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Lessons from European regulation and practice for Scottish district heating regulation

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Executive summary

1. Aims

Scotland's ambitions and commitments to reducing greenhouse gas emissions will require significant changes to much of the domestic heating sector. One low carbon alternative to individual gas-boilers which offers significant opportunity is district heating (DH). DH is a relatively immature sector within Scotland and is not currently regulated. The Competition and Markets Authority recently called for the introduction of regulation, to ensure consumer protection and support development of the sector.

This report looks at lessons from the regulation of district heating in seven European countries.[1] It builds on two public consultations relating to regulation and is intended to inform the Scottish Government regarding the potential introduction of regulation and the form it should take. Particular focus was directed to the following areas, identified from the second consultation: setting and enforcing heat network technical standards, introducing consumer protections, economic regulation of natural monopoly infrastructure asset, alignment of heat network owner's activities with Government and/or local authority priorities.

2. Key lessons

- Pricing is one of the primary reasons regulation has been introduced in the cases reviewed. Pricing regulation follows two broad models – regulating end user tariffs (such as in Norway and the Netherlands) and capping the profits made by DH operators (such as in Denmark, Hungary and Poland). Inflexible price setting can disincentivise developers from entering the market and upgrading current systems. It can also limit innovation and lead to domestic customers disconnecting from DH network for cheaper alternatives. However, full de-regulation of prices tends to negatively affect consumer outcomes as customer service and protections become eroded, as has been the case in Germany.
- Transparency is another cornerstone of most regulatory approaches, though this is achieved through different means and to varying degrees of success. Careful design and monitoring of

[1]Norway, The Netherlands, Sweden, Hungary, Denmark, Germany, Poland

approaches to transparency are necessary to ensure consumers benefit from them. A range of mandatory (Hungary) and voluntary options (Sweden, Denmark) have proven successful.

- Structures to handle consumer complaints are a core element to effective regulation and preventing abuses of monopoly positions by operators. Consumer protection standards and levels of satisfaction vary, though this is dependent on the extent protection is prioritised in the design of regulation. Both Denmark and Hungary appear to have effective complaints procedures in place, whereas in Germany the model seems to be less efficient and of less value to consumers.
- Technical standards are a key aspect of all regulatory models, though these differ in how they are introduced (e.g. through licensing or voluntary non-binding standards). These must involve flexibility to avoid becoming a major barrier to innovation and sector development. For example, stakeholders in Poland have suggested that the inclusion of stringent technical standards into licencing requirements has increased DH prices.
- Licensing, zoning or the awarding of concessions are key mechanisms for regulation in most countries reviewed. These allow for stabilisation of the market and were generally perceived as important and useful by stakeholders. However, excessive administration or rigidity in their application in some instances presented barriers for operators, as in Poland.
- Mandatory connections (where customers are obligated to connect to a DH network where available) can ensure sufficient heat demand. This can be a key aspect to encourage investment in the network development, as is the case in Norway.
- Third party access and the supply of excess heat have high potential to encourage investment in the market. However, in practice many countries have not found a way to fully encourage or benefit from the supply of excess heat. While third party access is a common feature in many countries reviewed, it can lead to investment uncertainty for operators. Requests can be declined where operators have the right to refuse, as is often the case in Sweden and Norway. Careful planning of whether and how to 'open up' the market is imperative.
- DH regulation needs to be aligned with national and municipal planning, as planning-related features such as zoning or mandatory connections tend to be central to the development of the market, as is demonstrated in Norway and Denmark. Clear division of responsibility between national and local government is also fundamental for effective market and sector development.
- Wider policy support is key for regulation to be effective. The presence or absence of well-planned subsidy schemes or frameworks which allow developers to access finance for development play a major role in how the market develops. Government financial support in Norway is a successful example of this. In contrast, the tax incentives and subsidies in Hungary have had limited success in stimulating DH investment. Care must be taken to plan and account for the wider socio-economic effects of such approaches.
- Each regulatory regime is inextricable from the socio-economic, infrastructure and historical aspects of that country. All regulatory models examined provide some positive and negative learnings which are relevant to informing decision makers in Scotland. The need for long-term planning and buy-in and collaboration from industry and political areas is key for regulation to be effective. However, given changes to the market, there is a need for flexibility and proactive identification of changes to the regulation.

3. Conclusions

This research provides lessons from European examples for DH regulation which can help to inform Scottish policy makers considering whether and how regulation should be introduced in Scotland. Regulation differs greatly between all countries assessed, and any regulatory model can only be reliably evaluated within the context of that country. Norway and The Netherlands provide some learnings which are of particular relevance to Scotland, given the emerging nature of their DH sectors and comparable economies. Germany and Poland highlight the interplay DH can have with the

transitioning from an historical dependence on fossil fuels. However, the Scottish context has some unique characteristics, including the prioritisation of fuel poverty, which is not an issue covered within energy policy in most European countries.

As a product of the research, four key components of an effective regulatory system for district heating are identified as:

- Long term planning and commitment to DH development
- Successful use of tools which stimulate market development and investment in the sector
- Co-ordination of national and municipal governments, and scope for industry interests to have a say in certain regulatory issues
- Flexibility to allow for innovation, and account for market changes

These are the key lessons to be considered for the introduction of district heating regulation in Scotland.

Contents

1 Introduction

Heating accounts for 51% of Scotland's energy demand, with the majority of domestic heating provided by natural gas (80% of households use gas as their primary heating fuel).[i] Significant and sustained reductions in consumption and greenhouse gas emissions from heat are fundamental to achieving the emissions targets set out in Scotland's Climate Change Act.

District heating (DH) will play a prominent role in this transition, and Scotland's Energy Strategy suggests that it could supply at least 10% of residential and service demand by 2050.[ii] The range of possible heat generation technologies (including renewables, recovered heat and cogeneration) which supply DH networks mean that networks can be developed to align with an area's supply opportunities, as well as demand. This flexibility also presents opportunities to align with decarbonisation objectives.

The district heating sector in Scotland is relatively immature by European standards and is currently unregulated. This has had an impact on the strategic growth of the sector and means that there is no enforced consumer protection for those connected to DH networks. In its 2018 market study into heat networks, the Competition and Markets Authority recommended the introduction of regulation throughout the UK[iii].

DH will play an important role in Scottish decarbonisation and energy policy. DH networks are most suitable in urban areas and align with the policy focus on area-based approaches through proposed Local Heat and Energy Efficiency Strategies. The Scottish Government is exploring feasible options to introduce regulation and have consulted twice, in 2017 and 2018 on this subject. DH is covered within Scotland's devolved powers, though Scotland does not currently have devolved responsibility for issues related to consumer protection.[2]

Some of the key aspects of proposed regulation which were included within the second consultation include:

- a requirement for developers to obtain consent to develop a DH scheme
- the introduction of a licensing system for DH operators to control market access and ensure quality of supply;
- means of encouraging private investment to develop the network through the supply of excess heat; and
- consumer protection and mediation mechanisms.

Decisions will be made about the introduction of regulation and aspects of a regulatory model in the response to the consultation which accompanied the Energy Efficient Scotland Route Map.

[2] Scotland's powers extend to consumer advocacy and advice, which are devolved, along with the funding for these. Citizens Advice Scotland has statutory responsibilities for representing energy consumers. But consumer protection law is reserved to the UK government, and many wider consumer protections stem from UK or EU law.

2 Lessons from European regulation and practice for Scottish district heating regulation

ClimateXChange commissioned Changeworks and the Centre for Energy Policy, University of Strathclyde to review existing European regulatory models and identify learning from each that are relevant to the Scottish context. The outputs will add to a body of existing research which will inform the Scottish Government's proposals regarding regulation in the coming years.

This report details the findings from a review of seven European DH regulatory models, including a contextualised evaluation of each model. A detailed methodology is included in Appendix A. The research used evidence gathered through a literature review and interviews.

A summary of our findings and the key lessons that have emerged from the research are presented in section 3. Descriptions and evaluations of the seven countries follow in section 4 as stand-alone case studies.

1. Case studies

Following initial scoping research of fourteen European countries in which district heating regulation has been established, seven countries were selected to analyse in depth. These were selected based on their variability across features of interest and their comparability to aspects of the Scottish context. These were developed into case studies which were used as the source material for regulatory evaluation and to guide stakeholder interviews. The countries selected, along with the rationale for inclusion are reported in the table below.

Table 1: Overview of case study countries

	Type of Regulation	Pricing Structure	Third Party Access	Legal Obligations	Points of Interest
Norway*	Regulated	Must be no more expensive than alternative sources of heat (No-More-Than-Otherwise principle)	DH operators are obliged to negotiate with any third parties requesting access	Licence required for heat plants >10MW. Mandatory connections decided by municipalities	Emerging DH market with similar market share to Scotland
The Netherlands*	Regulated	Price cap based on the No-More-Than-Otherwise principle. Fixed price element based on gas prices, with a consumption-based component	Negotiated access for heat producers (not suppliers)	Licences for suppliers, municipalities required to consider DH for new development areas	Emerging DH industry, regulated since 2010 Heating sector is comparable with Scotland High public acceptance and support

	Type of Regulation	Pricing Structure	Third Party Access	Legal Obligations	Points of Interest
Sweden	Liberalised	Unregulated. Voluntary pricing and complaints processes to aid transparency	DH operators are obliged to negotiate with any third parties requesting access	None, other than submitting annual accounts	Clear division of responsibilities between local and national governments Mixture of mandated and voluntary consumer protection schemes
Hungary	Regulated	Cost-plus (necessary costs plus a set mark-up) Prices are subsidised below market price, and set for producers and residential consumers	Possible through a tendering process, but is not frequently applied in practice	Licences for producers and suppliers, mandatory connections, operator profit caps	Highly regulated which has influenced market Regulation has been reformed repeatedly Challenges with decarbonisation
Denmark	Regulated	Cost-plus (necessary costs plus a set mark-up)	Access guaranteed to enable competition	Obligation to connect to DH in designated zones (enforced by municipalities)	Well established sector and supply chain Waste heat is a major priority
Germany	Liberalised	Unregulated	Access is guaranteed to enable competition	Municipalities can decide whether to make connections mandatory	Less robust consumer protection mechanisms than comparable countries
Poland	Regulated	Cost-plus (necessary costs plus a set mark-up) Prices are not capped	Access exists but there is limited application	Operator-funded mandatory connections for consumers who can connect to a DH network	Largest network in Europe Wide-scale licensing Historical dependence on fossil fuel

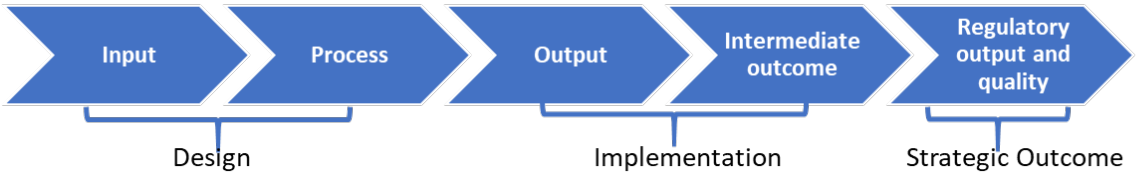
*DH markets are not mature

2. Framework for Evaluation

The evaluation broadly employs the Organisation for Economic Co-operation and Development (OECD) Framework for Regulatory Policy Evaluation. This is an established framework that can accommodate the complexity of the topic and facilitate evaluation of each of the regulatory models explored. The framework approach also ensures that regulatory policy is assessed holistically across

the different stages of the regulatory process; at design, implementation and strategic outcome level. It supports evaluation of regulatory models in light of each country's historical, economic, energy system and social contexts.

Figure 1: Stages of OECD Framework



The most relevant features specific to each regulatory model and context were evaluated across these five stages. Further detail on the Framework is provided in Appendix A.

The OECD framework allows for flexibility in evaluating different models and the most pertinent aspects of any model can be weighted accordingly as is evident in the following case studies. With Hungary, for example, the drivers for regulation influenced the type of regulation and its market-effects substantially. However, in the German example, the influence of European decarbonisation policy plays a more central role. The corresponding sections in the case studies reflect these differences between models.

3. Interviews

The case studies blend findings from the literature review with insights from a range of expert stakeholders. Effort was made to seek inputs from stakeholders with a range of sectoral expertise, including academics, industry body representatives, policy makers and operators. The stakeholders interviewed are listed in Appendix A, along with the countries about which they were most able to contribute. Views expressed as part of this research may not represent those of the organisations involved.

We found it easier to identify willing research participants in Denmark, Norway and Sweden, which may be linked to the fact that these countries have well-established or rapidly developing district heating sectors and export potential for DH expertise. As stakeholders from these countries are more fluent in English, they may therefore be more confident about participating in the research. The case studies should be read with this in mind as these countries could be evaluated more comprehensively than Hungary or Poland for example.

We wish to gratefully acknowledge the time committed by stakeholders for interviews, as well as the stakeholders not listed who provided contacts and information relevant to the research.

3 Lessons

Our review of seven case studies of DH regulation reveals a diversity of approaches, tailored to the socio-economic, energy system and political context of each country. Here we draw out key points from the review and present lessons of relevance to the debate about potential regulation in Scotland.

The chief purpose of most of the regulatory models we reviewed is managing the cost to consumers of district heating. We can distinguish three overarching models in relation to cost: regulation of prices; regulation of profits and deregulation. These are discussed below.

Transparency seems to be an essential component of consumer protection in all of the regulatory models we reviewed. There is a clear expectation across the case studies that companies should make tariff information available publicly. In some cases, work is ongoing to improve and extend information provision.

In addition to price and transparency, a range of other issues arose consistently across the case studies which are particularly relevant to questions around how district heating could be regulated in Scotland. These are: complaints; technical standards; licensing, zoning, consents and concessions; ensuring sufficient heat demand; open networks: third party access and surplus heat; links to planning and wider policy; securing investment; and, regulatory change. These are discussed in turn below.

1. Regulation of Costs to Consumers

Regulation of prices

The prices paid by DH customers in Norway and the Netherlands have been capped. The levels of the cap are calculated based on the consumer costs of an alternative heating source (an individual household gas boiler in the case of the Netherlands; electric heating in the case of Norway). The principle is that DH customers should not be relatively disadvantaged because they are 'captive' customers of what is effectively a monopoly company.

We found evidence of concern that price capping can act as a disincentive as it allows prices to be 'held' up at the level of the cap even where actual costs are well below the cap. Transparency (discussed below) and regular monitoring by the regulator are used in both the Netherlands and Norway to mitigate this risk.

A second challenge is how to set the comparator price of the alternative heating source. Reaching consensus on the right calculation method has been problematic in the Netherlands, for example. In practice, a calculation based on average costs is never going to apply to every customer. Furthermore, pegging DH prices to an alternative can have the perverse effect of maintaining DH prices at an inflated level, when the price of the alternative is high, and of depressing DH prices – potentially below actual costs to the DH operator – when the price of the alternative is low. Regular review and good stakeholder engagement with the DH industry are essential for price capping to work effectively.

Regulation of profits

In Denmark, Hungary and Poland, consumer prices are effectively regulated via capping profits. Denmark applies a no-profit principle, so consumers are only charged enough to cover operators' costs. The profit regulation approach seems to work well in the Danish context, resulting in benefits being passed on to consumers through high quality service. Even co-operative owned networks (with lower recorded levels of customer service) appear to manage prices well.

The Danish example springs from a particular history of DH development, with particular ownership and existing asset models. There is complete transparency on prices charged, so price setting can be

interrogated. But there is currently no consistent way of comparing DH companies' prices across different networks (see the commentary on 'benchmarking' below for further discussion of this point).

Poland and Hungary have adopted a similar approach to regulating prices, where it is the cost profile of DH companies that is regulated, (excepting the no-profit requirement that exists in Denmark). DH operators must have their tariffs approved by the regulator based upon a calculation of 'justifiable' costs. In Hungary, profits are capped at 4.5% and customer prices set accordingly.

Price deregulation

In two of our case studies, Sweden and Germany, regulation has been removed or scaled back as part of wider liberalisation of energy markets. In Sweden, prior to deregulation in 1996, all DH networks were municipally-owned and regulated on a non-profit basis (as is currently the case in Denmark). The drive for deregulation was prompted by concerns that price regulation was driving prices up to the cap and disincentivising efficiency.

Deregulation seemed to lead to price rises in Sweden (and Germany), and to some consolidation of the sector, with smaller networks being bought up by larger companies. We found no evidence that these larger companies are charging lower prices than smaller DH operators a point also picked up in the UK Competition and Markets Authority's 2018 report.[iv]

The decision not to regulate in Germany was driven partly by experiences of regulation within other energy markets, but also by a sense that other means could achieve the same outcomes – especially regular retendering of networks.[v] Our interview evidence suggests that in practice, retendering may not happen as often or as transparently as intended by national policy.

Other means are also being employed to protect customers from excessive pricing. In Germany, for example, reviews have been used to assess the extent to which consumer prices might be excessive, both across the industry and in specific cases. Municipally-owned and private companies have both been the subject of investigations by the German Competition Authority and have been required to compensate customers for excessive pricing. In Sweden, a new system of negotiated price-setting (see below) introduced in 2015 seems to have been successful.

Lessons – Regulation of Prices:

- A lack of flexibility in price-setting can act as a disincentive for developers. It may also result in customers failing to benefit from efficiencies, as DH providers are not incentivised to set prices below any cap or to seek to reduce costs. Additionally, lack of pricing flexibility may stymie innovative approaches to integration with other technologies and energy system actors. This in turn may have implications for the extent to which DH providers may be able to engage with and contribute to genuinely whole systems approaches.

- Full deregulation of prices, if accompanied by a weak or no regulatory regime, seems to result in, at best, patchy consumer outcomes - as is the case in Germany.

2. Transparency and consumer protection

We found transparency to be an important issue across the case studies we reviewed. Provision of clear and comparable information about pricing, in particular, is a feature (or at least an ambition) in all cases. In Denmark this appears not to have been completely successful to date, with the challenge exacerbated by the fact that there are companies and networks of such different scales and population densities. (Note however, that district heating in Denmark has high customer satisfaction and a very low level of customer complaints – see below).

Transparency seems to be particularly important as a means of providing consumer protection in the case of price deregulation. For example, Sweden found in 2015 that new industry standards on transparency had been effective in giving customers a better understanding of the make-up of their bill and helped them plan for future price changes, increasing the predictability of bills and customer confidence. The Swedish District Heating Act requires companies to publish annual reports so that prices can be compared. The 'Prisdialogen' voluntary scheme for price transparency, forward price-setting and mediation has been widely taken-up and was lauded as successful in evidence we gathered.

In Denmark, voluntary benchmarking has been introduced by the Danish Energy Regulatory Authority (DERA) to aid transparency. The benchmarking model sets out prices in a transparent way and allows direct comparison between DH companies. Benchmarking also been welcomed by the DH industry in the Netherlands and has obvious value for consumers.

In Germany, price setting and price changes must be reported online in an accessible manner. However, there appear to be different views on how useful these are. Our review suggests that the lack of a responsible authority to oversee transparency mechanisms has reduced the effectiveness of reporting in driving price protection.

Our stakeholder interviews suggest that broader consumer protection is widely regarded as a success of DH regulation in Hungary, which has a focus on quality of supply and customer service.

The Scottish and UK fuel poverty context seems to be unique in the case studies we reviewed, and fuel poor or vulnerable consumers were not a specific focus of regulation in any of our cases. Where there is a price cap, further protections for vulnerable consumers may not be deemed necessary (for example in the Netherlands) or might be believed to be the responsibility of the social welfare system (as is reportedly the case in Denmark and the Netherlands). There are examples of more direct support for DH customers, although again this has been provided by the state. For example, in the first few years of the transition to a privatised, liberalised market, Poland provided some financial support to households to help them meet the new, higher costs of district heating.

Lessons – Transparency and Consumer Protection:

- Transparency of consumer prices is a key complement to price regulation, and if well designed and monitored, can substitute for price protection in countries where the DH market is unregulated. Careful design and monitoring of transparency reporting is required for it to work effectively and deliver maximum benefits for consumers.

- Voluntary industry standards or codes of practice can be useful in promoting good customer service and transparency on pricing. The Swedish voluntary scheme is a good example.

3. Complaints

All the case studies we considered had some process for handling customer complaints, but these varied greatly. There is often a national body charged with handling complaints, such as the Competition Authority in Sweden or the DH regulator itself in Norway and Hungary. There are often supplementary mediation mechanisms. In the Swedish example, this is the DH Board, which mediates between customers, DH companies and heat suppliers. The level of complaints in Denmark appears to be very low with reportedly strong consumer protection mechanisms in place. Hungary seems to have effective complaints procedures in place.

We found a mixed picture in Germany. It seems that complaints are made to utilities but there is no systematic collection of complaints data. Complaints can be referred to the German Consumer Protection Agency, but it has no authority over companies and ultimately the only redress is through the courts if complaints cannot be resolved. As noted above, the German Competition Authority has

had to intervene previously, but according to the evidence from our case study, this has had little effect.

Consistent with our findings above in relation to protections for vulnerable consumers, we did not find evidence of any complaints processes and bodies with a specific vulnerability focus.

Lessons - Complaints:

- A mechanism for mediating and resolving complaints is an important component of DH regulation and needs to be seen to be effective and have the trust of consumers and industry.

4. Technical standards

We found evidence that Hungary's technical standards are viewed positively across the sector. The standards focus on quality of customer service and the timeframes for resolving issues. Customers receive direct compensation from the licensee in cases where timescales are not met. There are also standards regarding the continuity of supply, and suppliers are financially penalised for not meeting the minimum standards.

In Germany, technical standards have been developed by the German DH Board. These include customer installations, metering and billing, operational safety and security. Although these are non-binding, they are reported to be widely-adopted. Norway also does not have technical standards set out in its regulation, but the regulator's principles-based licensing approach appears to ensure a high level of technical standards is met in practice.

Danish regulation sets standards for choices of fuel and heat generation technology, but this (and other aspects of Danish regulation) are a subject of debate, with an expectation that these restrictions will be phased out. Poland has a range of relatively stringent technical standards in place. Stakeholders have suggested that the incorporation of such specific technical standards within licensing has increased prices in Poland.

Lessons - Technical Standards:

- Technical standards may be incorporated into regulation or sit separately under a non-binding code. A voluntary industry code can work well if taken up very widely. Standards need to incorporate enough flexibility to allow innovation and should be subject to review.

5. Licensing, zoning, consents and concessions

Our review identified a range of means of licensing (or permitting) DH operations, as well as of granting rights through concessions. Licensing, zoning, consents and concessions are closely related instruments and have a similar purpose, namely to provide certainty to DH companies and consumers that rights to develop and operate are well founded and that regulated standards are being met.

In the Netherlands, DH operators are required to obtain a licence from the regulator over a threshold of 10,000 Gigajoules of supply to ten or more customers. The licence applies to the DH company and not to individual network schemes, thus one licence may cover multiple schemes. In Hungary, separate licences are required for heat generation and heat supply. In Norway, licences are granted based upon a rigorous socio-economic-environmental assessment that demonstrates that DH is the most viable option. The Danish system has a similar requirement to demonstrate viability, with a standardised assessment conducted of all proposed schemes, and a focus on financial viability. Danish municipalities are also required to plan and zone for district heating.

In Poland, DH operators are given ten-year concessions. The German concessions model is more akin to franchising, with regular retendering of network operation. However, our stakeholder interviews suggested the retendering process is not universally applied.

In Norway, municipalities have responsibility for granting concessions, which provide DH companies with certainty about the zone in which they can operate without direct competition from another DH operator. Many municipalities own or part-own operations within their concession areas. Zoning through concessions can work alongside mandatory connection (see the next theme) to reinforce DH companies' confidence about access to future heat demand.

As every planning and regulatory system is different, we did not come across zoning and consents policies that are directly comparable to the sorts of policies that could be introduced under the Scottish planning system. However, our case study evidence would suggest that a system of identifying DH zones and providing consents would be broadly in line with concessions practice elsewhere.

Lessons - Licencing, zoning, consents and concessions:

- Appropriate licencing, zoning and concessions can support multiple objectives – improving market certainty, 'levelling the playing field' and working with other measures (such as incentives or mandatory connection) to help provide confidence in future heat demand. Flexibility to permit innovation in business models and financing (and potentially ownership models) through licensing and concessions is helpful for stimulating the market.

6. Ensuring Heat demand

Mandatory connection – where the local authority requires new buildings or housing developments to connect to an existing network – ensures maximum use of existing assets and acts as an incentive to invest, effectively providing a guaranteed increase in future demand. This is the practice in Norway. Mandatory connection in Norway is managed by local authorities through the planning system. If network operators are unable to enter into voluntary agreements with buildings owners (or developers), they can seek a mandatory connection order from the municipality.

Mandatory connection works in tandem with regulation, which then protects those customers who are obliged to connect. There is some concern that mandatory connection can distort the housing and house-building markets[vi] but this issue did not arise in our review.

In Poland the obligation to connect operates in the other direction and DH companies are required to connect new customers, and bear the cost, provided certain conditions are met regarding heat demand, technical compatibility and heat source.

Mandatory connection is not required in Sweden. Instead quality of service and wider considerations (such as environmental impacts) seem to be sufficient to drive consumer demand for connections. The Danish approach is slightly different. There, customers may not disconnect from the network without continuing to pay the fixed subscription fee. The aim is to minimise disconnection and to ensure disconnecting customers pay off the equivalent of their share of network costs.

We found some evidence of issues with heat demand reducing as new-builds become increasingly efficient (for example in Poland). This seems to be more evident in countries with older DH systems, which suggests that the problem may not be the increased efficiency of buildings, but rather that the networks were not designed to supply heat to low-demand buildings.

Lessons – Ensuring Heat Demand:

- Mandatory connections (and penalties for disconnection) can play a role in attracting investment, as well as mitigating the demand risk within network development. This in turn reduces investment risk, as demonstrated in the Norwegian case.

7. Open Networks: Third Party Access and Surplus Heat

Third party access (TPA) – regulated for in Hungary, Sweden, Poland and Norway, and common in Denmark where network operators may buy from a range of heat suppliers – can increase competition and therefore reduce consumer prices. However, even where TPA is possible, it appears not to occur often. In Hungary, TPA is run through a tendering process, but is rare in practice. This suggests that the external conditions need to be right to make TPA work.

However, we found arguments against TPA amongst some stakeholders in Sweden, the Netherlands and Norway. These arguments were founded on concerns that opening up the network to new generators increases investment uncertainty for network companies. In the case of Sweden, a 2008 Government review originally concluded that the potential for efficiently functioning competition in the DH market was limited. Subsequent opening up of the market to TPA (2014) requires DH operators to consider TPA to their network, but if they can demonstrate that TPA would damage the business, they can refuse access. The same conditions effectively apply in Norway. In Norway, the DH industry is resistant to TPA as a mechanism to allow heat generators to supply heat directly to end-users.

The issue of third party access also links to the extent to which network companies operate as vertically integrated businesses, with third party access diluting their ability to do so and requiring a different business model. (See below, under 'Securing Investment' for further discussion of vertical integration). TPA may be easier to introduce in countries with older networks – Hungary, Poland and Denmark – where the capital costs of the network infrastructure have already been repaid or were borne by the state.

We found a variety of approaches to stimulating use of surplus heat in DH networks. In Sweden, there is no direct incentive or obligation on networks or industrial plants, but surplus industrial heat is widely used in DH and the revenues from sale of this heat have been a sufficient driver for industry to engage. In Denmark, the use of surplus heat is factored into the financial assessment of the scheme at the approval stage, and thus surplus heat is used where there is a business case. Although Hungary regulates the DH industry's profits, surplus heat suppliers are exempt from the not-for-profit requirement and therefore are incentivised to sell to DH networks. In Germany and Norway, surplus industrial heat plays a very minor role in heat supply to DH networks. The reasons for this are various, but the lack of a strong policy driver (whether incentive or mandated requirement) and the fact that other heat supplies are incentivised (for example heat from waste incineration in Norway) seem key.

Lessons – Open Networks:

- In the case of both third party access and the use of surplus heat, it seems that policy drivers are needed in order for these to be established at scale. Given the effective monopoly status of DH systems and the extent of vertical integration in the industry, any policy ambition to 'open up' DH networks requires thorough analysis of the potential effects this might have and the mechanisms by which this could be achieved, as well as careful design of the incentives/requirements to promote it. Currently this is less relevant to the Scottish context, as TPA and the use of surplus heat are more suited to larger scale DH systems.

8. Links to Planning and Wider Policy

We found several examples in our case studies of strong linkages between DH regulation and wider energy and planning policies, which we set out below.

Planning

Our case studies demonstrate clearly that DH outcomes are most successful where planning and regulation work in tandem. This relates for example to mandatory connection, which is dealt with in Norway through planning powers at municipal level, and to zoning, which has been a long-standing feature of the Danish DH market.

Scotland's planning system currently supports development of DH though Scottish Planning Policy, under which new Local Development Plans will identify where heat networks, heat storage and energy centres exist, or would be appropriate, and will include policies to support their implementation.

National and local policy

Clarity in the relationships between DH regulation, national policy and local policy was important across the cases. Policy disconnect was evident in Hungary in the 2000s, when DH prices were regulated by the national Hungarian Energy Office where the network was supplied by combined heat and power, but by municipal authorities where there was no co-generation of electricity.

In Denmark, Poland, Hungary, Germany and Norway, municipalities have powers that range across planning policy and implementation of regulation. For example, municipalities have power over preparing heat plans and approving projects in Denmark, granting concessions in the Norwegian case, and tendering for network operation in Germany.

Wider policy

Wider, national policies on energy market regulation and decarbonisation have had a significant impact on the development of district heating in most of our case studies. In Germany and Hungary, subsidies for DH are delivered through surcharges on electricity bills. In Hungary, customers also pay only 5% VAT on their DH bills (significantly lower than the standard VAT rate). In Germany, DH is also incentivised through policy requirements to increase energy efficiency, combined heat and power and renewables in buildings. In Denmark, where combined heat and power has been a significant part of the DH market, falling electricity prices, driven by policies to decarbonise electricity, have in fact reduced the revenues available to DH operators from selling their co-generated electricity.

Government-funded loans are available in Denmark and Germany providing low interest rates to DH developers. In Norway, the Government provides financial support for renewable heat with district heating – something that is credited with supporting the rapid expansion of the DH sector since the early 2000s. As a counter example, policies which are explicitly intended to stimulate DH investment have had limited success in the Hungary case, including tax incentives and subsidies for combined heat and power plant.

Decarbonisation policies have had a significant impact on DH markets across our cases, in particular in terms of the make-up of heat generation sources (for example: increasingly the case in Poland, as well as on a more established basis in Norway, Denmark and Sweden). In principle, wider decarbonisation policies may encourage DH that is in fact more expensive for consumers than a higher carbon, individual boiler alternative. Incentives and subsidies in other policy areas (e.g. electricity, waste or energy efficiency) may help address this risk and also support the expansion of DH (as is the case in Sweden, Norway and Denmark, for example). Arguably, the extent and level of the carbon tax in Denmark and Sweden has also had a significant effect in stimulating district heating.

Overall, our findings suggest that regulation, planning and wider policy need to work together.

Lessons – Links to Planning and Wider Policy:

- Clarity on the overall purpose of regulation helps enable a coherent and coordinated policy approach across regulation, planning and wider policy. The regulations we reviewed are focused mainly on consumer price protection. Interactions – including tensions – with wider policies and planning should be properly understood and taken into account.

- A clear division of responsibility and competence between the national body (government and/or regulator) and local authorities is important. This is in relation to planning policy as well as their respective roles in implementing regulation, and in supporting financing, information sharing and decarbonisation.

- The interactions between regulation and wider policy support for DH require careful consideration and design. Wider incentives and subsidies for DH need to work with the grain of the regulatory regime (and vice versa).

9. Securing Investment

We found reflections in our case studies of a wider debate about how the requirement for upfront investment in networks can be delivered alongside fair consumer pricing. The Netherlands example demonstrates the challenge of balancing DH companies' interests in securing sufficient return on investment and consumer groups' interests in preventing consumer detriment.

Vertical integration – where heat generation, network operation and retailing are 'bundled' together in one company – is one means for companies to increase investment certainty. In Sweden, a review of vertical integration determined that unbundling would not work in the context of district heating, given the nature of the market. 'Unbundling' of heat generation, network operation and retailing (billing and customer service) seems to be rare in the case studies we reviewed. From a consumer perspective, it may be that any efficiency gains from unbundling would be outweighed by the increased costs associated with the greater investment uncertainty for companies.

This issue links to the first theme considered above – price regulation. There are challenges of how to regulate prices across the market where there are two different sorts of networks to be priced, some where capital costs need to be recovered (i.e. where new networks are being built, or investment in existing networks is required) and some where those costs have already been recovered. This was a challenge in the Netherlands for example, which partly explains the length of time it took to pass the Heat Act and the extent of debate between the regulator and industry on how fair returns can be determined.

Lessons - Securing Investment:

- The design of regulation should involve due consideration of the extent to which vertical integration of DH companies is desirable (or not) and feasible (or not), given the state of the existing DH sector and the incumbent heat regime with which it is competing. In Scotland's case, this is the gas network and supply market, with some electric heating and small amounts of biomass and oil-fired heating.

- Mandatory connection (covered in more detail above), zoning/concessions and provision of support through other policy mechanisms offer routes to supporting the business case for investment. Investment uncertainty can also be reduced by providing regulatory stability and 'line of sight' (see next theme), and by creating strong linkages between national policy, local policy and planning.

10. Regulatory Change

In all of our case studies there have been revisions to regulation, often to address particular issues following a review or inquiry, but sometimes as a result of wider energy policy reform. There is also ongoing discussion of further changes to regulation in all of the countries we reviewed. Cycles of revisions to regulation can have both positive and negative impacts, from the perspective of both the DH industry and consumers.

In the Netherlands case, price regulation was introduced where none had previously existed, but the regulation was designed based on the voluntary standard that was already being applied by industry. Thus, industry had some role in designing the regulation. Industry stakeholders in the Netherlands appear also to be engaged in dialogue with policy makers and the regulator on a series of planned changes to DH regulation, which they seem broadly to welcome.

In the Hungary case, there has been a large amount of regulatory change since 2005, and evidence would suggest that that the uncertainty this caused has had a negative effect on the DH market (although wider economic factors have perhaps had greater influence).

Arguments are made in some of the case study countries that DH companies find regulatory compliance burdensome and costly. For example, in Poland some industry stakeholders allege that compliance is pushing up their costs and therefore consumer prices, and that it acts as a brake on companies innovating and investing in the network. And in Denmark, some DH operators suggest they would like to be able to introduce more flexible pricing but are prevented by the rigid way that prices are regulated.

Arguments for reform of regulation thus come as often from industry as from consumers and their representatives, and the regulator.

Lessons – Regulatory Change:

- Long-term commitment and planning are fundamental, providing a ‘line of sight’ for developers and DH companies on the evolving regulatory context. Frequent regulatory change (such as we recorded in Hungary in the 2000s) can damage investment confidence. Key components of a long-term commitment are: transparent forward planning on the part of the regulator/government; thorough analysis of the likely market effects of different proposed regulatory measures; and, wide stakeholder engagement. The Netherlands case appears to be a relatively successful example of this approach, albeit the Dutch Heat Act took almost a decade to pass.

- Alongside long-term planning, regular opportunities to review the effectiveness of regulation and to introduce change are also important. This sort of structured flexibility helps maintain the regulatory regime as fit-for-purpose in a changing wider energy system and supports innovation (such as time of use tariffs).

- An option which has shown to be effective in some cases is where broad principles determine the regulation, rather than stringent specifications. This includes the technical details of how the market functions and how individual developments and providers operate to be determined. In practice, principle-based regulation may still need to be dynamic to account for unintended consequences and new consumer and/or industry expectations.

4 Conclusions

Applicability of lessons to Scotland

The review aimed to capture the relevant features of all regulatory models, as they relate to the Scottish context. A common thread throughout this research was the country-specificity of regulation, policy and decision-making. One stakeholder remarked that "*Danish district heating regulation works really well. In Denmark*"[vii] to emphasise this point. Regulatory decisions may also be the best option at a point in time but will warrant review and in some cases reform.

Features of effective regulation

Key elements to effective regulation were identified both from the literature review and from stakeholder experience. The absence of these was also linked with poor regulatory performance. The list below outlines the common components for effective regulation of district heating, based on the systems examined in this research. Although implemented differently in each regulatory system, these points repeatedly emerged as significant themes.

- Long term planning and commitment to DH development
- Tools which stimulate market development and investment in the sector
- Co-ordination of national and municipal governments, and scope for industry interests to have a say in certain regulatory issues
- Flexibility to allow for innovation, and account for market changes

As is clear from the case studies reviewed, regulation is a complex process. Aspects of regulation often require review and adaptations. However, this research highlights how these four principles have been in European regulation to date.

Limitations of the research

Some topics covered within the research drew opposing views from stakeholders (e.g. customer satisfaction in Germany). Different perspectives are to be expected, particularly where different market actors are concerned. However, some of the views expressed may not be fully reflective of the wider population.

In addition, the scope of this project also included a rapid literature review and a limited number of stakeholder interviews. Every effort has been made to triangulate sources and provide a balanced assessment of each country, though the Research Team acknowledge that all views and points of note may not have been captured.

Zoning is one aspect which this research was unable to fully assess. This is largely due to the nature of the regulatory regimes assessed, where municipality boundaries acted as zones. This approach seems to be ineffective in a lot of circumstances as rigid zonal boundaries can prevent strategic supply to match an area's demand. Customers can also be negatively affected by this, for example where mandatory connections can prevent individuals from accessing optimal supply options.

5 Country Case Studies

Norway

Norway	
Type of Price Regulation	District heating must be no more expensive than alternative sources of heat
Regulatory Body	Norwegian Water Resources and Energy Directorate (NVE)
Legal Obligations (e.g. zones, connections)	Licences within concession zones, mandatory connection, operator obligation to expand network
Ownership Structure	Mostly privately owned, municipalities own/partly own some schemes
Length of network	1,894 km
Number of DH schemes	110 approx.

1. Context: District Heating in Norway

Norway is the world's fastest growing district heating market and approximately 11% of heat demand is supplied by district heating, with electricity accounting for approximately 85% of the remainder[viii].

Energy sources used in DH production include surplus heat from waste incineration (51%), wood product and biofuel (28%), with the remainder from electric boilers (13%), fossil fuels (5%), waste heat (2%) and CHP. Heat loss from networks of 15% was recorded for 2017[ix]. The service sector accounts for over 80% of heat demand.

2. Design Stage - Inputs

Drivers for regulation

Between 1950 and 1980 a massive development of hydropower took place, laying the groundwork for an electricity-based heating sector. DH was effectively non-existent before the 1980s[x]. Prior to the 1970s oil crisis, oil-fired heating was also prevalent, particularly in municipally owned buildings[xi]. However, two key drivers – renewable energy and energy efficiency – led to a new national vision on district energy. Some of the changes that have been introduced to regulation are mentioned below but largely it has remained unchanged since inception[xii].

Wider drivers for regulating the DH market came from two other policy areas: the requirement to use heat from waste incineration efficiently, and the concern amongst electricity network operators of the potential costs of upgrading the grid to take increased volumes of electric heating.

3. Design Stage - Process

Regulatory Structure

Two complementary acts serve to regulate DH. The Energy Act regulates through licencing and pricing to protect consumer rights. The Planning and Building Act introduced an obligation to connect to the DH system in 1986. It is assumed that the developer tries to enter into voluntary agreements with all affected landowners. If a

voluntary agreement is not reached, the heat developer may seek a compulsory connection order from the municipality.[xiii] The operator is not obliged to supply all individual buildings within the license area, even those who have a connection obligation.

The Norwegian Water Resources and Energy Directorate (NVE) is a government agency under the Ministry of Petroleum and Energy.[xiv] It is responsible for regulating electricity and DH markets and grants licenses for transmission and production of renewable energy.

NVE also monitor district heating and licensee practice. The monitoring is funded by a levy on district heating companies, who pay an annual inspection fee that is set as a fixed amount plus a variable amount calculated based on the plant's heat capacity.

While there is strong national legislation for DH, municipalities have a number of responsibilities and their role has increased over time. Municipalities set and maintain concession zones, which are required for all DH plants with a total heat capacity exceeding 10MW. A concession allows the municipality to make connection to the DH network (DHN) mandatory for new buildings with the zone. Many municipalities also own or part-own the network within their concession area so there is a shared motivation for financial prosperity with other actors in the market. Concerns have been raised through previous research[xv] that this level of municipal interest has led to biasing of the licensing regime, though this issue did not arise over the course of this research. NVE guidance states that all licence application documents should be made publicly available, presumably to combat this perceived bias.[xvi]

Market forces

Energy prices from different producers are set on the competitive market. However, prices for buildings with mandatory connections are regulated in line with the Energy Act. For these consumers, the price of heat from a DH system cannot exceed the price of electric heating within the relevant supply area. [xvii]

For customers without mandatory connections, prices are not regulated as customers are free to choose their heating source. In this way the DHN is competing with other available types of heating such as electricity or heat pumps. Therefore, in practice, many DH suppliers' prices will follow the market price of electricity.[xviii]

4. Implementation Stage - Outputs

Licensing

NVE issues licences 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.[xix]

An installation above 10 MW per fuel source requires a licence. The licence holder must meet consumer protection conditions and is granted sole access to the specified area . [xx] Despite having sole access, the licenced DH operator is obliged to negotiate with any third parties requesting access to the network to produce or supply heat.[xxi] The municipalities may, when a licence is issued, adopt compulsory connection to the district heating system for new and renovated buildings. If the owner and operator of a scheme are different, the operator holds the licence and the owner must agree that the operator has control of the operation. The licence holder is responsible for running, building and owning the district heat network (DHN), so must adhere to all relevant legislation which is relevant to the DHN, including that linked to air pollution, cultural heritage and environmental protection.

Three principles drive the licensing:

- Quality of supply (Along with security of supply, operators must meet minimum standards of consumer service and protection)
- Price of supply (Less than electric heating)

- Quality of heat (Heat supply must meet conditions relating to carbon intensity)

Licences apply primarily to the location of a DHN, its boundaries and source(s) of heat and do not include specific details about technical specifications. However, the three guiding principles above ensure that these more granular aspects 'look after themselves'. As operators need to meet these overarching criteria and have a shared interest in the commercial success of schemes, enforcement and fines (within the competence of NVE) are neither a priority nor generally necessary. Similarly, the process places the onus on the licensee to demonstrate how their network will meet the criteria required, as NVE do not have a high level or resource to 'hand-hold' through the application process.

Mandatory Connections

One of the key aspects of the Norwegian model, and one which affects so many aspects of the market, is the mandatory connection (covered within the Planning Act). It is understandably also one of the more contentious aspects being introduced explicitly to make DH the most attractive means of heating, though initially it was linked with concession areas. This meant that consumers living in isolated areas were being obligated to connect, even though pipes did not and would not reach them. This has been addressed with new schemes by NVE, through enforcing dialogue between the community, DH operators and owners of buildings as well as narrowing the geographical perimeters of schemes.

Mandatory connections are managed by municipalities. The municipality can grant partial or full exemptions from the obligation to connect, where alternative solutions are demonstrated to be environmentally favourable.

The initial regulation appears to have been quite rigid in design and did not accommodate the heterogeneity of networks and communities across Norway. For example, concession areas and compulsory connections had initially been linked. This meant that local conditions such as demand were often overlooked.

Since 2010, concession areas and mandatory connections have begun to be decoupled, something which the industry body for Norwegian District Heat has welcomed.

While licensing is only compulsory for large networks, approximately half of licences are held for <10 MW. This is so that the licensees can benefit from mandatory connections, despite the additional wider regulatory requirements which they must meet.

The costs to ensure readiness for connection are covered by building owners, whether they wish (or are able) to avail of the district heat or not. However, after this, DH is generally the most financially viable option for them.[xxii] The perception that the process is complex and involves unnecessary bureaucracy seems to be one of the main issues for the Government who are considering deregulation and for the licensing system to be removed.[xxiii] As yet, no consensus appears to have been reached as to what should replace the current licensing approach. The industry representative body, Norsk Fjernvarme advocate that licensing should remain, so long as concession areas are properly planned.

One interviewee described an obligation on the operator to expand the network within the concessionary area. This is reported to have interacted with the mandatory connection to increase confidence of operators to invest in extensions as demand was assured.[xxiv] It appears this obligation only exists in some cases and concessionary areas, such as the development of a scheme in Drammen.

Role of recovered heat

This is not an area that has been prioritised nor gathered traction in Norway, though is increasing annually. The high temperatures within DH networks in Norway means that much of the excess heat from industrial plants and manufacturers is of insufficient temperatures to be of value. In addition, the continued role that waste combustion plays within district heating appears to be another factor that has hampered the development of recovering excess industrial heat. Landfill is forbidden by law, so waste which cannot be recycled is incinerated. DH regulation has been driven by the fact that energy from waste (EFW) plants are mandated through waste policy. Norwegian waste regulations state that all thermal energy generated by waste combustion process must

be utilised as far as practicable.[xxv] The national environment agency recommends that at least 50% of thermal energy from incinerators is repurposed through district heat networks, although the exact obligations on incinerators vary by region, as it is the regional authorities who specify the exact amount of heat.[xxvi]

Currently there is pressure on the Government to introduce similar regulations for other industries, particularly data centres. Data centres benefit from lower electricity tariffs. Norsk Fjernvarme have proposed that as a condition of cheap electricity tariffs, they should be required to make use of their excess heat. While NVE have published guidance documents relating to data centres, this is another element which seems to be acknowledged as sub-optimal by many stakeholders, though no change has been made.

Concessions or incentives are not available for industries with available excess heat to supply it. While they must pay a fee to sell to the network, there is little financial benefit or otherwise for suppliers of excess industrial heat.[xxvii] Rather, should the DH operator determine the value of excess heat in a particular area, they will acquire it through voluntary or mandatory connection as required. In other words, where it is financially viable for the operator, excess heat may be used. However, at present there is little political or industry will to develop this. There are ongoing discussions about developing this through a) making this process attractive and feasible for suppliers of excess heat and/or b) for a compulsory obligation for DH companies to acquire excess heat.

5. Implementation Stage - Intermediate Outcomes

Sector growth

In addition to price regulation, a number of national policies have supported the rapid growth and dominance of DH. A state-owned company, ENOVA provides support and funding options for large scale low carbon infrastructure including DH. For example, there is a support scheme for renewable heat production for district energy companies and for small-scale renewable heat production, which offers up to 30 per cent support per project (on average 15–20 per cent). This funding has been linked with the rapid expansion of the sector since the early 2000s.

Customer perceptions

DH networks in some concession areas have been operational for decades and so DH is just assumed as 'the norm', though this can vary from area to area.

While consumer protection responsibilities, (including the right to appeal prices and service delivery terms)[xxviii] are an aspect of licensing, this does not appear to be an area of great focus in Norway. In Nordic countries, inequality is not as pertinent an issue as in other parts of Europe. In addition, as some schemes target larger buildings rather than a high concentration of domestic connections, end-users are not necessarily domestic consumers.

Annual customer complaints are low[xxix] which is indicative of satisfaction with prices and service delivery in general. Only consumers of a licenced scheme can raise complaints through NVE. Although customers who have voluntarily connected to district heating schemes cannot raise complaints, in practice they are not generally at a disadvantage. This is due to similar standards of service and heat delivery.[xxx]

Pricing

DH prices are regulated on the basis of the alternative cost of heating, which is generally electricity. Heat price includes the connection price, fixed early price and price for the heat consumed. DH prices are therefore capped by the consumer electricity price, including taxes.

Rather than a fixed tariff, heat-use is metered and the half-hourly tariffs correlate directly to wholesale electricity prices. On average, industry customers pay significantly lower prices than households and services.[xxxi] Energy

in Norway is cheap by European standards, though attempts to reinforce the grid due to increased demand for Electric Vehicles (EVs) could lead to increased costs, relative to DH in the coming years.

The market price for heat is set lower than the electricity price, but is not lower than the price of using a heat pump. However, consumers tend to choose to connect to a DHN in order to avoid the capital expenditure and risks associated with owning a heat pump.

Metering is not currently practiced in Norway which can disadvantage consumers who receive a lower quality of heat than others in their building or network. However, the case for, and options to introduce metering are currently being explored.

Another change in the way electricity tariffs are structured is likely to impact on the market. Domestic users will now pay for a set capacity of electricity rather than actual usage (this structure is already in place for commercial consumers).[xxxii] Users will pay a premium if they exceed their pre-arranged capacity and provides an incentive for users to store electricity. This is to try and balance the grid, especially as demand is rising with the large number of EVs. This will impact upon DH – not only the pricing, but in that DH offers opportunities to reduce grid demand. The main reason for the change in electricity price structure is to create an understanding among the public of what drives electricity prices.

6. Strategic Outcome Stage - Regulatory Quality and Outputs

Efficiency of network

Given the aforementioned principles which guide the regulation, and the multiple actors who benefit from the network being profitable, capital tends to be spent on increasing efficiencies and making other improvements to the infrastructure. However, it was the view of one stakeholder that this alone is insufficient: *"The regulation can lead to DH companies sitting back and just do what the regulation says. There is no innovation".*[xxxiii]

Alignment with government strategy and policy

District heating represents around 3 percent of energy supplied for heating in Norway[xxxiv]. Ambitions as part of a plan set in 2010 are to increase this to 16% by 2020 are likely to fall short, in part due to the historical dependence on heat from waste. The first individual plants in all the Nordic countries were established to make use of municipal waste.[xxxv]

One of the barriers to the further expansion of the DH network in Norway, is the dependence on heat produced from waste combustion (60% of DH supply). This is a well-developed and regulated area which obviously serves the dual purpose of waste deposition and heat generation, though investments have ceased for new incineration plants.[xxxvi] In addition, the potential for expansion of DH is limited, as it is not feasible to extend networks to the large number of remote properties across Norway. Similarly, the cost of expanding DH networks is high due to difficult geological conditions. Comparisons can be drawn here with Scotland, which may face similar barriers in terms of geology and the presence of remote, rural properties.

However, it was highlighted in the interviews that the electricity industry have concerns about the costs of upgrading electricity networks to deliver more electrical heat. As such, they favour DH as an alternative heat source, which could influence development in the coming years and present useful learnings for other country's decarbonisation ambitions.[xxxvii]

The regulatory requirement for new houses not to be built with electric heating has recently been removed. This means new homes are being constructed which cannot connect to DH networks, even in areas which have been designated as compulsory connection zones by municipalities. Such unforeseen impacts highlight the need for long-term planning, particularly where regulation is de-centralised.

The Netherlands

Netherlands	
Type of Price Regulation	Price Cap (comprising a fixed element and a consumption-based element)
Regulatory Body	The Netherlands Authority for Consumers and Markets (ACM)
Legal Obligations (zones, connections)	Licences for suppliers, municipalities required to consider DH for new development areas
Ownership Structure	Mostly private developers/operators, some municipality owned
Length of Network	4000km
Number of DH schemes	13 large-scale networks and 6,900 small-scale representing 5% of domestic heat

1. Context: District Heating in the Netherlands

The first Dutch district heating systems, producing both heat and power, were implemented in Utrecht (1923) and Rotterdam (1949). No new systems were constructed in the 1950s and 1960s, but there has been rapid growth of small-scale and industrial combined heat and power (CHP) since the late 1980s and a moderate uptake of associated district heating schemes. The total share of district heating is slowly increasing.

At present, DH represents a small proportion of the Netherlands' heat market, with only around 5% of dwellings connected to a heat network. There are 13 large-scale heat distribution networks and 6,900 small-scale networks (some of which are very small). Ownership is in the hands of energy supply companies (around 300 networks), small firms, associations of homeowners, housing associations and municipalities. In terms of heat generation, four companies dominate, two of which are relatively vertically integrated and also manage transmission and supply of heat.

2. Design Stage - Inputs

Drivers for regulation

According to the Netherlands Authority for Consumers and Markets (ACM) and the Dutch energy association, the chief motivation to regulate heat networks was consumer protection. This concern for consumer protection sat against a context of policy ambition to stimulate a heat market, in order to meet wider policy goals of becoming less reliant on natural gas, improving energy security and increasing energy efficiency. An additional, secondary driver was the EU-wide Energy Performance of Buildings Directive (2003). This motivated an approach to assessing overall energy performance (including the effectiveness of energy supply and usage as well as energy efficiency and demand reduction), in turn encouraging innovation, in particular in new, low-energy building projects[xxxviii].

Later drivers are the relatively strong, cross-sector consensus on the need to decarbonise heat and, in light of falling levels of natural gas extraction and depleting gas stocks, the Dutch Government's stated intention to avoid becoming dependent on imported gas[xxxix]. These have become increasingly salient in motivating reform of DH regulation and the overarching Heat Act (see below).

3. Design Stage - Process

Focus of regulation

Regulation to date has focused on one principal aim: consumer protection. The heat market is regulated under the 2014 Heat Act[xl] – the Warmtewet. (Note that the passing of the Heat Act predates the Dutch Government's 2015 Heat Vision, which sets a clear decarbonisation vision for heat). At the heart of the 2014 Heat Act is the principle that consumers on heat networks should pay no more than the alternative, which is assumed to be a domestic, natural gas condensing boiler.

The licencing regime provides for minimum standards of heat service that must be delivered to customers. It also requires that suppliers can be referred to a Disputes Committee for arbitration in the event of an unresolved disagreement between a supplier and customer.

As discussed in more detail below, the focus of regulation on consumer protection alone is weakening as objectives around heat decarbonisation are increasingly coming to the fore. Integrating decarbonisation objectives into existing consumer-focused heat regulation is not wholly straightforward.

Process for setting regulation

The development and passing of the Dutch Heat Act took almost a decade. The Heat Act drew on a long process of enagagement with the DH industry, in particular on pricing mechanisms. Although there was extensive debate in the Dutch Parliament, and concerns about windfall profits from some parliamentarians, the pricing approach that was ultimately taken in the regulation was based on the existing voluntary agreement established by the industry itself. Thus the price calculation methods adopted in the regulation were based upon the voluntary code already being applied by industry. Whilst the method of calculation was familiar, the actual price levels set after the adoption of the regulation reportedly had the effect of suppressing revenues for most companies.

4. Implementation Stage - Outputs

Licencing

Licences are issued by the ACM. A licence is required to legally supply heat above 10,000GigaJoules per customer to ten or more customers. When the Heat Act was first passed, the regulation applied to some very small heat networks (in particular, within-building systems run by housing associations) and so the threshold was adjusted to exempt schemes of this scale. Licence conditions set out a DH company's obligations regarding quality of service, disconnection and interruption of supply. Monitoring and enforcement of licence conditions is managed by the ACM. However, resources for enforcement are limited.

Supply Chain

The heat supply chain involves heat production, transport, distribution and end use by the consumer. In a heat distribution network, hot water or steam is produced at a heat source and transported in a network of insulated pipes to end-users. End-users can be non-residential buildings (i.e. school buildings, offices, stores, swimming pools), industrial firms, agriculture (i.e. mostly greenhouses) and dwellings.[xli]

In the past few years, several heat network suppliers have purchased combined heat and power production assets from large power utilities in an effort to enhance the economic efficiency and ensure the sustainability of the DH supply chain. This has resulted in a more integrated value chain for large-scale district heating systems, where the heat suppliers also own and operate the main heat production units.[xlii]

Role of excess heat

There is no direct incentivisation of use of excess heat through the Dutch regulation. One innovation in the market is the 'heat buffer' which stores heat from dwellings and non-residential buildings in Almere, Amsterdam, Diemen and Amstelveen, to improve the flexibility and cost effectiveness of heat supply. The heat buffer allows storage as heat when electricity demand is low and the release of heat when electricity demand is high. The buffer was commissioned in 2015.[xliii]

5. Implementation Stage - Intermediate outcomes

Sector growth

As noted above, the DH sector in the Netherlands is currently relatively small. However, the heat sector in the Netherlands is undergoing rapid change, driven by a strong political commitment to dramatically cut emissions from the Dutch building stock and to decarbonise heat, as set out in the joint Government-industry-civic society *Energy Agreement for Sustainable Growth* agreement in 2013 and subsequent Government Heat Vision, 2015.[xliv] Introducing its 2015 Heat Vision, the Dutch Government noted its ambition to reform legislation and regulation for heat supply to make the heat market function more like the electricity and gas markets.[xlv] Expert commentators, therefore, anticipate an increase in heat network development.

The regulatory regime for DH is the subject of ongoing revisions. A revised Heat Act will come into force in January 2019, with a further revision under negotiation and expected to apply from 2022.

The current price-cap system covers costs relating to connection, generation and supply. The calculation applies to the gigajoule price and the fixed fee or standing charge. With the new Act, the regulation will be expanded such that there is not only a cap on the total heat bill but also a price cap on individual components of consumer bills that have not been specifically capped to date; namely, the price per heat unit, and the connection and disconnection fee. These will be based on average costs across the sector. New provisions also include a more straightforward process for customer disconnection, and better tailored obligations on DH companies in relation to interruption of supply.

The current system of price cap regulation itself may change in the future, with active debate about possible alternatives including a system based on regulation of profits rather than a price cap. Options include cost-plus pricing (based on the justified costs of heat production, distribution, maintenance/upgrades, depreciation and return on capital) or marginal cost-pricing (based on cost of heat production and network operation only). Some in the industry feel that marginal cost-pricing would be a better solution that would be more reflective of the actual costs of supplying heat to different communities with different heat densities, in different locations.

The regulatory regime in the Netherlands appears to have had some success in stimulating the sector, but one industry interviewee felt there may have been constraints on growth as a result of limits to profitability, identifying uncertainty around cost projections as the key cause of this. With the revenues that DH companies can make effectively pegged to the gas price (see below), companies may have limited foresight around how they will recover their costs and what their revenues will be in future years.

Pricing

The No-More-Than-Alternative principle, derived from the 2014 Heat Act, underpins Dutch DH regulation. The principle is that DH consumers must not pay more than they would if they had gas heating – i.e. the price of gas-fuelled heating is the reference case. The currently most widely used heating technology in the Netherlands is a domestic gas-fired condensing boiler (GFCB). In 2006, more than 91% of the boilers in the Netherlands were of this type. The GFCB is therefore used as the reference heating technology for the Netherlands when comparing with other heating technologies[xlvi]

The ACM sets licence holders' tariffs each year based on the price of natural gas, using a price calculation process set out in the Heat Act and taking into account certain parameters determined by the Ministry of Economic Affairs.

The maximum price for the supply of heat consists of a fixed sum (281.78 EUR incl. VAT in 2015) and a variable part that depends on consumption: 22.64 EUR per gigajoule consumed (incl. VAT, 2015 figures; or 81 EUR/MWh incl. VAT).

The fact that DH prices track a gas reference price means that when the supply price of gas drops, the maximum price of heat also decreases. Clearly, this affects the returns that district heating providers are able to make.

6. Strategic Outcome Stage - Regulatory Quality and Outputs

Complaints by consumers

In such highly concentrated (local) supply markets, one of the key concerns of the end-user – on top of the supply security –is the pricing and fixed connection costs of the service.

A substantial part of the concerns relates to the fixed costs that are charged, which are considered not to be in line with the No-More-Than-Alternative principle. Consumer organisations consider the reference pricing method not to be sufficiently comprehensive. To them, it does not properly reflect real market conditions and there are concerns that regulation is currently failing to sufficiently protect consumers against monopoly pricing.

Consumers' complaints relate to excessive prices and being worse off than with gas fired boilers. There is a strain of public perception that the Heat Act is not effective in protecting consumers. Consumers also complain that they are not protected against sudden price increases (notably price increases up to the level of the price cap that occurred after the introduction of the Heat Act). Many consumer complaints concern price, in particular a lack of transparency and clarity on how exactly pricing is determined.[xlvii]

Demand risk

There is some concern amongst industry stakeholders that the regulatory price cap is squeezing out investment by increasing uncertainty and therefore investment risk. In terms of measures to reduce that risk, there is one key tool that supports more certainty around future heat demand: the ability of municipalities effectively to require new housing developments to use district heating by not seeking an extension of the gas network. This municipality-driven mechanism has provided DH operators with an effective obligation on new houses to connect, with costs borne by the developer. In July 2018, this 'no gas network extension' principle was applied across the country through national policy (i.e. it will now be consistently applied by all municipalities).

Alignment with government strategy and policy

The main heat sources are CHP plants (coal, gas power plant), biomass-to-energy plants (a co-firing unit or a dedicated biomass unit, or biogas CHP plant) and waste incinerators. In most cases, a certain share of natural gas is also used to produce heat.

Data from 2013 suggest that the share of renewable sources used for DH is 14%, with forecasts that by 2030 the share may rise to > 44% (including waste 30%, biomass/biogas 14%).[xlviii]

Sweden

Sweden	
Type of Price Regulation	Voluntary pricing scheme; price transparency
Regulatory Body	Deregulated (since 1996) with voluntary standards for pricing, complaints and the use of surplus heat Supervised by Energy Markets Inspectorate and Competition Authority
Legal Obligations (e.g. zones, connections)	None, other than submitting annual accounts
Ownership Structure	Initially owned by municipalities, ownership is now a mix of municipal limited companies, private companies, state-owned and publicly-owned.
Length of network	23,400 km
Number of DH schemes	500-600 systems operated by over 200 companies

1. Context: District Heating in Sweden

First introduced in 1848, all major cities and towns in Sweden now have district heating (DH) systems. Across the country DH supplies the majority of heating to both residential and service sectors, meeting about 60% of heating demand.

Development was initially intended to increase energy efficiency, improve air quality and latterly as a response to the 1970s oil crisis.

Following the oil crisis, Swedish energy policy focused on replacing oil, mainly with biomass. By 2015, 46% of DH was supplied by biomass, 24% from waste incineration and 7% from fossil fuels.[xlix] Other inputs include industrial excess heat (8%), ambient heat (6%), recovered gases (2%), peat (2%) and electricity (6%). The high share of biomass can be explained by the extensive forestry industry in Sweden which generates large volumes of wood waste, meaning there is little concern about fuel shortages affecting the functioning of DH systems.[l]

2. Design Stage- Inputs

Drivers for regulation

Until the 1960s Swedish electricity supply relied heavily on hydropower. Due to controversy surrounding the exploitation of rivers for hydropower, attention turned to nuclear power. Twelve nuclear reactors were built between 1974 – 1985 which reduced Sweden's oil dependency and increased its reliance on electricity. Following the 1970s oil crisis, both DH and electric heating were expanded in order to shift away from oil.

Initially the regulation of DH was based on public ownership and governed through the Local Authority Act (1991). The regulation was based on three principles: equal treatment, locality, and cost-based pricing. In 1996, the market was deregulated as part of the deregulation of electricity markets. Deregulation brought issues to the DH market, such as high prices and a lack of transparent pricing.

Light-touch voluntary regulation of pricing and complaints has since been introduced to address these issues.

All DH plants and distribution networks were owned and operated by Swedish municipalities[li] under a non-profit pricing principle,[lii] until deregulation. The deregulation was designed for the electricity market (in line with EU legislation), and the impacts on the DH market (which had no specific legislation in Sweden) were not thoroughly investigated.[liii] Seemingly, the Government did not fully recognise the importance and impact of the electric regulatory reform for the DH industry as it had never been considered as a market in its own right.[liv]

A government commission in 2008 implemented light-touch regulation under the District Heating Act, mainly focussed around consumer protection. Companies are required to submit annual reports so that prices can be compared. The Act rejected proposals for the unbundling of production, sales and transmission; Third Party Access (TPA); and price regulation.

3. Design Stage - Process

Focus of regulation

National government has never had a specific policy on DH, they provide an overarching policy agenda, such as moving away from fossil fuels. Such agendas are normally technology neutral and so will not promote DH over any other technologies providing similar outcomes (e.g. heat pumps).

Sweden has used a mix of policies to drive a transition to low carbon heating (including both DH and heat pumps):

- A high carbon tax, an energy tax on natural gas for heating, a tax on heating oil and an exemption for renewable electricity and heat production from CHP;
- Investment subsidy programmes for biomass CHP from 1991 to 2002 and tradable renewable energy certificates introduced in 2003.
- Bans on landfill of combustible/biodegradable waste in 2002 and 2005 which drove an increase in heat from waste incineration.
- Subsidies for households to switch from oil and direct electricity to alternative heating systems available from 2006 to 2010[lv]

The initiative for development of DH networks is at the local level, based on local supply, conditions, and markets. This is an effective arrangement, as it provides more flexibility than a central government policy.[lvi]

Regulatory Structure

Following deregulation, many municipalities sold their DH companies either to the private sector or municipality/ state-owned large energy companies.[lvii] Municipalities still play a key role in the development of DH, however, their responsibilities and powers regarding heat planning have decreased following energy market liberalisation, and heat planning has become less widely practiced.[lviii]

4. Implementation Stage - Outputs

The sector is continuously monitored by the Energy Market Inspectorate, which ensures that companies comply with the DH Act; and the Competition Authority which investigates suspected abuse of DH companies' monopoly positions. However, as DH operators tend to be municipal entities they are prevented from making excess profit, and this seems to be an effective protection against monopoly abuse. There are cases where the regulator needs to intervene.[lix]

The 2008 DH Act also saw the introduction of the DH Board, which mediates negotiations between DH companies and customers about prices and other conditions, and between surplus heat producers and DH companies. The Board is an independent organisational unit within the Energy Agency, and members are appointed by the Government. It creates incentives for the self-regulation of DH companies by increasing the public visibility of complaints, and pressuring companies to make price strategies transparent without the use of formal price regulation.[lx]

Role of excess heat

As there are no legal requirements for the use of surplus heat, all arrangements are voluntary. Industrial waste heat has been the key driver for building DH systems in some Swedish cities and towns. There are no incentives or subsidies for industrial plants to recover heat but the supplementary income from DH operators is enough to encourage the sale of excess heat. Heat demand drives regional industrial development and the sale of recovered heat is built into the business case for new industrial developments:

> *"When a new plant [which produces surplus heat] is built, the location will always factor in whether there is a DH network. The demand for heat is a key contributing factor in the location of industry."*[lxi]

However, another stakeholder added that although it is common for industrial plants or data centres to evaluate heat recovery, in many cases discussions around the sale of excess heat are in fact initiated by local DH companies.[lxii]

5. Implementation Stage - Intermediate Outcomes

Sector growth

There are no specific requirements, either for municipalities or operators to develop networks, however, they tend to work cooperatively:

> *"Generally, the municipalities, DH operators and plants with surplus heat have a common goal, so there is no need for mechanisms to align their work. For example, when the City of Malmö sold the DH network to E.ON, one part of that agreement was that the City agreed to help E.ON to continue to develop the DH network."*[lxiii]

Development and investment in DH networks are driven by the DH companies, not municipalities or central government. Currently, there is heavy investment from DH companies in the interconnection of existing DH networks between cities and towns. This allows systems to take large volumes of surplus heat, ensures security of supply and boosts system efficiency.

The investment is co-operative. For example, three DH companies collaborated to link the networks in Helsingborg, Lund and Landskrona creating a network with a total length of 90km. This innovation and collaboration between DH companies is seen as a positive outcome of the lack of regulation.[lxiv]

Stakeholder experiences

Sweden has several times investigated the possibility of legislating for third part access (TPA) (i.e. opening the grids for other heat producers to increase competition). The most recent investigation concluded that this would be possible (at high cost), however in practice, few steps have been taken since then towards a realisation of TPA.[lxv] Nevertheless, in 2014 a bill was passed that said access should be granted to new entrants under specific circumstances.

Under the 2014 TPA law, there is an obligation for DH companies to negotiate TPA to a network, if a producer wants to sell heat or use the network for distribution of heat. The obligation means that the DH company must attempt to reach an agreement but can refuse to give the access if it states reasons for the refusal, e.g. if it would harm business. The obligation only applies to those heat producers that are selling heat as a by-product, not purpose-built heat producers such as CHP.[lxvi]

This law was not foreseen as having much of an impact, as excess heat agreements were made anyway without this regulation, and because the entire risk is borne by the third party for the investment in additional networks.[lxvii]

For producers of surplus industrial heat, the TPA negotiation law does not create a risk in terms of supply competition, due to the contracts agreed with the DH operator. Generally, it works well.[lxviii]

Customer perceptions

Transparency is the key motive behind most of the light-touch regulation introduced since 1996, which includes contract conditions and information provision. The District Heating Board acts as a mediator in any disputes with DH companies. Mediation is voluntary as the District Heating Board cannot make any binding decision that the company, customer or producer must follow.

> *"Due to Swedish competition law requirements on equal-treatment, the board does not hold that much power. But it has improved the dialogue between DH companies and consumers. In this sense it is very successful, and this is reflected in customer satisfaction levels which have improved – especially in comparison to electricity network fees."*[lxix]

Historically, DH has had a good reputation in Sweden due to its lower environmental impacts. However, with shifting energy demands customers are starting to raise the question about the benefits of being 'locked in' to DH systems.[lxx]

Pricing

The non-profit pricing principle for DH was removed in 1996 with deregulation. As a result, consumer prices rose by over 15% in some cases. This led to protest and much national media debate. The protesters argued that the energy companies were taking advantage of their natural monopoly.[lxxi] This was a key motive for the 2008 District Heating Act, which focuses on price transparency.

Since market deregulation, the Swedish Competition Authority has argued for price regulation; however, this was not included in the DH Act.

A voluntary price agreement "Prisdialogen" between DH companies and customers was initiated in 2013. The scheme, which requires price forecasts for the following two years, is very successful, with around 70% of DH companies registered. It provides transparent pricing information for customers and has improved pricing consistency among suppliers. There is a good platform for customer engagement, which is a key benefit for the DH companies involved, and the scheme is also positively regarded by consumers.

The light-touch price regulation and Prisdialogen exercise are successful, as Sweden's DH prices are generally lower than those countries with regulated prices. The lack of regulation allows DH companies to focus on efficiency and meeting customers' needs, rather than meeting the terms of the

regulations.[lxxii] Consumers also have the right to negotiate prices and price changes.[lxxiii] If a negotiation between a district heating company and a customer does not lead to an agreement, the company or customer can apply for mediation by the DH Board.

The focus on customer engagement is key for DH companies as there are no compulsory connections in Sweden, and companies rely on good consumer relations to increase the market share of DH in the heating market.

Another argument against price regulation is that DH operates as part of a wider heating market, where other technologies such as heat pumps compete with DH.[lxxiv]

6. Strategic Outcome Stage- Regulatory quality and outputs

Alignment with government strategy and policy

Several factors seem to have led to an apparent turning point for DH in Sweden, as it has been reported that the current model is no longer fit for purpose.[lxxv] On one hand, changes have been made to the regulation to build trust, loyalty and long-term interactions between DH companies and their customers. However, the development of the generation- and production-side has been slower. Business models are still very much focussed on bulk generation which is increasingly in contrast to the shrinking heat demand from increased efficiencies.[lxxvi] DH companies are currently attempting to extend the lifespan of the current business model, though there is a growing belief amongst industry experts that this logic of economies of scale needs to change. This could involve changing financial incentives (which currently exist for inefficient oversized biofuel production units), and an increase in the number of heat prosumers, and new technology. An interviewee also reported that due to the positive narrative around DH in Sweden (I.e. it has been largely successful to date), industry stakeholders find it difficult to accept that the model and technologies need to change.[lxxvii]

According to one interviewee, this kind of development must be at a city-wide level. If left in the hands of those constructing DH networks, they will choose what is most cost-efficient now, and will not engage in long term development. Municipalities need to incentivise technological development.

Hungary

Hungary	
Type of Price Regulation	Subsidised below market price, prices set for producers and residential consumers
Regulatory Body	Hungarian Energy and Public Utility Regulatory Authority (HEA)
Legal Obligations (e.g. zones, connections)	Licences for producers and suppliers, mandatory connections, Operator profit caps,
Ownership Structure	Most DH utilities are owned by municipalities. Heat producers mixed: about half are private companies
Number of DH schemes	216, owned by approximately 100 different supply companies

1. Context: District Heating in Hungary

In the 1950s and 60s extensive district heating systems were constructed for industrial heat consumers. Industrial heat demand in Hungary has since fallen, and many systems are now oversized and inefficient. In addition to this decline, an ongoing trend is householders disconnecting from the network.

In 2017 there were nearly 650 000 households (15% of total) supplied with DH. Approximately 73% of thermal energy sold by DH providers is used by residential consumers (for heating and hot water).

Natural gas provides 78% of DH demand, which is reflective of a national dependence on imported natural gas from Russia throughout the electricity, heat and CHP sectors. In general, most villages and cities are connected to the gas network, with some coal and wood fired boilers also being used in rural areas.[lxxviii] The share of renewables in district heating production is below 8% from which biomass (5.1%), waste (1.6%) and geothermal energy (0.8%) are the most significant.[lxxix]

2. Design Stage -Inputs

Drivers for regulation

Hungary's heat production is dominated by natural gas, both for co-generation and directly for space heating via individual boilers. Gas-fired CHP units provide heat for two thirds of the country's DH schemes.[lxxx] Gas heating is the main competition with DH, and is often more competitively priced, though cost differences exist between areas.

Since regulation was introduced in 1998, the Hungarian context has been characterised by a high level of intervention and major reforms, which have impacted on the market. These changes are described below and are important to consider when evaluating the regulation. Policy tools intended to promote the DH market, including tax advantages and CHP production subsidies have largely been unsuccessful.[lxxxi]

Hungary transitioned from a planned to a market economy based on private ownership in the 1990s.

1998-2005: The Energy Office became the regulatory authority for district heating. It was responsible for the licencing of both the production and supply of district heat. It issued establishment, operation and commissioning licences for heat production, as well as production and operation licences for heat supply[lxxxii].

Producers which co-generated electricity were licensed by the Energy Office, while DH production without generating electricity fell under the remit of municipalities.[lxxxiii]

The current law, The District Heating Act (2005) has been modified many times. The Act regulates the legal relationship between the district heating supplier and the customer, and also between the heat producer and the district heating utility.

2005-2008: The licensing responsibility remained split between the Energy Office and municipalities. Prices were regulated where a city's demand capacity was high (over 50MW). There was no price regulation for producers not supplying residential customers, so they sold heat at freely negotiated prices.

The electricity and gas markets were liberalised in 2008 and 2009 respectively, so that consumers were entitled to choose their supplier, though this did not extend to DH.

2011: The Hungarian Energy Office was transformed to an independent regulatory authority (Hungarian Energy and Public Utility Regulatory Authority or HEA)[lxxxiv]. The HEA is responsible for licensing, supervision, price-regulation, tariff-and fee preparatory tasks for the electricity, gas, DH and water sectors, as well as being the official statistical body. Municipalities no longer hold any licensing powers.

Due to high energy costs, the government initiated a policy framework to reduce household utility costs. Legislative amendments resulted in a series of price cuts for universal service provision (natural gas, electricity and DH), throughout 2013-2014. The government-mandated end-user prices reduced competition, increased regulatory uncertainty and saw foreign-owned companies exit the Hungarian energy sector[lxxxv]. The sale of gas is now mainly associated with the state-owned supplier.

3. Design Stage - Process

Focus of regulation

One evident feature of the regulation is a focus on consumer protection. Hungarian regulation on quality of supply has served as an example for several European countries, indicating the successes in this domain. The quality of supply is assessed through[lxxxvi]:

1. Continuity of supply - suppliers are financially penalised for not meeting the minimum standards
2. Quality of customer service
3. Whether specific timeframes are met – users receive direct compensation from licensee in cases where they are not.

To support consumer protection, HEA works in partnership with consumer-focused NGOS and The Hungarian authority for consumer protection. The HEA has formal agreements with Hungarian Competition Authority and Hungarian Financial Supervisory Authority in order to detect market abuses and co-operate in market analyses on competition issues.

Market forces

Approximately 2/3 of the 100+ DH suppliers are owned fully by municipalities , with partial ownership by local governments common for the remainder. There are also localities where DH suppliers are operated by concession agreement by private enterprises. For, producers, the ownership structure is mixed: about half of these companies are owned at least partly by private companies[lxxxvii].

District heating service providers have monopoly power on their district heating system. In the case of heat producers, competition is possible. However, half of the districts heated are supplied by a single heat producer and the remainder of districts are supplied by only two or three producers. Therefore, opportunities to introduce competition are restricted.

Both gas and DH are fixed below market prices[lxxxviii] and both consumers and producers receive significant financial support:

- **Investment support:** To increase energy efficiency of DH systems and incentivise renewable heat generation investment schemes are financed with EU funding.
- **Reduced VAT:** Compared to the normal VAT rate of 27%, DH consumers are only obliged to pay 5% VAT, which translates to a subsidy of 79 million euro per year[lxxxix].
- **Direct cross-financing**: This system exists between electricity consumption and DH consumption. All electricity consumers pay a surcharge on their electricity consumption which is used to subsidise DH production/consumption. One concern raised within the literature was that private investment in the network where generation potential was high could pick up these costs, disadvantaging users in sparsely populated areas.[xc]
- **Subsidies:** CHP generation was subsidised until 2011 through a Feed in Tarif (FIT). However, as generators were not under competitive pressure, these savings were passed on to end users. These subsidies were stopped for this reason, as well as the fact that they disincentivised renewable generation.[xci] CHP market share dropped significantly as a result, and regulation was re-focused on end-user price regulation rather than support for producers.[xcii]

The high level of public investment which has supported the sector has an inherent degree of risk to public finances and retailers. The International Energy Agency (IEA) have recommended that Hungary liberalise the market so that it can become more self-sustaining.[xciii]

4. Implementation Stage - Outputs

Licensing

The HEA provides licences for electricity, gas, DH and water. For DH there are three types of licence:

- Generation
- Supply
- Establishment of DH production units with heat output greater than 5 MW

Separate licences are required for the heat generation and heat supply. The HEA can revoke licences and can act against licensees failing to comply with licence terms. The HEA also undertakes site visits and inspections to verify compliance.

Where operation licences are withdrawn, the HEA appoints another supplier to ensure continuity of supply for consumers. In 2015 there were two instances where the HEA withdrew the generation and operation licences of DH companies and appointed another company to fulfil these roles.[xciv] It appears the HEA invited offers from other providers to take over the companies' customers, and if no suitable offers were made, the Agency appointed a supplier to take over the clients.[xcv]

Profit caps of 4.5% are in place for DH/CHP operators with options to reinvest profits in excess of this into modernisation of network.[xcvi] Third party access is possible through a tendering process, where the cheapest option is selected. This is not frequently applied in practice, however.

Role of excess heat

Manufactures can sell waste heat at a benchmark price level, and not on basis of their real costs. This ensures that those with profitable excess heat are incentivised to sell it to DH networks. These waste heat producers also have freedom from the profit limit. As this aspect of the regulation was introduced in 2016, the HEA were unable to comment on its effectiveness.[xcvii]

5. Implementation Stage - Intermediate Outcomes

Growth of Sector

Hungary's district heating demand is forecast to decline by 20% between 2015 and 2020 and another 8% between then and 2025, as a result of energy savings obtained from further refurbishment in the residential sector (EU, 2015).[xcviii]

Pricing

Gas and heat prices are regulated so that they remain below oil and coal prices which are set on the open market. Subsidies cover DH producers' losses from rising energy costs and consumer price regulation, and account for 20% of producers' incomes. Prices vary significantly between different utilities.[xcix]

The wholesale price from DH producers is also regulated, with a profit margin of 4.5% allowed for DH produced from renewable energy sources, compared to a 2% profit from fossil fuel-based heat.

Customer perceptions

The main reason that consumers have disconnected from the DH network is the high cost of heating. Over 75% of district heated buildings were constructed as prefabricated buildings with high heat losses, which do not offer the possibility for individual regulation of heating. Over the past decade, several energy retrofit programs targeted these buildings, improving their energy performance. Additionally, consumers have disconnected due to the central operation of the network by the operator, with no end user control.[c]

Improving the social acceptance of DH is a national priority. Campaigns linked to corporate social responsibility and emphasising the positive environmental aspects of DH are reportedly having an impact by reducing negative perceptions.[ci]

6. Strategic Outcome Stage - Regulatory quality and outputs

Complaints by consumers

Consumers contact the HEA with complaints across all areas of utility provision (electricity, gas, DH and water) relating to violation of contract, switching suppliers, metering and invoicing.

Government authorities manage complaints from householders whilst the HEA investigate complaints from non-residential consumers.

To inform consumers, the HEA also performs customer service functions. The HEA provides information for consumers through customer service in person or by phone through call centres, or it answers questions in writing. Information on the levels and nature of complaints relates to all utilities, not just DH. Complaints relate mainly to violation of contract and delays in switching suppliers. In 2015, 1,423 new complaints were raised (across all utilities).[cii].

To aid transparency, DH producers and suppliers are obliged to separate accounting streams as part of their yearly financial report. They must represent separated balance sheet and profit and loss statement for each of their business units.[ciii]

Efficiency of network

Due to the age of pipes, many DH systems in Hungary are inefficient. The decline in industrial heat demand since 1989 has reduced efficiencies and quality of service within many networks. Various efficiency improvements have reduced average heat losses, though figures for current losses proved difficult to obtain[civ]. EU funding has seen major upgrades of pipelines being completed by operators to reach environmental standards.

Alignment with local government strategy and policy

The Hungarian Energy Act aims to achieve 25% of total heat supply by renewables by 2030, from current rates of 8%. It has been recognised as one of the European countries which is showing the slowest progress at reaching its renewables targets.[cv] Renewable supply for DH is increasing however, particularly biomass and geothermal energy, both of which provide huge supply potential for Hungary.[cvi] Increased efficiencies in building stock are further reducing heat demand which further threatens the Hungarian DH sector.[cvii]

Denmark

Denmark	
Type of Price Regulation	'Cost Plus' i.e. necessary costs plus a predetermined mark-up
Regulatory Body	Danish Energy Regulatory Authority (DERA)
Legal Obligations (e.g. zones, connections)	Licences, obligation to supply and connect within zone
Ownership Structure	Mostly cooperative, also municipality owned
Length of network	60,000 km
Number of DH schemes	460

1. Context: District Heating in Denmark

During the 1920's and 1930's, a collective district heating system was developed based on waste heat from local electricity production. At the time of the first Oil Crisis in 1973, 99% of Denmark's heat came from imported fossil fuels.[cviii] DH based on Combined Heat and Power (CHP) plants was one of the priority measures to achieve security of supply. This crisis paved the way for robust interventionist policy, which Danish consumers were open to, as there was widespread agreement that change was desperately needed. This was coupled with historically high levels of trust in both national and local government, common in Nordic countries.[cix]

Today DH supplies space and water heating for 64% of households in Denmark (1.7 m people). Renewable sources, mainly biomass, provide the largest proportion of heat (52%) for the network, with the remaining proportion coming from natural gas (24%), coal (13%), waste combustion (9%), oil (1%), heat pumps and electric boilers (1%).[cx]

2. Design Stage - Input

Strong planning regulation, under the Heat Supply Act[cxi] (1979), along with national and municipal buy-in, helped develop a strong base for regulating and further developing the network. As municipalities owned networks, commercial actors did not have significant influence in the market. This facilitated voluntary compliance in the energy sectors, which was favoured over direct legislation. These conditions supported a fairly unique approach built on co-operation between the political level and energy sector which effectively created the market. Following this, financial incentives were introduced to ensure the on-going economic viability of DH and CHP.

DH has also been promoted through direct policy intervention. Municipalities can enforce mandatory connections for new and existing buildings. A carbon tax (higher than many European comparators)[cxii] was introduced in 1992 to limit fossil fuel usage, and oil burners were banned in new buildings in 2013 and existing builds in 2016.[cxiii] Heat pumps are now the most competitive alternative to DH for a large sector of the population.[cxiv] However, the context in which these policies were introduced is very different to Scotland, given the much higher cost of gas in Denmark.

One of the key factors supporting the development of the Danish DH sector is access to capital for investment. Low interest rates (c. 2%) on capital mean that even if the rate of return on a network is only 4%, a financial case can be built. Denmark has municipality-guaranteed loans, which lowers the interest rate, though in practice this guarantee has never needed to be put into effect. There is also a public works fund, from which municipalities can borrow for the development of DH.

3. Design Stage - Process

Regulatory Structure

The Danish approach to heat regulation provides a clear division of responsibility. National and regional regulation has been rolled back so that local decision-makers have complete control over local heating system designs. However, they do so by relying on a technical framework and centralised policy provided by the national government. The 98 municipalities are responsible for preparing and updating municipal heating plans and approving heating projects within the area.

Market forces

From the outset, the regulation was founded on a thorough understanding of the market, the market effects of networks being monopolies and effective ways of promoting competition, such that all aspects (building, install, financing, supply chain) operated in open competition to ensure investments were financially sustainable. In addition, all market actors had an interest in the financial viability of networks due to the ownership models employed. For example, shareholders and end users are one and the same. Low prices benefit all, and surpluses are paid back through reduced costs rather than going to private investors. Schemes are developed only where they meet the criteria of a standardised assessment which indicates DH will provide cheaper heat than alternative available options.

The main ownership model involves cooperatives, owned by consumers, municipalities, utility companies or a combination of these[cxv]. The smaller schemes (large by UK standards) account for approximately 80% of schemes but provide about 20% of heat. The other dominant model is arms-length companies, generally owned by utilities or municipalities, while a few commercial schemes also exist. There are no differences regarding market entry, irrespective of ownership model. The heat suppliers buy the heat from third party companies: utilities or municipalities - for example, municipality-owned waste incinerators.

All commercial contracts are subject to the supervision of the DERA which can intervene if necessary. General supervision is performed by the Danish Competition and Consumer Authority.

4. Implementation Stage – Output

Mandatory connections

In 1979, The Heat Supply Act was implemented, which introduced heat planning processes. This enabled municipalities to dedicate a certain area to district heating and make it mandatory for households to connect to district heating. This increased the coverage of district heating considerably. The Heat Supply Act also allows electric heating to be banned in new buildings located within a district heating or natural gas supply network. In 1994 the Act was revised to extend this to include a ban on conversion to electric heating in existing buildings.

Supply chain

Denmark has locked-in certain technological solutions through policy, in particular CHP. The Heat Supply Act mandates that plants larger than 1 MW must be operated as combined heating plants, which has resulted in about 80% of district heating being co-produced with electricity. [cxvi]

Role of excess heat

Research shows that 5.1% of existing DH demand could be supplied with industrial excess heat from thermal processes. This potential for use of industrial heat is not uniform across different areas, which

prevents it from being a dominant source for DH at the national level, though it can be very important in some local DH systems.[cxvii]

The role of excess heat is treated similarly to every aspect of the Danish system – it is a commodity which is used where it proves financially viable. While connection by a manufacturer is voluntary, the supply of excess heat is in both operators' and manufacturers' financial interests, which is a successful driver.

There is flexibility for innovative business models and cost-sharing, depending on interest rates of commercial loans and associated risk. In an interview, a Danish expert remarked:
"District heating companies can be very patient as long-term payback is likely."[cxviii]

Therefore, they can finance proposals with low returns and long payback periods. Investment contracts can be structured in several ways, for example around the amount of heat available from a manufacturer, or an obligation to produce heat at times of peak demand.

However, to promote energy efficiency in industry, there is a tax on selling excess heat. This ensures that heat production will only be a secondary objective for manufacturers. This appears to be successful, with no untoward impacts reported, though introducing a requirement for energy efficiency has been recommended.[cxix]

5. Implementation Stage - Intermediate Outcome

Sector growth

The huge investment in and prioritisation of DH over the past 40 years have had significant impacts in Denmark, and not just for fuel security and efficiency as initially planned. Given the successes of DH in terms of market share, network length and competitive market, Denmark has developed and benefitted from a strong supply chain. The sector employs 11,000 and there is a large export potential for DH, both of technology and expertise. This is worth 1.9 bn GBP (>1% of GDP) to the economy each year.[cxx]

A major issue that has received much media attention in Denmark is that some utilities date back from before regulation was introduced. Owners of assets pre-dating the Heat Supply Act claim the assets are not covered by the Act. So these assets are 'free equity' which owners demand interest to be paid on. The amounts to be paid and timeframes are pending at the moment.[cxxi]

In spite of the 'not-for-profit' rule, many companies entered the market with the intention of achieving profit. When unable to do so, costs have increased and many companies, including Vattenfall, are now 'stuck' with networks which they do not want.[cxxii] This has led to co-operatives buying back DH networks, lowering costs by up to 50%, as the service level costs can be set much lower.[cxxiii] Co-operatives have been able to fine-tune (and reduce) levels of service whilst still meeting customer needs. For example, technicians may not need to be on standby to deal with issues, as their roles could be met informally from community-based technicians. Despite cutting costs on service delivery, this does not appear to lead to differences in customer service between commercial or co-operative customers.

Stakeholder experiences

The pricing mechanism, including the fixed annual rate, can be inflexible and is viewed as a "*one size fits all*" approach which constrains market actors. DH operators would like to find ways to introduce more flexibility with pricing (e.g. time of use tariffs) as it would benefit them and end-users by reducing peak demands.

"During the summer in Copenhagen, they get more than enough heat so why not provide low-cost hot water which could, in turn, reduce cooling costs"[cxxiv]

This approach has not yet been discussed or developed in detail, as benefits from the more actionable low-hanging fruit have yet to be realised. These include decreasing temperatures and rewarding DH networks that have increased densities. Additionally, variable rates of energy could benefit low energy users, who would be willing to pay a higher fixed rate but still save money.[cxxv]

Customer perceptions

Whilst the not-for-profit rule protects consumers from 'unfair' prices, consumers are not explicitly protected against inefficient management or practices. However, as the regulation mandates that all aspects must be financially better than business-as-usual, this still leads to better efficiencies throughout the network and market. Waste is reduced at all opportunities to lower the costs. Voluntary benchmarking has been introduced by the DERA to aid transparency. The benchmarking model compares prices and provides a platform for knowledge exchange and improvements in cost-effectiveness. It is practised by most operators.[cxxvi]

In Denmark, the central role of government in the DH sector and its regulation sits well with consumer protection. Tighter regulation is accepted, and high-quality service and protection are expected.[cxxvii] Consumer protection has been "*more or less positive from day one,*"[cxxviii] as the stability and costs were so much more favourable than during the oil crisis. Linked to the strong initial planning, the prevailing view amongst consumers is "*it's easy, someone else deals with it, there is transparency. It just works*."[cxxix]

In addition to this and satisfaction with prices, general satisfaction and trust in the DH sector is high.[cxxx] Despite disconnection from DH networks now being permitted, DH consumer membership is increasing[cxxxi], according to some sources by about 1% per annum. [cxxxii] Again this is indicative of the positive perceptions of DH.

Pricing

The legislation states that the heat price paid by the consumer should cover all necessary costs related to supplying heat. In addition to production and transport costs, this includes financing costs and depreciation of assets to ensure long-term financial sustainability for operators. However, both production and network companies must remain *not-for-profit*, to protect consumers from abuse of the monopoly. Services and supplies to the operator, such as consulting services are considered commercial activities and can generate profit.

Heat tariffs are set annually by each DH company based on its actual expenditures and published in the public domain, with details of all calculations to aid transparency. The tariffs must be the same for all types of consumers (population, industry, public sector etc.). As sub-meters are compulsory in all apartments, users' bills include usage costs as well as fixed costs. Prices vary widely (by a factor of 3 or 4) between different schemes. Interestingly, consumers are reportedly unconcerned by these differences and accept that they are based on factors such as the availability of waste heat and demand. Changes from one year to the next are also more salient for consumers than actual costs or comparable costs[cxxxiii].

The fixed costs and mandatory connection interact to better support vulnerable consumers in some cases. Fuel poverty is not a major social or political issue in Denmark. However, where a customer self-disconnects, they will continue to pay the fixed subscription fee and will not receive immediate financial benefits as this will show up as a refund for low consumption at the end of the year.

6. Strategic Outcome Stage - Regulatory Quality and Outputs

Complaints by consumers and scheme owners

Private consumers' complaints about DH companies are handled by their DH supplier. Where the outcomes are unsatisfactory, they are elevated to The Energy Supplies Complaint Board (issues not regulated by sectoral law) or DERA (regulated issues). However, they have few decisions to make as there are few complaints, and those that are made are generally resolved satisfactorily by the municipality.[cxxxiv] The next level is the Energy Board of Appeal. In 2014, they had only 84 rulings broken down as follows: 53 related to the obligation to connect or remain connected, 9 heat planning issues, 8 "consumer complaints" along with various administrative issues, sponsorship, complaint deadlines missed etc.[cxxxv] These figures are exceptionally low, given the level of DH across Denmark and are indicative of high satisfaction with a system that generally meets end-user expectation and needs.

Efficiency of network

Since 2016, the regulation has been reformed to stimulate cost-savings through the consolidation of many small suppliers into larger entities. A benchmarking system to evaluate the efficiencies of companies and drive improvements has also been introduced. Discussions are also being held about the discontinuation of the not-for-profit clause. The aim is to gradually phase out regulation on companies' choice of production (fuel and technology) and the use of mandatory connection to DH. This is already being phased out by some operators, as DH remains the most cost-effective choice for many consumers, so they do not disconnect when the option is available. This change is also contributing to perceptions of trust of operators.

Finally, the regulatory framework has been criticised as being outdated, due to its focus on production rather than consumption of electricity (e.g. prioritising CHP over heat-pumps).[cxxxvi] There is an acknowledgement within the industry that this needs to change, but as 2018 is an election year, progress is limited which is likely to lead to price increases for the majority of consumers.[cxxxvii]

Alignment with government strategy and policy

The national political goal for the Danish energy system is to have a 100% renewable energy supply in 2050, which has been deemed achievable without excessive costs to society.[cxxxviii] Currently, the transition is challenged by very low electricity prices, which reduce the short-term feasibility of wind turbines and the incentive to invest in new turbines. The low electricity prices also limit the operation of CHP plants in DH networks. Hence, CHP is being replaced by biomass-based heat-only boilers (exempt from the emissions tax)[cxxxix] and the incentive to reinvest in CHP capacity is small.[cxl] These changes are gradually driving a change in focus, to increasing the use of electricity for heat production,[cxli] though this incremental change will be insufficient to achieve the 2050 targets.[cxlii]

Germany

Germany	
Type of Price Regulation	Liberalised; price not regulated
Regulatory Body	No regulatory body
Legal Obligations (e.g. zones, connections)	Mandatory connection by some municipalities
Ownership Structure	Mixed, primarily privatised
Length of network	100,000 km
Number of DH schemes	400

1. Context: District Heating in Germany

Since the first pilot systems in the 1950s, DH has expanded and is among the longest European grids (although not in market share). The growth of the sector has remained relatively stable over the last decade,[cxliii] currently with slow but steady expansion. The number of German citizens served by district heating is 10 million, or 14% of the country's population. Due to pre-1990 policies district heating is more widely used in the Eastern (30% market share) than in the Western (9% market share) parts of Germany.

Fossil fuels continue to dominate DH fuel sources, with the 2015 breakdown between sources as follows: coal & lignite (47%), natural gas (39%), biomass (6%). The majority of this (84%) is generated in CHP plants.[cxliv]

Germany's DH market is a liberalised competitive market and is not regulated at the national level. Most of the DH networks in Germany are operated by city administrations.

2. Design Stage – Inputs

Drivers for regulation

There is no distinct regulation of district heating in Germany, unlike the gas and electricity markets which are regulated by a central body that benchmarks grid operations. In general, this can be attributed to the strong lobbying power of DH companies, who have lobbied the government to maintain an unregulated market.[cxlv]

An investigation in 2014 into regulating the district heating market identified various barriers to the practical implementation of DH regulation. As the production, transmission and supply of heat are all integrated within single DH companies, it is difficult to regulate any one of these activities. For example, price regulation of distribution grids could lead DH operators to shift costs into production prices. As there is no competition in these areas, this would bring no relief for end-users because all costs would still be contained in end-user prices. Unbundling the accounting of production, transmission and supply could partially alleviate this shifting of costs, as the costs would be better understood.

Additionally, the administrative costs of introducing regulation are not proportional to the expected benefits to consumers, particularly due to the accounting practices of DH companies which do not separate production, transmission and supply activity.

Regulating end-use prices would avoid the issue of costs being shifted. This could therefore be an alternative to district heating distribution grids regulation. However, it is an option only if there is no competition in the heating market.[cxlvi]

3. Design Stage - Process

Regulatory Structure

No regulatory body exists for DH in Germany. However, DH is affected by most of the laws ruling the energy sector, which have significantly evolved during the last decade. Some of these laws incentivise DH by supporting CHP, energy efficiency or renewable energy requirements in buildings. A direct cross-financing system exists, in that all electricity consumers pay a surcharge on their electricity consumption which is used to subsidise DH production/consumption.[cxlvii]

Most of the DH networks in Germany are operated by city administrations. This ensures regularised unit prices and smooth expansion of the current facilities. However, this leads to differences between how permits to operate are awarded, though these must be allocated fairly and transparently.

Many schemes are community owned, though this is credited more to motivated community members than supportive financial and legal frameworks. Financial support small heating grids is only available where medium to high demand exists. Thus, areas with high efficiency building standards can find they are unable to get support.[cxlviii]

The German DH organisation (AGFW) advocate for better DH planning at the municipality level to be included in the national energy strategy, from which it is currently omitted. Another idea supported by the AGFW is a reduced VAT rate for district heating to encourage its use.[cxlix]

Market forces

Germany's DH market is a liberalised competitive market, which has had positive impacts on consumer pricing.[cl] District heating companies can set prices, in accordance with Germany's competition law[cli] and the competition authority (Bundeskartellamt) monitors excessive profits. While abuse of the price-setting process occurs, this is not common.[cli] Market-based price setting increases the credit worthiness of the DH companies, while in Germany, capital is relatively cheap and easily available in the first place.

An overarching aim in Germany is the connection of decentralised small-scale heating sources to a regional grid, to the point that policy favours excess-electricity driven heat pumps. This is to achieve flexibility, security and reliability that comes with a central heating source. However, the investment needed to develop such a system, and the level of control needed is very high, limiting the success of these ambitions.[cliii]

Though the continued development of the DH network has been an important objective, DH is more of a vehicle to support other policies such as the increased use of renewables and reduction in emissions.

4. Implementation Stage - Outputs

Supply chain

The closed-circuit infrastructure used in the network minimises opportunities for third party access (i.e. opening the grids for other heat producers to increase competition), or strategic development across networks.[cliv] The limited opportunity for third party access means that the separation of distribution from supply would have minimal impact on competition within the heat market. As such it is not being promoted or explored.[clv]

Role of excess heat

Waste heat from industrial processes does not currently play a significant role in the DH market. The use of excess industrial heat is increasing, but heat is predominantly produced through oil-, coal-, and gas-fired CHP units. There are examples of systems utilising waste heat, but generally these are private self-contained systems which do not provide heating for the domestic market.[clvi] However, federal funding has been set-aside to increase the share of waste heat, in line with the EU Renewable Energy Directive.[clvii]

5. Implementation Stage - Intermediate Outcomes

Customer perceptions

Closed-circuit infrastructure which is incompatible with third party access, combined with the mandatory connection practiced by some municipalities, allows monopoly abuse by DH operators. An inquiry in 2012 by the Bundeskartellamt (Federal Cartel Office) found that customers in such areas generally pay a higher price (20-30% higher)[clviii] than those in voluntary connection areas.[clix] Mandatory connection is the exception rather than the rule in Germany, occurring in only 9% of cases.[clx] Mandatory connection is directed by municipalities and is seen as *"an opportunity that is used by some of the municipalities to increase their revenues,"* as they often have part-ownership of the local DH company.[clxi]

For those consumers in areas with no mandated connection, district heating operates in the heating market in competition with other heat sources such as gas and oil. However, in practice there are only certain points in time when consumers can switch to/from DH, for example when a new house is constructed. Supply contracts are generally 10-15 years long, which gives limited opportunities for consumers to switch.[clxii] If the contract is not terminated by either party nine months before the end of the contract then the contract will be automatically renewed for a further five years. DH suppliers can only deviate from the conditions of a contract with the explicit consent from customers and any proposed changes to supply must first be publicly announced.

According to a representative AGFW, end user satisfaction is reported to be high. However, as there is no central organisation responsible for the DH sector, it can be difficult to collate complaints and satisfaction levels on a national scale.[clxiii]

Pricing

Heat tariffs are not regulated but are produced in the competitive market. There is significant variability of prices between areas (of over 100 per cent), with larger networks having cheaper prices. Suppliers must state clearly the relevant calculation factors used to set a price, and the breakdown of the fuel costs.[clxiv] However, the formulas used by DH companies to calculate prices are inconsistent, and in reality, there is little transparency on pricing. In 2012, an investigation by The Bundeskartellamt resulted in a number of DH companies being fined a total of approximately 55 million Euros for abuse through price setting. This appeared to have little impact, and DH prices remained high following the fines.[clxv]

It appears that more transparency is necessary in terms of pricing. One stakeholder, who has investigated the possibilities for DH regulation in Germany,[clxvi] stated that there should be clearer accounting principles which require generation, transmission and supply activities to be reported separately. They also suggested that DH companies should be required to give clearer explanations for any price increases for consumers.[clxvii] Consumer protection organisations in Germany are continually pushing for further transparency in relation to DH, which AGFW push back on. The EU Energy Efficiency Directive is predicted to mandate increased transparency in the coming years.[clxviii]

6. Strategic Outcome Stage - Regulatory Quality and Outputs

Demand risk

Mandatory connections where DH is available are only used in some municipalities, as regulated by local laws (e.g. some areas of Hamburg). In general, consumers are free to choose their source of heat supply. This puts the associated demand risk on operators who invest without knowing the exact heat consumption.

The fall in the demand for heat, as a consequence of energy saving initiatives, is compensated for by the intensification of existing DH grids in urban areas. This opens up development areas with isolated networks and

local small-scale DH and contracting projects.[clxix] As an indicator of this development, the number of DH substations is steadily increasing while the average connected load of each substation is slowly decreasing.

Complaints by consumers

There is no specific body for DH complaints. Consumers can go to the Consumer Protection Agency (CPA) with complaints regarding pricing. However, there is no system through which the CPA can negotiate with DH companies. The only means of redress is to take legal action through the courts.[clxx]

Seven groups of technical standards, including customer installations, operational safety and security[3] have been developed by AGFW and are non-binding. These are reported to be widely-adopted by operators and achieve their aims in maintaining high standards.[clxxi]

Alignment with government strategy and policy

The main focus of policies is on the power sector and not the heating sector.[clxxii] This has led to a lack of political support for reducing greenhouse gases in the building sector.[clxxiii] Market share of DH has accelerated in new buildings, as builders are required to generate a percentage of their heating needs from renewable energy sources, complete compensatory measures such as installing additional insulation, or using DH or CHP. The core legislation on renewables in the heating sector is the Renewable Energies Heat Act (2009). Under this law, new buildings are required to be well insulated and have a percentage of their heating requirements met by renewable energy sources or make use of CHP or DH. A main criticism of the act is that it only addresses new buildings, though existing building stock contributes much greater to emissions.[clxxv]

Renewable energy sources play an increasingly important role in DH.[clxxvi] However, DH still has weak competitiveness against oil and gas boilers which has limited and slowed growth of the sector.[clxxvii] A strong lobby still promotes the use of natural gas and oil heating systems. Furthermore, in some federal states these are even incentivised.

About 33 % of electricity now derives from wind, solar, biomass and other regenerative sources of energy, due to Renewables Act (EEG).[clxxviii] Renewables have been prioritised over the DH sector in the public debate and in legislation (e.g. feed in tariffs). The exceptions to this are the low interest loans and grants available[clxxix] for renewables which apply to the development of new DH networks that use renewable sources. These supports have been and continue to be successful in the development of small renewable heating grids which would otherwise not have been possible.[clxxx]

The ongoing decline in specific heat demand due to thermal insulation measures, the replacement of old buildings and demographic changes followed by urban restructuring have also contributed to the DH market stagnating.

[3] The seven groups of technical standards are District heating in general, Heat metering and billing, Heat production, Heat distribution, Customer installations, Qualification requirements, Urban development, Operational safety and security

Poland

Poland	
Type of Price Regulation	'Cost Plus' – all costs involved in supply must be accounted for within customer prices, though this is not capped
Regulatory Body	The Energy Regulatory Authority (URE)
Legal Obligations (E.g. zones, connections)	Third party access is guaranteed, operator-funded mandatory connections for consumers who can connect to a DH network, Concessions for producers of >5MW
Ownership Structure	Municipally owned (60%), Private – commercial and municipality arm's-length (40%)
Length of network	20,000 km
Number of DH schemes	443[clxxxi]

1. Context: District Heating in Poland

Poland is one of the largest markets for District Heating (DH) in Europe. Large heat networks were developed to supply heat to Polish workers' homes from the 1930s onwards. Figures vary, but between around 41% and 53%[clxxxii] of the 38.1 million inhabitants are connected to a DH network, satisfying 72% of demand for heat in Polish cities.[clxxxiii] Housing associations and communal flats account for 2/3 of the total DH customer base.[clxxxiv] Both DH production and sales are stable and the DH pipeline has doubled to approximately 20,000km since around 2010.[clxxxv]

Roughly 75% of fuel used for DH was coal. Around 4% was oil, 8% natural gas, 7% biomass and 4% from other sources. Natural gas and biomass are on the rise and oil is decreasing, though these are all less competitive than coal.[clxxxvi,clxxxvii] Heat from waste incineration is increasing. Since 2016, 10 waste incineration plants have been built or are currently being built[clxxxviii]

2. Design Stage - Inputs

Drivers for regulation

In the centrally planned economy of the former Soviet Union, regulated prices were distorted because 1) input prices were below their economic value; coal was subsidised, and investment costs were borne by the state, and 2) the heat supplied to households was cross-subsidised by the industry.[clxxxix]

In 1990, government intervention in the market was limited. Only prices paid by households were still regulated. Housing cooperatives were not allowed to charge more than the maximum price which was set by the state. However, negotiable prices were introduced that covered relations between distributors and institutional customers, housing cooperatives, public institutions, enterprises and other commercial clients. Also, the price paid by a distributor to a producer was negotiable.[cxc]

Since the regulated price was often below negotiable prices, housing cooperatives experienced heavy losses, so the government supported regulated prices with subsidies from 1990 – 1997.[cxci] Negotiable prices allowed all interested parties to settle more realistic prices, but the government could always intervene, which was important since the distributors had monopolistic powers.[cxcii] This went through many iterations over this period.

In 1997, the Polish Parliament passed the Energy Law which set a legal framework for reforms. In 1998, heat prices were freed and subsidies to households withdrawn. The Energy Regulatory Authority (URE) was set up to scrutinise the behaviour of the sector.[cxciii] EU accession in 2004 has shaped the sector since, and Poland has accepted obligations from EU directives.

Because of its high domestic availability and relatively low price,[cxciv] coal is the dominant fuel for heating, including DH, and is expected to remain so in the medium term.[cxcv] This coal dependence has played a significant role in Polish economic and energy policy. Around 60% of heat is co-generated in CHP plants,[cxcvi,cxcvii] which the developed and centralised heat system favour. However, there are still many small DH systems being supplied by inefficient heat boilers that could be replaced by CHP technology.[cxcviii]

Poland has no explicit carbon tax. The implicit tax on CO emissions from energy use is low relative to other OECD European economies. Household coal use for heating, often in inefficient systems, is not subject to environmental taxation, even though this is a significant source of urban air pollution and CO emissions.[cxcix] However, it was the belief of one stakeholder that this CO tax is a sufficient disincentive for end-users to reduce their emissions.[cc]

3. Design Stage - Process

Focus of regulation

Polish energy policy is driven largely by EU directives and requirements; in particular, it is required to liberalise its gas and electricity markets. Also, the EU 20/20/20 goals have the following targets for Poland:

- Increase the share of renewable energy to 20% of total energy demand (binding) [cci]
- Reduce energy consumption by 20% of the projected 2020 levels (non-binding)
- Limit GHG emissions in the sectors not covered by the EU Emissions Trading System (ETS) to 14% above 2005 levels (binding);

These three primary targets are discussed in detail in section 5 – Regulatory Quality and Outputs.

Another driving force for Poland's energy policy is energy security, and specifically reducing its energy dependence on Russia. Poland focusses on maximising the use of existing domestic energy resources.[ccii]

Regulatory Structure

The state or municipalities control 59.8% of DH companies, while 40.2% have dominant private ownership.[cciii] Companies often operate across several cities or provinces. The Polish DH market is very fragmented though it is undergoing consolidation.

Since 2004, significant investment has come from EU funding. However, a substantial proportion of funding has come from the companies themselves who are subsidised by municipalities.

Market Forces

Competition exists in the market due to alternative heating sources: individual heating, small local generation units and other heat producers connected to the same network as third party access is ensured.[cciv] However, consumer opportunity to choose a heat provider is limited by technical conditions and the capacity of different operators DH schemes in all sections of the network.[ccv]

From 2012, the Act on Energy Efficiency has imposed an obligation on DH companies to connect customers if the following conditions are met: 1) the heating of the building requires at least 50kW thermal capacity, 2) technical conditions of delivery from the DH network are met, and 3) at least 75% of the heat provided from the

network comes from renewable energy, CHP or waste industrial heat. The energy company is required to implement and finance the necessary network expansion and connection.[ccvi]

4. Implementation Stage - Outputs

Concessions

Production, transmission and distribution companies with at least 5MW capacity must apply to the URE for a concession and are subject to price regulation. Companies below this threshold are regulated by the municipalities. To prove they have an economical and technical case to be granted a concession, applicants must meet minimum standards relating to equipment, whether the applicant has ownership, access to an energy source, existing market of potential customers etc. To aid the development of the sector following the Energy Act (1997), existing networks were assumed to meet the criteria and were awarded concessions. These must be renewed every 10 years which seems to have been successful in ensuring good practice in the long run.[ccvii]

The main issue highlighted with concessions is the inflexibility which municipalities can have regarding documentation that applicants are required to provide. Municipalities have a meticulous approach to documentation which others deem to be an unnecessary administrative barrier. For example, requirement of proof of ownership of the network can be difficult where an owner has insufficient documentation for all relevant parts of the network.[ccviii]

5. Implementation Stage - Intermediate outcomes

Sector growth

Regulatory reform is being discussed through two main approaches though neither have been introduced as yet. The first option is the introduction of an emissions tax, which would help address the coal issue that characterises the Polish context.

The alternative option is strategic planning by municipalities about the supply of heat. It was suggested that preventing consumers from disconnecting would be the most useful tool to limit demand risk.[ccix] Conversations are ongoing to elevate the acceptance of this option.

The Polish DH sector is about to undergo a major modernisation programme,[ccx] involving greater support for cogeneration, modernisation of the existing DH network, and investment to expand the customer base.[ccxi] Cogenerated electricity is intended to drive development with targets to double from 25TWh (16% of production in 2009) to 50 TWh in 2030.[ccxii]

Customer Perceptions

Mixed opinions on customer perceptions and experiences were found. One stakeholder reported that consumers are generally satisfied with prices and service quality. In addition, innovative network controls are helping to manage supply so that interruptions are rare.[ccxiii]

However, this view was at odds with the fact that many customers are switching from DH to individual boilers. A current state campaign to encourage people to switch to DH focuses on air pollution and convenience and aims to improve the image of DH as an eco-friendly option.[ccxiv]

Stakeholder experiences

For industry representatives, the regulation is seen as creating barriers through intervention. A stakeholder suggested that it is preventing companies from expanding and investing as The Energy Regulatory Authority (URE)may find these costs unjustifiable and reject tariff change proposals submitted by a supplier.[ccxv]

From interviews, the regulation has been described as presenting administrative burdens which creates barriers for DH companies and market actors.[ccxvi] Constant changes to emission caps, for example, are felt to interfere with the day to day operations and achievement of long-term goals. A *"short-sighted*" approach which deprioritises future-planning was also reported in the interviews.[ccxvii]

It was also reported that the regulatory system is perceived by operators as rigid and unaccommodating of individual situations. It appears to offer little opportunity for flexibility or innovation which is resulting in stagnation of the services offered to customers. ***"We have to bear in mind that the heat market involves many actors. DH suppliers are regulated, people with individual heating installations are not."***[ccxviii] The numerous standards which concessionaires must meet drive prices up. This is leading customers to switch fuel supply which was noted to be an ongoing problem.[ccxix]

Pricing

Under cost-plus price regulation, companies calculate their tariffs and submit them for approval to the URE. Tariff setting is based on the justified costs of heat production and distribution and includes justified costs of modernisation, development and environmental protection, as well as the return on capital.[ccxx,ccxxi] The process around this is reported to be complex and inflexible.

There is considerable variability in DH prices due to factors linked to generation, distribution and transmission. Heat prices are particularly low in large cities served by modern heating systems and might be much higher in smaller cities with less modern installations.[ccxxii] This perceived lack of fairness is one reason why *"the pricing system is no longer practical or suitable"* according to one stakeholder[ccxxiii]. The extra costs incurred by the regulatory requirements get passed onto DH customers which can encourage switching to alternative heat sources. The current pricing system was also criticised by a stakeholder for being incompatible with changing needs and technologies that consider time of use and peak demands.[ccxxiv]

In the past two years the URE have investigated anti-competition activity by suppliers. The legislation mandates that tariffs must include all 'real costs' involved in supplying heat, including depreciation costs and re-investment costs to improve efficiencies. Companies were omitting these from their tariffs. While this impacted on profit margins, the lower tariffs incentivised more customers to switch to them, as third party access is guaranteed.[ccxxv]

Changes to the Energy Act are being progressed in relation to heat price regulation. A draft proposal to the legislation will introduce ex-post tariff if passed, to simplify this process.[ccxxvi] There has also been discussion about liberalising the market completely.

6. Strategic Outcome Stage -Regulatory Quality and Outputs

Alignment with government strategy and policy

Increasing the Share of Renewables

An important element of Poland's energy security policy is fuel and technology diversification, and the government is supporting the development of cleaner technologies and the production of liquid and gaseous fuels from coal.[ccxxvii] It is expected that biomass will make up the vast majority of any new renewable energy contributions.[ccxxviii]

The contribution from renewable energy in DH has increased at a faster pace than that of natural gas during the last 10 years. This is mainly because of the partial replacement of coal with biomass in large CHP plants, encouraged by Poland's renewable electricity support system.[ccxxix]

However, the country is very early in its journey to transition from coal. *"We have targets but not the tools yet to change existing structure".*[ccxxx] Poland's obligation to reduce its emissions will mean higher costs for CO_2 emissions and therefore a higher price for coal-based DH. This may continue the trend of individuals replacing DH with individual boilers.[ccxxxi] The EU has provided much funding for the development of renewable energy and EU directives have ensured high-quality heat from renewable sources.

DH networks must accept heat from new sources (including renewables) on the condition that purchasing this energy won't increase prices for clients.[ccxxxii]

Reducing Consumption

Efficient production and energy use is regulated in the EU Energy Efficiency Directive (EED). The success of this has been brought into question, as CHP is not fully prioritised. This is reflected by the fact that cogeneration has remained stable, with 64% of potential economic benefits realised. Administrative barriers and the lack of a financial support framework to develop CHP have contributed to this.[ccxxxiii]

Average heat losses from DH networks were at 11.8% in 2017. This varies greatly between networks due to the age and construction technology. In 2014, 54% of networks were in DH channels and only 40% utilised pre-insulated pipework.[ccxxxiv] Despite a growing value of investments, ongoing privatisation and the inflow of international investors, there is a great need for replacement investments. The average age of the equipment is 35 years which, together with long power lines, results in increased power losses. Furthermore, old equipment produces more pollution and CO_2.[ccxxxv]

The flip-side to the efficiency targets is demand risk. DH use in industry and households has been falling, mainly as a result of improved energy efficiency. Increased consumption is only being seen in the services sector (10% of total consumption).[ccxxxvi] However, the number of new households connected to the system has increased which will offset the declining demand due to improved energy efficiency. A study commissioned by the Ministry of Economics forecasts a 15% increase in DH consumption up to 2030, expected to be achieved mainly in the service sector, while a moderate uplift is projected in the industrial, agricultural and residential sectors.[ccxxxvii] Changes to habitation patterns will also mitigate this demand risk, through increase heat demand. Polish people are increasingly looking to live in larger apartments, while young people are purchasing and renting apartments rather than living at home as was previously done.[ccxxxviii]

Emissions Reductions

The CO_2 emissions regulations have mobilised the Polish DH sector to urge the authorities to introduce regulatory changes that would promote new investment and modify the current heat tariff system.[ccxxxix] However, coal will continue to play a major role. Coal-based heat sources with a plant size of over 20MW fall under the scope of the EU Emissions Trading Scheme (EU ETS) but received free allowances until 2013. The allowance purchase obligation will increase gradually until the phase-out of free allocation by 2027, and this is expected to raise the DH price, depending on the market price of CO_2.[ccxl] Producers must also comply with the standards set by the Industrial Emissions Directive (2010/75/EU), which requires investment in cleaner, more efficient generation units by 2023.

These changes might challenge the future competitiveness of DH companies, due to the necessity to incur additional cost for modernisation by 2020,[ccxli,ccxlii] particularly for smaller systems. Further disconnection of customers from DH is also likely[ccxliii].

Regulation related to energy efficiency standards in the construction sector is supporting positive change in terms of decarbonisation. Passive or close to zero emission buildings are becoming a priority under building regulations and for the past 2-3 years, buildings must meet efficiency standards at the design phase to be granted planning permission. The efficiency of existing stock is also being upgraded under the EED.

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Appendix A – Methodology

This methodology for completing this research involved the following stages, which are described in detail below.

1. Desk based research
2. Stakeholder interviews
3. Evaluation of regulatory models using the OECD framework

1. Desk based research

The countries on which the case studies are based were selected following initial scoping research, to provide a range of examples which involved features which could be applicable to the Scottish context. Grey literature, official reports and academic literature relating to the seven countries were reviewed in a two phase process. The first stage set out a broad overview of each country's regulatory structure, while the second stage drilled down into aspects which are of particular interest to the Scottish Government.

Both stages of the literature review involved using standard academic databases; Scopus and Web of Science, as well as Google Scholar. Google was also used, as a non-academic database. In conjunction with the country name, 'district heat*' and 'district heating regulation', search terms included the following: 'community heating', 'city-wide heating' 'consumer protection'; 'licensing' 'evaluation' 'tariff'; 'price'; regulation'; 'market'; 'suppliers'; 'market-making'; 'market development'; 'business model*'; 'legal framework; 'renewable heat' and 'supply chain*'. Boolean search criteria (AND/OR) were used to maximise search results. Search results were recorded by the research team and can be made available on request.

The majority of reports retrieved were written in English. Those which were unavailable in English were translated using Google translate. Where this was the case, this is noted in the references section.

Further sources were sought on an ad hoc basis, to validate or expand on information.

2. Stakeholder interviews

Telephone interviews were completed with nineteen stakeholders in October and November 2018. The majority of these commented specifically on the country with which they were most familiar. Effort was also made to speak to stakeholders who could provide insights from a Europe-wide perspective or were familiar with the DH sector in the UK or Scotland. The stakeholders involved employees of DH network operators, representatives of industry bodies, policy makers, and academics who have published relevant work. Numerous stakeholders, including those not listed here also provided written responses and sources of information via e-mail.

Stakeholder responses informed the evaluation of different regulatory models as described in the following section.

Table 3: Stakeholders interviewed

Name	Title, Organisation	Region (s)
Tanja Groth	Technical Manager, Energy Economics Sweco UK	Scotland/ Denmark
Morten Duedahl	Business Development Manager, Danish Board of District Heating (DBDH)	Denmark
Birgir Lauersen	International Affairs Manager Danish District Heating Office	Denmark/ EU
Jørgen Kocbach Bølling	Senior Project Leader Norwegian water resources and energy directorate (NVE)	Norway
Trygve Mellvang-Berg	Communications Manager Norwegian District heating Board	Norway
David Pearson	Director, Star Renewables	Scotland/ Norway
Dr. Kristina Lygnerud	Academic, Swedish Environmental Institute	Sweden/ EU
Erik Thornström	Senior Advisor, Energiforetage (Energy Companies Sweden)	Sweden
Håkan Lindsjö	Chief Operating officer, Sysav Industries	Sweden
Matthias Wissner	Senior Economist - Regulation and competition, WIK GmbH	Germany
Roel Kaljee	Retail & Regulatory Affairs, Association of Energy Companies in the Netherlands (Energie-Nederland)	The Netherlands
Peter van Asperen	Senior Legal Counsel, Authority for Consumers and Markets	The Netherlands
Kata Konstantin	Chief Project Associate Budapest District Heating Works	Hungary
Boguslaw Regulski	Vice President Chamber of Commerce of Polish District Heating	Poland
Jan Webb	Professor of Sociology of Organisations, University of Edinburgh	Scotland/ EU
Paul Voss	Managing Director, Euroheat and Power	EU
Dominika Moczko	Manager of European Affairs, German District Heating Organisation (AGFW)	Germany

Malgorzata Mika-Bryska Jakub Patalas	Director of Regulatory Matters and Public Relations Director of Engineering, Veolia Energy Warsaw	Poland

3. Evaluation using OECD Framework

The research team compiled the findings from the literature review and stakeholder interviews to assess each regulatory model for DH using the Organisation for Economic Co-operation and Development (OECD) Framework for Regulatory Policy Evaluation. This allows for comprehensive evaluation of the entire regulatory process, from development to the long-term effects of introducing the regulation. The OECD Framework's five stages encompass:

Design

I. Input
The resources committed to designing and implementing regulation. This includes contextual factors which will shape and impact on the regulatory policy, including the structures, triggers and precursors to the development of regulation.

II. Process
The system (or process) that enables the inputs to operate.

Implementation

III. Output
Products of the policy resulting from the interaction of the previous stages. What practices have been implemented and how successful have they been.

IV. Intermediate Outcome
Changes which are likely to have been the result of the regulation. These include changes by market actors such as satisfaction, perceptions and actions.

Strategic outcome

V. Regulatory Quality and Output

The effectiveness of the regulation in achieving its aims, as well as wider interactions with different local, national and European policies and directions.