state-level institutions and resources are facilitating the development of local networks, the DH TIS in the UK is weakly established. In spite of the maturity of DH technologies therefore, and some supportive UK and Scottish governance measures, deployment of DH in the UK represents a significant collective action problem.

4.3.2 The Role of LAs in Governance of DH

Following the European trajectory of DH, local authorities might be expected to have a central role in effective governance and leadership, and the UK Government's Infrastructure Plan (2011) identifies LAs as playing a central role in delivery³. At the end of 2011, the UK and Scottish governments also published plans to enable certain cities to gain greater autonomy and financial powers, in exchange for accelerated investment in local economic development⁴. The UK local governance context differs significantly however from that which supported earlier extensive innovation in Europe.

Whether in England, Scotland or Wales, LAs have limited autonomy; the majority of funding is controlled through the respective devolved governments, and they are restricted by the ultra vires principle to undertake only those activities permitted by statute (although general powers to promote "well being" were introduced in 2000). They have restricted trading and revenue raising powers, which constrain their ability to provide energy services; they may charge for discretionary services, though only to recover the costs of provision. Trading on more commercial terms can be carried out through arms length companies, but the higher the degree of LA involvement, the tighter the regulation. Until recently local authorities have been allowed to sell electricity only when produced in association with heat (and, in Scotland, from waste incineration). Partial lifting of this restriction in 2010, allowing sale of electricity from renewable sources, opens opportunities for development of a wider portfolio of energy services. LAs also have powers centrally relevant to district heating: permission⁵ to produce and sell heat; to lay heat networks and to access pipes for maintenance. The powers can be exercised by contractors, or an ESCo, on behalf of the LA. Since 2004 LAs have had prudential borrowing powers, giving access to lower interest loans for investment, without consent from other levels of government.

LA duties and plans under climate change legislation, and the introduction of 'penalties' for emissions from energy use, notably the UK CRC, an energy saving 'tax' on the organisation's carbon emissions, have created impetus for LAs to reduce their own estate energy use, and, more ambitiously, to consider the potential for low-carbon district energy. Resources are however constrained, plans are mostly at an early stage, and capabilities for municipal energy provision are lacking, in the context of a centralised, privatised energy system, marked by structural tensions between

³ See 3.88-3.90, p.64

⁴ UK Government *Unlocking Growth in Cities*, Dec 2011 www.cabinetoffice.gov.uk; Scottish Government *Scotland's Cities*, Dec 2011.

⁵ The Local Government (Miscellaneous Provisions) Act 1976 confers these powers on local authorities in England and Wales, and amendments to the Local Government (Scotland) Act 1973 confer the powers in Scotland.

local initiatives and the global scale of energy utilities. Energy consumption data, necessary for systematic heat mapping, for example, is dispersed across incumbent energy companies, and access is constrained by its status as commercial property. In contrast with many European countries, UK LAs have had virtually no involvement in energy provision since nationalisation of the energy industries in the 1940s, and then privatisation in the 1990s. Although a number of companies (often local subsidiaries of international companies) offer consultancy and contracting services, there is a lack of local technical, commercial and project management expertise, and lack of the type of local supply chains which arise from involvement of municipalities in energy supply. While engineering expertise can be translated from experience in other countries, appropriate commercial and legal models are less developed.

4.3.3 The Current Governance Context: Uncertain Routes to Collective Action

The absence of a supportive UK multi-level governance ‘template’ leaves space for different organisational and business forms to be developed, but makes experimentation in development of DH highly challenging. From a TIS perspective, this has some positive connotations: a number of local initiatives act as experiments in ways of working, contributing to a spectrum of feasible governance structures, from community interest companies to PPPs and commercial ESCos. However, the perceived risks and uncertainties associated with DH, and the transaction costs arising from coordinating multiple stakeholders around an unfamiliar socio-technical system, slow the pace of deployment. Key uncertainties are:

Regulatory: urban heat networks may be subject to future regulation, potentially changing the long term performance of business models;

Financial: high costs of initial infrastructure investment has long-term payback, with modest rates of return, and support mechanisms are uncertain; tax advantages for electricity from CHP, for example, are due to be revised in 2013, but future schemes are yet to be developed; energy price volatility adds uncertainty in calculation of expected cash flows;

Subscriber commitment: perceived risk of long-term supply contracts with a company with limited track record, coupled with absence of standardised consumer protections;

Public procurement and state aid rules: limited experience in energy services procurement and limited accessible guidance makes LAs uncertain about effective procurement of a commercial DH delivery partner. This is made more complex by LA plans to integrate development of DH networks with other low carbon energy initiatives;

Objective-setting: limited LA expertise in DH systems leads to confusion about the capabilities of DH, and there may be tensions between social, environmental and economic objectives for combating fuel poverty, reducing carbon emissions and reducing energy costs/creating new revenue streams for the LA.

4.3.4 Local Governance Case Studies: Aberdeen, Birmingham and Woking

ABERDEEN: from fuel poverty to local community interest company for the benefit of the citizens of Aberdeen.

Political campaigns against fuel poverty in the 1980s eventually led to UK legislation for home energy conservation, which in turn enabled Aberdeen City Council (ACC) to appoint a housing officer with responsibility for energy conservation. Public funding provided a means to carry out an options appraisal of solutions to fuel poverty in the worst of the city's electrically-heated multi-storey residences. The study identified gas CHP with DH as achieving the lowest cost in use to residents. The 'cost in use' assessment criterion, which was justified by the Council's social priorities for affordable warmth, outweighed the conventional 'lowest cost' option, and Councillors took the politically-courageous decision to proceed against the legal advice of the council in-house lawyers. The combination of a determined officer, a burst of UK government funding for community energy, access to an informal network of community energy expertise, and local political leadership resulted in formation of an arms length non-profit ESCo, Aberdeen Heat and Power (AHP), with responsibility to act for the good of the citizens of Aberdeen. Several heat networks have since been developed, each supplying multi-storey flats, and progressively expanding to other municipally-controlled buildings. Networks have been financed by local authority housing capital, prudential borrowing against current and future expenditures which the initiatives avoid, UK and Scottish government grant funding, and a commercial bank loan and overdraft.

The focus on local authority buildings and social housing enabled the system to develop, without the uncertainties introduced by supplying external public or commercial organisations. During this period of formation, AHP has developed technical and financial expertise. Domestic users receive unmetered supply of heat at a fixed cost (paid with rent) reflective of the costs incurred by AHP. AHP and ACC now have ambitions to expand supply to commercial organisations. Connection of a sports facility, a joint venture between ACC and other public bodies, provides an opportunity to develop capacities for such supply (e.g. development of a template contract) in a quasi-commercial setting. However, management of bad debt risk is a challenging issue, and is likely to require a different organisational form in order to protect the LA from liability.

BIRMINGHAM: risk aversion, carbon management and local economic regeneration via private-public partnership (PPP).

Fuel poverty in social housing was also the issue which aroused initial DH interest among building engineers in Birmingham City Council (BCC). The Council faced a series of court cases, brought by tenant campaigners in the 1980s, which resulted in orders for improvements in the energy performance of its housing stock. They focused however on short term, lowest cost measures (rather than cost in use), which led to new electrical heating and improved building insulation. A small scale in-house CHP and DH pilot was however established, connecting a local leisure centre to a number of multi-storey residences. Building engineers continued to assert the value of CHP with DH, despite opposition from Council finance and legal teams. The eventual adoption of whole-life-costing accountancy rules, driven by UK government private finance and PPP contracts, became a means of justifying subsequent CHP and DH investment, when opportunities arose from planned heating boiler replacement at Birmingham's city centre national arena and conference centre. The main objective for the project was economic regeneration alongside carbon saving. UK government funding for community energy again proved instrumental in gaining Council support. Seeking to minimise BCC's exposure to financial risk, however, and partly inspired

by the success of Southampton Geothermal Heating Company, the council procured a commercial contractor, Cofely, to build, own and operate three DH networks with gas CHP. Cofely established Birmingham District Energy Company (BDEC) as a joint venture with the Council, the local university and a hospital. This approach allowed public sector partners to draw on Cofely's access to loan and equity finance through parent company GDF-Suez, as well as its experience of network development and operation, and of establishing supply contracts with third parties. The networks predominantly supply large heat users (BCC, a university, a hotel, an arena, a convention centre, and a hospital). The commercial company model results in limited motivation to address fuel poverty, which is seen as having high costs and low returns. A small number of council owned flats have been connected to the network, but this has relied on further grant-funding from UK government.

Establishing the BDEC model was challenging, as grant funding imposed a deadline for negotiations. The steep learning curve and lack of experience of the BCC legal team were significant, and both BCC and Cofely worked under pressure in the final days up to the deadline. The final procurement agreement is regarded by BCC as too tightly specified to allow expansion of the system without a further procurement process. In addition, despite caution on the part of BCC, the initiative contravened state aid rules, resulting in fines. Nevertheless the model is regarded as highly successful and the Council has used the experience to develop ambitious plans for city-wide district energy, building on secondary schools as local network hubs, using BCC biomass for heating, and investing in energy from waste.

WOKING: Environmental activism, executive leadership, energy saving, and local enterprise ESCos

Commitment of the Chief Executive and local political support for environmental issues made Woking Borough Council (WBC) an early innovator in energy saving and DE. WBC began an in-house energy efficiency programme in 1992, setting up a £250,000 revolving fund for council estate measures. The success of the programme (including small scale CHP) strengthened political support for energy saving, on the double benefit of environmental and financial gains. The council sought to develop larger scale CHP/DH systems, while reducing its exposure to risk, and complying with regulations governing local authority trading. Governance of DE projects is via two arms length companies, whose profits are retained by WBC for use in further energy saving projects. A wholly owned arms-length company, Thameswey, in turn established a joint venture company, Thameswey Energy Limited (TEL), with a Danish company. Development of this arrangement was complex: initial support from government funding has been extended through prudential borrowing and commercial loans. WBC lends to TEL at commercial rates, using the resulting interest payment differential to reinvest in further sustainability projects. The model requires TEL to behave entrepreneurially, seeking energy investment opportunities outside the Borough of Woking. The effort involved in establishing this organisational form is expressed in the £2m valuation Thameswey places on the intellectual property.

TEL developed and operates several CHP/DH schemes, both in Woking and in Milton Keynes (about 100km away). By developing a system performance database, and recruiting specialist staff, it has built distinctive capacity in energy trading through private wires, a virtual private wire arrangement with the area Distribution Network Operator, and participation in wholesale market and grid balancing payments.

5. Discussion

As a recognised urban energy saving solution, which is materially, socially and economically embedded, the level of district heating development acts as an indicator of the quality of governance and sustainability of wider energy systems. Under the current UK political-economic settlement, DH innovations struggle to get established: intermittent funding has been highly valuable, but project developers face multiple sources, and dimensions, of uncertainty: in relation to finance and business viability, fragmented governance instruments which send contradictory market signals, and weakly-established technical and professional expertise and supply chains. Nevertheless, in governance circumstances very different from those which supported earlier European development, a number of enterprising and resourceful LA actors have established DH projects. They have acted because they have analysed the complex interconnecting demands on LAs for carbon reduction, energy saving, affordable heating and local economic regeneration. Given the constraints on their powers, which limit the scope for more radical action, they have identified local energy projects as an innovative way to integrate social, economic and environmental goals. Extensive, and creative, work has been done by emergent local leaders, to configure project teams, and to negotiate locally-appropriate technical and organisational solutions. Governance practices have however been newly constituted with each project, in order to fit the matrix of global energy market, local social economy and shifting state regulatory frames. What makes local officers and some local politicians willing to act against the dominant ‘regime’? In each case, local actors have been part of wider professional and informal social networks of expertise, which produce commitment to the project: in Woking this stemmed from environmental activism; in Aberdeen from fuel poverty campaigns and in Birmingham from a commitment to regeneration in a city which prided itself on its industrial engineering history. In all cases, local commitment was made consequential as a result of the opportunity created by time-limited government funding, but equally by the activities of officers in intersecting informal networks of community energy expertise, which in turn are strengthened through interaction with decontextualized project finance, engineering and procurement bodies.

In the language of the MLP, this innovation system can to some degree be understood as occupying a niche in an unsupportive energy regime, with a shifting landscape constituted by political struggle over low carbon energy and urban infrastructures. Local Authority DH projects are ‘protected innovation spaces’ in the sense that grant funding for part of the costs has enabled creation of a business case. Viable projects have to be crafted in the context of dominant processes and practices of evaluation which are unsupportive of investment in DH. Public benefit is not an acceptable rationale in its own right, but must be carefully translated into the dominant financial logic of calculative rationality and risk mitigation. International comparisons show that changing the parameters of governance alters the pace and scale of development. Over the longer term, changing the parameters of the dominant evaluation framework will be critical to secure systematic development of urban heat networks and identification of optimal locales. Stronger roles for local and state levels of government are therefore important for DH to contribute to system change.

Governance occurs at a range of nested scales (organisation, municipality, region, country, EU) each of which may be variously interpreted as comprising the “system” within which innovation has to occur, or the site of a “regime” whose sociotechnical

stability represents the context for deployment of DH. Actors are not confined to one of these scales or levels: project development and implementation bring local and ‘cosmopolitan’ interests into structured and (to some degree) spontaneous interaction; local governments, state governments, politicians, financiers, transnational and local businesses, technical, legal and commercial experts, and publics intersect with each other through particular people, in the planning, development and implementation of DH projects. Actors are aware of each other, and of the complexity of their roles and motivations. They have overlapping or complementary, as well as competing or conflicting, agendas and goals. As demonstrated by the case studies, the planning and financing of DH projects are framed by the constraints and opportunities of regime and landscape, but simultaneously contribute to its structuring and restructuring. District heating systems provide particular arenas for combining locally-embedded actors and resources, with global flows of financial, legal and technical expertise. Summerton (1992) characterised DH systems as part technical, part institutional, as examples of grid-based multi-organisations (GBMOs) drawn together in the complex interdependence necessary to secure the initial market, professional and institutional support structures for the technology, and successful mobilisation and enrolment of powerful external interest. The physical grid is paralleled by an "invisible grid", based on the interdependence between the different organisations, where more overtly social aspects of system building are often more difficult and time consuming than physical or technical aspects. Actors seek to mobilise global networks in order to obtain resources to build a local project. In line with Law and Callon (1992), we found that eventual success, and defining attributes of the system, depended on the constitution of two intersecting networks: global finance, political support and technical specifications on the one hand, and local commitment, assets and skills on the other. Success depends on the degree to which the project can establish itself as an essential link between the two worlds; at their intersection a new local network centred on a project is created. It has to deliver some degree of reward to the global network of interests, but social indeterminacy in the ways in which such networks are connected means that the trajectory and relative success of such projects is never straightforwardly predictable.

A focus on situated practices of governance for local DE, does not therefore equate to ‘the micro-social’ level. The local scale is neither the necessary incubator of socio-technical innovation in energy systems, nor a bounded stand-alone project in a ‘niche’ separated from ‘regime’ and ‘landscape’. Instead energy systems’ innovation exercised through specific DE projects is co-produced by state, market and civil society actors in structured, but to some degree indeterminate, interaction. From this perspective, the micro, meso and macro are each implicated in DH innovations, offering a more dynamic and realistic analysis than either top-down or bottom-up models. Any DE innovation, however limited in scale, entails decisions about allocation of risk and reward, positive and negative ‘externalities’ in relation to environment or public health, and terms of access to social goods such as energy. These decisions bring local interests into interaction with delocalised, decontextualised capital and expertise. They are not decisions amenable to technocratic solutions, because they entail political questions about contested frameworks of valuation (Helm, 2010). This perspective is in line with a politically-informed analysis of energy transitions (Shove and Walker, 2007; Smith and Stirling, 2007), which retains a reflexive and social constructivist perspective on power. There is therefore a need for further development of structurally and institutionally informed

perspectives on the governance of innovation than those currently offered by Transitions Theory and TIS models. The latter under-appreciate the social and technical embeddedness of energy systems.

6. Conclusions: What Forms of Governance?

What forms of governance would accelerate the deployment of DH networks, with what consequences for local control? Different governance models have different implications for the DH trajectory, particularly in terms of the identities and configurations of central actors, networks, heat sources and users: constructing networks in areas of fuel poverty meets social objectives, but brings higher costs and risks which commercial actors avoid. Governance options can be conceptualised as distributed along a continuum. If the current status quo is regarded as one extreme, which can be characterised as ‘governance under uncertainty’, then the opposite end of the spectrum might be described as ‘command and control’ governance, which sets top-down ‘planned’ measures for take-up of DH in specified zones. ‘Governance under uncertainty’ is unlikely to increase the momentum, or result in the provision envisaged in even relatively modest government policy for urban heat networks. Each project development team have to find discrete solutions through the maze of uncertainty with high transaction costs. Risk of failure is high. Ad hoc innovation is likely to continue, with reliance on local authorities for project development, situated in relation to local contingencies. In the absence of standardised commercial and operating models, LA leadership and democratic oversight of urban heat networks is essential to mitigating subscriber perceptions of risk. Development however is likely to remain small scale and uneven, sub-optimal in technical, economic and social terms, and to carry high costs for local actors. Small scale experimentation seems unlikely to be sufficient to meet radical decarbonisation targets with tight timetables.

A ‘command and control’ model of governance has advantages of relative certainty for investors, assuming that forms of public guarantee for sunk costs of investment in infrastructure could be politically delivered, and that questions of regulation, ownership and control could be resolved. This may encourage major utilities or ‘regime incumbents’ to invest in DH initiatives, and incorporate DH into their portfolios. Established DH operators, currently outside the UK energy supply regime, may enter the competition, with the effect of adaptation of the dominant regime, although mergers and acquisitions in European energy markets suggest that further concentration of ownership may also follow. This model seems likely to produce the greatest continuity in energy regime actors, and may be necessary, if the statutory GHG emissions targets for decarbonising heat supply in the UK are going to be met. There are risks associated with ‘command and control’ solutions however, which stem from limited sensitivity to local circumstances, potential for perverse incentives and ‘rent seeking’ by major businesses, and potentially less than optimal solutions to the combined social, environmental and economic goals of sustainable energy.

As illustrated by the governance solutions devised in the context of liberalised energy markets in Norway and the Netherlands, there are intermediary locations along such a spectrum. These can be characterised as ‘regularised reflexive governance’ and give scope for recognition of polycentric locally-optimised solutions devised by constructive meshing of local and global expertise. Scope is retained for empowering local actors to shape innovative solutions, while improving inter-municipal learning, and reducing uncertainties and transaction costs, in an attempt to streamline

development and mobilise investment. Reflexive governance which is able to encompass different scales of urban DH systems, and public interest goals, including retaining revenues in the local economy, is however under-developed. Changing the regulatory parameters can reshape the risk calculus, by for example integrating social and environment goods into dominant financial evaluation practices, as practiced under the Norwegian DH licensing model. ‘Regularised’ reflexive governance, which seeks to devolve control and resources in a cohesive policy framework, yet without determining outcomes, may be the most effective route to a more resilient low carbon energy system, which minimises ‘stranded assets’, edits out poor quality systems, and is encompasses social and environmental values. It should also enable accelerated transferable learning between projects and shared standard templates for legal compliance. It retains the value of the LA, with long-term commitment to the area, local democratic participation, and local knowledge, acting potentially as a quasi-regulator, to reduce downstream transaction costs, improve systems design and energy saving, and give clarity to the implications of different control and ownership arrangements.

The dilemma faced by central, devolved and local governments therefore is how to coordinate action to devise intelligent regulatory measures, which neither exclude local economic interests and potential for the public good in secure and affordable heating, nor lose the public value embedded in resources and capacities, which the major utilities can bring to bear in constituting a sustainable energy system. Regularising governance may enable a constructive transition pathway, to the extent that ‘regime’ configurations are subject to engagement and democratic scrutiny, beyond the ‘engineered’ and bureaucratically-determined configuration of technical artefacts. The struggle over a governance model to enable scaling-up of urban DH, as an appropriate contributor to UK energy systems, will be played out between the incumbent interests of utilities, based on sunk investments in infrastructure, contractors who control legal, technical and financial expertise, and municipal and state governments, with their mixed competing and collaborative interests in public goods and private profit.

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