



The role of intermediaries in low carbon transitions – Empowering innovations to unlock district heating in the UK



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ABSTRACT

The literature on socio-technical transitions considers how technological innovations can be established within the context of an incumbent regime that is often resistant or inflexible to change. Strategic niche management is an approach to catalysing a transition to a new regime using protected 'niche' spaces to enable development and experimentation with an innovation. Intermediary actors play an important role in establishing these niches as they facilitate knowledge sharing and build the wider networks and systems needed to support an innovation.

The influence of intermediaries within socio-technical transitions and strategic niche management is still an under-researched area. In this paper, we use a decision theatre research process to collect empirical evidence from a range of local stakeholders involved in establishing new district heating projects in the United Kingdom (UK). This method, carried out in a group workshop format, enables understanding of the interactions between stakeholders throughout the stages of the district heating development process.

The study suggests that intermediaries can play a role in supporting niche empowering processes. The existing institutional framework surrounding intermediary actors, and the geographical scale at which they work within that framework, are shown to be influential on actors' agency to choose their approach to empowering an innovation. The work highlights the potential for intermediaries to support the restructuring of this institutional framework to enable more radical 'stretch and transform' empowering activities.

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1. Introduction

The challenge of mitigating climate change has brought with it various visions and scenarios for how to decarbonise a world currently reliant on fossil fuels (Connolly et al., 2014; IEA, 2013). Arguably, the challenge is no longer about finding plausible scenarios for how a decarbonised future could look, but instead setting in motion a process for delivering that decarbonisation. Low carbon innovations can be locked-out of incumbent regimes in the context of a complex socio-technical system that is often resistant to radical changes (van der Vleuten and Raven, 2006).

Socio-technical transitions theories seek to understand how new innovations can be established and become widespread within a new regime (Foxon, 2011; Geels, 2002; Rip and Kemp, 1998). The concept of a niche is used to describe a protected space where an innovation can develop away from the pressures of the incumbent regime. Strategic niche management provides one framework for understanding how niches can be created and developed to catalyse a wider transition (Kemp et al., 1998; Schot and Geels, 2008). Emphasis is placed on the importance of supporting development of an innovation within a niche through facilitating learning processes, establishing shared visions of the future between niche actors, and forming supportive networks of actors (Hamann and April 2013; Kivimaa, 2014; Küçüksayrac et al., 2015; Lovell, 2007). These processes are seen as nurturing an innovation. However, niche processes must go beyond nurturing for a transition to take

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place. They must also empower it to diffuse beyond the niche space (Smith and Raven, 2012). The theoretical understanding of niche empowering processes is still developing and it is to this area of the socio-technical transitions literature that this paper seeks to contribute.

In particular, it explores the role of intermediaries within socio-technical transitions for supporting niche nurturing and empowering processes. Intermediaries are actors and institutions who enable exchange of knowledge, skills development, and perform connecting and mediating functions to support an innovation (Geels and Deuten, 2006; Kivimaa, 2014). We use an empirical case study of district heating development within the United Kingdom (UK) to explore the role and characteristics of intermediary activities for shaping transitions, considering their role over different geographical scales.

The following research question is addressed: How do intermediary activities across different geographical scales support niche nurturing and empowering processes for district heating innovations in the UK?

The rest of this paper is structured as follows: First, the theoretical approach is set out in more detail. The case study is introduced, along with the method of data collection where a decision theatre workshop was used to simulate the district heating development process and collect in-depth data on stakeholder interactions. The results of the analysis are presented and discussed for the empirical case. Finally, lessons are drawn on the role of intermediaries in empowering processes.

2. Theoretical approach

The need to transition to a more sustainable regime has stimulated interest in how socio-technical transitions could be actively shaped and facilitated. For example, Kemp et al. (1998) first outlined the idea of strategic niche management in 1998, defining it as “the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technology and (2) enhancing the further development and the rate of application of the new technology” (p.186, Kemp et al., 1998).

Smith and Raven (2012) elaborated on the strategic niche management literature and differentiated between three types of activities for supporting niche processes: shielding, nurturing and empowering of innovations within a niche. ‘Shielding’ may take the form of ‘passive’ shielding, where a niche is naturally created due to contextual circumstances such as an off-grid area of the energy system. ‘Active’ shielding uses active measures to shield the innovation, for example tax incentives or subsidy, which shield the technology from the market environment. Shielding can also be accompanied by ‘nurturing’ processes that enhance learning opportunities and develop institutional networks to enable experimental innovations. ‘Empowering processes’ focus on enabling innovations to transition from niche activities and become part of a regime. Understanding how actors can influence and support empowering processes is a key question within the socio-technical transitions literature (Smith and Raven, 2012; Smith et al., 2005).

Smith and Raven (2012) argue that empowering processes can either seek to ‘fit and conform’ with the incumbent regime, or seek to ‘stretch and transform’ the regime to suit the niche innovation.

A ‘fit and conform’ empowering process is where an actor is seeking to develop an innovation to a stage where it can compete within the selection environment of the incumbent regime. In this form of empowering process, activities might take the form of research and development activities, training for key stakeholders, or shielding policies such as subsidy (Kern et al., 2015). Ultimately

the activities would seek to enable the innovation to compete within the existing regime environment without on-going support.

A ‘stretch and transform’ empowering process is where an actor is seeking to transform the incumbent regime to the extent that it becomes possible for an innovation to diffuse. Activities might include creating institutional changes, the use of political narratives to advocate for the introduction or reform of regulations, or establishing a supportive and long-term policy approach that removes barriers to innovation (Smith and Raven, 2012; Verhees et al., 2015).

An actor's choice of approach and the success of different empowering activities are influenced by the wider landscape (e.g. what is considered socially and politically legitimate) and the stability of the incumbent regime (Raven et al., 2016; Verhees et al., 2015). In practice, actors' approaches to empowering processes are known to change and evolve over time, depending on the wider socio-political context or who is being addressed (Raven et al., 2016; Smith, 2007; Smith and Raven, 2012). The political narratives used by actors can also have different impacts depending on an actor's legitimacy in the eyes of policy makers or politicians, or the composition of the actor networks that are circulating the narratives (Raven et al., 2016). For example, Raven et al. (2016) explored empowering processes for solar PV in the UK and The Netherlands. Until the late 1980s, solar PV was perceived as too expensive to compete with other electricity generation options and was not given policy support. However, entry into the solar PV market of large companies such as Shell provided policy makers with greater confidence of its potential become financially competitive and it gained policy support.

Another under-developed area in the literature is whether niche actors can develop sufficient agency within a resistant incumbent regime to support more radical forms of transition. Do actors have the agency to choose between a ‘fit and conform’ or ‘stretch and transform’ empowering approach and to support that approach with action? The existing regime and institutional framework surrounding actors is influential over actors' agency to design and support empowering processes. For example, Kern et al. (2015) compared empowering activities in two contrasting case studies: the fast growing offshore wind industry in the UK and the stagnating offshore wind sector in the Netherlands. Although actors in both countries undertook many similar activities, the institutional framework in the UK involved an influential and proactive national-level facilitator of offshore wind development in the form of the Crown Estate, which ‘rented’ the seabed to offshore wind operators. In the Netherlands, no single influential advocate existed, and instead actors were divided across several smaller institutions and struggled to establish a consistent approach or to create a sufficient power-base to affect institutional reforms which favoured off-shore wind. The institutional framework in the Netherlands made it difficult for actors to successfully empower the offshore wind industry. Kern et al. (2015) recommend that future research should “consider what kind of processes enable the building of a sufficient power base to challenge dominant rules” (p.354, Kern et al., 2015). We address this question by considering the role of intermediaries in developing a supportive institutional framework for successful niche empowering processes in the case of district heating.

2.1. The role of intermediaries in low carbon transitions

Intermediaries are actors that facilitate relationships between key actors and enable sharing and pooling of knowledge. These actors can be individuals or a group of people within organisations that range from public bodies, to trade associations, non-governmental organisations (NGOs), or consultancies

(Küçüksayraç et al., 2015; Lovell, 2007). They can undertake work at multiple geographical levels; using their expertise to enable delivery of innovations by mediating between different interests, making connections, enabling relationships, or aggregating and sharing learning between similar niches (Geels and Deuten, 2006; Hargreaves et al., 2013; Kivimaa, 2014).

Studies of intermediaries to date have primarily focused on demonstrating the role that they play in niche nurturing processes (Hamann and April 2013; Hargreaves et al., 2013; Hodson et al., 2013; Kivimaa, 2014). Several empirical studies highlight common challenges faced by intermediaries due to their often limited resources and capabilities, as well as a lack of established powers which could limit their ability to reconfigure governance systems for empowering an innovation (Hawkey et al., 2013; Hodson et al., 2013; Küçüksayraç et al., 2015; Thakore et al., 2013).

The role of intermediaries in empowering innovations is less researched. In two studies, Hodson and Marvin (2010) and Hodson et al. (2013) explore the role of ‘energy intermediaries’ in enabling cities to transition to low carbon energy. They explore actors’ agency to shape a transition using case studies of major cities, such as London, New York, and Tokyo. Such cities have sufficient power and scale to shape their own transition pathway, independently of national governments. A conceptual framework is used to explore the different ‘modes’ of energy intermediaries and the purposes that these can serve. We draw upon this framework in our analysis (outlined in the next section) to consider how different modes of energy intermediaries might support empowering processes in our case study of district heating in the UK.

3. Analytical framework

The first stage of analysis in this paper is conducted using the analytical framework defined by Kivimaa (2014) to identify where intermediary activities are supporting nurturing processes within the case study. The framework is categorised by three distinct purposes for intermediary activities. Under these categories, example activities are used as guidance for analysis of the data. These are summarised in Table 1.

The role of intermediaries in supporting empowering processes was initially recognised by Hargreaves et al. (2013) as “brokering and coordinating partnerships beyond the niche”. Kivimaa (2014) also recognises the wider roles that intermediaries might play in empowering processes through supporting “policy or regime renewal, [acting as an] opinion influencer or a change initiator” (p.1378). However, this intermediary role is not articulated or developed explicitly within the framework set out by Kivimaa. We therefore add an extra dimension to our analytical framework to consider this role explicitly. Table 2 details practical examples of intermediary activities, as identified by Hargreaves et al. (2013) and Kivimaa (2014), which support empowering processes for widespread uptake of the technology and a transition to a supportive regime.

A second analytical framework is applied in order to answer our second research question; ‘How can intermediaries support and shape niche empowering processes?’ The framework was developed by Hodson et al. (2013) to highlight the different modes of

Table 2

Intermediary activities observed by Hargreaves et al. (2013) and Kivimaa (2014) which support brokering and coordinating partnerships beyond the niche.

Brokering and coordinating partnerships beyond the niche
Embedding a new regime, e.g. Accreditation and setting of standards
Opinion and change influencer, e.g. responding to consultation on policies
Policy renewal, e.g. Policy communication and implementation

urban energy intermediaries and it is used to explore the characteristics of actors delivering empowering processes within the case study (Fig. 1). It enables consideration of “whose priorities are being pursued by energy intermediaries and how this is translated into programmes and projects” (p.1420, Hodson et al., 2013). Through exploring the two dimensions of the framework we begin to consider critical characteristics of intermediaries for contributing to the different types of ‘fit and conform’ and ‘stretch and transform’ empowering processes. The two dimensions of the framework are:

- (1) The **scale and depth** at which intermediaries and their functions are embedded into institutional practice - Intermediary activities can be delivered as a stand-alone response, or they can be delivered in a systemic way, for example through embedding within the long-term functioning of existing organisations. They can be delivered at the local niche level, or across multiple niches. Hodson et al. (2013) note that intermediaries that deliver a longer term and sustained approach are more able to bridge and facilitate between multiple actors. Balancing this, local, stand-alone

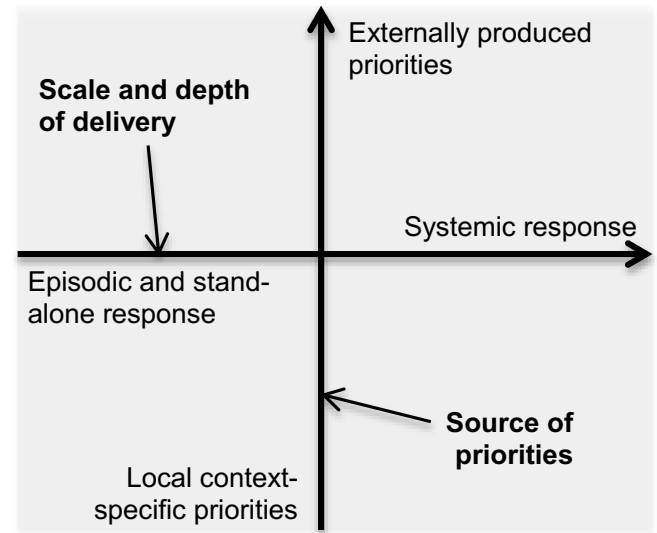


Fig. 1. Modes of urban energy intermediation conceptualised by Hodson et al. (2013). X axis representing the ‘Scale and depth of delivery’, with a spectrum from ‘Systemic response’ to ‘Episodic and stand-alone response’. Y axis representing ‘Source of priorities’, with a spectrum from ‘Externally produced priorities’ to ‘Local context-specific priorities’.

Table 1

Analytical framework categorising types of intermediary activities into the three roles that intermediaries play in niche nurturing processes (Kivimaa, 2014).

Articulation of values and visions	Building of social networks	Exchange of knowledge and supporting learning processes
Strategy development	Aligning interests	Knowledge gathering, processing & combination
Demonstration of technology benefits	Creation and facilitation of new networks for both learning & project delivery	Communication and dissemination of knowledge
Acceleration of the application and commercialisation of new technologies	Finding funding sources to support activities.	Advice and support

responses are able to react to specific circumstances and opportunities to enable delivery of new innovations.

- (2) The **source of priorities** driving intermediaries' activities – Intermediary priorities could be driven by local priorities through to top-down national policy objectives. The roots of an intermediary's priorities influence their ability to effectively communicate and empathise with diverse actors across the regime and niche spaces. For example, an intermediary driven by the interests of regime-embedded actors may be able to access resources or hold influence with government policy makers. However, it may also be unable to pose radical disruption to incumbent regime practices due to the constraints imposed upon it by regime actors. On the other hand, an intermediary driven by niche-based actors' priorities may be more able to challenge regime practices.

4. The challenge of district heating delivery – case study of the UK

This paper uses the case of district heating development in the UK to build understanding on how intermediaries can support niche empowering processes. District heating is a decentralised infrastructure of highly insulated pipes that can transport heat in the form of hot water or steam over many kilometres from a heat source to where there is demand. For the purposes of energy decarbonisation, use of district heating at scale enables use of heat sources that would otherwise not be possible, such as intermittent waste heat from industrial processes, large-scale heat pumps or geothermal heat. It can offer benefits of affordability with increased efficiency and use of waste heat sources. It also offers flexibility, with options of seasonal storage to enable use of solar thermal heat sources during winter, as well as storage of excess electricity generation from intermittent renewable generation such as wind turbines.

District heating is not a new infrastructure technology. For several decades, it has been a well-established part of the energy systems of numerous countries, including Denmark, Sweden and Finland, where the oil crises of the 1970s catalysed a transition to the use of district heating. These were initially based on oil, coal and gas-fired combined heat and power plants and heat-only boilers (Ericsson, 2009; Sperling et al., 2011). The percentage of citizens served by district heating in these countries now reaches 61%, 48%, and 50% respectively and work is on-going to decarbonise these existing systems (Euroheat and Power, 2013). Although there are many lessons that can be learnt from the experiences of such countries, introducing district heating for the first time as part of a transition to low carbon heating poses a different set of challenges and contexts to those faced by the now-experienced district heating countries in the 1970s and 1980s. These include low fossil fuel prices and extensive existing infrastructures (particularly natural gas networks), the pace of change required to meet decarbonisation targets, and competition with other low carbon heating solutions. New approaches and innovations are therefore required within the district heating development process for countries looking to use it for the first time as part of meeting their low carbon heat demand.

As a decentralised infrastructure, the facilitation and coordination of new district heating development necessarily takes place at the local level. Local authorities (also called municipalities) are therefore recognised as having a crucial role to play in enabling strategic delivery of new schemes (Chittum and Østergaard, 2014; Riahi, 2015). They are often seen as trusted long-term facilitators with knowledge of the local geography, context and actors. District heating also has clear benefits and implications for the wider national energy system (DECC, 2012). However, local level priorities

and drivers do not always align with the national level visions for low carbon energy, and conversely national level policy drivers do not always recognise the complexities of delivery in the local context (Bush et al., 2016; Hawkey et al., 2013). Integration of district heating into the wider energy system therefore requires activities and coordination across multiple geographical scales.

In the context of countries with few existing networks and little cultural heritage to support a shift to urban scale heat provision, the institutional framework surrounding a national energy system is not always set up to empower local authorities to take on this local coordination role for district heating development. Local authority officers can also be working with little previous experience or knowledge of what is required for the technology (BRE, 2013; Bush et al., 2016). Development of new systems requires the introduction of innovative business models and a supportive institutional infrastructure that unlocks the technology for deployment, alongside a cultural shift in public and practitioner perceptions of the technology (Hawkey, 2012). The process of learning and knowledge exchange across multiple actors is also a crucial aspect of unlocking district heating potential in learning countries.

Due to these complexities, the case study of district heating in the UK provides an interesting example for exploring both the importance of the geographical scale of intermediaries, and the re-configuring the institutional framework for supporting empowering processes for an innovation. The UK is an archetypal example of a country with an energy system that was not designed with district heating in mind. The UK has a highly centralised energy system, a liberalised energy market, and a high penetration of natural gas networks for heat supply to buildings (Hawkey and Webb, 2014). Approximately 2% of heat demand is delivered by district heating (DECC, 2012). The few existing district heating networks tend to be small scale and their development has come about through the hard work of a few key local leaders using their social capital and local political or institutional contexts to lever schemes into operation (Hawkey et al., 2013).

5. Method

Data for this work were collected through an adaptation of a decision theatre; a method originally developed by Arizona State University as a way of using complex data visualisation, modelling and simulation to facilitate collaborative decision making between a group of relevant stakeholders in a complex group decision process (Bale et al., 2014; Walsh et al., 2013; White et al., 2010).

The method was originally focused on increasing the impact of quantitative modelling and data analysis within complex decision making processes. It made use of high-speed servers with multiple screens to display data to participants (Walsh et al., 2013). The method enables collection of rich and detailed data both about the role of evidence and data within a decision process, and also about the interactions and relationships between stakeholders during the process of decision making. The number of stakeholders participating within a decision theatres, and the set-up of the process, varies according to the issue in focus and the objectives of the research project. For example, White et al. (2010) held several sessions, splitting participants by roles into 'policy makers', 'data analysts', etc. This approach allowed them to explore different dimensions of the decision making process according to the type of stakeholder.

For the purposes of this research, the decision theatre process and objectives were adapted to focus upon the interactions and relationships between stakeholders throughout a fictionalised district heating development process. Using a fictionalised scenario was important because this enabled participants to voice issues and concerns based on their own professional experiences, but in ways

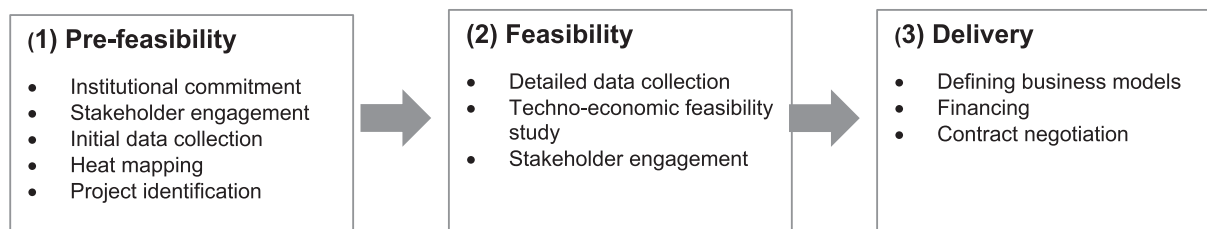


Fig. 2. Diagram describing the three stages of the district heating development process and the types of activities that take place within each stage: (1) Pre-feasibility; (2) Feasibility; (3) Delivery.

that did not compromise other professional relationships. Participants were encouraged to explore a combination of techno-economic, quantitative information, with non-quantifiable factors such as the conditions of the local economy, investors' appetite for risk, and perceptions of the technology held by key institutions such as the local authority, housing associations or the local university.

In the scenario, three 'stages' of the district heating development process were presented; namely pre-feasibility, feasibility, and delivery (detailed in Fig. 2). The participants were set the task of discussing how they would develop the example scenario from the pre-feasibility stage through to delivery. At pre-feasibility stage, participants were presented with an example of an area-wide heat map that indicated heat demand density including a number of specific large heat demand users that might be able to act as key anchor loads for a network, as well as existing CHP plants and other potential heat sources. At the feasibility stage, participants were presented with information about a specific project that had been selected for a feasibility study. Finally, at the delivery stage, the groups were informed that the given project was technically and financially viable for delivery, given the involvement of key anchor loads and heat supply sources. Participant discussions were facilitated around the key points listed in Fig. 2 to understand actors' objectives and perceived challenges, including:

- When and where actors sought advice and resources to support project development
- Actors' perceptions of risks,
- Differences in objectives between stakeholders,
- How available information was used to inform decision making,
- The process of stakeholder engagement and relationship building

A range of eight stakeholders participated in the daylong decision theatre workshop held in October 2014 (ten stakeholders were originally invited, only eight were able to attend on the day). The participants were all involved in professional capacities in local-level activities for establishing new district heating networks across the UK. Participants were purposefully chosen from a range of different geographical areas and contexts to capture if there were differences in perspectives. The workshop was presented to invitees as an opportunity to contribute to a research project focusing on the role of local stakeholders in facilitating district heating development. The specific focus of the research on intermediaries was not shared with the participants. The workshop was attended by five local authority sustainability/energy officers, a university estates energy manager, a representative of a community energy group¹ and a local enterprise partnership representative. None of the

participants had successfully completed a district heating project but all were actively involved at one of the stages. The workshop was organised so that stakeholders with different kinds of organisational experience and knowledge were grouped together.

The number of stakeholders participating in the workshop was kept small to enable the decision theatre to collect data at the level of detail required to usefully inform the research process. This small number of participants means that the findings represent a case study of a potential project development process, rather than a representative sample of all project development in the UK.

While conversations were limited to participants in the workshop, they were contextualised within a wider policy framework by ensuring any comments and questions directed at national policy stakeholders, such as government ministers, were captured via sticky notes and pinned to their poster image. This approach allowed the participants to discuss their interactions with actors not represented in the room, and to identify issues and concerns that needed to be addressed at different scales such as through government policy measures.

Having secured agreement in advance, group conversations and narratives were audio recorded. Session conveners queried participant comments in an effort to reveal some of the underlying decision-making rationales. In this way it was possible to gain an insight into the interests and focus of each participant and align these with their experiences of working in particular kinds of economic, political, and policy contexts.

Data was transcribed and analysed using the analytical frameworks set out in Tables 1 and 2. A thematic analysis method was used (Braun and Clarke, 2006; Robson, 2002) to categorise the data from the decision theatre into the four intermediary functions set out in Tables 1 and 2. The example activities set out in the framework served as indicators for identifying and categorising activities.

Since the role of intermediaries in supporting empowering processes is an under-researched topic, the list of activities in 'brokering and coordinating partnerships beyond the niche' is not a fully developed framework. In particular, it does not help to consider whether an empowering activity is supporting a 'fit and conform' or 'stretch and transform' approach. As a result, a general thematic analysis was conducted, seeking to identify activities beyond those listed within the framework in Table 2. Consideration was also given to how an activity might be contributing to empowering an innovation ('fit and conform' or 'stretch and transform'). This study seeks to contribute empirical evidence to inform development of such a framework.

6. Results

6.1. Evolution of intermediary roles throughout the district heating development process

Table 3 presents the results of the data analysis using Kivimaa's

¹ The community actor present at the workshop was in the early stages of exploring the potential for community-led district heating development. As a result, there was no evidence identified within the data of intermediary activities supporting community groups.

Table 3
Types of intermediary activities undertaken at each stage of the district heating development process, categorised into the three dimensions of Kivimaa's intermediary framework (Kivimaa, 2014).

Inter'y role	Dev't stage	Activity observed in the case study	Challenges or gaps in intermediary provision?
Articulation of values and visions	(1) Pre-feasibility	Increasing local awareness of district heating opportunities (internally and externally): In the context of very little existing district heating, it is rare that local stakeholders had experience of the technology at the start of a project. Local authority intermediary activities to raise awareness of the technology's potential could be observed both internally within a local authority, and externally, focused on introducing key decision makers to the technology. For example, before initial heat mapping could take place internal local authority stakeholders needed to be persuaded that this was a valid use of scarce local authority staff and budget resource and to make the case that this was of sufficient priority to justify investment.	Lack of local authority resource to undertake these early intermediary activities and establish a common understanding of the value of district heating was a key challenge in progressing through the development stages. One solution was to establish activities at the regional authority level, such as the local enterprise partnership. The pooling of resource at this stage enabled work to be undertaken on behalf of local authorities that would not have been able to take place otherwise.
	(2) Feasibility	Creation of an evidence base to demonstrate viability: Local and regional authorities gathered detailed data to feed into feasibility studies; obtained funding for a feasibility study to be carried out by an expert consultant (funding was primarily obtained through a grant from national government, or alternatively by direct funding from the local or regional authority).	
	(3) Delivery	n/a	
Building of social networks	(1) Pre-feasibility	Aligning interests and establishing cooperation between key-stakeholders (internally and externally to a local authority): Local authorities and regional local enterprise partnerships worked to create partnerships between potential external partners by holding consultation meetings, and shaping project design to meet the varying objectives of stakeholders.	There was still some frustration amongst local authorities that opportunities were being missed through lack of established communication channels or powers to support local coordination: <i>"There should be a duty to consult with neighbouring organisations. [...] In [our city] we've got a prison, a hospital, and so on, who will be thinking about [their sustainability statement for the treasury standards]. So thinking about plant placement and plant investment, which all could be part of the jigsaw of a future district heating scheme. But there is no duty apart from to themselves. They don't need planning permission for this sort of change, so the local authority wouldn't necessarily know"</i> (Local Authority)
	(2) Feasibility		
	(3) Delivery	Acting as a catalyst for new schemes and expansion: There were two approaches used for this purpose. Local authorities could use planning powers to lever in private delivery of district heating schemes in new-build developments. Alternatively, the local public sector estate could be used to offer an anchor load of long-term heat demand to increase certainty around the long-term business case for a scheme. Local authority-led development to enable access to lower-cost finance: Local authorities considered using their own borrowing power, through public sector-only access to low-interest loans to enable development of strategic schemes that might not otherwise have been developed due to too low returns on investment for private investors.	Perceived lack of powers to establish strong planning policy: Although local authorities well understood the potential of planning policies, their use was not always considered successful or viable in the absence of national policy measures, because of competition for attracting developments to their area. Local authority aversion to taking on greater levels of debt and risk – district heating was perceived as a risky investment for local authorities. Some local authorities also had a limit to the amount of debt that it could take on at any one time. Deciding to invest in a district heating network would mean that investment would have to be curtailed in another area.
Exchange of knowledge and supporting learning processes	(1) Pre-feasibility	Creation of an evidence base to demonstrate viability: Since local authorities lacked key skills for carrying out opportunity assessments, they would commission a consultant to undertake an initial study of potential opportunities in their area.	Specialist government support units played an important role supporting project development, as well as connecting and sharing information between key contacts at local authorities. However, participants identified a gap in support for knowledge sharing between non-local authority peer groups , such as university or hospital finance directors, as well as specific officers within local authorities such as planning officers or local politicians.
	(2) Feasibility	Sharing of case studies to overcome high perceptions of risk: Despite the involvement of expert consultants and techno-economic analysis of projects, the appetite to take risks to enable a projects' success was often felt to be low. Case studies were seen as an important tool for increasing confidence in district heating. Participants talked of the "responsibility" of successful projects to share more details with others.	

Table 3 (continued)

Inter'y role	Dev't stage	Activity observed in the case study	Challenges or gaps in intermediary provision?
	(3) Delivery	Facilitating access to technical, financial and legal consultants: funding for local authorities to access expert consultants to support their work helped to inform financing decisions, business models and technical specifications for construction, operation and maintenance.	The involvement of consultants was important for bringing in more expertise and experience to the process, but actors expressed a worry that some consultants were bidding for work that they did not have expertise to do. The government support units were used to sense-check reports in some of these situations.

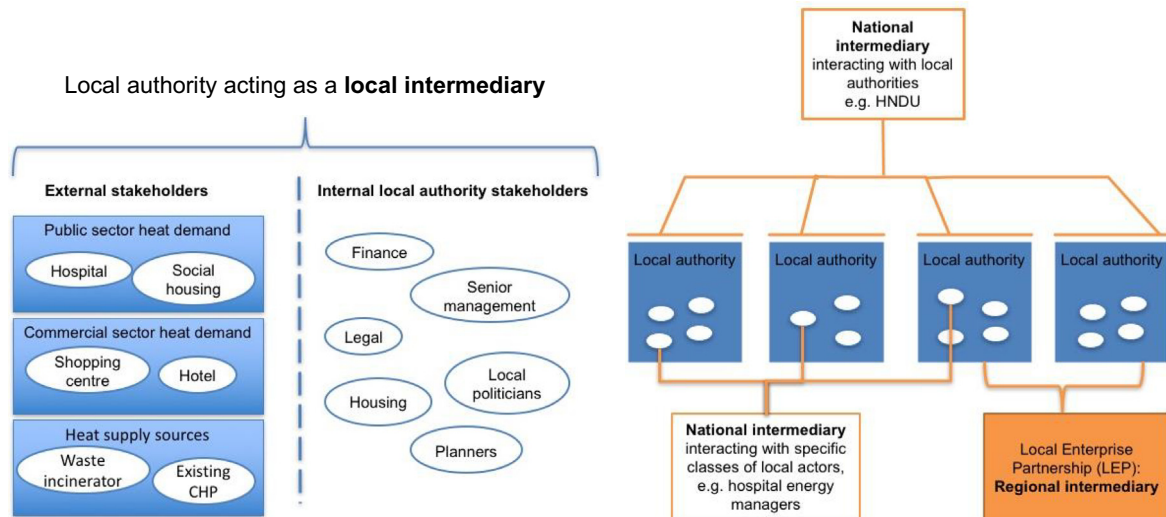


Fig. 3. Illustration of the local, regional and national intermediary relationships where engagement and networks currently exist for enabling district heating development in the UK. There are two types of national intermediaries represented: (1) that works with local authorities and (2) that works with other specific types of actors such as hospital or university energy managers.

intermediary framework (Kivimaa, 2014) to identify nurturing intermediary activities within the case study. Alongside this, challenges encountered by practitioners, or recognised gaps in the existing intermediary provision within the case study are summarised. Most of the actors within the decision theatre were at stages (1) pre-feasibility and (2) feasibility of the delivery process (c.f. Fig. 2), establishing conditions for successful development of an initial project.

This analysis demonstrates a number of roles that intermediaries can play in delivering niche nurturing processes. Public sector actors delivered most of the intermediary functions, but private sector actors also played intermediary roles for supporting learning processes. This was observed in the case study in the form of consultants, although national government funding was needed to enable their involvement at the local level. The intermediary roles evolved as the project developed to fulfil new functions and serve different needs. Activities at the beginning of the process served to convince key actors of the value of district heating and potential benefits that could be realised with use of the technology. As the project developed to the later stages of feasibility and delivery this intermediary role became less important and activities shifted to focus on the building of social networks and exchange of knowledge between actors.

6.2. The geographical scales of intermediaries within district heating development

Analysis of the decision theatre data, summarised in Table 3 emphasized the central role of local authorities within the district heating niche creation process, either undertaking intermediary

activities themselves or being supported by the intermediary activities of others. Activities were delivered by actors across three geographical scales of engagement: locally (primarily delivered by the local authority); regionally (several local authorities working together, e.g. through a local enterprise partnership or regional government); and nationally (via institutions such as trade associations, community group networks, or government programmes). Fig. 3 shows examples of the range of local stakeholders involved with district heating delivery and the connections where local, regional and national actors were undertaking intermediary activity.

At the **local level**, the local authority sustainability or energy team played an intermediary role by persuading local stakeholders of the value of district heating, and building the social networks required to deliver projects. These activities were directed both externally, facilitating cooperation between local, public and private sector stakeholders, but also internally to develop local authority capacity and get corporate buy in from across the local authority. As new actors in the energy system, these intermediary activities internally within local authorities were crucial to creating the multi-skilled team of planners, mapping specialists, lawyers, finance specialists and energy managers needed to facilitate strategic district heating development. Beyond the local authority, other actors involved in intermediary activities at the local level were community energy groups, who explored opportunities to develop community owned schemes. Private sector district heating companies also played an intermediary role, sharing expertise and experience from previous schemes, and offering to deliver and operate commercially attractive schemes.

At the **regional level**, there was some evidence of local

enterprise partnerships undertaking intermediary activities as well. Their regional scale, joining multiple neighbouring local authorities, enabled the building of social networks required for employment of a shared specialist staff member for district heating that would not have been possible for individual authorities acting alone. This scale of working also facilitated greater sharing of knowledge and cooperation between the neighbouring local authorities working on similar challenges.

National level actors undertook intermediary knowledge sharing activities between local actors, although none provided comprehensive coverage, or had enough capacity to meet the demands of all the local actors. Key successes were government support units such as the Heat Networks Delivery Unit (HNDU),² which primarily acted as a source of funding to enable English and Welsh local authorities or regional local enterprise partnerships to buy in consultancy expertise, and also as a source of information sharing between local projects. The Core Cities group,³ the Vanguard Network⁴ and the trade associations (Association of Decentralised Energy (ADE) and the UK District Energy Association (UKDEA)) were also cited as valuable sources of information and best practice sharing.

6.3. Intermediary activities for empowering an innovation

Building on this first stage of analysis, we then explored the extent to which there were examples of intermediary activities contributing to niche empowering processes within the activities highlighted in the decision theatre. We use the examples of empowering intermediary activities set out in Table 2 as a framework for analysis, and consider whether these activities support a 'fit and conform' or 'stretch and transform' transition (Smith and Raven, 2012):

6.3.1. Embedding a new regime locally - through the creation of a supportive local policy framework

The data showed examples of where local authorities wanted to play a strategic coordination role for district heating development. They saw their role as highlighting opportunities for interconnection or expansion of existing networks, and using their local planning powers to require consideration of district heating in new developments and refurbishments where appropriate.

Some local authorities had undertaken demonstrable actions on this, mentioning district heating explicitly in their climate change action plans, fuel poverty strategies and within planning policy. This use of planning policy, in particular, was a 'fit and conform' approach to empowering district heating by supporting private sector-led development of networks.

A lack of political commitment and resources was a key issue preventing more consistent actions taking place. Development of low carbon energy was not a formal responsibility for local authorities and had to be done after other legally-mandated responsibilities had been fulfilled, such as social care provision or

waste management. Some local authority actors lacked a clear steer on whether their local authority was willing to take on this new strategic role in local energy development:

"And part of that is because this is new. This is not core business, so perceived risk is greater." (Local Authority).

6.3.2. Embedding a new regime locally - use of ownership models for strategic development

A local authority taking a lead role in developing and owning a district heating network was posed as a means of establishing a strategic influence over district heating development and leveraging greater benefits for the area (e.g. ensuring affordable heat costs for fuel poverty reduction, encouraging expansion of existing schemes, or generating income for the local authority through scheme profits). This intermediary activity supported a 'stretch and transform' approach to empowering district heating, with local authorities taking on a new role in energy system development and seeking to shift the metrics of energy supply from profit-making to a public service.

The lack of precedent and experience for local authorities in this role meant that there was a high perceived risk associated with taking on full local authority ownership of a scheme. However, the option of a fully private scheme, or partnership with the private sector was also associated with caution.

"It's a way of diluting the risk and also bringing in expertise and funding. Because a local authority might identify it as a really wholesome thing to do, but they may not have done it before, and they don't have the funding for it. So I think to bring in an external partner - it would probably be an energy company that's got the skills and knowledge in both the design and delivery, and can get the funding. It's getting the balance right between the local authority and the private finance really. Because they can take over the nest." (Local Authority)

6.3.3. Embedding a new regime nationally - through the creation of national standards

At the national level, a long-standing trade association was in the process of setting up a voluntary customer protection scheme to drive up standards and increase confidence in district heating (Association of Decentralised Energy (2015)). Similarly, a voluntary technical code of practice had been produced by two leading technical institutions (Wiltshire et al., 2014). This aimed to ensure good technical practice to promote and preserve the reputation of the technology as an energy efficient heat supply infrastructure. These measures were initially done with a 'fit and conform' approach; in the absence of government approved binding standards. However, they had the potential to also become part of a 'stretch and transform' approach in the future.

Despite these initiatives from national actors, there was still a complete lack of action from the national government on introducing any form of regulation on heat supply in the UK. The voluntary nature of these standards meant that there was no guarantee that district heating operators would abide by the standards set out by the two initiatives.

7. Discussion

These results highlight the multiple scales and evolving roles of intermediaries in supporting niche nurturing processes throughout the district heating delivery process. There was also an awareness

² The Heat Network Delivery Unit (HNDU) was set up within the UK National Government's Department for Energy and Climate Change (DECC) in 2013 to support local authorities in England and Wales. It sought to tackle issues of "capability and capacity" by offering guidance, support and funding to commission expert consultant studies (DECC, 2014).

³ The Core Cities is a network formed to represent the local authorities of England's eight largest city economies outside London along with Glasgow and Cardiff, aiming to enable each city to enhance their economic performance and attractiveness as places to live, work, visit and do business.

⁴ The Vanguard Network was set up by the University of Edinburgh as a forum to discuss detailed aspects of district heating development for local authorities in the UK at a more advanced stage of the development process.

of the potential to undertake intermediary activities that could establish a new regime which is more supportive of district heating. However, in the UK context of an under-developed district heating market, there were barriers to actors taking on these roles. This section explores the role of intermediaries in supporting niche empowering processes further by considering how the ‘mode’ of energy intermediation (Hodson et al., 2013) influences whether the activity supports a ‘fit and conform’ or ‘stretch and transform’ transition.

7.1. Considering intermediary typologies for supporting niche empowering processes

The **scale and depth** of the intermediary activities observed in the analysis varied across actors at different geographical scales. At the local level, local authorities had a particularly crucial role as the only local actors with responsibilities and interests across all the sectors; and objectives focusing on the wider public good of the area. They had the potential to play a ‘stretch and transform’ intermediary role for district heating through retaining ownership of networks and offering strategic coordination and priorities for development (e.g. local authority-owned energy service companies). However, delivering these activities required a systemic response from the local authorities, with consistent access to staff and resources so that they could develop the expertise and capacities to confidently take on this financial and reputational risk.

In practice, the scale and depth of the local authority activities observed were not consistent. No consensus had yet been established for the extent of local authority responsibility in this area and UK governance structures did not attribute formal responsibility for energy matters to local authorities. This could be observed in the variability of local authorities’ levels of political commitment to district heating and the levels of risk they were willing to take on to support development. Combining this lack of an established approach with the challenges of internal capacity and lack of resources created significant barriers to some local authority actors performing this type of sustained intermediary role. Instead, they were constrained in their activities to the use of planning powers for new developments and encouraging the private sector to take on the development and ownership of networks.

In contrast, national intermediary actors in the case study were from well established institutions with long-term access to resources which could deliver a systemic response for activities such as creating of standards and practices for the technology. For example, a trade association in the case study had founded a voluntary customer protection scheme to drive up standards and increase confidence in the technology (Association of Decentralised Energy, 2015). The position of these actors embedded within the incumbent regime enabled leveraging of resources for niche actors and intermediaries, as well as use of shielding policy measures to support the innovation. However, these national level activities were largely restricted to supporting a ‘fit and conform’ approach to empowering district heating. This could be because, given their established nature within the incumbent regime and place within the institutional framework, their key stakeholders and resources are tied to existing institutional set-up, making it hard for them to justify activities which might undermine their other key stakeholders’ interests.

We suggest that the local nature of district heating means that a systemic intermediary response is needed across the geographical scales to support empowerment. In this case study, particular attention was needed at the local-level where capacity and resources to provide a consistent, long-term intermediary function was lacking. As Hawkey et al. (2013) identified, the way that successful schemes have overcome these barriers to date is through a

reliance on key individuals and social capital within the local authority. Pooling of resources at the regional level, such as in the cases of local enterprise partnerships, to enable consistent and expert support to the development process could be one way of moving beyond this reliance on individual social capital. In general, the role that local intermediaries play in niche nurturing and empowering processes would be strengthened by being recognised and resourced in a systemic way.

To consider the **source of intermediary priorities**, we again look first at local level intermediaries embedded in local niches, and then we consider national level intermediaries. At the local level, where local authorities had made commitments of resource and staff time in the absence of any national government mandate, their local priorities and objectives were particularly important in enabling them to justify their intermediary activities:

“[In our city], we’ve got a Climate Change Strategy with senior level commitment. It’s that obligation that is needed, because without the obligation I’d just carry on ... I’m really busy, I’ve got less staff, I’ve got less resources. I don’t need to change anything so why do it?” (Local Authority)

This differed from incumbent regime practices where energy policy priorities were driven from national government or large energy company agendas. However, this distinction from incumbent regime practices also created a perceived risk to local authorities delivering intermediary activities, and sometimes led to a watering-down of local priorities. For example, one actor in the case study expressed a desire to retain local authority ownership to gain local benefits and to influence expansion and future development in the area. However, when it came to making a commitment it was felt that sharing risk with other actors, at least to some extent, was more appropriate for their capacity and ability to manage risk:

“You want to share the risk and the rewards because the scale of the ultimate project could be massive. These things tend to start off with one scheme, but they can build over the years. So you want to share that risk and reward.”

Currently, a local authority must shoulder the risk of investing their resources into the early project development stages, with the potential for no rewards at the end. A greater use of shielding policies, re-distribution of resources from the national level as well as the establishment of the roles and responsibilities of local authorities could support local authorities to take on a more systemic approach to delivery of local intermediary activities. This could enable them to create local institutional structures that facilitate strategic development of networks and unlock the option for taking a ‘stretch and transform’ approach to district heating empowerment.

At the national level, a number of forms of intermediaries existed, including the trade associations and a government support unit (the Heat Network Delivery Unit). The government support unit was ultimately driven by the objectives of national government rather than local authorities. Their main engagement with local authorities was to distribute resources such as advice and funding. In the case of the trade associations, they were driven by their members’ priorities. This membership included some local authorities, although private sector energy companies comprised their largest proportion of members. This made their activities less focused on the specific contexts and challenges of local authorities.

In general, there was a gap in intermediary provision for activities that linked up local authorities and regime-embedded actors.

Local authority actors often articulated a need for regime-level changes or a greater need for shielding policies. However, there was little evidence of an intermediary providing a coordinated narrative from local authority interests on the need for regime change. Instead, individual local authorities fed their experiences through to regime actors such as the UK Government on an ad hoc basis.

7.2. Lessons on the role of intermediaries in facilitating a supportive institutional framework for a 'stretch and transform' approach

The case study analysis demonstrates an example of where the institutional framework required by a technology innovation is distinct from the set-up of the incumbent regime. The agency of local intermediaries within the case study was limited due to their lack of resources and policy powers. Some local authorities sought to 'stretch and transform' the incumbent regime by seeking to establish local authority-owned networks and create a key strategic power-base. However, other actors were disempowered by the multiple barriers to them taking on this new role, and instead sought to support district heating development within the boundaries of their existing powers and roles. District heating, by its nature, requires local support and coordination. This meant that the under-resourced local intermediary function within the case study was a key challenge. Re-structuring of the institutional framework is likely to require the re-distribution of resources and power from existing institutions.

The case study showed some examples of how intermediaries can potentially play a role in enabling this restructuring and re-distribution of resources. For example, where local authorities had the agency to take on a new intermediary role within the energy system, they were able to work towards more radical 'stretch and transform' visions where heat supply was delivered through local authority-owned networks, strategically located and expanded to ensure affordable, low carbon heat provision (rather than privately-owned networks operating only in areas offering maximum profit margins). The nurturing activities of the local intermediaries in the case study had the potential to provide the foundation for them to extend their activities for supporting empowering processes by developing skills and knowledge. This investment in niche nurturing activities had the potential to build the legitimacy of local intermediaries in the eyes of resource-holders, paving the way for them to be granted greater powers and resources in the future. However, these activities require a systemic response from local intermediaries and correspondingly a re-distribution of resources to the local level. We suggest that determining this redistribution of resources will require a process of negotiation and compromise between resource-holders and local intermediaries, balancing priorities that 'fit and conform' with the incumbent regime with more radical 'stretch and transform' priorities. This highlights again the question of actor agency and landscape-level influences in shaping transitions.

8. Conclusions

In this paper, we have used a case study of new district heating development in the UK to demonstrate that intermediaries can play a role in supporting niche empowering processes as well as niche nurturing processes. In particular, they have the potential to play a part in restructuring the institutional framework surrounding an innovation to enable more radical 'stretch and transform' empowering activities.

This research highlighted the multiple intermediary activities that take place when establishing an innovation within a resistant regime, and how they can evolve over time and lay the foundations

for future activities. The geographical scales of intermediary actors, and their place within the existing regime, had an important influence over the actors' agency to support niche empowering processes. Intermediary functions would ideally be carried out by actors working at a geographical scale that is most appropriate for the innovation (in this example, local-level intermediation was particularly important). However, the existing institutional framework surrounding an innovation can prevent relevant actors from taking on this role. In this case study, the position of intermediaries within the incumbent regime determined how well they were able to access resources for delivering a systemic intermediary response. The more embedded they were within the regime, in this case sitting at the national level with connections to existing energy companies and actors, the more they were able to access resources and deliver a systemic response. However, these regime-embedded intermediary actors were also restricted to 'fit and conform' approaches in their empowering activities. Local intermediaries, on the other hand, often lacked the resources and agency to take the 'stretch and transform' approaches that they desired. However, they showed the potential to build the legitimacy and capacities of niche actors to lay the foundations for restructuring the regime's institutional framework to better support a 'stretch and transform' transition in the future. Although intermediary activities can clearly play a role in influencing the development of a supportive institutional framework for an innovation, we suggest that the context of the incumbent regime and landscape influences still play a pivotal role in determining to what extent institutional change can take place.

Building on the contributions made in this paper, we suggest that there is a need to extend the framework for intermediary activities proposed by Kivimaa (2014) to incorporate the role of intermediaries in supporting niche empowering processes. In particular, such a framework should explore the types of activities that support 'fit and conform' and 'stretch and transform' approaches. The use of a decision theatre for data collection has enabled a detailed exploration of the experiences of the actors in our case study. However, given the small number of participants in the decision theatre, the limitations for drawing wider conclusions from this study alone must be noted. Our conclusions are intended to serve as suggestions and hypotheses for future studies that can explore these issues further, ideally across different technologies and national contexts.

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