District energy development in liberalised markets

District Energy Development in Liberalised Markets: situating UK heat network development in comparison with Dutch and Norwegian case studies

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Abstract

Many national energy policies envisage residual and renewable heat sources with district heating as a component of sustainable energy systems. There is however limited empirical evidence about facilitation of development in the context of liberalised markets and diminished local government control over direct service provision. Recent attempts to stimulate district heating have had variable outcomes in different countries. Using five case studies, we ask why heat network development in the UK takes a relatively piecemeal and fragmented form in comparison with the Netherlands and Norway, countries whose heating sectors are comparable with the UK and where district heating provision is limited. We argue that energy market liberalisation has been enacted differentially, resulting in different political and economic governance structures: in comparison with the UK liberal market economy, the more coordinated market economies of Netherlands and Norway retain greater capacity for collaboration between energy utilities, localities and states, resulting in stronger foundations for district energy. Implications for UK governance are considered.

Key Words: Urban, energy, market governance, sustainability.

1. Introduction

UK policy for development of low carbon and renewable energy has largely relied on a technology-driven, supply-side model of innovation (Steward, 2012). It is however increasingly recognised that transformation of energy systems also requires innovation in societal institutions and among energy users (Coutard and Rutherford, 2010; Geels 2010; Mitchell, 2008). A key setting for such socio-technical innovation is likely to be the urban and regional scale, where economy, ecology and politics intersect in the intensive end-use of energy in public, commercial and domestic sectors (Hodson and Marvin, 2012; Monstadt, 2007).

At urban scale, energy scenario analyses suggest that district heating (and cooling[1]) networks could solve the problem of sustainable heat (and cooling) supply to densely populated areas and hence could form important components of integrated low carbon energy systems. Heat networks exploit the synergies between electricity, heating and transport services to achieve higher efficiency and greater deployment of renewable resources (IEA 2014). Heat networks can use any locally available fuel, including heat recovered from primary sources which would otherwise be wasted, and which are difficult to use at individual building scale. Cogeneration of heat and electricity can reduce electricity network losses and defer, or reduce, costs of capacity upgrades in distribution networks (Kelly and Pollitt, 2010). Heat networks can also contribute to system balancing by generating heat locally and by thermal storage of excess electricity generation, reducing the need for investment in fossil-fuel 'stand by' plant and reducing costs of transmission network reinforcement (Lehtonen and Nye 2009; UK Low Carbon Innovation Coordination Group, 2012). Securing the systemic benefits of sustainability and flexibility in integration of alternative heat sources, however, is dependent on use of integrated networks operating across urban areas, rather than fragmented or small scale developments (IEA 2005).

Establishing such district energy infrastructure can be understood as a form of socio-technical innovation to assemble the long-term, stable coordination of interdependencies between heat suppliers, investors, network operators and heat users in a particular locality (Summerton, 1992). There is however limited knowledge about

[1] Here we focus on heating rather than cooling, networks, as this reflects the choices made in the cases examined.

the political and economic governance institutions most likely to facilitate such developments in liberalised energy markets, when provision has historically been limited. The development of extensive district energy systems in Denmark and Sweden occurred prior to energy liberalisation across Europe, and was planned and organised by local governments, mandated by states; local authorities exercised considerable control over the relationships between energy systems, infrastructure finance and heat use (Rutherford 2008, Ericson 2009, Grohnheit and Gram Mortensen 2003). Municipal ownership of both electricity and district heating undertakings was the norm; municipal house building programmes created significant heat load to secure network efficiencies and the combined welfare, economic development and environmental protection responsibilities of local government created scope to cross-subsidise development with other municipal services.

This paper contributes to evidence about heat network development in contemporary conditions characterised by liberalised energy markets and diminished local government control over direct service and welfare provision. This allows us to move beyond anachronistic accounts, which emphasise the difference between development in state-planned vs liberalised energy sectors. Our principle focus is on the UK and our key question is why recent UK heat network developments remain small scale, fragmented and hence technically sub-optimal, in comparison with those in relatively similar European countries (Wiltshire, et al 2013). Hence we compare developments in the liberalised energy markets of the UK, Netherlands and Norway. These countries are selected on the following criteria: first none have a history of significant use of district heating (7% of heat demand in the Netherlands, 4% in Norway and 2% in the UK, Euroheat & Power 2011); second each has recently introduced energy and climate policies advocating their energy and carbon saving potential (Netherlands Ministry of Economic Affairs, 2011; Dutch Warmtewet (Heating Supply Act), 2014; Norwegian Water Resources and Energy Directorate, 2009; UK DECC 2013; Scottish Government 2014); third all were early in liberalisation of energy; fourth they display homogeneity in the energy source underpinning heating services (gas in the UK and Netherlands, electricity in Norway). The key difference between them however is that they appear to have differential capacities for new development of urban-scale heat networks, with Netherlands and Norway being more advanced than the UK. The comparison is expected to provide insight into the factors which differentiate between

them. Specifically we examine the conjecture that the contrasting political and economic institutions of liberal and coordinated market economies (Hall and Soskice, 2001) result in differential forms of energy market liberalisation, which are associated with different capacities for district heating (DH) development. The UK represents an example of a liberal market economy (LME) and the Netherlands and Norway are examples of coordinated market economies (CMEs).

The remainder of the paper is structured as follows. First we discuss the inter-relations between the knowledge and resources needed for district energy development and the governance institutions which shape liberalised energy markets in these three European states. Second we introduce case studies of five district energy developments. Since our primary focus is on the UK, we examine three UK examples of small projects in Aberdeen, Birmingham and Woking and compare these with developments in Rotterdam, Netherlands and Bergen, Norway. Lastly we discuss findings and draw conclusions about lessons for the UK in implementation of policy for low carbon heat.

2. Inter-Relations of District Energy and Political and Economic Governance in Liberalised Energy Markets

Securing the sustainability benefits of district energy relies on establishing long-term interdependencies between locally-embedded actors and resources, and non-embedded financial and technical expertise (Summerton, 1992). Project development hence entails coordination and translation between technical-economic logics of infrastructure cost and risk mitigation, and goals of durable social and environmental benefits in relation to multiple organisational interests. Relative to other energy networks, DH infrastructure has high sunk (fixed) costs, justified by the exploitation of low cost heat sources (low variable costs) over the long term (networks are expected to last for up to 50 years). Its economic viability is hence dependent on long-term user commitments to take heat supply from the local monopoly network; potential for price competition operates between heat providers to the network at area, rather than building, level. Summerton (1992) emphasises these features in her characterisation of DH systems as "grid-based multi-organisations" (GBMOs) with multiple interdependencies between heat generators, network operator, users and investors. As noted above, where heat networks are a significant part of national

energy systems, local and regional governments have historically played a critical coordinating role in the assembly of local GBMOs. Under these conditions, and supported by national government policies and programmes, local authorities in several European countries planned for spatially optimised heat network development in coordination with other utility systems, managed risks associated with a monopoly heat supplier and represented long-term public interests (Ericson, 2009; Grohnheit and Gram Mortensen 2003; Rutherford 2008).

The contemporary institutional framework for DH development is very different. European political decisions to liberalise energy provision have prioritised forms of market competition, which are regarded as securing short term cost efficiencies. Commercial goals are achieved by disaggregating transmission and distribution from generation and retail, and the introduction of competition in wholesale and retail markets (Mitchell, 2008); social obligations are limited and policies are oriented to profitable returns on private capital (Rutherford, 2008; Sundberg and Sjodin, 2003). Energy liberalisation is part of the broader shift 'from government to governance' observed in many countries whereby activities and responsibilities which were the preserve of governments have been increasingly contracted out to an array of public, private and civil society organisations. This shift is both multi-dimensional and differentially enacted across countries (Lange et al. 2013), but in relation to localised energy, it has been associated with decline in capacity to effect coordinated planning and increased fragmentation in services (Bulkeley and Kern, 2006; Rutherford 2008; Monstadt 2007).

The differential scale of new DH developments in the Netherlands, Norway and UK however suggest that the political and economic institutions of energy market liberalisation vary between countries, resulting in different opportunities or patterns of support for localised low carbon infrastructure. Comparative studies of capitalism in affluent economies notably distinguish between ideal types of liberal and coordinated market economies (Hall and Soskice, 2001). These two models are characterised by contrasting institutional and cultural frameworks which condition the interactions between state, market and civil society organisations, resulting in enduring differences in levels of social protection, business strategies, forms of innovation, terms of access to finance and availability of collective goods. In LMEs, businesses (and UK local governments) are incentivised to coordinate activities via market

contracts, competition and price signals. In CMEs, there is greater dependence on strategic coordination and deliberative problem-solving via information sharing in non-market and cross-sectoral networks. Differences in political and economic institutions, enacted through formal organisations, build different strategic understandings, through repeated experience, about how interested parties will act in relation to changes in economic context. Although in reality there are considerable overlaps between practices in different capitalist economies, as well as competitive pressures towards institutional convergence, evidence suggests that the institutional distinctiveness of LMEs and CMEs has not disappeared: economic and political organisations in CMEs have adapted to market principles, while the legitimacy of stakeholder capitalism and shared economic citizenship has persisted (Ingham, 2011).

In addition the political and economic institutions characteristic of CMEs are argued to result in greater capacity for sustainable energy development than those of LMEs, because they create the necessary social infrastructure for cross-sectoral planning and deliberative problem-solving which is discouraged on grounds of inefficiency in LMEs (Mikler and Harrison, 2012). We identify two features of CMEs as likely to be advantageous in relation to new district energy development in liberalised energy systems. First, the political and economic institutions of CMEs are more likely to enable inter-firm collaboration over long-term trust-based relationships than LMEs; notably CME governance institutions are more likely to promote information sharing and reputational monitoring and to discipline non-cooperation. Second, CME governance institutions are likely to have greater capacity to shape market formation to secure urban DH economies of scope and scale. DH systems have an intensive capital investment phase during the period of network construction. This creates risks of stranded assets if the capacity to bring new subscribers onto the system is uncertain. National and local governments have scope to shape this process through planning policies, heat network operator regulation and area-wide concessions. The extent to which such policies are adopted, and are regarded by firms as credibly robust, influences the willingness of companies to invest. Neo-corporatist practices, and decentralised policy-making allowing multiple points of access and veto, are more prevalent in CMEs than LMEs, and are associated with establishing the long-term credibility of coordinating policies (Hall and Soskice, 2001). Survey data from 2,500 local authorities in 14 OECD countries also suggest that equivalent contrasts in

capacities for cross-sector coordination operate at local scale (Navarro Yáñez et al., 2008). In countries where local government has both a high degree of responsibility for service delivery and a high degree of financial autonomy, as in Northern European CMEs (Sellers and Kwak 2011), coordinated action is more common, and becomes increasingly common the more central government interacts with local decision making.

These theoretical observations lead to expected differences between outcomes for district energy developments in Norway and the Netherlands, commonly categorised as CMEs, and the UK, as an archetypal LME. Norwegian local authorities work under state supervision of expenditure, and are governed by principles of economic redistribution, but they exercise considerable direct control over revenues and their autonomy is treated as critical to effectiveness (Sellers and Kwak, 2011). Local taxes account for 44% of income, with an additional 14% from fees, and they remain significant stakeholders in enterprises including energy (Norwegian Ministry of Local Government and Regional Development, 2013). Although financial centralisation is strong in Netherlands' government, municipalities own stakes in regional energy enterprises (OECD 2013), and local political leaders have considerable discretion over budget allocation and play prominent roles in state and European politics. In contrast UK local government is constrained by statutory duties prescribed by central governments, and is principally dependent on central government grant funding rather than local taxation (Sellers and Kwak 2011); moreover it has no direct mandate in relation to localised energy provision. It is expected therefore that multi-organisation collaboration for district energy will be more feasible, and the role of the state in forming local DH markets more supportive, in the Netherlands and Norway than the UK.

3. Governance of Urban Energy Development in Europe: Netherlands, Norway and UK Case Studies

Case study data are derived principally from 15 semi-structured interviews with project developers, local government and state policy documents, and framework contracts and evaluations. The analysis draws on a larger dataset of 114 semi-structured interviews with district energy project teams, policy-makers, finance, legal and engineering experts and representatives of large scale utilities, as well as four one

day workshops with UK local authorities active in district energy developments. Interviews typically lasted for around one and a half to two hours. These brief accounts of projects inevitably gloss over the nuances of the process, which in each case was marked by forms of dissent, uncertainty and changes of direction.

a. **District Energy in BERGEN, Norway**: multi-level governance and joint ventures

Bergen's district heating network connects a waste incinerator 12km from the city to public, commercial and residential buildings, delivering over 200GWh heat per year. The initial construction phase of the 75km network commenced in 2000, with first heat supply three years later.

The network origins lie in Norwegian regulations requiring a minimum 50% recovery of useable energy from waste incineration, effectively prohibiting electricity-only design and necessitating heat use. Bergen's municipal waste company (BIR) was granted an operating licence in 1996, but exploration of industrial uses of the heat proved unsuccessful, and the company approached a Bergen electricity utility, BKK, to collaborate in DH development. BKK had expertise in energy retail, and hydraulic engineering. BKK also identified complementarity between DH and its core electricity network business, because supplying non-electric heating to new buildings would defer costs of electricity network reinforcement. A joint venture, BKK Varme, owns and operates the network; BKK exercises overall control through a 51% shareholding.

The Norwegian DH licensing regime acted as a complementary enabling framework to energy from waste efficiency regulations. The 1990 Energy Act introduced licensing for DH systems over 10MW, requiring applicants to produce detailed development plans, including evidence of integrated social, economic and environmental advantages relative to other options, and of customer commitments to connect (Norwegian Water Resources and Energy Directorate, 2009). Customer protection is included in licence conditions, lending legitimacy to the technology by establishing service standards and requiring tariffs to be competitive with electric heating. In exchange, the licence holder is granted sole rights to heat supply in a specified area.

BKK Varme adopted several strategies to accelerate deployment of the network. Established social networks were used to identify likely customers and to coordinate with other infrastructure projects in Bergen. The technical consultants selected for example had established relationships with other infrastructure operators such as the sewage company. The main heat pipe was laid alongside a motorway under construction at the time, and BKK Varme subsequently initiated the *Graveklubben*, a joint initiative among subterranean infrastructure companies to share costs of opening streets.

The local authority, Bergen Kommune, was not initially a direct participant in development, although it is a major shareholder in both BKK and BIR. From 2007 it adopted a more pro-active role, partly because of growing Norwegian political emphasis on climate protection which gave salience to pre-existing local policies, and partly because of the perceived local economic benefits of the rapid development of a large heat network. The Kommune collaborated with BKK Varme in subsequent development to identify long-term heat loads and sites for new energy centres, and has converted major municipal buildings to water-based heating.

District heating thus emerged from the 'problem' created by state regulation of needing to use a large heat source; its solution required coordination between heat generator (BIR) and users. A state regime of DH licensing afforded the developer a degree of confidence in the long-term security of its heat market, and simultaneously protected user interests. Local government did not directly stimulate the project in its early phase, but subsequently engaged in supporting expansion.

b. District Energy in ROTTERDAM, Netherlands: knowledge exchange to joint venture

The Rotterdam Warmtebedrijf connects a large waste incinerator in Rotterdam Harbour with older and new DH networks in the city, via a 26km pipeline supplying a mix of public, commercial and domestic users. Heat delivery commenced in 2013 with planned connection of the equivalent of 50,000 homes; longer range visions incorporate heat off-take from multiple industrial sites and interconnection with regional networks including Delft and the Hague.

As in Bergen, the origins of the Rotterdam initiative lie in business engagement with regulatory issues concerning waste heat. In the 1990s, harbour industries were collaborating in industrial ecology programmes, with the objective of reframing environmental damage as a joint problem over which industry could exert more influence, rather than as a site of antagonism between industry, regulators, regional and state government and environmental movements (Baas, 2008; Baas and Korevaar, 2010). Plant managers shared data for feasibility studies for heat recovery and use, and plans coalesced around DH supply to Rotterdam city regeneration districts as more achievable than inter-industry heat supply.

Rotterdam city municipality was not a central participant in the industrial ecology programme, but the harbour company is itself a municipal business. As climate politics gained prominence in the early 2000s, the Mayor of Rotterdam joined the C40 Cities climate leadership group on the basis of a claim to environmental sustainability innovator status. The city's political leaders adopted an active role in sustainability initiatives, including industrial heat recovery, in partnership with businesses. The consequences of municipal involvement are contested, with some claims that trust between industrial ecology programme participants was undermined, that there were political mistakes and that new market procurement procedures, requiring competitive tendering and contractualisation, slowed development (Visser, 2008). The municipality nevertheless played an increasingly important role in the initiative, through financial investment, risk underwriting and use of its powers to support development of heat markets which the *Warmtebedrijf* would supply. Notably the municipality granted concessions to heat distribution companies in identified zones, and adopted building control regulations supporting connection of new and refurbished buildings to the heat network.

At this stage, the DH business case (PVW, 2005) was the product of a partnership between municipality, businesses, the harbour industry association and three energy utilities; these are transnational E.ON; Nuon, a former Dutch municipal enterprise in which Swedish state-owned Vattenfall has a controlling share, and Eneco, owned by a consortium of Dutch municipalities. Two setbacks had a significant impact. The initial business plan used heat recovery from a harbour oil refinery, but the refinery operator withdrew during the engineering design period amid contested accounts as to whether political or technical factors lay behind escalating estimates of the cost of

extracting surplus heat from the refinery. Refinery withdrawal undermined system economics, at a point when competitive tendering had already resulted in operating concessions to Nuon and Eneco for new heat distribution networks. Political divisions arose within the municipality over the differential risks of uncertain future costs versus loss of sunk investment. A new business model, developed over two years, resulted in considerable scaling up and reorganisation of roles. E.ON presented a new set of financial models for the initiative, based on a more sophisticated model of heat dispatch, and including connection of an existing heat distribution network which E.ON supplied. The original plan for public ownership and operation evolved into a disaggregated structure, designed to secure the joint venture with E.ON and to govern commercial arrangements for heat supply to E.ON's existing networks. A publicly owned company proceeded to build the transmission network, but operation is managed as a joint venture with E.ON. Whereas the original proposal combined heat from the refinery with a waste incinerator, the new proposal rested solely on the latter. However, in 2009 when the incinerator was closed in response to national overcapacity. A second incinerator was identified as replacement, but the greater distance from heat demand increased costs. The financial powers of the municipality were crucial; its equity investment increased from €9m to €38m, and the commercial loans it underwrites increased from €58m to €150m (Warmtebedrijf, 2010). The project received a €27m grant from central government, calculated as equivalent to the avoided social costs of CO2 and NOx emissions.

Several parallels between Rotterdam and Bergen are clear. In both cases the relationships between firms and regulators and regional business networks motivated and sustained coordination to explore DH as a solution to an environmental problem. The rising salience of climate politics stimulated direct municipal government engagement in the initiative. In contrast with Bergen, where the state licensed the heat network operator, the involvement of Rotterdam municipality appeared crucial in establishing the framework for user connection, and in ensuring financial stability. Survival of the initiative, following withdrawal of the refinery, depended on extended collaboration, particularly between E.ON and the municipality.

c. UK District Energy Projects

ABERDEEN: a non-profit company for the benefit of citizens.

Aberdeen Heat and Power (AHP) is a non-profit company established by Aberdeen city council in 2002. It has developed and operates three DH schemes serving buildings under council control, including 1500 flats in 24 multi-storey social housing blocks, a school and community facilities. Heat supply is from gas CHP (total capacity 2.6MW_e) and back-up gas boilers to three small networks; combined network length is 14km. AHP origins are situated in 1990s fuel poverty campaigns, mediated via UK and devolved government policies. In response to the UK Home Energy Conservation Act 1995 (HECA), Aberdeen city council commissioned a technical appraisal of fuel poverty solutions for tenants in electrically-heated multi-storey housing. Gas CHP/DH was identified as the most affordable way of achieving low 'cost in use' of heating, as well as meeting HECA energy-saving targets. The recommendation was highly contentious in council, and the capital cost of CHP/DH infrastructure was regarded as unviable in the absence of grant funding.

In the first years of the 21st century, the increasing prominence of climate politics, combined with poor UK social housing standards, led to the Labour government establishing a short-lived (2002-2007) Community Energy Programme (CEP). The CEP offered grant finance of up to 40% of capital expenditure for carbon savings achieved from DH; this proved instrumental in mobilising Aberdeen political commitment. The feasibility work already completed enabled successful funding applications, despite short timescales. Council housing capital, and government-imposed energy company obligations to invest in energy efficiency, provided the remaining funding. Somewhat unusually in the UK context, loans to AHP for initial construction were underwritten by the council. Council investment is however small scale, at a total of £3.78m, in comparison with Rotterdam's investment of €38m and its underwriting of €150m of commercial loans. AHP aims to expand beyond public sector loads to commercial supply, and has established a commercial subsidiary, District Energy Aberdeen Ltd, in order to limit council liability for bad debt, and to ensure compliance with EU competitive procurement.

BIRMINGHAM: risk aversion and economic regeneration via a private partner.

Although anti-poverty campaigns were a factor in promotion of CHP/DH in Birmingham, eventual developments were configured around goals of city centre economic regeneration, and a politically-contested calculus of whole life costs of alternative options for energy provision. Court cases brought by tenant campaigners against the council in the 1980s had resulted in orders for improvements in energy performance of housing stock. City engineers advocated CHP/DH as a long-term solution for affordable warmth; a pilot project gained approval, resulting in a small system serving a leisure centre and three multi-storey housing blocks. Local acclaim for the heating created a degree of political legitimacy for subsequent action in the context of economic regeneration strategy, and UK government CEP funding again proved instrumental in council support. Direct investment was, however, regarded as an unacceptable risk to council finances, and in line with the UK market-commissioning model of local government, Birmingham council opted for the commercial contract route to finance, development and operation of DH.

The successful bidder, Utilicom[2], established Birmingham District Energy Company (BDEC) as a wholly owned subsidiary in 2006, under a 25 year concession contract guaranteeing heat and power purchase by the council and other public and private sector customers. The local authority relied on Utilicom's access to loan and equity finance for the majority of investment, as well as its experience of network development, operation and retail supply. It thus externalised the project risk, but ceded direct control over future development. BDEC has established three CHP/DH schemes (total CHP capacity 7.5MW_e). In the first scheme BCC owns or has a significant ownership stake in most of the heat subscribers (council offices, convention centre, sports arena and a leisure and retail development area). Additional subscribers include a hotel built by BCC, but operated by an international company, and the local repertory theatre. The scheme was subsequently expanded to the city's new public library and two BCC multi-storey housing blocks, the latter relying on further UK government grant finance. The second and third schemes supply a university, a children's hospital, magistrates court and BCC buildings, and are close to a regeneration area which may provide future subscribers.

[2] Subsequently Cofely following takeover by GDF Suez

WOKING: environmental politics, executive leadership and local enterprise.

Local environmental politics and chief executive commitment made Woking borough council (WBC) an early innovator in energy saving, commencing in 1992 with a £250,000 revolving fund for reducing energy use in council buildings. Success of the programme on environmental and financial criteria strengthened political legitimacy and the council sought to scale up to larger DH projects. WBC developed a business model combining local authority participation with commercial finance and expertise. Its first attempted partnership with a regional electricity company (London Electricity) in 1998 was abandoned when the latter was bought by a transnational utility. In 1999 WBC established a joint venture, Thameswey Energy Limited (TEL), with a Danish company, with CHP and DH developments again supported by CEP grants. Of the remaining finance, 80% was commercial debt, and WBC took a 19% equity stake (i.e. WBC contributed 3.8% of the non-grant finance).

TEL developed a number of small systems for WBC services such as sheltered housing. The most significant initiative, Woking Central (CHP capacity 1.4MW_e), is anchored by heat loads from council buildings and has been extended to several private sector residential and commercial subscribers. The scheme was sized to serve a county council housing development, which was subsequently cancelled, creating financial problems due to over-sizing of the energy centre. TEL has also developed a CHP/DH scheme in Milton Keynes (about 100km away) serving new development on land held by a state owned regeneration agency, which supports DH connection through planning requirements.

WBC's ambitions for DH have been scaled back following two significant events. First, legislative changes (in UK and Denmark) resulted in 2004 in WBC buying out its Danish partner. The company's legal form, however, requires it to mobilise commercial finance, so in 2005 a 10% stake was sold back to the partner. TEL continues to use commercial debt for project finance, but long term debt finance is now provided by WBC, increasing the council's exposure to the project costs and their representation in its financial accounts. Second, the recession has slowed development in Milton Keynes and hence delayed DH development. The initial 6MW_e energy centre was intended as the first phase of a 24MW_e system, but the envisaged trajectory of heat loads has not been met. The under-utilisation of heat (in

common with the Woking Central initiative) has led to an underperformance of financial models with, for example, the anticipated first year of financial returns from the Milton Keynes project being extended from 2015 to 2020. Political and media pressure, in a context of austerity in public finances, has led WBC to cancel further expansion in Milton Keynes.

d. Comparison of Fragmented Governance in UK District Energy Development with Coordinated Governance in Netherlands and Norway

While the UK cases have different objectives and organisational structures, with different relationships between local government and commercial district energy specialists, they also exemplify general characteristics of UK DH development which contrast with the European cases. First both Rotterdam and Bergen heat networks have origins in state regulation of economic activities, such as waste incineration, which generate large quantities of surplus heat. In contrast, in UK cases the 'problem' was not framed by regulatory requirements, but by finding local solutions to varying economic, social and/or environmental issues which were amenable to translation through localised energy provision, albeit this proved politically contentious.

Second in the UK cases DH is structured in relation to fixed and bounded heat user commitments, mainly local authority controlled, without significant mechanisms for market expansion; in both Bergen and Rotterdam, licensing and planning and regulatory measures supported heat market development, and large heat sources were correspondingly exploited under relatively open market-expansion models. The scale achieved in the UK is hence smaller. Integration of TEL's investment in Milton Keynes with planning regulation requiring new developments to connect to DH is an exception, but this has stalled. In Bergen the Norwegian area-based licence system protected BKK Varme's target market from competing DH, and legitimised the system among subscribers as certified at high standards of economic, social and environmental sustainability. Local government further supported market development by adopting directive planning policies and helping BKK Varme to plan strategically in relation to anticipated developments, facilitating speculative investment. In the Netherlands' governance was framed as a joint responsibility of public authorities and industries, and underpinned by consumer protection legislation; Rotterdam municipality acted to secure the heat market by granting a series of

exclusive area-based DH concessions to utilities, and applying supportive building control policies.

The contrast illustrates a wider point that the UK GBMOs incorporate a narrower set of organisational interests. UK DH projects relied on initiatives taken by local authorities. Private sector involvement was coordinated by contracts governed by price signals and did not extend to identifying wider business or market expansion opportunities. In Bergen and Rotterdam, local authorities joined an established collaborative initiative with multiple stakeholders. The utilities involved were able to conceive of DH as a joint solution to their specific problems: incinerator licence conditions and electricity network constraints in Bergen; regulation of surplus heat and sustainability of E.ON's existing heat network in Rotterdam. In Bergen and Rotterdam, DH development was thus less directly dependent on the capacity of local government to mobilise political support and expertise, although local governments continued to play significant intermediary roles. The relative weakness of UK local government, and lack of direct mandate for district energy, constrained the political confidence to coordinate such developments and the scale of investment.

4. Discussion and Conclusions

The case study comparison suggests that, despite the considerable socio-technical challenges of all of these district energy projects, multi-organisation collaboration to establish larger scale heat networks proved more feasible in the Netherlands and Norway than in the UK. Case study comparisons indicated two important aspects of political and economic institutions which underpinned progress in European cases, and which were largely absent in the UK: first state regulation to align business interests around utilisation of surplus heat; and second coordination mechanisms by which national and/or local governments can establish heat markets through area-based concessions which sustain business confidence in opportunities for expansion, while protecting user interests in reliable service standards and fair prices. These differences can be understood in relation to contrasting institutions of coordinated and liberal market economies through which the same discourse of energy market liberalisation has been enacted. The distinction between LMEs and CMEs is drawn in relation to ideal types, with considerable similarities and competitive pressures towards institutional convergence in practice. Netherlands and Norway seem however

to have greater capacity for cross-sector strategic coordination and deliberative problem solving suited to establishing the mutual inter-dependencies of new heat network infrastructure.

In the more liberalised market economy of the UK, coordination via market contracts, price signals and short-term, fluctuating support initiatives appears to have weakened capacity for development of larger scale systems, with scope for more significant long term cost and carbon savings. Constant change in grant schemes and tax initiatives has created uncertainty and perceived risk for both local government and the commercial sector. Programmes have had short timescales, including abrupt cancellation of the Community Energy Programme which supported our UK cases (Hawkey, 2012); technical definitions and programme rules for carbon saving have been repeatedly altered and weakened, as in the definition of the 'zero carbon home' (Zero Carbon Hub, 2011), and revisions to the English planning framework have undermined local government energy planning (Hawkey, 2013). Whereas private sector involvement in Bergen and Rotterdam district energy was stimulated by regulatory frameworks which situated disposal of surplus heat as a problem confronting commercial organisations, analogous regulatory structures are absent in the UK. Instead UK policy requires only voluntary appraisal of heat capture opportunities from large thermal-input plants (particularly thermal electricity generators) (Hawkey, forthcoming). Commercial and policy officer research participants also suggested that UK government lobbying was instrumental in weakening the EU Energy Efficiency Directive, resulting in replacement of mandatory surplus heat capture and use with a lesser requirement for business case analysis; this has reduced the estimated impact of the measure by 70% (Services of the European Commission, 2012). As Hall and Soskice (2001) suggest, the centralisation of power in the UK's 'Westminster model' appears to undermine the establishment of policies supporting cross-sector coordination, as firms and local governments justifiably have limited confidence in the long-term stability of policies.

Despite this context, the increasing prominence of climate politics and pressure of statutory climate change targets, combined with growing political salience of slow progress in decarbonisation of heat, suggest scope for policy innovation to address the weaknesses of current political and economic institutions for energy governance.

There is potential to build on the integrated disciplining and enabling regulatory practices for heat market development in the liberalised energy markets of Netherlands and Norway. There is renewed interest from UK central and devolved governments in evidence gathering to support low carbon district energy, and in developing local authority coordination capacity. UK heat policy (UK DECC, 2013) included measures for creation of a Heat Networks Delivery Unit, exploration of regulatory frameworks for heat, and potential for a recovered heat incentive. There is also tacit acknowledgement that heat network provision is necessarily regional and local, and the National Assembly of Wales and Scottish Government have plans for coordination of heat network development along distinct pathways. These steps suggest the embryonic forms for strategic action, as well as potential for diverging energy policy in devolved UK governments. In particular, Scottish regulations requiring new waste incineration plants to meet minimum energy efficiency standards could drive businesses to identify DH as a means of meeting their objectives, which could give momentum to complementary enabling measures for heat market development through planning and licensing, as in Netherlands and Norway. There is hence opportunity for systemic transformation of UK provision for sustainable urban heating, but there are significant questions about whether the necessary shift in the liberalised political and economic institutions of the UK can occur without sharp public objection to the long-term costs of current energy and climate change trajectories.

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