Supporting diffusion of low-energy systems: what can the UK learn from the diffusion of Biomass District Heating in Austria?

Policy Briefing 01

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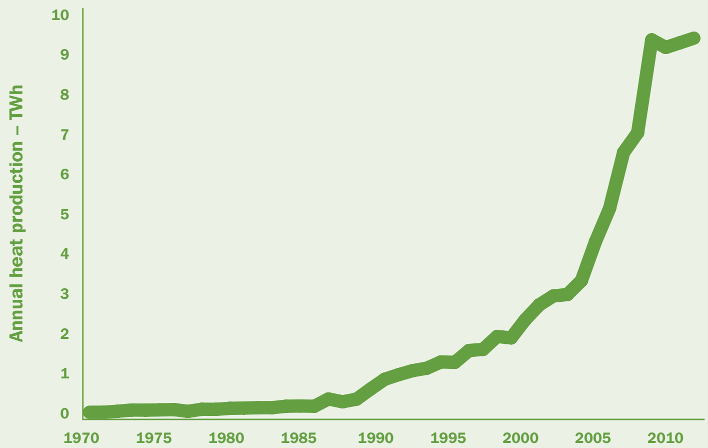
FIGURE 1: ANNUAL HEAT PRODUCTION FROM AUSTRIAN BIOMASS DISTRICT HEATING, IN TWH (STATISTIK AUSTRIA, 2015)



- In the 1980s, Austria experienced diffusion of small-scale biomass district-heating schemes (BMDH). This accelerated in the mid 2000's.
- Austrian BMDH schemes are distinctly different from earlier citywide schemes fuelled by fossil fuels.
- BMDH emerged as small-scale plants (<1MWth) located in rural areas, and pioneered and operated primarily by agricultural cooperatives.

Domestic and non-domestic space and hot water heating accounts for almost a quarter of UK total CO_2 emissions. To meet climate change targets, the UK will need to achieve complete decarbonisation of domestic heat by 2050.

Heat networks – district heating and combined heat and power schemes – are one of three ways the UK government plans to decarbonise heat. By 2050 heat networks could 'cost effectively' meet around 40% of UK heat demand. Despite more than 60 years of experimentation, however, heat networks currently meet less than 2% of UK heat demand.

Drawing on research examining the rapid diffusion of biomass district heating (BMDH) in Austria, this policy paper provides key insights for the diffusion of heat networks in the UK and diffusion of low-energy systems more broadly.

Key Findings:

- The diffusion of low-energy systems is best viewed as a process involving a wide-range of actors and mechanisms.
- Austria's more balanced distribution of power and resources between national and local actors enabled experimentation and policies tailored to regional social, economic and cultural contexts, supporting early phases of BMDH diffusion.
- Capital grants and enduring polices were crucial for supporting actors to build and operate BMDH schemes and the development of supply-chains and supply-side actors.
- Intermediary actors such as regional energy agencies played a pivotal role in the replication and circulation of knowledge throughout the diffusion process.
- Rather than a top-down, market-led and centralised approach to policymaking, diffusion of BMDH in Austria highlights the importance of adopting a range of policy styles, which evolve over the diffusion process and vary across geographical scales.

About the authors:

Victoria Johnson is Research Associate at the Sustainable Consumption Institute, University of Manchester and the Centre on Innovation and Energy Demand. **Frank Geels** is Professor of System Innovation and Sustainability at the Manchester Institute of Innovation Research (MIoIR) and the Sustainable Consumption Institute (SCI) both at the University of Manchester. Frank is also co-director of the Centre on Innovation and Energy Demand.

About this briefing:

This briefing is based on work carried out on behalf of the Centre on Innovation and Energy Demand (CIED) an EPSRC-funded End-Use Energy Demand Centre and draws on research presented in a forthcoming paper by Frank Geels and Victoria Johnson 'Adoption, upscaling, replication/circulation, and societal embedding: Four theoretical models of technology diffusion applied to biomass district heating systems in Austria (1979-2013)'.

Contact:

Dr Victoria Johnston, Sustainable Consumption Institute, University of Manchester, UK
E: victoria.johnson-2@manchester.ac.uk

Professor Frank Geels, Sustainable Consumption Institute, Manchester Institute of Innovation Research University of Manchester, UK
E: frank.geels@manchester.ac.uk

Centre on Innovation and Energy Demand

MANCHESTER 1824
The University of Manchester
Sustainable Consumption Institute

System diffusion of BMDH in Austria

The first Austrian BMDH plant was installed in 1979. Twenty years later there were 500 schemes, and by the end of 2014 this had risen to 3,100. The country went from importing biomass boilers, to a global leader in their manufacture. Now BMDH provides 10% of space heating and hot water in Austria, while all forms of heat networks provide around 22%.

Despite the relatively smooth diffusion curve in Figure 1, three different configurations of BMDH exist which vary in scale, location, operators, and customers (Table 1). As such, rather than one diffusing BMDH-system there are several, each with their own diffusion curve. This suggests three key phases of BMDH diffusion:

1. 1970s and early 1980s: small-scale village BMDH-systems developed by new entrants in the absence of dedicated federal and provincial policies.

2. Mid-1980s to early 2000s: programmes of subsidies supported by Ministry of Agriculture, provincial Chambers of Agriculture and Forestry and provincial governments led to rapid growth in village-scale schemes. During the 1990s, BMDH increasingly aligned with federal-level climate change and renewable energy policies, which provided further support.

3. 2002 onwards: a feed-in-tariff for electricity generated from biomass introduced in 2002 led to rapid growth in biomass CHP plant stimulating the involvement of incumbent energy utilities. More recently, considerable growth in micro-nets (short, small-scale heat networks involving two or more buildings) occurred. These tend to be operated by energy service companies (ESCos) and agricultural cooperatives.

Table 1: Multiple configurations[1]

Configuration	Scale	Developers	Customers
Village heating systems	Small- medium-scale heat-only plants (most <1MW$_{th}$)	Agricultural cooperatives, sawmills, ESCos	• Publicly owned buildings (e.g. schools, townhalls, hospitals, nursing homes, public swimming pools) • Less often, private homes and commercial buildings.
Co-generation of heat and power (CHP)	Medium- (<10MW$_{th}$) and large=scale (<65 MW$_{th}$) plants that generate both	Energy utilities are dominant, although ESCos and industrial actors (e.g. paper and pulp industry, sawmill industry) are also involved	• Electricity is fed into the grid • Heat for industry or semi-urban district heating • Typical locations are business parks, industrial sites, and small- and medium size towns
Micro-net	Small-scale (between 100 and 400 kW$_{th}$)	ESCos and agricultural cooperatives, although energy utilities have recently moved into market	A limited number of closely situated buildings (e.g. rented houses or flats, public buildings, hotels)

A sociotechnical perspective of diffusion

A *sociotechnical* – technologies, infrastructure, consumer practices, firms, markets, policy and cultural meaning – perspective of diffusion suggests that in order to fully understand system diffusion, a wide-range of actors and mechanisms need to be considered. This is counter to *adoption models* of diffusion that dominate the innovation literature.

Adoption models of diffusion understand diffusion as the result of purchase decisions by consumers. Although a range of adoption models exist, each emphasising different factors that shape adoption decisions, broadly speaking they assume:

- Diffusion of an innovation results from a rational calculation or is informed by adopters' attitudes and beliefs;
- The adopter is the primary actor in the diffusion process; and
- The environment in which diffusion takes place is fairly static.

While adoption models may explain the diffusion of discrete products, they face problems explaining the diffusion of *system*, something that has received relatively little attention within the innovation literature.

- Systems differ from discrete products in terms of scale, complexity, capital intensity, as well as in spatial, social and political dimensions.
- System diffusion involves a range of actors, such as policymakers, supply-side actors (e.g. installers, manufacturers) and civil society, in addition to adopters.
- System diffusion takes years or decades rather than months or years, so the environment the system diffuses into is neither static nor homogeneous. Instead it varies across space and time.

Given these limitations insights from three further approaches are necessary to understand *system diffusion*: upscaling (system building), replication and circulation, and societal embedding.

1. *Upscaling (system building)* models suggest that diffusion of systems involves, first, piecemeal development, then integration. New systems start as small-scale local schemes and subsequently diffuse when they are combined into large-scale national systems. Electricity or railway systems are good examples.

2. *Replication and circulation models* suggest diffusion happens by systems in one location being replicated in another location. So, diffusion happens through circulation of people, ideas and knowledge between different locations.

3. *Societal embedding models* suggest that new systems need to find their place in the wider society. Thus diffusion occurs through the 'alignment' of system components with broader political, cultural and business contexts.

Key Findings from the Austrian Context

1 System-builders, who were crucial for diffusion of BMDH-systems, were motivated by perceived economic opportunities

System builders – actors who actively integrate technological and organisational components (e.g. business models) of a system – played a central role throughout BMDH diffusion. Early system-builders were private sawmill owners who built small BMDH schemes fuelled by wood residues for neighbouring properties. From the mid-1980s, forest-owning farmers became important system-builders. With support from regional Chambers of Agricultural and regional governments, farmers formed agricultural cooperatives to develop and operate BMDH, in order to create new markets for wood products. By the early 2000s, energy utilities became important system-builders, taking advantage of green electricity policies, leading to a boom in biomass-CHP. ESCos were also important system-builders at this time, primarily focussing on micro-net development.

2 Intermediary actors, like regional energy agencies, facilitated information circulation between local practices

During early phases of BMDH diffusion, information circulated by word-of-mouth between neighbouring villages. From the mid-1980s intermediary actors played an important role in the diffusion process. These actors included regional energy agencies, regional government, Chamber of Agriculture, and the Austrian Biomass Association. They stimulated the circulation of information and knowledge, organised workshops, compared local experiences and funded 'technological introduction managers' who worked with developers such as agricultural cooperatives to plan and install BMDH schemes. These intermediaries played a key role in creating rules and standards and lobbying policy-makers for funding and support.

3 Elements of societal embedding were crucial

Policy support was important to reduce investments risks (via capital grants and feed-in tariffs), stimulate adoption (via subsidies and price regulation) and stimulate knowledge development and circulation (via workshops and quality standards). Policy support existed from the early 1980s and continues to the present day. Initial support came from agricultural policymakers, who saw BMDH as a means of assisting farmers and countering rural decline. Energy and climate policy considerations gradually gained importance in the 1990s and 2000s. Additionally, positive narratives created legitimacy for state support. While early narratives focused on rural revitalization, BMDH was subsequently framed in terms of climate change and, since the mid-2000s, in terms of green growth, energy independence, and the national biomass strategy.

4 Adoption models were less important for the explanation of early phase diffusion

Economic considerations were less important for early adopters of village BMDH-schemes, who were more motivated by environmental and social considerations (helping local farmers and regional economic prosperity).

Diffusion of low-carbon systems involves multiple interacting factors and actors, which span techno-economic, political, social and cultural dimensions. A general insight is that single policy styles are unlikely to result in the successful diffusion of a low energy system.

Table 2: Different policy styles

	Market-led model (bottom up)	Classic steering (top down)	Interactive network governance
Characterisation of relationships	Autonomous (government creates incentives and 'rules of the game', but lets actors choose freely).	Hierarchical, command-and-control (government sets goals or tells actors what to do).	Mutually dependent interactions
Characterisation of coordination processes	Incentives and price signals	Government coordinates through regulations, goals and targets	Coordination happens through social interaction and exchange of information and resources.
Policy instruments	Financial incentives (subsidies, taxes)	Formal rules, regulations and laws	Demonstration projects and experiments, knowledge transfers policies, network management, vision building through scenario workshops, strategic conferences, and public debates.

Key Lessons for Low Carbon Policy

1 The need for a more balanced distribution of power and resources between central and local government

Austria's multi-level governance structure enables two-way interactions between regional and national policies and actors. This led to a more balanced distribution of power and resources between the two, supporting experimentation and policies tailored to provincial social, economic and cultural contexts. National policies set encompassing regulations, quality standards and offered substantial financial support.

In contrast, English local government has the most restricted powers of any equivalent tier internationally.[2] With limited powers and resources to experiment and influence central government, local authorities are tasked with simply implementing centralised policies. The devolution agenda offers the opportunity to consider redressing this balance but so far discussions have focussed on economic growth rather than energy or carbon reduction.

The Greater London Authority (GLA) illustrates the potential, however. Recent growth in heat networks has been concentrated in Greater London due to the GLA's active support, independent of national policy and achieved through strategy, facilitating cooperation between local actors and developers, heat mapping and technical guidance.

2 Intermediary actors, like regional energy agencies, facilitated information circulation between local practices

Capital grants administered at the provincial level in Austria provided opportunities for experimentation and stimulated the development of supply-side actors and experience. Direct cost subsidies remain to this day, creating stability and certainty for system-builders over decades enabling them to make cost/ benefit calculations and strategic investments.

In the UK, private investment is expected to deliver the low carbon energy transition. Yet, energy policies have been tightly coupled to political cycles reducing the certainty necessary to attract private investment. Furthermore, capital grants sit outside the 'frame' of current 'market-led' UK energy policy.[3]

DECC's time limited Heat Network Development Unit (HNDU) administers grants in England and Wales for local authority activities such as heat mapping, energy master planning, heat network feasibility studies, and project development support. Capital investment is not, however, available. There has been high demand for HNDU since its launch.[4] The absence of capital grants to support system-builders and the development supply-side actors means HNDU funding is unlikely to translate into installed capacity on the scale required.

3 Network governance stimulates the circulation of knowledge

Network governance policies (Table 2) by provincially sponsored energy agencies and the Austrian Biomass Association were crucial in early phases to stimulate circulation and build knowledge. Workshops and seminars helped develop standards and procedures. Provincial governments and regional Chambers of Agriculture provided funding and support for experimentation, supply chain development and articulated positive narratives in support of BMDH schemes.

A range of intermediary actors exist in the UK. HNDU, for example, operates as a national level intermediary, providing funding, information, guidance and best practice examples to support local authorities, although it is only scheduled to run until early 2016. At the sub-national scale, local authorities can and do act as intermediaries, facilitating cooperation between the numerous local actors involved in heat network development.[5] Although articulation of their role is ambiguous, local authorities are expected to play a key part in the deployment of heat networks.[6] However, enabling local authorities to play a significant role in diffusion of heat networks, requires policies that address financial and technical capacity and expertise to deliver services.[7]

4 A mix of policy instruments that co-evolve with the diffusing system will support rapid and long-term diffusion

Austrian policymakers used a mix of instruments and policy styles (Table 2), which co-evolved with the diffusion process. During the early diffusion phase, an interactive network governance policy style prevailed at the provincial level, supporting learning, circulation and societal embedding. Later stages of diffusion also saw the introduction of market and classic-steering policy styles (regulation, standards, feed-in-tariffs), while network governance continued to play an important role.

Adoption models often underpin a 'market' policy style as in the UK, where the focus is on individual adopters (e.g. pricing, subsidies, taxes or information campaigns). These kinds of policies only played a significant role in the later stages of Austrian case, however, once supply chains; networks of actors and a knowledge base had been developed.

With market instruments dominating the UK government's heat network policy framework, a coherent and evolving policy mix has been lacking. Classic steering and interactive network governance styles are either absent or ad-hoc. As heat networks are still an emergent technology in the UK, supply chains, experience and the skills base to install plants are currently deficient. [8,9] Recent schemes have had excessive development costs and installations have been sub-optimal due to poor design, over dimensioning and the need to import network components. This has increased their perceived investment risk and reduced the efficacy of market-led policy instruments. [8,10]

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